Welsh Assembly Government

Facilitating Planning for Renewable Energy in Wales: Meeting the Target

Final Report - Research Contracts 105/2002 and 269/2003

Contents

APPENDICES

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EXECUTIVE SUMMARY

Background

The Welsh Assembly Government provides planning guidance on renewable energy in the form of a Technical Advice Note (TAN 8: Renewable Energy). The current version of this document is now eight years old and the process is underway to update and re-issue it; at time of finalisation of this research it is envisaged a Consultation Draft of a revised TAN 8 will be issued in late Summer 2004. This report is the result of research commissioned by the Welsh Assembly Government to assist it with the re-drafting and implementation of the updated TAN 8. Arup and its sub-consultants were appointed in September 2002 to undertake the research.

The research was commissioned in two phases.

The objective of the first phase was to "review available information, techniques, research and projects and from it develop a decision support tool for TAN 8 to assist local planning authorities in providing for renewable energy".

The first phase (Stage 1) research lasted 9 months and its outputs were generally inconclusive. The team succeeded however in the following:

- Bringing closer together the members of the steering panel for the research (also the technical advice group for the re-drafting of the TAN) and focussing in on the substantive issues that the TAN and the group needed to address.
- Scoping the renewable energy technologies that the TAN, and hence the 'planning tool', had to address. The conclusions were that onshore wind energy represented the only technology that required some form of 'planning tool'.
- Understanding the renewable energy technology mix that was most likely to come forward over the next six years; this was concluded as comprising mostly onshore wind.
- Identifying the planning constraints applicable to onshore wind energy development in Wales; together with a broad understanding of their relative weight in the decision making process.
- Developing a Geographic Information System (GIS) during the Stage 1 research to store and map spatial constraint data. This was used to understand the influence that various environmental designations might have on the spatial planning of onshore wind energy developments in Wales.

The broad conclusions of Stage 1 were that leaving local authorities in isolation to plan for renewable energy (with or without a 'planning tool') was unlikely to allow Wales to meet its wider obligations with respect to national and international carbon dioxide reduction. It was also considered that the degree of environmental assets present in Wales is such that if they are all to remain unaffected by renewable energy developments then very few further projects would be likely to be developed without a significant change in approach in the planning system. As such the Stage 1 research had been a useful exercise, but it was clear further work was required if the TAN 8 document was to facilitate renewable energy effectively and achieve the Assembly Government's renewable energy target of 4 Terrawatt hours by 2010 (just over 10% of current electricity production).

Given the conclusions of the Stage 1 research and the wider economic situation relating to the development of renewable energy technologies in UK, it was inevitable that the major proportion of this target would be delivered by onshore wind energy developments. The Welsh Assembly Government therefore took the view that there was a need to plan for between 800 –1000 Megawatts of installed capacity of onshore wind (some 400-600 additional turbines approximately) by 2010 if there was to be a realistic chance of achieving the 4TWh target.

Arup were therefore appointed in April 2004 to undertake a second phase of research (Stage 2).

The brief for this second stage was to build upon the results of the Stage 1 research and provide a map for Wales that identifies 'strategic search areas' capable of delivering the Welsh Assembly Governments Renewable energy target of 4 Terrawatt hours by 2010. The search areas were needed to accommodate (as a minimum) 800 Megawatts of installed onshore wind capacity by 2010.

Methodology

Arup and its sub-consultants developed further the GIS established during the Stage 1 research contract in accordance with the following methodology:

a) An initial screening exercise - 'absolute' and 'variable' environmental and practical constraint data were gathered and mapped. To these were added the outputs from a separate study of the capacity of the electric distribution network in Wales to accommodate distributed generation from renewable energy development. The results allowed the elimination of several broad zones of Wales from the available land for strategic areas. Spare electrical capacity sufficient to accommodate large-scale onshore wind energy developments was shown to be scarce and unevenly distributed. Without the implementation of planned improvements to the network by 2010/2015 in mid- and north-Wales, there would not be sufficient gird capacity to allow achievement of the 4 Terrawatt hour target.

b) A refinement exercise – the areas which 'fell-through' the initial screening exercise were subject to a further more detailed review at 1:50 000 scale in which more site-specific constraints (such as the presence or absence of isolated properties, land availability and access) were considered.

c) Testing and validation – In order to inform the subsequent debate about the strategic areas arising from the results of a) and b) above, the draft areas were subject to a further review stage. In this, the derived areas were examined with respect to visibility from National Parks/Areas of Outstanding Natural Beauty/National Trails, visibility of other existing (or committed) wind farms, landscapes likely to be 'wild' in character and higher wind speeds. The strategic areas were also subject to a capacity exercise, in which likely scale of developments possible in each was determined (to +/- 50 Megawatts). This was felt to be an important part of conveying the magnitude of development that was required in some areas in order to meet the 2010 target.

Results

The result of the analysis was the derivation of seven strategic areas for large-scale onshore wind energy development in Wales as shown on the Figure overleaf. These are:

A - Denbigh Moors (200 Megawatt capacity)

B - Carno (200 Megawatt capacity)

C - Llandinam East (100 Megawatt capacity)

D - Nant-y-Moch (100 Megawatt capacity)

E - Pontardawe (100 Megawatt capacity)

F - Glyncorrwg (350 Megawatt capacity)

G - Brechfa Forest (150 Megawatt capacity)

In total a potential capacity for up to about 1200 Megawatts of onshore wind energy generation was identified to allow for some flexibility through consultation and possible site-specific issues within the strategic areas.

The implications for Wales of the strategic areas for onshore wind are significant. If the areas are incorporated into the revised TAN, and are subsequently developed in full, this will lead to several discrete 'wind farm landscapes' as part of the consequence of target achievement. For this reason the report makes recommendations with respect to the need for consultation on the results of this research to seek acceptance of the need for a more strategic approach. The combination of the results of this research, the revised TAN 8, plus the recommended consultations, should facilitate the planning for renewable energy in Wales.

CRYNODEB GWEITHREDOL

Cefndir

Mae Llywodraeth Cynulliad Cymru'n darparu cyfarwyddyd cynllunio ynghylch ynni adnewyddadwy ar ffurf Nodyn Hysbysu Technegol (TAN 8: Ynni Adnewyddadwy). Mae'r fersiwn cyfredol o'r ddogfen hon yn wyth mlwydd oed erbyn hyn ac mae'r broses ar waith i'w diweddaru a'i hailgyhoeddi; pan gwblheir yr ymchwil hwn disgwylir y caiff Drafft Ymgynghorol o TAN 8 diwygiedig gael ei gyhoeddi cyn ddiwedd Haf 2004. Mae'r adroddiad hwn yn ganlyniad i ymchwil a gomisiynwyd gan Lywodraeth Cynulliad Cymru i'w chynorthwyo yn y gwaith o ail-lunio a gweithredu'r TAN 8 diwygiedig. Penodwyd Arup a'i is-ymgynghorwyr ym Medi 2002 i ymgymryd â'r ymchwil.

Comisiynwyd yr ymchwil mewn dau gam.

Bwriad y cam cyntaf oedd i "adolygu gwybodaeth sydd ar gael, technegau, ymchwil a phrosiectau ac o hynny ddatblygu erfyn cefnogi penderfyniad ar gyfer TAN 8 i helpu awdurdodau cynllunio lleol ddarparu ar gyfer ynni adnewyddadwy".

Parhaodd ymchwil y cam cyntaf (Cam 1) am 9 mis ac roedd ei chanlyniadau'n amhendant yn gyffredinol. Fodd bynnag, llwyddodd y tîm i wneud y canlynol:

- Dod ag aelodau'r panel llywio ar gyfer yr ymchwil yn agosach at ei gilydd (hefyd y grŵp cyngor technegol ar gyfer ail-lunio'r TAN) a chanolbwyntio ar y pynciau gwirioneddol roedd angen i'r TAN a'r grŵp fynd i'r afael â hwy.
- Darganfod rhychwant y technolegau ynni adnewyddadwy roedd yn rhaid i'r TAN, a thrwy hyn yr 'erfyn cynllunio' fynd i'r afael â hwy. Daethpwyd i'r canlyniad mai ynni gwynt wedi'i seilio ar y tir oedd yr unig dechnoleg a oedd angen rhyw fath o 'erfyn cynllunio'.
- Deall y gymysgedd o dechnoleg ynni adnewyddadwy a oedd fwyaf tebygol o ddyfod i'r amlwg dros y chwe blynedd nesaf; daethpwyd i'r canlyniad mai ynni gwynt wedi'i seilio ar y tir fyddai hwnnw gan mwyaf.
- Nod-adnabod y cyfyngiadau cynllunio sy'n berthnasol i ddatblygu ynni gwynt wedi'i seilio ar y tir yng Nghymru; ynghyd â dealltwriaeth fras o'u pwys cymharol yng nghyswllt y broses o benderfynu.
- Datblygu System Gwybodaeth Ddaearyddol (GIS) yn ystod ymchwil Cam 1 i storio a mapio data cyfyngiad gofodol. Defnyddiwyd hon er mwyn deall y dylanwad y medrai dynodiadau amgylcheddol amrywiol eu cael ar gynllunio gofodol datblygiadau ynni gwynt wedi'u seilio ar y tir yng Nghymru.

Y casgliadau bras y daethpwyd iddynt yng Ngham 1 oedd bod gadael awdurdodau lleol ar eu pennau eu hunain i gynllunio ar gyfer ynni adnewyddadwy (gyda neu heb 'erfyn cynllunio') yn annhebygol o ganiatáu i Gymru gwrdd â'i hymrwymiadau ehangach yng nghyswllt lleihau deuocsid carbon yn genedlaethol ac yn rhyngwladol. Ystyriwyd yn ogystal fod asedau amgylcheddol yn bresennol yng Nghymru i'r fath raddau, os ydynt i gyd yn mynd i osgoi cael eu heffeithio gan ddatblygiadau ynni adnewyddadwy, yna nifer fach iawn o brosiectau pellach a fyddai'n debygol o gael eu datblygu heb newid mawr o ran agwedd o fewn y system gynllunio. Fel y cyfryw, bu'r ymchwil Cam 1 yn ymarfer defnyddiol, ond roedd yn amlwg fod angen rhagor o waith os oedd dogfen TAN 8 yn mynd i hwyluso ynni adnewyddadwy mewn modd effeithiol a chyrraedd targed ynni adnewyddadwy Llywodraeth Cynulliad Cymru o 4 awr Terrawat erbyn 2010 (mymryn dros 10% o'r trydan a gynhyrchir ar hyn o bryd).

O wybod canlyniadau ymchwil Cam 1 a'r sefyllfa economaidd ehangach yng nghyswllt datblygu technolegau ynni adnewyddadwy yn y DU, roedd yn anorfod mai datblygiadau ynni gwynt wedi'u seilio ar y tir a fyddai'n darparu'r gyfran fwyaf o'r targed hwn. Oherwydd hyn penderfynodd Llywodraeth Cynulliad Cymru bod angen cynllunio ar gyfer rhwng 800 –1000 Megawat o gynhwysedd gwynt gosodedig wedi'i seilio ar y tir (oddeutu 400-600 o dyrbinau ychwanegol) erbyn 2010 er mwyn sicrhau gobaith realistig o gyflawni'r targed 4TWh.

Oherwydd hyn penodwyd Arup yn Ebrill 2004 i ymgymryd ag ail gyfnod o ymchwil (Cam 2).

Y cyfarwyddyd ar gyfer yr ail gam hwn oedd i adeiladu ar ganlyniadau ymchwil Cam 1 a darparu map o Gymru sy'n nod-adnabod 'ardaloedd chwilio strategol' sydd â'r gallu i gyflawni nod ynni adnewyddadwy Llywodraeth Cynulliad Cymru o 4 awr Terrawat erbyn 2010. Roedd yr ardaloedd chwilio'n angenrheidiol er mwyn dod o hyd i le ar gyfer 800 Megawat (fel lleiafswm) o gynhwysedd gwynt gosodedig wedi'i seilio ar y tir erbyn 2010.

Methodoleg

Gwnaeth Arup a'i is-ymgynghorwyr fwy o waith datblygu ar y GIS a sefydlwyd yn ystod y cytundeb ymchwil Cam 1 yn unol â'r fethodoleg ganlynol:

a) Ymarfer sgrinio cychwynnol – casglwyd a mapiwyd data cyfyngiadau amgylcheddol ac ymarferol 'absoliwt' ac 'amrywiol' . Ychwanegwyd at y rhain y canlyniadau o astudiaeth ar wahân ar allu'r rhwydwaith dosbarthu trydan yng Nghymru i gynnwys cynhyrchiant a ddosbarthwyd o ddatblygiad ynni adnewyddadwy. Caniataodd y canlyniadau i nifer o barthau eang o Gymru gael eu dileu o'r tir a oedd ar gael ar gyfer ardaloedd strategol. Dangoswyd fod cynhwysedd trydanol dros ben a oedd yn ddigonol er mwyn cynnwys datblygiadau ynni gwynt ar raddfa eang a seiliwyd ar y tir yn brin ac wedi'i ddosbarthu'n anwastad. Heb weithredu gwelliannau arfaethedig yn y rhwydwaith erbyn 2010/2015 yng nghanolbarth a gogledd Cymru, ni fyddai cynhwysedd y grid yn ddigon i ganiatáu i'r targed o 4 awr Terrawat gael ei gyflawni.

b) Ymarfer mireinio – gwnaethpwyd arolwg mwy manwl ar yr ardaloedd y bu iddynt 'gwympo drwy'r ' ymarfer sgrinio cychwynnol ar raddfa o 1:50 000 lle'r ystyriwyd cyfyngiadau mwy safle-penodol (megis presenoldeb neu absenoldeb eiddo diarffordd, argaeledd tir a mynediad iddo).

c) Rhoi ar brawf a dilysu – Er mwyn goleuo'r drafodaeth ddilynol ynghylch yr ardaloedd strategol a fyddai'n deillio o ganlyniadau a) a b) uchod, gwnaethpwyd arolwg arall o'r ardaloedd drafft. Yn yr arolwg hwn, ymchwiliwyd i'r ardaloedd deilliadol o safbwynt eu natur weladwy o Barciau Cenedlaethol/Ardaloedd o Harddwch Naturiol Eithriadol/ Llwybrau Cenedlaethol, natur weladwy ffermydd gwynt eraill sy'n bodoli eisoes (neu ymrwymedig), tirweddau sy'n debygol o fod yn 'wyllt' o ran eu natur a chyflymderau gwynt uwch. Roedd yr ardaloedd strategol hefyd yn ddarostyngedig i ymarfer cynhwysedd, lle pennwyd maint tebygol y datblygiadau ym mhob un ohonynt (hyd at +/- 50 Megawat). Teimlwyd bod hon yn rhan bwysig o fynegi maintioli'r datblygiad a oedd yn angenrheidiol mewn rhai ardaloedd er mwyn cwrdd â tharged 2010.

Canlyniadau

Canlyniad y dadansoddiad oedd darganfod saith ardal strategol ar gyfer datblygu ynni gwynt ar raddfa eang wedi'i seilio ar y tir yng Nghymru fel a ddangosir yn y Ffigur drosodd. Maent fel a ganlyn:

A - Gweunydd Dinbych	(cynhwysedd 200 Megawat)
B - Carno	(cynhwysedd 200 Megawat)
C - Dwyrain Llandinam	(cynhwysedd 100 Megawat)
D - Nant-y-Moch	(cynhwysedd 100 Megawat)
E - Pontardawe	(cynhwysedd 100 Megawat)
F - Glyncorrwg	(cynhwysedd 350 Megawat)
G - Coedwig Brechfa (	cynhwysedd 150 Megawat)

Nod-adnabuwyd cynhwysedd potensial rhwng popeth o hyd at oddeutu 1200 Megawat o gynhyrchiant ynni gwynt wedi'i seilio ar y tir er mwyn caniatáu ar gyfer peth hyblygrwydd drwy ymgynghori a phynciau safle-penodol posib o fewn yr ardaloedd strategol.

Mae'r goblygiadau o safbwynt Cymru o ardaloedd strategol ar gyfer gwynt wedi'i seilio ar y tir yn arwyddocaol. Os caiff yr ardaloedd eu cynnwys o fewn y TAN diwygiedig, a'u datblygu'n llawn, bydd hyn yn arwain at nifer o 'dirweddau fferm wynt' gwahanol, fel rhan o ganlyniad cyrraedd y targed. Oherwydd hyn mae'r adroddiad yn cynnig argymelliadau yng nghyswllt yr angen i ymgynghori ynghylch canlyniadau'r ymchwil hwn er mwyn ymofyn am dderbyniad o'r angen am agwedd fwy strategol. Dylai cyfuniad o'r canlyniadau o'r ymchwil hwn, y Tan 8 diwygiedig, yn ogystal â'r ymgynghoriadau argymelledig, hwyluso'r broses o gynllunio ar gyfer ynni adnewyddadwy yng Nghymru.

Glossary

Blade tip	–	Height from ground level on a wind turbine to the highest point reached by the blades
BWEA	–	British Wind Energy Association
CCW	–	Countryside Council for Wales
DTI	–	Department of Trade and Industry
EIA	–	Environmental Impact Assessment
GIS	–	Geographic Information System
GWh	–	One thousand megawatts hours(see below)
Hub	–	The part of a wind turbine onto which the blades are attached, which in turn is fixed to the nacelle (containing generator and gearbox)
Hub height	–	Height from ground level on a wind turbine to the central point at which the blades are attached
LPA	–	Local Planning Authority
MOD	–	Ministry of Defence
MW	–	Megawatt – 1000 Kilowatts - a unit of total energy production
OCTO	–	Office of the Chief Technical Officer of the Welsh Assembly Government
PPW	–	Planning Policy Wales
RE	–	Renewable Energy
SAM	–	Scheduled Ancient Monument
SPG	–	Supplementary Planning Guidance
SSSI	–	Site of Special Scientific Interest
TAN	–	Technical Advice Note
TWh	–	Terrawatt hour - this is a unit of total energy production per annum. One terrawatt is equal to one million megawatts or one thousand gigawatts
UDP	–	Unitary Development Plan
WAG	–	Welsh Assembly Government
WDA	–	Welsh Development Agency
WLGA	–	Welsh Local Government Association

Acknowledgements – Stage 1

On behalf of the Welsh Assembly Government

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1 Introduction and overview

1.1 Project background and aim

In recent years, renewable energy has become the subject of increasing Government attention in response to fears of accelerated global warming[1]. Generating energy from renewable sources including wind, water and vegetation may offer significant reductions in the amount of carbon dioxide produced in order to supply society with electricity and heat, thereby slowing the pace of global warming. The Welsh Assembly Government has recommended that by 2020, some 20% of electricity produced in Wales should come from renewable sources[2].

Developers of renewable energy technologies are keen to promote these schemes in Wales, as Welsh natural resources offer great potential for energy generation. Hydro power has been exploited in Wales for decades. More recently, attention has focused on wind energy: in the past decade, planning permission has been granted for over 20 wind energy schemes in Wales, of varying scales from single installations to over 100 turbines.

The Welsh Assembly Government provides planning guidance on renewable energy development in the form of a Technical Advice Note (TAN 8: Renewables)[3]. This is currently under review and it is anticipated will be issued in consultation draft form in late Summer 2004. Planning Policy Wales[4] expects local authorities to identify their potential for renewable energy development (referred to in this report as a Renewable Energy Assessment). TAN 8 seeks to offer planners, developers and other interested parties clear information and guidance on how to address technical issues associated with renewable energy proposals.

This report is the result of research commissioned by the Welsh Assembly Government to assist it with the re-drafting and implementation of the revised TAN 8.

The contents of this report and its appendices represent the views therefore of Arup and its sub-consultants and are not the policy of the Welsh Assembly Government.

1.2 Phasing of Project

The research took place over an extended period between September 2002 and July 2004. This report summarises the work undertaken over the entire period and presents the overall findings.

The Welsh Assembly Government commissioned the research in two phases. These are set out below.

- **Stage 1** – A research contract let by the Planning Division of the Welsh Assembly Government that ran from September 2002 until June 2003. This was formally entitled "*Contract 105/2002 – Facilitating Planning for Renewable Energy*" and is described in more detail below in **Part B** of this report (hereafter referred to as the 'Stage 1' contract)
- **Stage 2** – A research contract let by the Office of the Chief Technology Officer (OCTO) of the Welsh Assembly Government that ran from April 2004 to July 2004. This was formally entitled "*Contract 269/2003 – Facilitating Renewable Energy in Wales: Meeting the target*" and is described in more detail within **Part C** of this report. This work is hereafter referred to as the 'Stage 2' contract. The Stage 2 contract was designed to utilise the Stage 1 work to ensure the output was capable of achieving the Welsh renewable energy targets to 2010.

[1] DTI, Energy White Paper (2003) Our Energy Future – Creating a low carbon economy.
[2] Economic Development Committee (January 2003) Review of Energy Policy in Wales – Renewable Energy
[3] Welsh Assembly Government (1996) Technical Advice Note (TAN) 8 Renewable Energy
[4] Welsh Assembly Government (2002) Planning Policy Wales

1.3 Report Structure

The report is divided into four parts.

Part A sets out the context for both research contracts. It examines relevant energy and planning policies and approaches available for the planning for renewable energy in Wales..

Part B describes the Stage 1 brief for the research and gives a broad overview of the work undertaken and its principal findings. It covers in particular the renewable energy technology review which formed a central part of Stage 1.

Part C describes the work undertaken in the development of the research output to assist with the implementation of the revised TAN 8. It describes the Stage 2 brief and the practical implications of supporting the 4TWh target by 2010. This is followed by a detailed consideration of the factors that should be considered in the strategic planning for large-scale onshore wind energy developments in Wales. Finally how these factors were brought together in a Geographic Information System is described, together with the results of the subsequent analysis of the data. Included in this section of the report is the methodology for the identification and validation of the strategic areas for onshore wind; the principal output from the Stage 2 research.

Part D presents overall conclusions and recommendations from the entire research process.

1.4 Methodology

A number of research streams have been followed during this project, both in sequence and later, simultaneously.

- **Desk Study**

  An extensive literature review was undertaken to determine a) appropriate renewable energy technologies, b) best practice in regional, national and local planning for renewable energy developments in the UK, c) Previous GIS approaches, d) available data on grid and other relevant constraints/factors and e) current best practice guidance on the visual and landscape approach to assessments of renewable energy developments.

- **Site Visits**

  Most of the upland areas of Wales beyond the National Parks/Areas of Outstanding Natural Beauty, together with most of south and west Wales were visited at various stages of the research to a) gain geographic familiarity, b) review GIS data in the field, c) gain a general appreciation of relevant visual, landscape and cumulative impact issues as related to onshore wind energy developments and d) test and review the principal findings from the research.

- **Technical Analysis**

  A comprehensive analysis of spatial environmental data was undertaken, initially using overlays and subsequently utilising an all Wales Geographic Information System developed specifically for the research. Numerical analysis of electrical output data was also undertaken to determine the ability to achieve targets and the contributions that could be expected from different renewable energy developments.

- **Consultations**

  Extensive consultations were undertaken during the early stages of the research (principally Stage 1) to gauge stakeholder views on the issues surrounding the planning for renewable energy developments in Wales. In view of the potential commercial sensitivity of some of the work for Stage 2 of the research, it was undertaken in confidence at the request of the Welsh Assembly Government.

- **Steering Panels**

A Steering Panel was appointed by the client at the beginning of the whole process, which met on five occasions between September 2002 and May 2003. This initial project steering group also comprised the 'Technical Advice Group' or TAG convened by Welsh Assembly Government Planning Division to assist with the re-drafting of Technical Advice Note 8. It comprised representatives from a wide spectrum of organisations on all sides of the renewable energy debate in Wales (see Acknowledgments for details of attendees to the Stage 1 Steering Panel). It was felt by the Welsh Assembly Government that to reconvene the same steering panel for Stage 2 of the research would be inappropriate due to the nature of the brief and the time pressures on bringing the TAN 8 work to a conclusion; hence a smaller grouping of organisations was responsible for overseeing the development of the Stage 2 research output. (See Acknowledgements for details of attendees to the Stage 2 Steering Panel).

Part A - Context

Part A of this report sets the context for the research contract. It outlines the existing policy context with respect to both energy and planning and approaches available for the planning for renewable energy in Wales.

2 Policy context in Wales

2.1 Introduction

The legislative and policy framework which applies to renewable energy development in Wales includes energy / economic development policy and planning policy. These are produced by different departments of the Welsh Assembly Government, and are discussed separately below.

2.2 Energy Policy

2.2.1 Central government policy

Under the internationally-agreed Kyoto Protocol, the UK government has a commitment to reduce greenhouse gas emissions by 12.5% (below 1990 levels) by **2008-12.**

Energy policy is not a fully devolved function. Following a Cabinet Office review in February 2002 (see text box below), the DTI produced a UK **Energy White Paper** in February 2003 which applies in Wales[5]

Cabinet Office PIU Energy Review (February 2002)

"the target for the proportion of electricity generated from renewable sources should be increased to 20% by 2020" (Exec Summ point viii)

"In many parts of the energy industries, investors have found that their projects have difficulty in gaining planning permission. The attitude of local communities to proposals for new energy developments is important. They must continue to have their say in the planning process, which is one reason why it is important to engage the public in the energy policy debate. But **national planning guidance needs to make it clear where there is a national case for new investment in energy-related facilities by establishing the relevant national and regional context for each type of development**." (Exec Summ)

The Energy White Paper emphasises the fundamental importance of using less energy and sets a long-term aim of a low carbon economy by 2050. It aims for 20% of our electricity to come from renewable sources by 2020, in the context of a more ambitious aspiration: the long-term aim is to reduce carbon dioxide emissions by 60% by 2050, a reduction of around 65 million tonnes. This is to be addressed through a mix of measures including increased energy efficiency in domestic buildings, industry and transport, and investment in renewable technologies.

The White Paper asserts that if the 60% target is to be achieved, renewables will have to contribute at least 30-40% of UK electricity generation by 2050 (para 4.5). Financial support for renewables has recently been increased; two-thirds of this increase (£40m) is available as capital grants to offshore wind developers and includes £10m to the North Hoyle and £4m to the Rhyl Flats projects in North Wales[6]

[5] DTI (2003) Energy White Paper: Our Energy Future – creating a low carbon economy
[6] DTI Press release, 26th March 2003, 'Wilson Announces Major Boost to Offshore Wind'; Bellew (2003) Response to Arup Consultation Draft Report, pers comm.

2.2.2 Energy policy in Wales

Welsh renewable energy policy comprises two statements on behalf of the Welsh Assembly Cabinet by Andrew Davies, Minister for Economic Development: an Energy Statement (26th February 2003)[7] and the Cabinet Response to the EDC (5th March 2003)[8].

The Economic Development Committee of the National Assembly conducted a **Review of Energy Policy in Wales**. The part of this review relating to renewable energy was completed in January 2003.

Within the scope of the White Paper, the Economic Development Committee of the Welsh Assembly Government has been conducting a **Review of Energy Policy in Wales**. The part of this review relating to renewable energy was completed in January 2003.

A key recommendation was that in terms of renewable electricity *generation*, "Wales should set itself a benchmark of **4TWh per year**. This is a realistic figure for 2010 on the basis of existing plans and amounts to just over 10% of Welsh electricity production. The Committee estimates that this would be made up of **roughly equal parts on shore wind, off shore wind and other renewable sources**. In the longer term, it expects on shore wind to play a decreasingly smaller part in this." (para 4.11)

The Economic Minister's Energy Statement endorses the 4TWh benchmark, although the Assembly Government did not explicitly endorse the 'three-way split' anticipated by the Economic Development Committee which officials have confirmed was on the basis that within the UK's competitive energy market, Wales' energy mix has to be determined by market forces. The Energy Statement acknowledges that in the short to medium term, onshore and offshore wind are respectively likely to be the renewable technologies which contribute most to the Welsh carbon reduction target. In the longer term, the Statement suggests that tidal stream and biomass schemes may play a growing role.

The Government Response offers a more detailed policy view and supports a 20% carbon reduction by 2020 (as opposed to a 20% renewable energy target), although it describes the 4TWh renewable energy benchmark as "a realistic target". It states that the 20% by 2020 target would however require around 7TWh of renewable energy to be generated by then. In the shorter term, the Cabinet considers that "wind energy is most likely to contribute substantially", although "between 2010 and 2020, tidal stream, PV and biomass, and perhaps wave, are expected to begin to make significant contributions.

2.3 Planning Policy

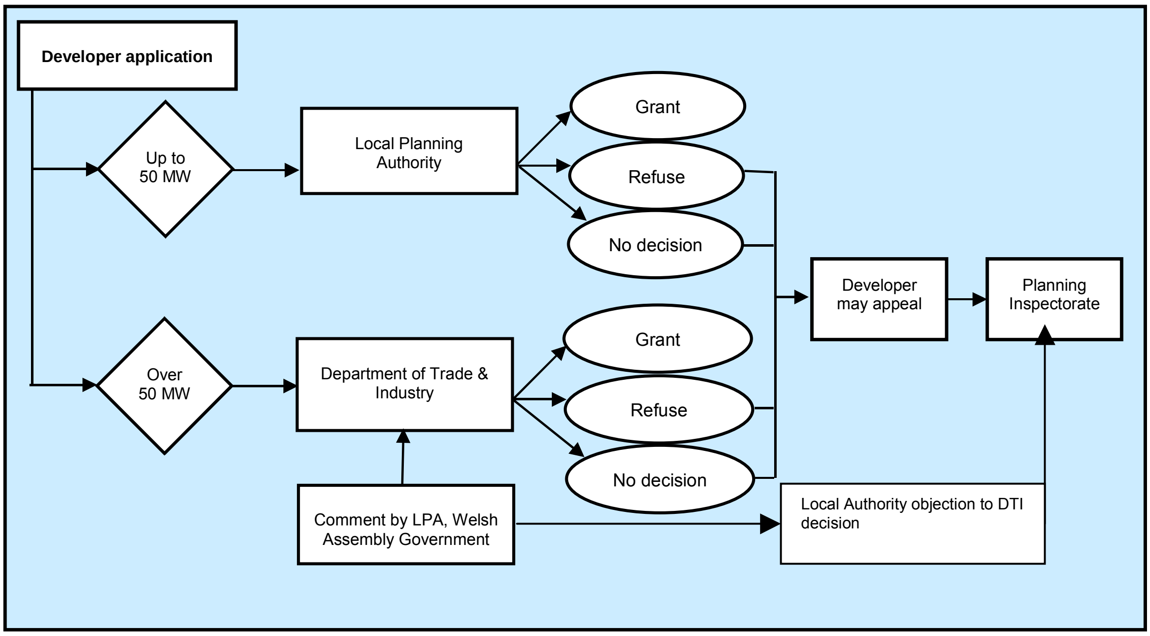
2.3.1 The onshore land use planning system in Wales

The land use planning system controls the location and extent of virtually all built development, including most small to medium scale renewable energy infrastructure and related buildings.

For schemes under 50MW, developers must apply to the local planning authority for permission; those over 50MW are referred to the DTI (see figure 2.1 overleaf) under Section 36 of the Electricity Act[9]. DTI permission must also be sought for overhead lines generally greater than 2km length also from the DTI under Section 37 of the same act. Where appropriate, the DTI will determine the application with reference to national planning policy and the public interest, although it must consult the local planning authority.

[7] http://www.wales.gov.uk/organicabinet/content/statements/2003/energy-260203-e.doc
[8] http://www.wales.gov.uk/organicabinet/content/statements/2003/energy-050303-e.doc
[9] Electricity Act 1989

Figure 2.1 – Renewable energy planning framework



The local planning authority (LPA) will determine relevant applications (or offer advice to DTI) with reference to its Unitary Development Plan (UDP) and other planning guidance. It is expected that development control decisions such as these be made in accordance with the relevant development plan, unless material considerations indicate otherwise. If the LPA objects to the application, its concerns must be addressed or the application may be refused. If planning permission is refused, the developer may appeal and a public inquiry may be held. Sufficient third party objections, or objections from statutory consultees may trigger a call-in of those applications of less than 50MW by the Welsh Assembly Government.

The local planning authority sets out planning policies in its Unitary Development Plan (UDP), in line with Welsh guidance (see above). The UDP is the combination of strategic, county-wide policies (similar to former Structure Plans) and more detailed policies relating to specific geographical areas (similar to former Local Plans). Public consultation is undertaken on the UDP, and a Public Inquiry is held before it is formally adopted.

In addition, a local authority may choose to produce Supplementary Planning Guidance (SPG) on particular issues which are of local importance. SPG is not subject to the same degree of public consultation and testing as the UDP, but may offer more technically detailed advice to potential developers. For example, Cumbria County Council produced an SPG document in July 1997 on 'landscape guidance areas for wind energy' with detailed recommendations for the design and siting of wind energy developments in the County.

A study by Oxera Environmental and Arup (2002)[10] assessed the planning framework for onshore wind across the UK and found that "..there has been a positive correlation between the rate of approval of planning applications and the existence of an up-to-date development plan. The success rate for planning applications in such areas was almost three approvals to every one refusal, compared to fewer than two to one in areas without a supportive development plan policy" (page 8).

2.3.2 Offshore Planning Policy

[10] OXERA & Arup Economics and Planning (February 2002) Regional Renewable Energy Assessments – a report to the DTI and DTLR

The UK land use planning system applies only as far as the mean low water mark. Beyond this, development consent for renewable energy schemes and other development within territorial waters is granted by the UK government (Secretary of State for the Environment or SoS for Trade & Industry, as appropriate). The Welsh Assembly Government is a consultee in the process. Its remit covers "the sea adjacent to Wales out as far as the seaward boundary of the territorial sea" (section 155 of the Government of Wales Act, 1998). However, it has no decision-making power. The Assembly Government also has consent responsibilities under the Transport and Works Act 1992.

The land use planning system in Wales has little scope to directly influence the strategic development of offshore wind energy generation schemes. However, planning authorities may receive applications for associated onshore infrastructure, and are likely to be consulted on offshore proposals adjacent to their local authority boundary. Further information is provided in **Appendix B**.

2.3.3 Planning Policy Wales (2002)

This document covers a wide variety of different land use planning issues and includes renewable energy insofar as it relates to the work of planners.

The Welsh Assembly Government is keen to "encourage the development of the renewables sector and promote energy efficiency and conservation in an economic, environmentally sound and socially acceptable way" (para 12.8.4). Planning Policy Wales (PPW) states that the planning system will "work towards an agreed target of its electricity and heat requirements from renewable sources by 2010" (para12.8.6). It directs that "local planning authorities should therefore facilitate the development of all forms of renewable energy and energy efficiency and conservation measures where they are environmentally and socially acceptable" (para 12.8.9).

Of most relevance to the research is the fact that local planning authorities are directed to "undertake an assessment of the potential of all renewable energy resources and the potential of renewable energy technologies and energy efficiency and conservation measures and include detailed policies [to this effect] in their UDPs" (para 12.9.1). This assessment has been slow to happen in some local planning authorities.

2.3.4 Technical Advice Note 8

Technical Advice Note 8 (Renewable Energy) was first published in 1996 and is currently being updated following the results of this research contract. The role of Technical Advice Notes is to support the strategic policy contained within Planning Policy Wales and to detail the Assembly's approach to technical matters arising from it. To assist with this process, a Technical Advisory Group (TAG) has been meeting for over 18 months to discuss the issues and offer guidance to the policy makers. Broad stakeholder interests are represented on the TAG, including renewable energy developers, nature conservation bodies, the Council for National Parks, the Campaign for the Protection of Rural Wales, the Forestry Commission, council planning officers' representatives and the Welsh Development Agency. The TAG has also acted as a steering panel for Stage 1 of the current project.

TAN 8 is intended to apply in Wales for approximately 5-7 years as the rapid pace of change in the renewables sector is likely to render such a document obsolete relatively quickly. Consequently, the range of technologies considered within the re-draft of TAN 8 will be limited predominantly to those which are expected to exert realistic planning pressure in approximately the next 5 years although the TAN will no doubt encourage other technologies through its proactive approach. There has been a great deal of discussion (still ongoing) into the appropriate proportion of Welsh electricity that various technologies may be expected to generate within the TAN 8 period. The key issues are discussed in more detail later in this report.

2.3.5 Existing UDP Planning Policies

Planning bodies can develop lists of criteria to be considered when identifying suitable sites for particular types of renewable energy schemes. Criteria may be developed in collaboration with NGOs, the wind industry and other stakeholder interests. These criteria are included in UDPs, and tested during the Inquiry process, lending them a degree of legitimacy. However, no spatial interpretation of the criteria is usually presented.

Criteria based planning policies directly or indirectly identify those parts of an area (e.g. local authority) which are (or are not) considered suitable for renewable energy development, such as National Parks, and then leaves the remaining areas for consideration by potential developers. Importantly, to work well such an approach relies on either mapped information or unequivocal criteria (e.g. presence or absence of sites designated under the EU Habitats Directive), which are easily capable of being mapped. (See below for details of this approach as tried in Cumbria).

Cumbria County Council: Statement of Supplementary Planning Guidance (SPG)[11]

Cumbria County Council assessed which areas of the County had the potential to accommodate onshore wind developments. The SPG **focused on landscape and visual issues**, and recognised the different impacts of different sizes of turbines, as well as 5 different scales of development (domestic, dispersed, small cluster [2-5 turbines], large cluster [6-9], wind farm [10 or more turbines]). At the time the guidance was written, a hub height of 40-50m was standard for wind turbines.

Five categories of landscape of relevance to wind energy generation were identified: exposed, open, rolling, forested and urban. Within these, 13 landscape types were identified: the sensitivity of each of these categories to wind energy development was then assessed.

Consequently, a map of Guidance Areas was produced for Cumbria. This identified which type of wind development might **be appropriate** in particular areas. It also identified areas in which any wind development would be **inappropriate** –by virtue of landscape type or nature / conservation designation.

A brief review of the current local authority renewable energy planning policies in Wales (largely contained within the various UDPs) reveals that all would appear at present to have adopted criteria-based policies. The emphasis varies considerably however as to whether the criteria are to be used to identify where renewable energy developments are deemed suitable or unsuitable. This would appear to reflect the differing attitudes to renewable energy developments (principally onshore wind) amongst the various planning authorities. Even where there is a positive presumption in favour of onshore wind energy developments as a matter of principle, this is usually followed by extensive lists of criteria clarifying the tests that such developments have to pass before they would be considered acceptable. These (in many cases) would seem on first inspection to significantly reduce the likelihood of significant wind energy developments occurring.

Local planning authorities could identify specific areas on their proposals maps that they consider to be suitable for renewable energy development. In identifying areas of search, local authorities must have a detailed understanding of the factors influencing the viability of the particular renewable energy development. It is believed that no Welsh Local Planning Authority has gone as far as to identify ‘areas of search’ for onshore wind energy developments, but some UDPs contain general comments about broad parts of the authority that may be suitable.

[11] Cumbria County Council (July 1997): Wind Energy Development in Cumbria: Statement of Supplementary Planning Guidance.

2.4 Conclusions of review

Energy policy in the UK and Wales is clear and gives a strong steer towards the achievement of renewable energy electricity generation targets by 2010 and 2020. In general however the means by which such targets are to be achieved, i.e. by which technology mixes, are not specified because these are the subject of competitive market forces and the economic viability of the technologies. Central to UK Government energy policy is the commitment to a market-based approach to delivering secure energy supplies. This is the basis of the Renewables Obligation, which brings the most commercially viable technologies to the marketplace. As a result, wind power is the most scaleable technology for the short to medium term, a fact endorsed by the DTI Renewable Innovation Review[12], completed earlier this year.

Planning policy for Wales is a devolved matter. However, the present context for renewable energy is complicated by the fact that a) the current TAN 8 (and to a lesser extent PPW) are now out of date with respect to many renewable energy technologies and b) applications for generating schemes of greater than 50MW are determined by the DTI under the Electricity Act, not the planning system.

Local planning policies are in some cases even more out of date and generally are at odds with national and international obligations for CO_2 reduction and hence renewable energy generation. The use of criteria –based planning policies is increasingly seen as unhelpful to all parties, leaving much room for interpretation and debate on a case-by-case basis, the result of which are public inquiries and the delay to decisions regarding renewable energy applications.

The Welsh Assembly Government has three potential options to update the present system and these are set out and discussed below.

2.5 Planning approaches available to the Welsh Assembly Government

The three main approaches are:

a) Utilising the existing planning framework, which stipulates that individual planning authorities should undertake renewable energy assessments

b) a regional approach or

c) a national approach

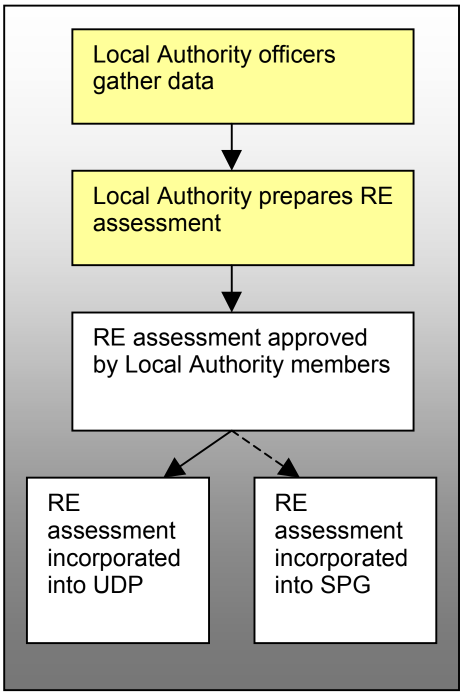
Each of these is set out below.

2.5.1 Implementation in accordance with existing planning framework

In accordance with the current version of Planning Policy Wales[13], local planning authorities "*should undertake an assessment of the potential of all renewable energy resources and the potential of renewable energy technologies*" in their area (paragraph 12.9.1). These assessments are subsequently expected to inform UDP policy, or may be produced as Supplementary Planning Guidance (SPG) if the UDP process is already at an advanced stage, as shown in **Figure 2.1**. The precise manner of encapsulating this information within the UDP process (i.e. whether indirectly via criteria-based policies, or by areas of search) is presently left for local authorities to determine. Importantly this process is currently to take place in the absence of regional or local targets for renewable energy generation.

[12] DTI Feb 2004 - http://www.dti.gov.uk/energy/renewables/policy/rirconclusions.pdf
[13] Welsh Assembly Government (2002), Planning Policy Wales

Figure 2.1: The existing planning framework (requiring renewable energy assessments at the local authority level).



Discussion

In theory, Wales is expected to meet its 4TWh benchmark/target for renewable energy generation through contributions from each local authority. If local authorities are simply requested to identify their potential contributions, it is likely that a significant shortfall in provision will result. This is because without an incentive to meet the target, renewable energy assessments are unlikely to be a priority for local authorities.

Apportioning the 4TWh benchmark/target to Unitary Authorities in Wales would create definable deliverables for local authorities, and would increase the likelihood of meeting the target by 2010. However, it would be problematic to apportion this target at the local authority level, as the current opportunities for renewable energy generation, and existing schemes, are unevenly distributed across Wales.

2.5.2 Implementation on a regional basis via a modified planning framework

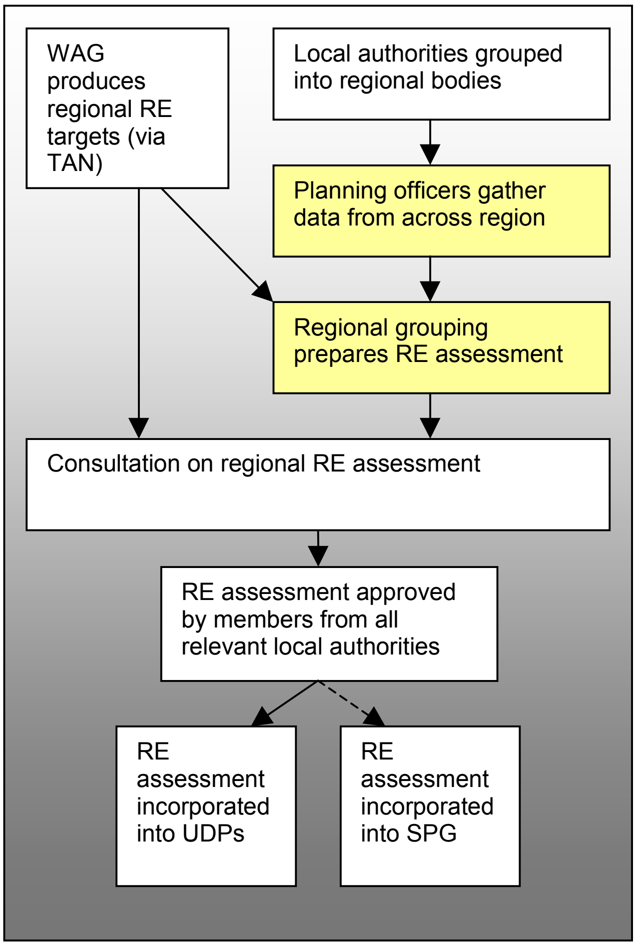
It may be more appropriate to identify regional groupings of authorities that can work together to identify renewable energy opportunities in their area, and to apportion the 4TWh benchmark/target between them; this is discussed below.

Appropriate regional groupings may be analogous with the Welsh Regional Waste Technical Groups (North Wales, South East and South West), or could relate more closely to the geographical distribution of renewable energy resources, existing installations and constraints. (There would however be resource implications for a number of bodies if a similar process to the Waste Technical Groups were established.). To encourage debate at the regional level under such an approach it would be advantageous to distribute a National onshore renewable energy benchmark/target for 2010 to the appropriate Welsh regional areas.

Regional groupings of local authorities could prepare possible *regional* renewable energy assessments. In this process regional groupings could create maps of their area and use them to identify opportunities for renewable energy generation with or without an appropriate regional renewable energy generation target. This could be a two stage process, starting with the initial assessment by an expert group of officers or consultants, and subsequently validated via stakeholder workshops or similar.

Such an approach is set out in **Figure 2.2** below.

Figure 2.2 A regional approach to planning for Renewable Energy



Monitoring would be required, to identify whether the region was approaching its target in the required timescale and there would remain the possibility that the targets would not be met within the intended timescale.

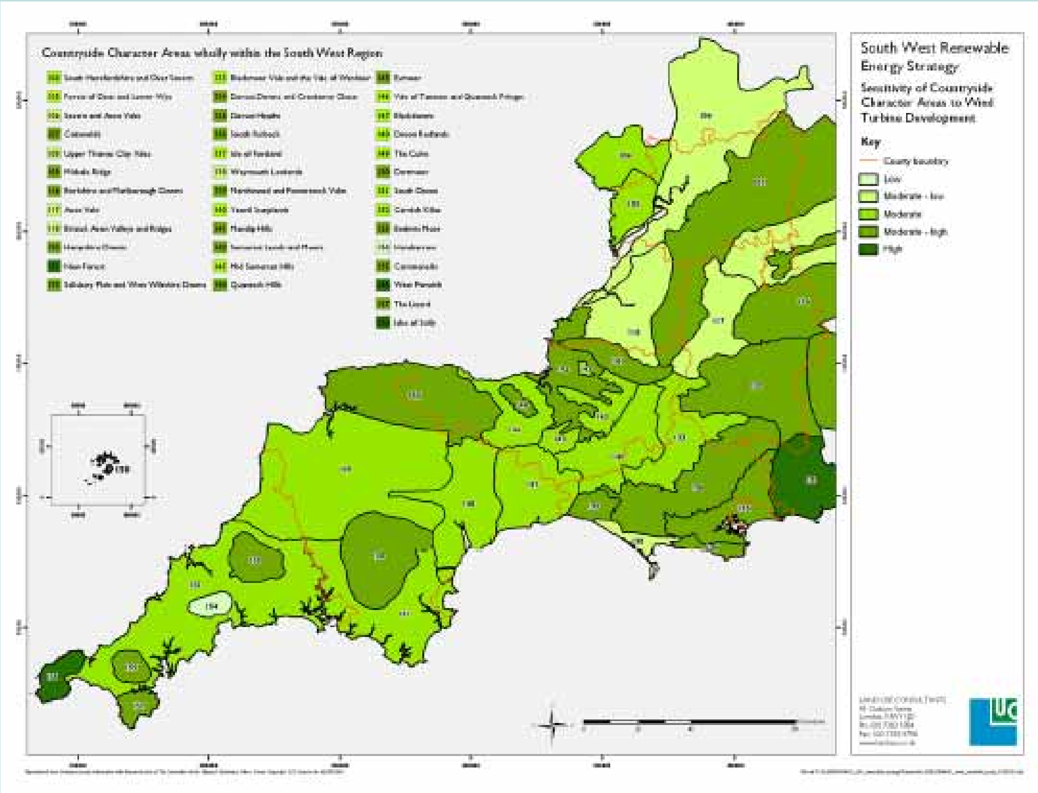
Discussion

Implementation on a regional basis is in essence the approach being advocated in the English equivalent of TAN 8, PPS 22[14].

In PPS 22 the English regions are encouraged to develop regional renewable energy targets (informed by expert studies). These are in most cases currently in the process of being apportioned to the county level via regional forum. The forum comprise a mixture of government and non-governmental organisations and they are making the sub-regional apportionment on the basis of further expert judgement and consultation.

The expert studies seek to establish appropriate spatial locations for renewable energy developments (principally wind and biomass) on the basis of a range of environmental criteria (see example below). It is then envisaged that the county/district (as appropriate) develop criteria-based planning policies which will allow the deployment of the appropriate technologies in the appropriate locations in accordance with the regional targets.

It is a matter of current debate as to whether this process as outlined in England will facilitate sufficient projects to allow target achievement by 2010.



South West Renewable Energy Strategy. Using Landscape Sensitivity to set Draft Targets for Wind Energy[15] This is a consultant's study, carried out by Land Use Consultants for the Government Office for the South West. It focussed on providing information on the sensitivity of different landscape character areas to wind turbines but also assessed whether a similar approach could be used for biomass crops..It is a strategic study of landscape sensitivity to a specific type of change/development. ·

[14] Planning Policy Statement 22 – Renewable Energy, ODPM 2004, Consultation Draft

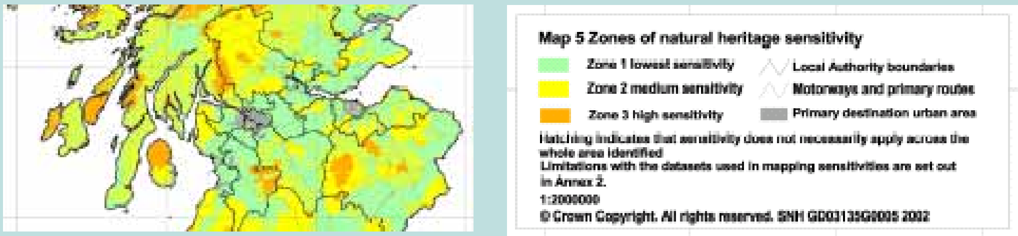
[15] Land Use Consultants (2003): South West Renewable Energy Strategy : Using Landscape Sensitivity to set Draft Targets for Wind Energy Unpublished report to the Government Office for the South West

2.5.3 Implementation at a national level

As well as implementation within the existing planning framework (largely at the unitary authority level) or implementation via regional groupings (both of which are described above) a third approach is available to the Welsh Assembly Government. This is implementation directly at a national level by Assembly Officers operating with appropriate ministerial approval. Under such an arrangement several steps in the processes outlined previously could be 'side-stepped', and spatial planning undertaken by the Welsh Assembly Government rather than local government with the output from the exercise used to directly inform the revised TAN 8. The revised TAN 8 would therefore contain spatial information appropriate to the major renewable energy technologies and could hence start influencing planning decisions immediately.

Discussion

Although national spatial planning of renewable energy opportunities has not been adopted by any of the other parts of UK government, Scottish Natural Heritage (SNH)[16] has attempted something similar with respect to just one technology, onshore wind. SNH has produced maps and tables showing the range of landscape and biodiversity issues to be considered when choosing appropriate wind farm locations, and their sensitivity. Consistent with a strategic overview, the SNH maps show Scotland at 1: 2,000,000 at A4 size (see extract below).



The SNH maps are to be worked into more detail in time by regional wind farm landscape capacity studies, the first of which has recently been completed for Argyll and Bute.

Implementation at a national level is considered to have the following advantages:

- There is no need to wait for the lengthy process of Unitary Development Plan preparation, or update and adoption
- Local and regional influence over decision making is significantly reduced giving greater consistency of approach and certainty over options for target delivery
- An appropriate renewable energy technology mix deemed necessary to meet the target, could be specified and planned for
- The balancing of different environmental and technical factors could be undertaken more objectively at a national, rather than regional or local level.

However, many of the advantages of such a national approach could/would be perceived as disadvantages by others, especially by groups opposed to a target driven mechanism for delivering renewable energy projects; lack of local and stakeholder involvement in strategic spatial decision making would be one of the main criticisms.

[16] SNH Policy Statement 02/02 (May 2002): Strategic Geographical Guidance for Onshore Wind Farms in respect of the natural heritage

Part B - Stage 1 -Initial work

This section of the report describes the Stage 1 brief for the research and gives a broad overview of the work undertaken and its principal findings. It covers in particular the renewable energy technology review which formed a central part of Stage 1.

3 Summary of the Stage 1 Research

3.1 Introduction and Stage 1 Brief

The Welsh Assembly Government Planning Division originally sought to facilitate the planning process for renewable energy by creating a ‘decision support tool’. The project brief for Stage 1 was set out as follows:

Aim:

“This project will review available information, techniques, research and projects and from it develop a **decision support tool for TAN 8** to assist local planning authorities in providing for renewable energy in the context of land use planning policy advocated in Planning Policy Wales (March 2002).

“the main output will be a tool which will be delivered as a supplement to TAN 8 and be used primarily by local planning authorities to positively provide for, and facilitate, renewable energy development. It will also be an important reference tool for developers and other stakeholders in the planning process. It will not be a substitute for detailed EIA but will enable broad scenarios to be drawn up as part of the forward planning process and enable informed policies for renewable energy to be developed.”

The project will involve:

- **Identifying the criteria relevant to the siting of all viable forms of renewable energy** in the on- and offshore environment, either in an integrated way or separately. These will include technical and environmental constraints as well as economic and social issues associated with each technology. It is recognised that these will differ for each technology and that the development of technical and environmental constraints should include the ability to incorporate grid issues and cumulative effects.
- **Reviewing these criteria in terms of their relative significance** with reference to available resource and estimated contribution, the current context for renewable energy, and the nature and form which the proposed planning tool will take in consultation with the Steering Group
- **Creation of a planning tool** based on the agreed criteria using an appropriate PC based programme suitable for local planning authorities to operate without copyright restrictions and with minimum requirements for additional bought-in data. This is likely to involve a hypothetical trial of the tool and the result will enable a clear methodology for the assessment of renewable energy potential for each technology, which is clearly understood and acceptable to all parties involved in the land-use planning process.
- Peer **review** of the use of similar planning tools and/or GIS techniques

Fairly early in the development of the Stage 1 research a number of changes to the above project brief were made with the agreement of the Welsh Assembly Government and the Stage 1 project steering panel. These were as follows:

a) Consideration of renewable energy developments in the *offshore environment* was only to extend to a review of the broad issues that were likely to be of relevance to the onshore land use planning system (including how the presence or absence of offshore renewable energy developments might affect similar developments onshore). This was instead of undertaking a strategic environmental assessment *per se* of the Welsh offshore environment to inform renewable energy developments; it was recognised early in the study that to do this would be a considerable exercise that was beyond the scope of the commission.

b) Social issues were not felt necessary to be included in the identification of relevant criteria.

c) Whilst the research contractor was to develop a planning tool using an appropriate PC based programme, it was not deemed essential that the tool be designed in such a way that enabled it could be passed to Unitary Authorities at the end of the process. Provided that the research output was made available to local authorities, together with the digital data, then the tool could remain an internal resource for the researchers.

d) Despite the reference to 'assessment of renewable energy potential for each technology' in the project brief, the research was not to establish the mix of renewable energy technologies for Wales over the next 8-10 years. This would remain a function of the market and/or policy decisions by the Welsh Assembly Government.

e) For technologies for which it was determined that a spatial planning tool was not required it was decided that the research team did not need to provide additional technical guidance for the land use planning system for other technologies than wind; this would be forthcoming from the TAN 8 Technical Advice Group itself.

3.2 Context – Developing a planning tool

The Stage 1 project brief requested that a decision support tool be created (likely to be a GIS incorporating multi-criteria analysis (MCA) functions), for local authority planning officers to manipulate, most likely on an authority by authority basis (see **Appendix G** for further details of Multi-criteria Analysis) . This follows the successful piloting of such a system by the Countryside Council for Wales (CCW) and the Macaulay Land use Research Institute[17] for use in Wales (see box below). Different weightings could be applied to the different data layers, offering the flexibility to explore different policy outcomes and – to a certain extent – advances in technology which enable the manufacture of larger turbines or power generation at lower wind speeds. Data sets could be updated over time, and new data added.

[17] Miller, et al (2002) Spatial Planning of Wind Turbine Developments in Wales. Macaulay Land use Research Institute for CCW.

Spatial Planning of Wind Energy Developments in Wales: Macaulay Land use Research Institute (Macaulay) for CCW

A national approach to planning for onshore wind turbines was developed. This was a GIS-based multi-criteria analysis tool which allowed the creation of a range of maps showing strategic constraints to wind turbine development across Wales, at a 1km grid square resolution. It used a ‘raster’ approach whereby all datasets were normalised to a 1km grid square basis.

The following data sets were included in the GIS:

- wind speed at different heights above ground level (1km x 1km resolution)
- land use classes, including types of woodland areas
- transport infrastructure (road, rail and canal)
- National Parks, Heritage Coast
- landscape designations (AONB)
- nature conservation designations (Biosphere Reserves, National Nature Reserves, SSSIs, Special Areas of Conservation, Special Protection Areas (including major rivers), Ramsar sites)
- archaeological sites
- airfields
- National Trails
- urban areas (considered inappropriate for any wind turbine development; in line with the contemporary version of TAN 8)

The Macaulay work acknowledged the importance of landscape and visual issues; buffer zones were added to some of the data layers, including zones of visual influence around National Parks and National Trails, estimated from the surrounding topographic and other data. Buffers were also placed around airfields and transport infrastructure.

The research findings classified Wales into seven levels of suitability for wind turbine development, according to a range of policy scenarios. The classes were:

- not available for turbine development
- unlikely to be available
- sensitive to turbine development
- moderate constraints to development
- weak constraints to development
- no constraints (wind speed above a selected threshold value – e.g. 7 metres per second, the recommended industry minimum for power generation)
- no constraints (wind speed below a selected threshold value)

The Macaulay work took the planning for wind energy developments a step forward in Wales and tended to highlight many of the principal constraints.

Areas where concern had been raised about the Macaulay work were as follows:

- Little consideration was given as to how the decision support system developed would be used either within the different facets of the local authority land-use planning process or by the Welsh Assembly Government.
- The system was believed to be not widely available and as having been developed by CCW (perceived by some developers as an organisation that was ‘anti-wind energy’).
- It did not include the MOD Tactical Training Areas or firing ranges, the national electricity distribution grid or population density; these and other factors were also considered very important in the planning process.

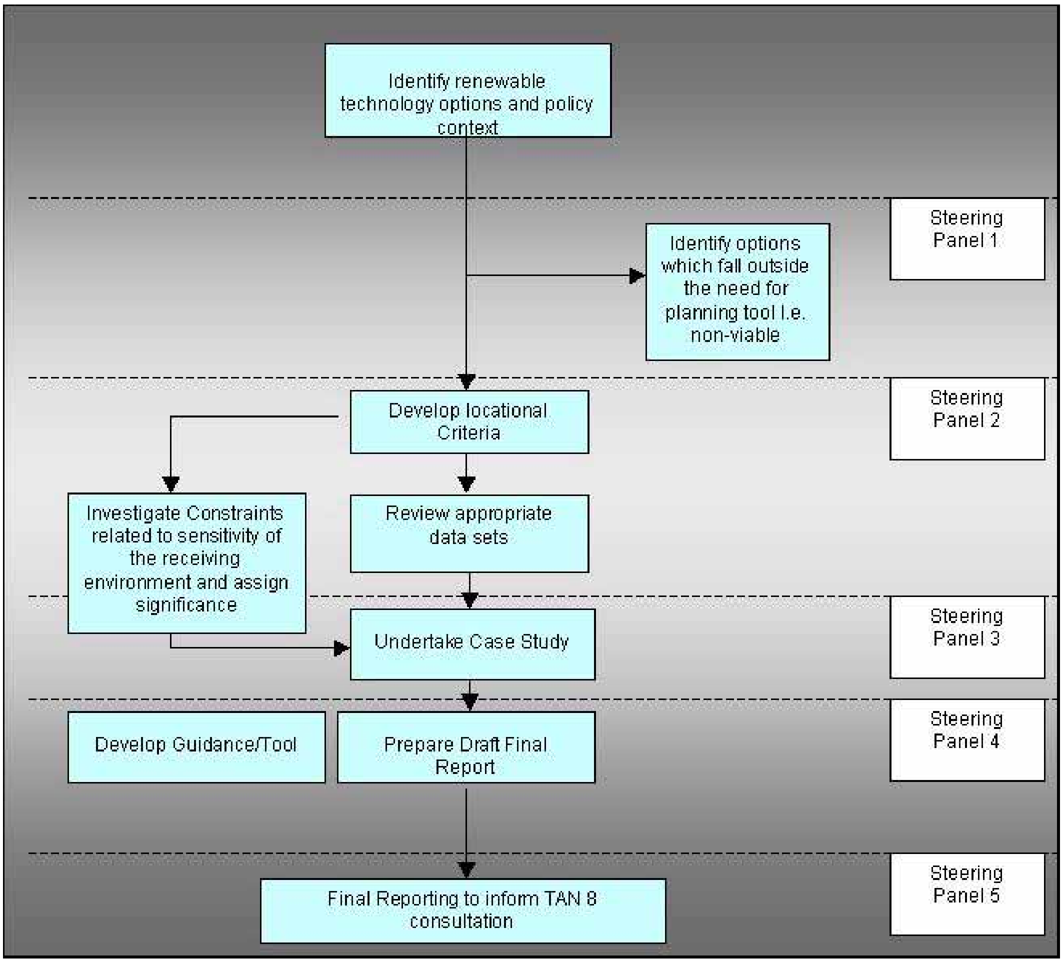
- By adopting a multi-criteria analysis approach the study presented over 10 different output scenarios / maps representing different ways of comparing different factors / constraint scenarios. The results are hence quite complex and do not present a single picture to decision makers.
- There was very limited stakeholder involvement to the development of the system and no validation of the findings in the field to give the output a 'reality check'.

Whilst the Macaulay work, as a hard copy report, was made available to Arup and its sub-consultants early in the research period for this contract, it proved impossible to obtain the data easily. In any event the GIS system used by the Macaulay Institute was incompatible with that proposed for use by Arup and its sub-consultants so, in effect, the team had to start from scratch for Stage 1.

3.3 Methodology for Stage 1

The majority of the research for Stage 1 took place over a seven-month period and was in part driven to accord with the steering panel/Technical Advice Group meetings. An overall flow chart indicating the linkages between the research streams pursued and the steering panel meetings is set out in **Figure 3.1** below. The first substantive exercise was to scope the technologies relevant to the research and which would have required a 'planning tool' under the Stage 1 brief and a summary of the main findings follows.

Figure 3.1 – Overall Methodology for Stage 1



3.4 Scoping the Technologies

3.4.1 Introduction

The project brief for Stage 1 stated that in order to develop the decision support tool, the research should **identify the criteria relevant to the siting of all viable forms of renewable energy in the on- and offshore environment**. The key issue was the extent to which any of the potential technologies would actually be *viable* (or generate realistic planning pressure) within the lifetime of the forthcoming revised TAN 8. It was also appropriate to identify the extent to which a spatial planning tool (as outlined in the brief) or any other approach would assist the delivery of each of the viable technologies.

In order to identify the viability of the different technologies, the research undertook a wide literature search and consulted with policy-makers, developers, proponents of new technologies and other experts. The main findings are explained below.

Principal references for this chapter include:

- Strategic Study of Renewable Energy Sources in Wales[18].
- Review of Strategic Study of Renewable Energy Resources in Wales[19]
- A Review of Renewable Energy Options and their Strategic Impact to inform the emerging Energy Framework for Wales[20]
- The Welsh Potential for Renewable Energy – Proceedings of a one day conference[21]

Subsequent to the work undertaken in Stage 1, various government studies have been published which further reinforce the work undertaken during the early parts of the research in 2002/3. These are the DTI and Carbon Trust Renewables Innovation Review[22] and several studies referenced in the UK Government Energy White Paper[23] .

3.4.2 Currently viable renewable technologies

Onshore wind

Since 1992, 365 turbines have been built in 19 installations in Wales, with a total capacity of approx 170MW and a generation capability of 0.45 TWh pa. Planning consents for four others (including Cefn Croes in Ceredigion) represent a further 72 turbines and bring the total capability to almost 0.7TWh pa[24].

[18] Sustainable Energy Ltd (2001) Strategic Study of Renewable Energy Sources in Wales
[19] AEA Technology (Sept 2001) Review of Strategic Study of Renewable Energy Resources in Wales – Results of 'Newport Workshop'
[20] CCW/Dulas Ltd (2002) A Review of Renewable Energy Options and their Strategic Impact to inform the emerging Energy Framework for Wales
[21] Institute of Welsh Affairs (Dec 2002) The Welsh Potential for Renewable Energy – Proceedings of Llanberis conference
[22] DTI Feb 2004 - http://www.dti.gov.uk/energy/renewables/policy/rirconclusions.pdf
[23] DTI, Energy White Paper (2003) Our Energy Future – Creating a low carbon economy.
[24] CPRW (May 2003) Position Statement. Available at www.cprw.org.uk/

The geographical distribution of onshore wind turbines in Wales is depicted in **Table 3.1** below:

Table 3.1 Geographical distribution of existing onshore wind turbines (by end 2003)

Planning Authority	No. of onshore installations	Number of turbines	Installed Capacity (MW)	Generation capability (TWh)
Anglesey	3	72	33.2	0.087
Carmarthenshire	3	19	13.0	0.034
Conwy	3	6	6.2	0.016
Ceredigion	3	47	18.6	0.049
Powys (Montgomeryshire)	5	179	80.45	0.216
Powys (Radnorshire)	1	22	9.9	0.026
Rhondda Cynon Taff	1	20	9.0	0.024
Totals	**19**	**365**	**170.35**	**0.448**

Onshore wind is one of the most problematic renewable energy technologies in terms of obtaining planning consent[25]. The introduction of turbines to rural landscapes is an issue that can raise strong opinions among local residents and other stakeholders, which often leads to lengthy public inquiries and associated expense. However, onshore wind is currently the most attractive option for renewable energy developers as it is the one of the few mature technologies and represents one of the lowest unit costs of electricity. Indeed, a recent report concluded that by around 2020, wind energy was likely to be the cheapest form of electricity generation available[26].

Wind turbines harness the power of the wind and convert it to electricity. The power output of a turbine is often expressed as rated capacity: the maximum power which a turbine can generate in a strong breeze. Turbines generally require wind speeds of at least 3.5 metres per second to operate, although it is considered that an average wind speed of around 6-7m/s at hub height is taken by the industry as the minimum commercial wind speed for the industry to date.

The turbine hub (nacelle) stands sufficiently high above the ground to capture the passing wind without interference from the ground surface. The average height of Welsh turbines to blade tip is currently 50m and this is rising with advances in technology. Turbines stand on foundations which consist of a concrete block, not much wider than the turbine itself, set into the ground so that it is almost flush with the surface. Almost all the turbines in Wales have 3 blades, which are considered to have less visual and noise impact than the older 2-bladed models.

[25] OXERA & Arup Economics and Planning (February 2002) Regional Renewable Energy Assessments – a report to the DTI and DTLR

[26] Performance and Innovation Unit (2002) Energy Review, cited by WAG Economic Development Committee (2003) Review of Energy Policy in Wales – final report page 30

Most wind turbines are clustered in wind farms, and connected to the regional electricity distribution network. Each wind farm requires a small substation and from here generally uses overhead wooden pole power lines to connect into the nearest grid point. In areas of particular sensitivity, underground cables can be used. There are no Welsh wind farms connected directly to the National Grid (275kV and upwards).

The output of a turbine is determined by a combination of the available wind speed and the rotor diameter: doubling the length of the rotor will generate four times the amount of electricity. To operate most effectively, wind turbines need to be positioned so that the distances between them are around 5-10 rotor diameters (currently 300-600 metres, depending on the size of the turbine). Positioning the turbines too close together will reduce the potential power of a wind farm due to the 'wind shadow' effect of upwind turbines. Allowing for the intermittency of operation and other factors, onshore turbines typically generate an average of 30% of their maximum installed electrical capacity[27].

It is considered that a specific planning tool/GIS would be beneficial for this technology, for the following reasons:

- onshore wind has been the dominant renewable energy technology developed in Wales to date;
- applications are currently addressed on a piecemeal basis as they arise, without a strategic overview of their potential impact on the national renewable energy generation target; and
- the strongly emotive issues associated with onshore wind proposals are debated at length; an agreed set of criteria (whether ultimately mapped or not) would be an important step forward in reaching consensus about the more appropriate locations for this type of development.

Offshore wind

In the past 18 months, permission has been granted for two offshore wind farms around the coast of Wales. Taken together, these three projects could make a significant contribution to the 4TWh target by 2010 of over 1TWh.

Photo: © Anthony Upton 2003

A wind farm at North Hoyle, off Prestatyn, was granted consent in October 2002 and construction was completed in December 2003. It is the first commercial offshore wind farm in the UK and has 30 turbines, with an installed capacity of 60MW. The other North Wales site is Rhyl Flats, off Abergele, where a development of approximately 90MW is proposed[28].

[27] Annual generation of an installation may be estimated as total installed capacity (IC) x 8766 (total hours in a year) x 30% (typical capacity factor, or CF). In practice output may be expressed in TWh by multiplying the IC in MW by 0.002628. A 30MW installation may thus generate 0.079TWh pa.
[28] DTI Press Release (26 March, 2003) Wilson announces major boost to offshore wind

In South Wales, an application was submitted for a 90MW wind farm at Scarweather Sands off Porthcawl. A Public Inquiry was held in Autumn 2003, in order for the pertinent issues to be debated in a public forum. In July 2004 the Planning Committee of the Welsh Assembly Government approved the application.

Similar constraints apply to offshore wind technology as onshore. The major difference for offshore wind is that turbine sizes can be considerably larger: a model under development in Germany has an installed capacity of 4.5MW, and weighs over 500 tonnes.
The nature of the seabed and the underlying geology are both important considerations for the siting and design of offshore turbines and their foundations. Suitable underlying geology is required in order to ensure that the turbine can resist the forces generated by the action of both the wind and the marine environment (waves, currents etc). Suitable geology is also important in minimising the cost of foundations and therefore the economic viability of offshore projects. Areas of significant sediment transport where this is sufficient to affect foundation support or where very significant scour may occur are likely to present greater technical challenges to developers.

Offshore turbines, which enjoy a steadier and more frequent wind regime, are recognised as having a 40% Capacity Factor which equates to a multiplier of 0.003504, on the basis explained for onshore turbines (above). Further sites for potential development around Wales are currently limited in geographic extent to within the DTI's 'second round block' in Liverpool Bay, subject to a recently completed Strategic Environmental Assessment (DTI)[29] (**see Appendix A**) . The Crown Estate advises that development outside the SEA blocks during the second round is highly unlikely. Some alternative sites are considered technically viable but other factors such as grid connection, nature conservation designations or port access for installation and maintenance vessels are considered to pose significant constraints.

It is considered that a specific offshore planning tool/GIS would be beneficial, for the following reasons:

- offshore wind power is expected to be an arena of developer interest in Wales
- there is a need for an all-Wales assessment of potential offshore wind development sites

However, offshore wind falls largely beyond the scope of the land use planning system established by the Town and Country Planning Act and hence would be only covered indirectly in the forthcoming Renewable Energy Technical Advice Note; the resource, therefore, was deemed to fall outside the scope of this project.

Hydro

The use of hydropower to generate electricity has a long history in Wales, and the current installed capacity is estimated to be in the region of 160MW[30]. This includes small scale run-of-river schemes, where turbines harness the power of natural watercourses, as well as storage schemes of up to 50MW such as the dam and reservoir at Llanberis in Snowdonia. The larger schemes only run at peak times when the price of electricity is high: typically between 1 and 4 hours per day.

Most of the potential sites for large hydropower schemes in Wales have already been developed. The major environmental impacts of creating reservoirs make it unlikely that further dams and reservoirs will be built in Wales in the foreseeable future.

More likely is an increased number of applications for run-of-river schemes, generating under 1MW, which are generally considered to have less severe environmental impacts.

[29] DTI/BMT Cordah Limited (2003) SEA (Phase 1) for offshore Wind Energy Generation: Scoping Report
[30] Sustainable Energy Ltd (2001) The Potential for Renewable Energy in Wales, section 3.4.1

Run of river schemes take water from the river behind a specially constructed weir, returning it directly to the river once it has passed through a turbine. The turbine house is connected to the local electricity network by low voltage overhead power lines. Such schemes require permission from the Environment Agency in the form of an abstraction licence, and from local planning authorities for the riverside turbine houses and associated maintenance access. Schemes designed to generate more than 0.5MW will be subject to an EIA Screening and Scoping opinion from the local planning authority and may require formal Environmental Impact Assessment.

It is not considered that a specific planning tool/GIS would be beneficial for this technology, for the following reasons:

- hydropower schemes are limited to areas where sufficient river flows are encountered: this is not as 'footloose' as wind power schemes;
- this technology is relatively mature, and the best sites for hydro have already been developed. Planning pressure for new schemes is expected to be limited to small-scale run-of-river schemes; and
- the Environment Agency is in the process of classifying / has classified the rivers of Wales in terms of their physical,and ecological character and fisheries (the SWALP test – surface water abstraction licensing policy development). This strategic overview of the nation's hydrological resource could be considered an appropriate level of assessment to inform national planning policy.

3.4.3 Potentially viable technologies during TAN 8 period

Research has suggested that certain nascent technologies may make some contribution to renewable energy targets in the medium or longer term[31]. These technologies, described in **Appendix B,** may become commercially operational during the forthcoming TAN 8 period or shortly thereafter, but for the reasons set out in the Appendix were not considered further in the research.

3.4.4 Minor or long-term renewable energy technologies

There are a number of existing renewable energy technologies which can make a contribution at a domestic scale, and currently do so. There are also technologies that are still in the early stages of development but may become significant in the longer term. It is not believed that a specific planning decision support tool/GIS would be appropriate or necessary for any of these technologies at the present time. These technologies are therefore discussed in **Appendix B**.

3.4.5 Conclusions

In order for a strategic planning tool to assist in the determination of renewable energy applications, it must apply to technologies which:

a) make a significant contribution to the *electricity* generation target; AND

b) present realistic planning pressure (i.e. are currently commercially attractive/ viable within the next 5 years); AND

[31] Various reports on www.dti.gov.uk/energy/developep

c) are not dealt with adequately by the existing land use planning system, but have strategic spatial land use implications for UDPs, and are relatively footloose.

Each of the potential technologies were assessed in relation to the three 'tests' above; our findings are shown in **Table 3.2** below.

Table 3.2: Summary of renewable energy technologies and how they perform against the need tests for a spatial planning tool

Technology	a) Significant contribution to the electricity generation target?		b) Realistic planning pressure?		c) Spatial planning implications?	
	Significant contribution?	Heat or electricity?	Technically feasible next 5 yrs?	Financially viable next 5 yrs?	Strategic Land use planning issue?	Geographical choice?
Onshore wind	Y	E	Y	Y	Y	Y
Offshore wind	Y	E	Y	Y	N	Y
Hydro	Y (most already in)	E	Y	Y (already in)	N	N
Biomass – woodfuel	Y – in part	H viable	Y	?	N for the most part	Y – in part
Tidal barrage/Lagoon	N	E	Y – in part	N	N	N
Active solar (water heating)	N	H	Y	Y	N	N
Solar PV	N	E	Y	N	N	Y
Solar passive	N	H	Y	Y	N	Y
Energy from waste	N/A (not renewable)	E/H	Y	?	Y	Y
Tidal stream	N	E	?	?	N	Y
Wave	N	E	Y	Y	N	Y

For the reasons set out above, it was considered that only one renewable energy technology would require a spatial planning tool or framework in Wales: onshore wind. Hydro power is a mature technology already contributing to the target, but is not expected to experience similar large-scale increases in developer interest during the TAN period. Biomass has some *potential* to contribute to the 4TWh target, but it is not believed that a spatial planning tool is necessary to facilitate the development of this technology and its economic feasibility is still in doubt.

The remainder of the Stage 1 research therefore related only to **onshore wind energy generation**. Offshore wind falls predominantly outside the land use planning system (only indirect effects such as seascape and visual impact and onshore infrastructure are encompassed by it) as discussed previously and within **Appendix A** and hence was eventually excluded from further study.

3.5 Developing locational criteria

The next phase of the Stage 1 research reflected the brief and was to both

- Identify the criteria relevant to the siting of onshore wind energy developments (they having been determined as the only applicable) and
- Review these criteria in terms of their relative significance with reference to the available wind resource.

This process was undertaken via consultation and discussion with the steering panel for the research and the initial results are included in **Table 3.3** below. Those factors that were initially considered of most relevance to the strategic planning process are highlighted.

Table 3.3 Factors influencing onshore wind energy development

FACTOR	CRITERIA/INDICATOR
Technical	
Wind speed	Average wind speed at hub height
	Max. wind speed
Wind directional variation	Rate of variation
	Impact of directional variation on turbine layout
Turbulence	Number of hours and extent of turbulent conditions
Ground conditions	Firmness of ground
Grid connectivity	Distance to appropriate electricity distribution network
Grid Capacity	Spare capacity of local electricity distribution system
Access to site for installation	Length of new road required to be built/existing track to be upgraded
	Capacity of existing road network to accommodate construction traffic
Access to site for monitoring/maintenance	Distance from service centre
	Roughness of terrain
Planning and Environmental	
Effect on birds[32]	Presence of designated bird site or non-designated sites of acknowledged importance
	Location in relation to bird migration routes
	Location in relation to important concentrations of breeding or wintering birds of acknowledged importance

[32] See English Nature et al (2001) Wind Farm Development and Nature Conservation

Impact on nature conservation[33]	Presence of designated nature conservation site. Possibility of gaining positive impacts through associated habitat enhancement/management
Visual and recreational impact	Proximity to nearest existing wind turbines
	Proximity to nearest public roads
	Proximity to nearest public footpaths/public access points
Landscape impact	Effect on landscape character / capacity / quality. Distance to nearest designated landscapes
Wayleaves	Existing services/land use/roads
Amenity	Noise impact
	Visual impact
	Proximity to settlements
Impact on telecommunications	Level of interference with civil electromagnetic communication (e.g. television transmitters)
Stimulation of local industry	Operation and maintenance of turbines
Impact on civil & military radar systems	Proximity to radar stations and their spheres of influence
Impact on civil & military flying zones	Proximity to flight paths
	Frequency of flight path use
	Clear 'flying height' required
Impact on meteorological data collection	Proximity to Met Office data collection stations
Economic	
Funding	Capital grants
	Renewables Obligation Certificates
	Climate Change Levy exemption
Cost of generation	Cost of unit electricity generated

[33] See English Nature et al (2001) Wind Farm Development and Nature Conservation

Assigning significance to the various factor/locational criteria set out in **Table 3.3** above proved to be a more difficult and complex exercise. The approach taken was a sequential one and comprised the following:

- A review of existing policy and designation status of the factors (e.g. of nature conservation sites)
- A review of case law relating to previous development control decisions involving wind farms in Wales
- An examination of existing guidance
- Discussions with steering panel members for the research
- Consultation with key stakeholders (e.g. CCW, BWEA and local planning officers in areas of Wales that had experienced several wind farm planning applications)
- The application of the knowledge and experience of the study team

The results indicated that a whole range of factors were highly significant in the siting of onshore wind farms. Landscape and visual issues however emerged ahead of all others as dominating recent planning decisions, followed closely by the influence of Ministry of Defence training areas and the availability of electrical grid infrastructure with appropriate capacity.

The difficulties for the Stage 1 arising from the significance evaluation were two-fold:

a) there were insufficient datasets available to give full spatial representation to the most significant factors in the planning for onshore wind energy developments (e.g. of grid capacity)

b) for landscape and visual issues not only were key datasets not available, but the issues were subjective and there was no developed consensus on at what point impacts were considered significant i.e. thresholds beyond which development should not normally proceed were not defined.

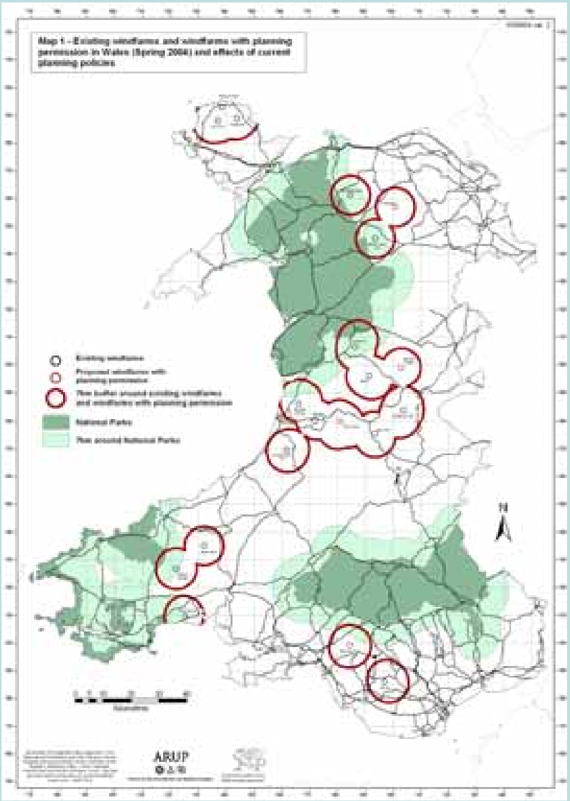
The Stage 1 study did not have the time or resources available to develop additional datasets not already in the public domain (whether as digital or hard copy). Attempts were therefore made to examine further landscape and visual issues and the influence of existing known factors/designations in greater detail via the use of a case study. This was based around an area of mid-Wales between Newtown, Machynlleth, Abersytwyth, Tragaron and Rhayader.

Case Study

Available data were mapped at 1:50000 scale (e.g. environmental designations and locations of existing wind farms) and the information was examined via desk study and in the field.

The aim was to determine whether any simple 'rules' could be developed that might inform an all-Wales mapping exercise / GIS. In particular the case-study considered:

- Visibility to/from nationally designated sites with a landscape/visual component (National Parks, AONBs, National Trails)
- Intervisibility between existing wind farms
- Cumulative impact thresholds
- Landscape capacity and sensitivity
- The effects of land use/vegetation
- Nature conservation



Whilst the exercise proved invaluable in familiarising the study team with all of the pertinent issues, with the time and resources available it proved impossible to robustly develop appropriate 'rules of thumb' that would be capable of standing future testing via the planning system. It became apparent that the existing approach of planning authorities and planning inspectors was to keep wind farms apart by some 10-15km centre-to centre, to avoid/minimise cumulative landscape and visual impacts and significant local impacts upon landscape character (see figure adjacent). It also became clear however that this approach, and the plethora of local, regional and national environmental designations was serving to prevent further development of large onshore wind energy developments. Adopting an 'environmental capacity' approach to the planning of onshore wind in Wales, whereby no material environmental assets were to be compromised, would be unlikely to lead to the delivery of the national target for renewable energy generation.

3.6 Conclusions of the Stage 1 Research

The objective of the first phase was to "review available information, techniques, research and projects and from it develop a decision support tool for TAN 8 to assist local planning authorities in providing for renewable energy".

The first phase (Stage 1) research lasted 9 months and its outputs were generally inconclusive. The team succeeded however in the following:

- Bringing closer together the members of the steering panel for the research (also the technical advice group for the re-drafting of the TAN) and focussing in on the substantive issues that the TAN and the group needed to address.
- Scoping the renewable energy technologies that the TAN, and hence the 'planning tool', had to address. The conclusions were that onshore wind energy represented the only technology that required some form of 'planning tool'.
- Understanding the renewable energy technology mix that was most likely to come forward over the next six years; this was concluded as comprising mostly onshore wind.
- Identifying the planning constraints applicable to onshore wind energy development in Wales; together with a broad understanding of their relative weight in the decision making process.
- Developing a Geographic Information System (GIS) during the Stage 1 research to store and map spatial constraint data. This was used to understand the influence that various environmental designations might have on the spatial planning of onshore wind energy developments in Wales.

The broad conclusions of Stage 1 were that leaving local authorities in isolation to plan for renewable energy (with or without a 'planning tool') was unlikely to allow Wales to meet its wider obligations with respect to national and international carbon dioxide reduction. It was also considered that the degree of environmental assets present in Wales is such that if they are all to remain unaffected by renewable energy developments then very few further projects would be likely to be developed without a significant change in approach in the planning system. As such the Stage 1 research had been a useful exercise, but it was clear further work was required if the TAN 8 document was to facilitate renewable energy effectively and achieve the Assembly Government's renewable energy target of 4 Terrawatt hours by 2010 (just over 10% of current electricity production).

Given the conclusions of the Stage 1 research and the wider economic situation relating to the development of renewable energy technologies in UK, it was inevitable that the major proportion of this target would be delivered by onshore wind energy developments. The Welsh Assembly Government therefore took the view that there was a need to plan for between 800 –1000 Megawatts of installed capacity of onshore wind (some 400-600 additional turbines approximately) by 2010 if there was to be a realistic chance of achieving the 4TWh target.

Arup were therefore appointed in April 2004 to undertake a second phase of research (Stage 2) and this is described in **Part C** of this report.

Part C- Stage 2 Research and Analysis

This section of the report describes the work undertaken in the development of the research output to assist with the implementation of the revised TAN 8. It describes the Stage 2 brief and the practical implications of supporting the 4TWh target by 2010. This is followed by a detailed consideration of the factors that should be considered in the strategic planning for large-scale onshore wind energy developments in Wales. Finally how these factors were brought together in a Geographic Information System is described, together with the results of the subsequent analysis of the data. Included in this section of the report is the methodology for the identification and validation of the strategic areas for onshore wind; the principal output from the Stage 2 research.

4 Context to the Stage 2 research

4.1 Introduction

The outputs from the Stage 1 contract were presented to the Welsh Assembly Government in December 2003. Officers of the Welsh Assembly Government considered its findings over a 3-month period. Both the Planning Division (the commissioning body for the Stage 1 research contract) and the Office of the Chief Technology Officer (OCTO) (the section of the Assembly responsible for energy policy) met on several occasions and presentations were made to both Environment and Economic Development Ministers.

It was eventually decided that achievement of the 4TWh benchmark target for renewable energy generation by 2010 as established in various Welsh Assembly policy documents (see Chapter 2) should be factored into the research by Arup to test the ability of the analysis to deliver the 4TWh 2010 benchmark target. National renewable energy targets and International obligations for the reduction in carbon dioxide emissions were to a certain extent, to take precedent over some local and regional environmental issues. Arup was therefore asked to develop further GIS mapping, at a national level, on behalf of the Assembly Government within the context of a firm commitment to the delivery of the 4TWh benchmark target. This process is hereafter termed the Stage 2 research contract. The main aim of the Stage 2 contract was to test the findings of previous work against a range of economic factors, including grid issues, to ensure that the guidance was capable of achieving the policy aims and the 2010 renewable energy target of the Welsh Assembly Government.

A brief for the Stage 2 research contract follows below

Stage 2 Brief

The Welsh Assembly Government is developing its approach to the strategic planning of the on-shore wind resource in Wales. The following brief builds upon the research undertaken for the previous contract '105/2002 – Facilitating Planning for Renewable Energy', in order to provide a map for Wales that identifies "strategic search areas" capable of delivering the Assembly Governments Renewable energy Target of 4TWh to 2010. In doing this the search areas will need to accommodate (as a minimum) 800 MW of installed onshore wind capacity by 2010.

The strategic areas should ideally encourage the concentration of wind farm development into several key areas to maximise economies of scale. It is likely the search areas will be included within the revised TAN 8. Any contribution that may be made from wind farm development on brownfield land will be considered a 'windfall' and additional to the 800MW needed.

This study will exclude non-statutory environmental constraints/factors such as landscape capacity and sensitivity, historic landscapes, National Trails, consideration of landscape quality and character using LANDMAP in the initial identification of 'strategic search areas'. These will be tested in due course via consultation on the outputs of this work.

The process necessary should comprise 4 stages:-

A) Scoping and identification of "Feasible Areas"

- Sieve mapping of existing grid capacity (existing and proposed) and suitable wind speeds (guided to some extent by current or recent expressions of interest which will be made available to the research contractor). Note wind speed areas will only be loosely defined i.e. >6m/s to allow flexibility for larger turbines. Data will be provided from the Electricity Distribution network operators to aid this exercise.
- Defining areas that are currently technically/economically feasible or could be feasible if large enough wind energy developments (i.e. >25MW) were implemented (in order to justify the costs of strengthening and connecting to the electricity distribution network).

B) Initial constraints review of "Feasible Areas" based on 'absolute constraints'

- Combine above with, as a minimum, the following factors to establish how economical/practical the areas will be:
  - a) MOD Tactical Training Area
  - b) Housing/settlements
  - c) Civil Aviation Authority Radar
- Apply environmental sieve of constraints which will include:
  - a) National Parks, Heritage Coasts and AONBs, MOD landholdings
  - b) Natura 2000 habitat sites (cSAC/SPAs), Ramsar sites, National Nature reserves, World Heritage Sites and Historic Parks and Gardens
  - c) Scheduled Ancient monuments

C) Overall GIS Analysis

Modify GIS as developed by Research Contract 105/2002 to include new relevant data for the "search areas".

D) Output

- In association with the client, provide a map for potential incorporation into planning policy that will guide the development of larger on-shore wind developments in Wales (i.e. >25MW) into "search areas" along with a reasoned justification for the decisions that have been made.

The first step was to review and fully understand the implications of achieving the 4TWh target in the manner set down by the Welsh Assembly. The research therefore examined the relative proportions of different technologies that might be possible and the likely physical implications of these.

4.2 Understanding the 4TWh Benchmark Target

The Welsh Assembly Government proposes a 'benchmark' of 4TWh of renewable energy by 2010, which equates to just over 10% of Welsh electricity *production* (Chapter 2 refers). This includes existing renewables as well as future developments.

The benchmark / target is expressed in terrawatt-hours (TWh); this is a unit of total energy production per annum. One terrawatt is equal to one million megawatts (see **Table 4.1** below).

Table 4.1 Converting Electricity Production to Watt-hours

Electricity production	Equivalent to
1 kWh (kilowatt-hour)	1,000 watt-hours
1 MWh (megawatt-hour)	1,000,000 watt-hours
1 GWh (gigawatt-hour)	1,000,000 kWh or 1,000 MWh
1 TWh (terrawatt-hour)	1,000,000 MWh or 1,000 GWh

Some forms of renewable electricity generation have a more consistent output than others. A theoretical 1MW power generation device operating continuously for 1 year will produce 8.76GWh of electricity. Onshore wind turbines typically operate for 30% of the time, producing approximately 2.6GWh per MW of installed capacity per annum. The offshore wind figure is closer to 40%, producing around 3.5GWh per MW of installed capacity per annum[34] . Other renewable energy technologies such as biomass or tidal energy rely upon more steadily available power sources, so their output per MW installed is expected to be higher. (Conventional fossil fuel power stations operate at around 80%).

This variation means that the amount of installed capacity (and hence land take) required to meet the 4TWh target will vary with the proportional contributions of the different technologies.

The following tables illustrate the relative installed capacity required to meet different supply scenarios for the 4TWh target with different renewable technologies. Further illustrative renewable energy electricity scenarios for 2010 in Wales are contained within the work of AEA Technology[35] and Dulas[36] respectively and have been utilised as part of this research.

Table 4.2 illustrates the implications of the '3 way split' envisaged by early work of the Economic Development Committee of the Walsh Assembly Government. **Table 4.3** illustrates the implications of a "market-driven" scenario, based upon estimates of the likely deployment of the different technologies in current economic conditions; this scenario meets with the expectations of the WDA and major renewable energy developers. The scenario presented in Table 4.3 is therefore considered to be more realistic than those considered previously (it assumes a lower contribution from some of the more currently uneconomic technologies) and has formed the basis of the remaining work.

Table 4.2 Installed capacity implications of the "3 way spilt" of the 4TWh benchmark

Technology	"three-way split" of 4TWh (4000 GWh)	GWh Output per MW installed (i.e. conversion factor)	Total MW of this technology required to meet three-way split
Onshore wind	1333 GWh (a)	2.6 (d)	517 (a)/ (d)
Offshore wind	1333 GWh (b)	3.5 (e)	381 (b)/ (e)
'Other': Hydro & Biomass (est)	1333 GWh (c)	4.38 approx. (f)	304 (c)/ (f)

Table 4.3 Installed capacity implications of a "market-driven" approach to the 4TWh Benchmark

Technology	"Market-driven" deployment of 4TWh (4000 GWh)	Output per MW installed (GWh) (i.e. conversion factor)	Total MW of this technology required to meet split
Onshore wind	2135 GWh (a)	2.6 (d)	820 (a)/ (d)
Offshore wind	945 GWh * (b)	3.5 (e)	270 (b)/ (e)
'Other': Hydro & Biomass (est)	920 GWh ** (c)	4.38 approx. (f)	210 (c)/ (f)

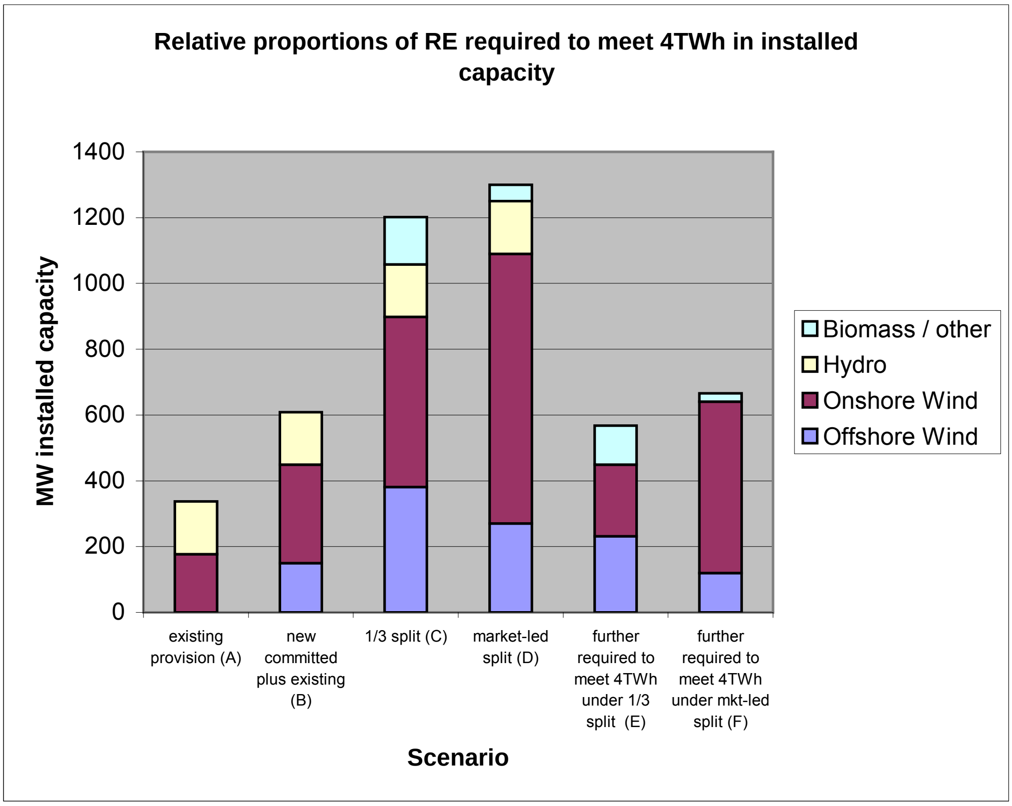
* assumes development of 3-4 offshore wind farms – a probable slight overestimate by 2010.

** assumes development of no further hydro but 50MW of biomass

34 Economic Development Committee Report, (January 2003), Appendix A
35 AEA Technology (Sept 2001) – Review of Strategic Study of RE Resources in Wales
36 Dulas/CCW – Review of Renewable Energy Options and their Strategic Impact to inform the Emerging Energy Framework in Wales

The differences between the scenarios discussed and their implications, together with a comparison against existing and planned provision for renewable energy in Wales is set out in **Figure 4.1** below.

Figure 4.1 Relative proportions of renewable energy required to meet 4TWh in installed capacity



Legend to Figure 4.1

A) “Existing provision”: *this consists only of schemes which are already operational*

B) “New committed and existing”: *this adds the schemes which have been granted consent in Wales but have yet to be constructed. (The offshore wind component consists of North Hoyle and Rhyl Flats; the onshore wind was identified on the BWEA website, July 2003).*

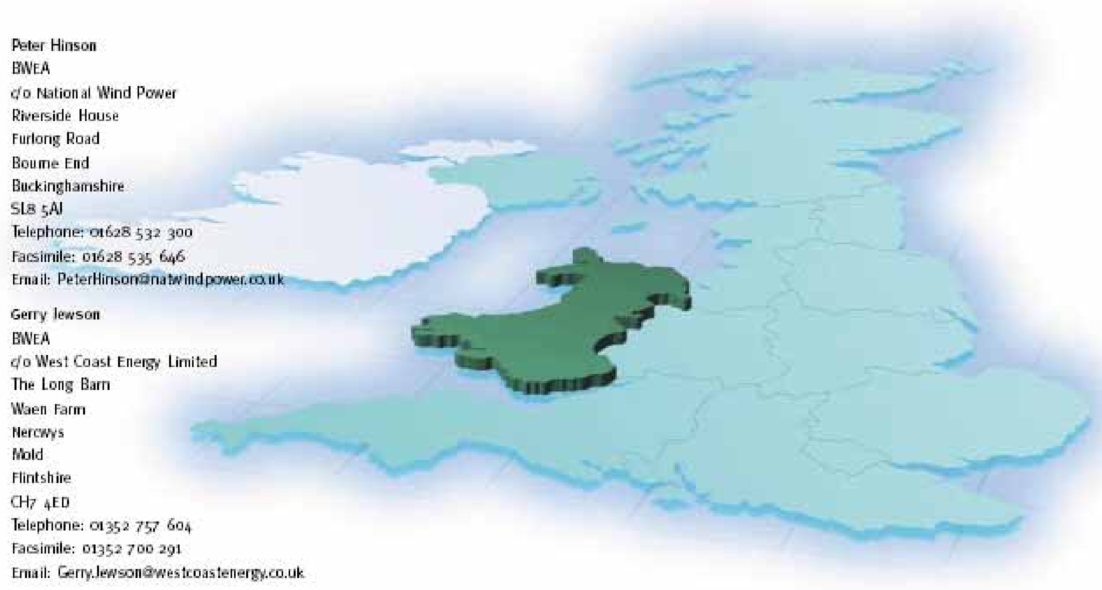
C) “three-way split”: *this demonstrates the relative proportions of onshore wind, offshore wind and other technologies (biomass and hydro assumed most likely) envisaged by the EDC. Note: This has taken account of the constancy of supply from each source, converted into MW installed capacity using the conversion factors stated in tables previously.*

D) “Market-led split”: *this is a graphical representation of the market-driven scenario set out previously.*

E) and F) ‘Further required’ *columns: amounts required under each scenario minus new committed and existing development.*

The above analysis is critical to the process of facilitating planning for renewable energy in Wales. It suggests that without considerable fiscal intervention to aid other currently non-viable renewable energy technologies, the majority of the 4TWh target would have to be met by onshore wind. The analysis also suggests that a minimum of 800 MW of new installed capacity of onshore wind will be needed by 2010, and this figure will increase if there is any reduction in the planned contribution from offshore wind or others. Hence to ensure achievement of the target it may be prudent to plan for a slighter greater contribution from onshore wind – up to 1000 MW.

	Regional share of onshore wind power target (%)	No. of wind turbines for region (using 1.5Mw machines) projected for 2010	Total land area (km²)	Land area suitable for wind generation (km²)	Land area required for regional wind target (km²)	Land area required as % of region's total land (km²)
Wales	8%	193	20,857	4,028	32.1	0.15



There is a considerable difference between the spatial implications of the installed capacity required to meet the 'three-way split' scenario envisaged by the Welsh Assembly Government Economic Development Committee and the likely outcome of a "market-driven" scenario. Concentrating on the onshore wind component in particular, the three-way split scenario anticipates that wind farms with an installed capacity of around 517MW will be required (including those already operational). Based on a energy yield estimate of 6MW/km², this implies that a surface area of approximately 90 km² would need to be taken up with wind farm developments. Wales has a land area of 20,700 sq km, thus the likely land take required to achieve the onshore wind component of the three-way split scenario is of the order of 0.43% of the land area of Wales.

Under the 'market-driven' scenario, the anticipated 820MW approximately of onshore wind (installed capacity required) would require approximately 140km² of land area for the physical footprints of the wind farms. This may be considered a 'worst case' scenario in terms of direct land take, although this amount is also relatively small, at 0.68% of the land area of Wales.

An analysis has been undertaken of the installed capacity (MW) of a number of Welsh wind farms and the approximate surface area they occupy, based on a review of their physical extent as indicated on 1:50 000 Ordnance Survey mapping. The analysis suggests that on the basis of historic turbine layouts and capacities, the average energy yield from land with an appropriate wind resource in Wales is approximately 6MW/km². Discussion with the renewable energy industry suggests that larger, higher output turbines (e.g. 1.5 MW per turbine and upwards) may enable yields up to 9 MW/km²; however, in general larger turbines need to be spaced further apart so such theoretical energy yields are not always likely to be realised.

The surface area estimates can be compared to those prepared by the British Wind Energy Association (BWEA)[37]. Using the average wind energy potential of each square kilometre of land BWEA presents the following data for Wales:

Regional share of UK onshore wind power target = 8%

No. of wind turbines for region (using 1.5MW machines) projected for 2010 = 193

Land area suitable for wind generation (km²) = 4028

Land area required for regional wind target (km²) = 32.1

Land area required as % of regions total land (km²) = 0.15%

The BWEA shows a smaller land area needed as it uses a) a feasible density of wind turbine development of 9MW/km² (c.f Arup figure of around 5-6MW/km²) b) a lower regional share of the UK wind power target than it is believed would be needed to help Wales meet its own benchmark target commitments.

Finding the 'least-worst' 140km² of Wales in which to locate the 800MW of onshore wind farms is the basis for the rest of this report.

[37] Bryn Titli; Carno; CAT; Cemmaes 2; Duffryn Brodyn; Haffoty Ucha; Llandinam; Llangwyryfon; Llyn Algw; Parc Cynog; Rhyd-y-Groes; Taff Ely and Trysglwyn

5 The identification of strategic areas for onshore wind

5.1 Introduction

The spatial implications of attempting to achieve the 4TWh benchmark target by 2010 under a “market driven” development scenario are set out clearly in the previous chapter; Wales would experience a significant increase in onshore wind farm development in the next few years.

This chapter sets out how Arup and its sub-consultants developed the strategic areas for onshore wind using a Geographic Information System (GIS).

5.2 Methodology

The development of the GIS used in the Stage 2 research and a detailed description of the way the data was collated and analysed in the GIS is presented in **Appendix H** as a separate report prepared by the Centre for Environmental and Spatial Analysis (CESA). Arup was responsible for identifying what factors to consider and assigning their relevant weight in the decision-making process based on its expert judgement and experience gained under the early stages of the contract (the previous chapters refer). CESA mapped the relevant datasets and under took several discrete pieces of analysis. The main emphasis of its work however was to present the mapped data to Arup for subsequent derivation of the strategic areas.

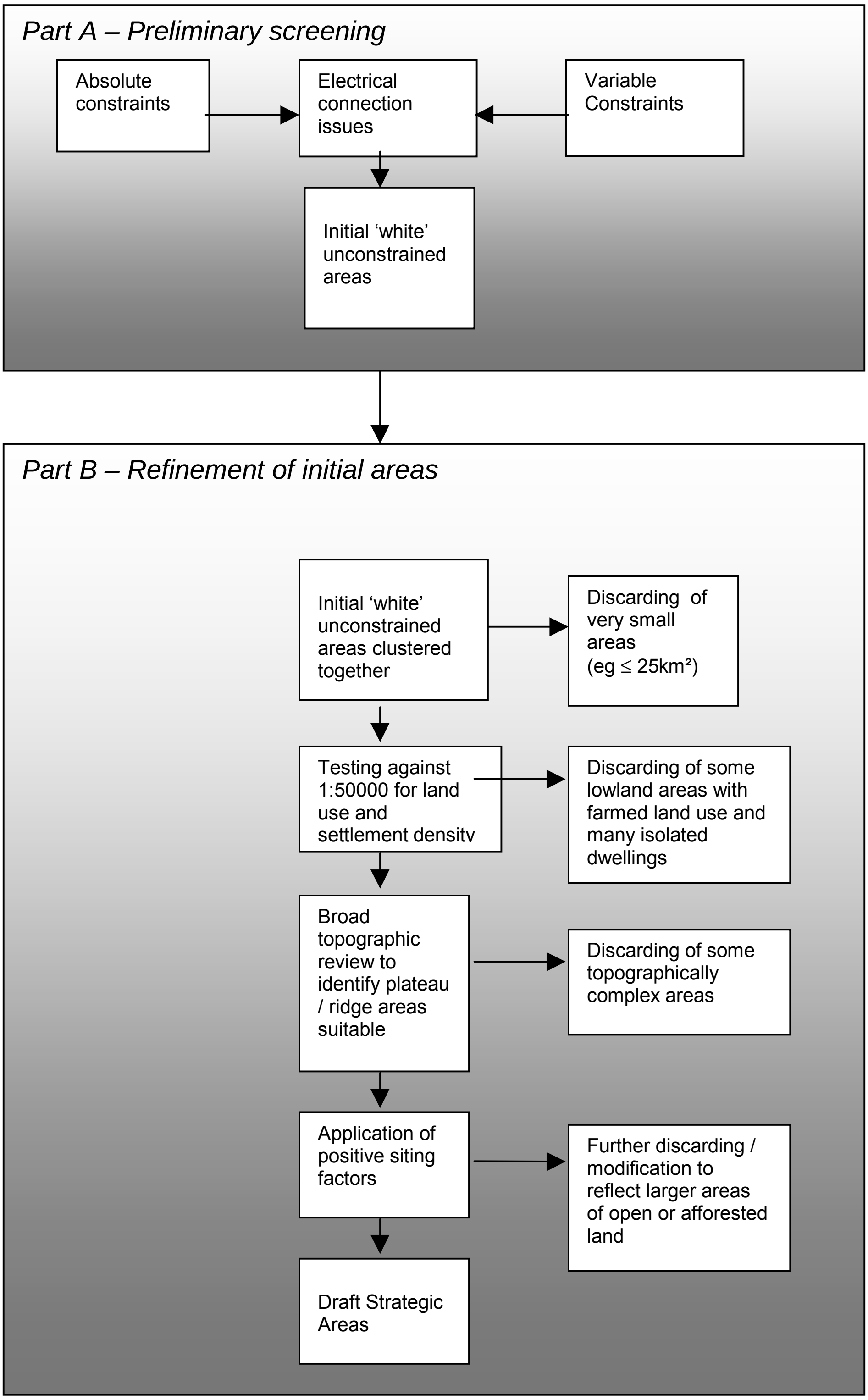
Data to inform the analysis was kindly provided by the Cartographic Unit of the Welsh Assembly Government or organised from third parties by the Office of the Chief Technical Officer.

As far as the research team were aware, no other attempts had been made in the UK to positively identify strategic areas for onshore wind at such a broad scale or for use in a national planning document. Hence the approach taken for this research was developed during the study and was by its nature, an iterative one; nevertheless it followed a methodology as set out in **Figure 5.1** below.

The methodology follows two broad stages. The first, *part A*, comprises a traditional ‘sieve analysis’ of spatial constraints. These are constraints to the development of onshore wind energy developments in Wales that are capable of being mapped and are available digitally for use in a GIS. The introduction of electrical connection issues into part A represents a significant step forward for a study of this type at a regional/national level and necessitated a further separate grid study. The second stage (*part B*) represents a refinement of the relatively unconstrained areas that emerged from the initial screening exercise. In the refinement stage the GIS was used to produce data for manual analysis and to check findings, rather than directly as an analytical tool. This was principally because the data sufficient to inform the part B exercise were not available electronically, however it was also because the refinement of the strategic areas inevitably requires some site-specific knowledge gained through field visits.

Parts A and B are described in further detail in the sections which follow.

Figure 5.1 Methodology for the Identification of the Strategic Areas



5.3 Part A - Preliminary screening for strategic areas

5.3.1 Introduction and context

It was necessary to aid development of the Geographic Information system for the research to determine how relevant factors pertaining to the development of onshore wind energy developments should be grouped and prioritised.

The grouping and prioritisation process evolved through both stages of the research contract and was a process which involved both external advice (from steering panel members and consultants who have acted on behalf of developers) and the expert views / experience of the research team.

In relation to spatial planning at a national level, the decision was taken for simplicity of analysis to treat the relevant factors in just three categories. These were

- Absolute constraints
- Variable constraints
- Electrical Connection issues

Each of these is described and discussed in the sections below.

The key issue for this study has been to determine what are the relevant factors appropriate to the strategic planning of onshore wind farms of large-scale (≥ 25MW) within Wales. Initial sensitivity testing (and the results of the stage 1 research) suggested that landscape and visual issues in their widest sense had the potential to complicate, and overtly influence, the identification of strategic areas for onshore wind energy. The brief for the Stage 2 research therefore indicates that landscape and visual issues (with the exception of the presence / absence of National Parks and AONBs) were not to directly influence the identification of strategic areas, but only to assist in their characterisation post-identification and this is considered in detail in the next chapter of this report.

5.3.2 Absolute Constraints

Absolute constraints are defined as those which, at the all-Wales level, would be likely to prevent large-scale wind energy developments

Table 5.1 overleaf sets out those factors considered absolute constraints for the purposes of this research contract and gives the reasons for their inclusion within this category.

Table 5.1 Absolute constraints to large-scale wind energy development in Wales

Constraint	Discussion / Justification
Windspeed ≤ 6 m/s at 45m above ground level	The economics of wind energy development change with time and between different developers. The economic viability of a wind farm does however depend to a degree to the windiness of a site. It is generally considered that wind speeds of less than 6 metres per second (defined at 45m above ground level) represent at present a minimum economic wind speed below which developers would not consider an area, regardless of turbine height. 6m/s was chosen as a conservative estimate to allow the largest area of land to come forward, however most developers of large (i.e. ≥25 MW) wind farms would still seek sites of 7 m/s and greater wind speeds if possible to maximise the commercial return on their investments. The most commonly used wind speed information is the ETSU NOABL[38] wind speed dataset. This DTI dataset is publicly available and includes data appropriate to different turbine heights above ground.
Ministry of Defence (MOD) Mid Wales Tactical Training Area  Spatial Extent of TTA LFA7T	The MOD is a statutory consultee in any wind farm application. It is common for potential developers to contact the MOD before submitting their planning application as its power to veto proposals is so significant.

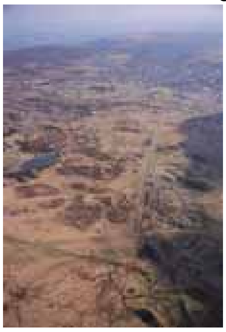
[38] **NOABL -UK Wind Speed Database -Background Information -**The data is the result of an air flow model that estimates the effect of topography on wind speed. There is no allowance for the effect of local thermally driven winds such as sea breezes or mountain/valley breezes. The model has a 1km square resolution and takes no account of topography on a small scale or local surface roughness (such as tall crops, stone walls, or trees), both of which may have a considerable effect on the wind speed. The data can only be used as a guide and should be followed by on-site measurements for a proper assessment. Each value stored in the database is the estimated average for a 1km square at either 10m, 25m or 45m above ground level (agl). Available via www.britishwindenergy.co.uk

Constraint	Discussion / Justification
	In October 2002, the Wind Energy, Defence and Civil Aviation Interests Working Group (led by DTI) published a set of interim guidelines with regard to Wind Energy and Aviation Interests[39]. The stated aim of the document was "to facilitate the development of wind energy to meet UK Government targets, whilst ensuring that the interests of both civil and military aviation are recognised" (paragraph 1.2.1). The document identifies and explains the strategic position with regard to onshore wind in the UK, detailing the technical constraints posed by civil and military aviation interests, setting out the potential conflicts between wind turbines and airborne or land-based aviation equipment. It also specifies the locations of civil aerodromes, technical sites and military tactical training areas (TTAs) which are safeguarded by UK regulations and therefore represent areas of constraint for developers. In the Tactical Training Area over much of Mid Wales (LFA7T) the MOD has stated with respect to wind "Our area in Wales, LFA7T, in particular, appears to be approaching what we deem to be saturation point, and we are likely to resist any further proposals for developments there"[40]. However, the published guidance states that "a wind farm on the edge of a [Tactical Training Area] may well be approved of as it presents little danger to training within the TTA, and several have been developed in the past" (paragraph 4.1.7.2).
Defence Estates Sennybridge Training Area. Myndd Eppynt	This area, covering over 10,000 hectares, forms part of the Army Training Estate in Wales and is used for artillery firing, live firing by ground-attack fighter aircraft and use of air-dropping zones.
Military 'Technical sites' - Ty Croes UK ACACS radar	The Ty Croes UK ACACS radar on Anglesey is an early warning air defence radar. At present, "MOD policy is not to accept any application within 75 km of an air defence radar site unless developers can prove that it will have no impact on the radar concerned. Where the turbines are not in the field of view of the radar due to local topography, this will be straight forward to achieve[41]" for this reason those parts of Wales within 74 km of the radar but not shielded by local topography were excluded and treated as absolute constraints.

[39] DTI et al (2002) Wind Energy and Aviation Interests: Interim Guidelines
[40] see www.mod.uk/issues/lowflying/ar-02-03/uklfs.htm
[41] DII et al (2002) Wind Energy and Aviation Interests Interim Guidelines

Constraint	**Discussion / Justification**
Lakes and reservoirs	Although it may be technically possible to site wind turbines within lakes and reservoirs, it is considered impractical and not cost effective. There are also likely to be ownership and recreation conflicts in the use of such sites for large wind farms.
Urban areas (i.e. settlements of village size and upwards)	Whilst there is an emerging best practice approach within the onshore wind industry of siting development more than 500m from residential properties (for noise/amenity and safety reasons) there are no other reasons why wind energy developments cannot be located within urban areas e.g. on former industrial land. The Welsh Assembly Government have recently commissioned research which specifically attempts to identify available urban and brown field sites for wind turbines / wind farms[42]. The study identifies some 144 MW of potential installed capacity in small to medium sized wind farms. (i.e. ≤ 25MW). The brief for this study however was to identify strategic areas for large (i.e. ≥ 25 MW) wind farms and it was felt that such developments were incompatible within urban areas.
National Parks / Areas of Outstanding Natural Beauty  *©Snowdonia National Park*	The three National Parks in Wales (Snowdonia, Pembrokeshire Coast and the Brecon Beacons) are protected for their importance in landscape, biodiversity and recreation terms. Planning Policy Wales states that "the statutory purposes of National Parks are to conserve and enhance their natural beauty, wildlife and cultural heritage and to promote opportunities for public understanding and enjoyment of their special qualities" (paragraph 5.3.4). The five AONBs in Wales (Anglesey coastline, Clwydian Range, Lleyn, Gower and Wye Valley) are designated to conserve and enhance their natural beauty and "local authorities, other public bodies and other relevant authorities have a statutory duty to have regard to AONB purposes" (PPW, paragraph 5.3.5). In landscape terms, AONBs and NPs are to be considered equal with respect to development. Whilst existing planning policies do not rule out the development of wind farms within the National Parks / AONBs of Wales it was felt that the designation of such areas was, for the time being, incompatible with large-scale (i.e. ≥25 MW) wind farms.

[42] Powys Energy Agency – The potential for wind power in urban, industrial and commercial sites in Wales – May 2003

Blaenavon World Heritage site  *View from west, looking towards Blaenavon ©Crown Copyright: RCAHMW*	There is one World Heritage Site in Wales at Blaenavon that includes an extensive series of historic landscapes and features protected by statutory means, the centre of which is the Blaenavon Ironworks. The site encompasses an area of some 35km², approximately half of which lies within the Brecon Beacons National Park. As with National Parks / AONBs, it was felt that the recognition of such an area at an international level was, for the time being, incompatible with large-scale (≥25 MW) wind energy developments.
Internationally designated ecological sites  *©CCW*	This set of designations, comprising Ramsar sites, Candidate and proposed Special Areas of Conservation (SAC) and Special Protection Areas (SPA) represents habitats that are considered of European Importance. Ramsar sites are internally important wetlands, designated under the international Ramsar convention, whilst SACs and SPAs are protected under the European Community Habitats and Birds Directives respectively. Sites which are proposed as candidate SACs (cSACs) receive the same legal protection as those which have already been designated. Development is not impossible within such sites, but it has to be demonstrated that it would not adversely affect the integrity of the site and/or contravene its conservation objectives. It is considered that at this point in time the development of large (≥25 MW) wind farms in internationally designated ecological sites is incompatible with the other obligations of the Welsh Assembly Government to protect and enhance such sites. The Dyfi Valley Biosphere site is an area in which people work to balance the conservation of biodiversity with its sustainable use. It is internationally recognised within the framework of UNESCO's programme on Man and the Biosphere. Whilst the area is a voluntary agreement and in itself does not provide legal protection, the Dyfi Valley biosphere site largely comprises a Ramsar site and two cSACs.

National Nature Reserves (NNRs) 	NNRs are "the very best examples of our wildlife habitats and geological features[43]" and they are afforded the highest level of conservation protection available under UK legislation. Most of the 65 NNRs in Wales are owned or leased by CCW. All of them are also Sites of Special Scientific Interest, but not all SSSIs are NNRs. It is considered highly unlikely that CCW would consent to the use of its land for large scale wind energy developments and thus these areas were considered, at the present time, absolute constraints.
Slopes ≥ 40 Degrees	It is considered highly unlikely that wind farms would be located on slopes greater than 40 degrees due to constraints of access track construction etc.
Areas of Wales either a) greater than 10km from appropriate electrical grid infrastructure or b) which have appropriate grid infrastructure but with small or very small grid capacity.	See section 5.3.4 of this chapter for further explanation.

5.3.3 Variable Constraints

Variable constraints are defined as those which, in general, are likely to inhibit the development of large wind energy developments but for which there is either a) some variability / uncertainty in their spatial extent or b) the possibility to develop within the area concerned but with appropriate mitigation.

Table 5.2 overleaf sets out those factors considered variable constraints for the purpose of this research contract and gives the reasons for spatial extent and their inclusion within this category.

43 www.ccw.gov.uk

Table 5.2 Variable constraints to the development of onshore wind farms in Wales

Constraint	Discussion / Justification
Registered Common Land	Common land is protected under several Acts of Parliament[44] and is subject to 'rights of common', for example the right to graze certain stock. For development to proceed on common land the applicant needs to both a) undertake a complex process of application to the National Assembly and b) needs consent from the various commoners who have rights. Achieving development of a large wind farm on common land is therefore seen as a practical constraint, setting aside environmental considerations.
Safeguarded Civil Aerodromes (Cardiff / Liverpool)	Cardiff and Liverpool are officially safeguarded aerodromes[45]. Each safeguarded aerodrome is issued with two safeguarding maps centred on the aerodrome. One map extends out to a radius of 15km and indicates the height above ground level for which any proposed development is subject to consultation. The second map extends out to a radius of 30km; the local planning authority is required to consult the relevant aerodrome regarding any wind turbine proposal within the radius. In the event of the penetration of a protected "3 dimensional surface" around an aerodrome by a development the aerodrome will raise an objection. 30 km radius 'line of sight' shapes generated around the two airports have been used as a variable constraint.
Non 'officially safeguarded' aerodomes	Wales has 5 smaller airports, Caernarfon, Swansea, Hawarden (Flintshire) Haverfordwest and Welshpool. There is no available guidance on how these might influence wind energy developments so an arbitrary 5 km radius 'surface' was placed around each, recognising that there will be some form of constraint posed by the aerodromes.
Military 'Technical sites' and aerodromes	These (RAF Valley, St Athan, Aberporth, Llanbedr and Pendine) were treated as per non-'officially safeguarded' aerodromes for the same reason.
Met Office Cloud Scanning Radar at Crug y Gorllwyn (near Newcastle Emlyn) and Wind Profiling Radar at Aberystwyth	These installations are also highlighted in the DTI interim guidelines[46] and were given a 10 km radius exclusion zone broadly in accordance with the recommendations in the guidelines.

[44] the Law of Property Act 1925, The Law of Commons Amendment Act 1893, National Trust Acts, 1907 and 1971, Commons Registration Act 1965 etc.
[45] DTI, 2002, Wind Energy and Aviation Interest: Interim Guidelines
[46] DTI, 2002, Wind Energy and Aviation Interest: Interim Guidelines

<table>
<tr><td>Terrestrial Television Reception</td><td>It is well known that large buildings and other structures such as wind farms can adversely affect terrestrial television reception. The broadcasters, the BBC and the Independent Television Commission (ITC), are keen to ensure that disruption to television distribution and reception is kept to a minimum and have produced appropriate guidance[47]

The effect of principal importance is that upon permanent broadcast links. For the purposes of assessing the likelihood of interference to domestic television reception the ‘shadow’ zone may be considered to be a sector with a radius of up to about 5km from the wind farm. Since the locations of potential wind farms are not known with certainty, the approach was taken to map broadcast links between major and minor TV masts and to place an arbitrary 5km buffer around the 6 major TV Transmitter Masts in Wales.</td></tr>
<tr><td>Slopes ≥20 Degrees but less than 40 Degrees</td><td>In general wind farms are located on plateau or ridges with a shallow gradient. Slopes between 20 and 40 degrees are therefore considered unlikely to be utilised by large scale wind energy developments.</td></tr>
<tr><td>Heritage Coasts

©CCW</td><td>One third of the Welsh coastline has been designated as Heritage Coast.

Countryside Council for Wales says:

“Heritage Coasts were identified in response to widespread concern about the loss of unspoiled coastlines to insensitive developments, including caravan sites, industry and urban expansion. Most Heritage Coasts simply extend along the shore between two named points. Some, however, include clearly defined inland boundaries. Their status carries no legal protection, but planning authorities must take the designation into account before taking decisions on matters which could affect the area.”

There is a strong landscape/visual element to Heritage Coast designations; large-scale wind energy developments were felt unlikely in the immediate vicinity of such areas.</td></tr>
</table>

[47] BBC et al, The Impact of large Buildings and Structures (including Wind Farms) on Terrestrial Television Reception.

Scheduled Ancient Monuments	Scheduled Ancient Monuments (SAMs) are designated by Cadw and are statutory protected. They are however generally quite limited in spatial extent and hence usually capable of avoidance at the detailed design stage (via the movement of individual turbines etc.). The broad distribution of SAMs has been taken as an indication of an area's likely cultural heritage potential, but has not been considered an absolute constraint.
Sites of Special Scientific Interest  *©CCW*	SSSIs cover one tenth of the land area of Wales[48]. These statutory nature conservation designations, are identified by CCW as sites of national importance. The reasons for SSSI designation may relate to the presence of a rare species of flora or fauna, rare geology or other factors. The Welsh Assembly has a commitment to ensure that "consistent with the objectives of the designation, statutorily designated sites are protected from damage and deterioration" (PPW paragraph 5.3.9). Wind farms generally have a very small physical footprint in proportion to the total area occupied by the development, since only the turbine footings and access / maintenance tracks require the disturbance of the ground surface. There is therefore not a total incompatibility between such developments and a SSSI designation.
Local Nature Reserves (LNRs), Royal Society for the Protection of Birds (RSPB) Reserves and Country Parks	Whilst rarely spatially extensive, the ownership and management arrangements for LNRs, RSPB reserves and country parks make them sites unlikely to be available for large wind energy developments.

The results of the application of the variable and absolute constraints are show on **Figure 5.2** overleaf. It is important to note the extent of the absolute constraints and the effect this has on reducing the land area available for large-scale wind energy developments in Wales. This availability is further reduced through the application of constraints associated with the gird infrastructure and these are considered in the section which follows.

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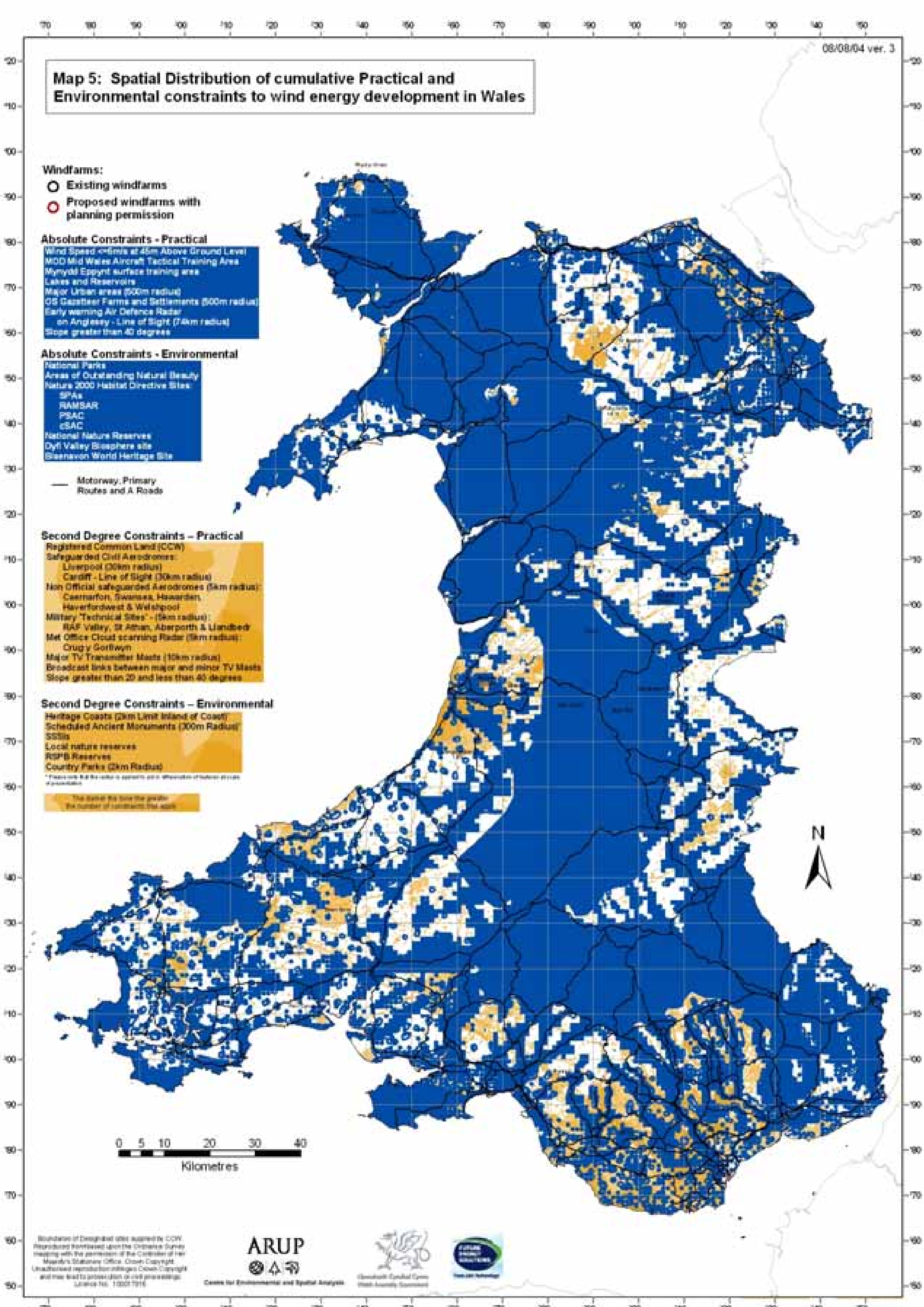
Figure 5.2 Cumulative practical and environmental constraints (absolute and variable)



5.3.4 Electrical Connections

The *national electricity transmission network* is owned by the National Grid company. It supplies power to and from *local distribution networks* in North Wales (operated by Manweb) and south Wales (operated by Western Power Distribution). The National Grid power cables have a high capacity, operating at 400kV and 250kV. These connect North and South Wales to the English network and further afield. There is no National Grid connection directly between North and South Wales.

The *local distribution network* in Wales transmits power from the National Grid to consumers. This local grid tends to reflect the population density of the areas it supplies. The capacity for additional load to be added to the network is considered to be limited, especially in remote or sparsely populated areas. However it is the *local distribution network* into which most wind farms would be connected: only the very largest schemes (≥150MW) would be appropriate to connect directly to the National Grid infrastructure. Some very small wind schemes (i.e. individual turbines) may stand alone and provide power directly to a local user (e.g. an industrial plant) but these are the exception.

There are two principal constraints relating to the provision of electrical connections to wind farms. These are:

a) The presence or absence of existing infrastructure (i.e. is there local distribution network / National Grid in the area in question)

b) The capability of infrastructure to accept electrical generation of the amount likely from the wind farm (termed distributed generation), either now or in the future.

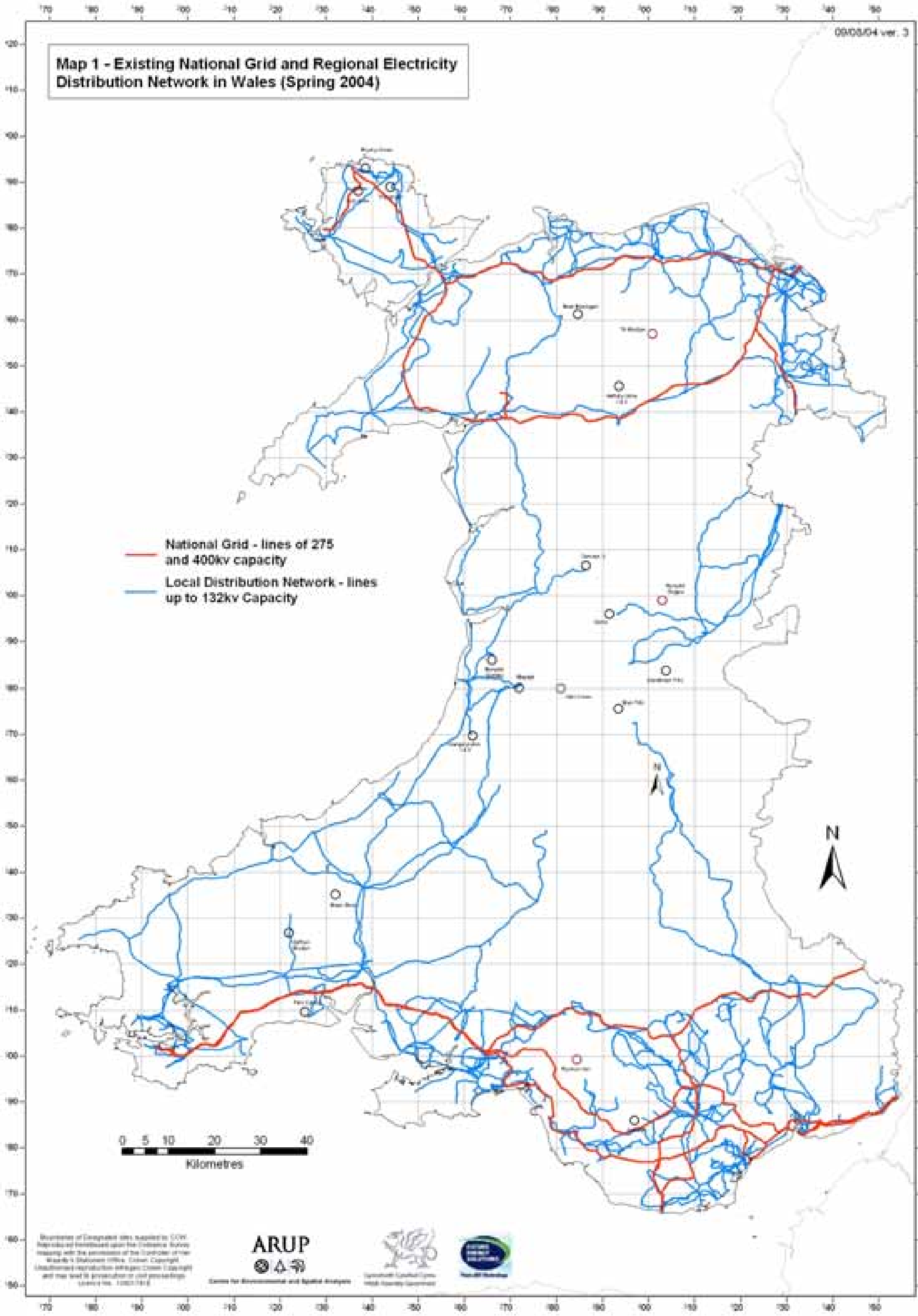
Each is discussed in turn below. In order to inform the research a study was specifically commissioned into the ability of the local distribution network in Wales to accommodate large-scale wind energy developments[49] and this is included as **Appendix C**.

Existing Infrastructure

The existing national grid and local distribution network can be mapped and is shown overleaf on **Figure 5.3**.

[49] Future Energy Solutions, Connection Areas for Wind Energy in Wales – Grid Considerations – unpublished report for the National Assembly for Wales, 2004.

Figure 5.3 Existing National Grid and Local Distribution Network



The likely proportion of the capital costs of wind farm development that developers might be willing to spend on electrical connection infrastructure is estimated to be in the region of 8%[50]. Discussions undertaken with developers as part of the separate gird study indicated that it was unlikely that connections in excess of 10km from a substation or line (by teeing off) would be considered viable

[50] Future Energy Solutions, Connection Areas for Wind Energy in Wales – Grid Considerations – unpublished report for the National Assembly for Wales.

from most large-scale proposals when the extra costs of planning, possible inquiries and way leaves are taken onto account. Therefore all parts of Wales greater than 10km from existing electrical transmission infrastructure (whether grid or local distribution network) were considered as unavailable for large-scale wind energy developments and hence 'absolutely constrained'.

The only exception to the 10km 'rule of thumb' would be a wind farm proposal of such a scale that it could afford electrical connection infrastructure in excess of this distance. Discussions held as part of this study suggest that such a proposal would need to be a single scheme of greater than 150-200 MW. This study has considered such 'mega' proposals to be capable of going almost anywhere in Wales with respect to grid (provided sufficient capacity exists) and hence they can fall outside the spatial grid constraints mapping exercise.

Electrical capacity

Depending on the strength of the electrical network, existing generation rates and remoteness to load centres the existing electrical infrastructure in Wales has differing capabilities to accept distributed generation from wind energy developments. Determining the capability of the various parts of the network is difficult and generalisations are required to inform an all –Wales picture.

Working with the two local distribution network operators in Wales, Manweb and Western Power distribution, it is possible to zone the country into 23 areas, and estimate approximately the current capacity for accepting large-scale wind energy developments. The zones were categorised as per **Table 5.3** below

Table 5.3 Categorisation of the grid zones in Wales to accept distributed electrical generation

Grid Capacity	Comment
A - Very Small and Small	The local distribution network has capacity of less than 30MW and is unable to accommodate large-scale wind energy developments – to be treated as an 'absolute constraint'
B - Small but with National Grid possibility (i.e. National Grid Supply Point/substation)	The local distribution network has capacity of less than 30MW as above, however the area has appropriate National Grid infrastructure which could accommodate very large wind energy developments (i.e. $\geq$150MW)
C - 30 – 50 MW without National Grid	The local distribution network has capacity between 30 – 50 MW
D - 30 – 50 MW with National Grid	As C but with National Grid connection point
E - 50 – 100 MW without National Grid	Self explanatory
F - 50 – 100 MW with National Grid	Self explanatory

The analysis undertaken[51] indicates that of those areas of Wales with existing electrical infrastructure, 100MW is the maximum capacity of any zone and that zones with such capacity are located predominantly within South East Wales. Mid and North Wales have virtually no additional capacity for distributed generation at present. The 11 areas identified that are able to accept more generation can only accommodate a further 510MW to 780MW approx between them.

[51] Future Energy Solutions, Connection Areas for Wind Energy in Wales – Grid Considerations – unpublished report for the National Assembly for Wales.

In addition the study considered planned improvements of the local distribution network. Western Power Distribution has no significant plans to improve electrical capacity in South Wales. Manweb, however, has two proposals for which capital funds are being sought. These are described in detail within the grid study[52] and allow by 2010/2015 for an additional 500MW of electrical capacity to be provided in the following areas:

- 100MW in the Denbigh Moor area (between St Asaph, Denbigh, Cerrigydrudion and Pentrefoelas)
- 380MW approx in the Mid Wales area (between Oswestry, Welshpool, Newtown, Aberystwyth, Machynlleth approx.)

Although the exact routes of possible new overhead lines have not been determined, the broad areas into which the lines would go have been identified. The areas have been mapped and the indicative capacities added to those available with existing infrastructure. Some of the previously 'constrained' areas are therefore 'opened-up' as a result.

New overhead lines of 132kv voltage such as would be required to facilitate some of the previous unconstrained areas would in, most cases, have wooden poles rather than steel overhead pylons. Separate consenting processes would be needed for such lines under Section 37 of the Electricity Act and the landscape and visual issues associated with the lines would be examined in detail. This study however does not consider them further.

It should be noted that available electrical capacity at an all-Wales level utilising only existing infrastructure is only equivalent to the total generation requirements of the 2010 target from onshore wind, regardless of other spatial constraints. The additional capacity planned for installation by the local distribution network operators is critical to increasing the likelihood of achieving the renewable electricity target by 2010.

Treatment of the grid information

As discussed above, parts of Wales beyond 10km of existing or planned electrical infrastructure have been considered 'absolutely constrained'. In addition parts of Wales with 'very small' and 'small' electrical capacity for distributed generation either now or with planned improvements, are also considered 'absolutely constrained'.

The greater difficulty has been in how to assess in the mapping exercise those areas that have available electrical capacity (and hence infrastructure) but for which that capacity is variable between 30 and 350MW.

Most existing wind farms in Wales have an output of less than 30MW at present, and the view from developers and the steering panel was that without a change to the planning regime, projects in the future promoted in Wales will still be at or around the 50MW size. For an area to be considered 'strategic' it was felt it should accommodate more than one 'typical size' wind farm of greater than 50MW and have the flexibility for size increases over time or re-powering into the future with larger capacity turbines. Given the uncertainties in the grid capacity data and the likelihood of over estimating the capacity for distributed generation, it was decided that for a grid zone in Wales to support a 'strategic area' for onshore wind it should have a minimum electrical capacity (as identified

[52] 'Connection areas for wind energy in Wales – grid considerations' by Geoff Scrivener, May 2004

by this research) for distributed generation of 100MW. It is accepted that this is a fairly arbitrary threshold but testing of the spatial implications via the GIS suggested that it fitted fairly well with other factors and still allowed reasonable spatial flexibility.

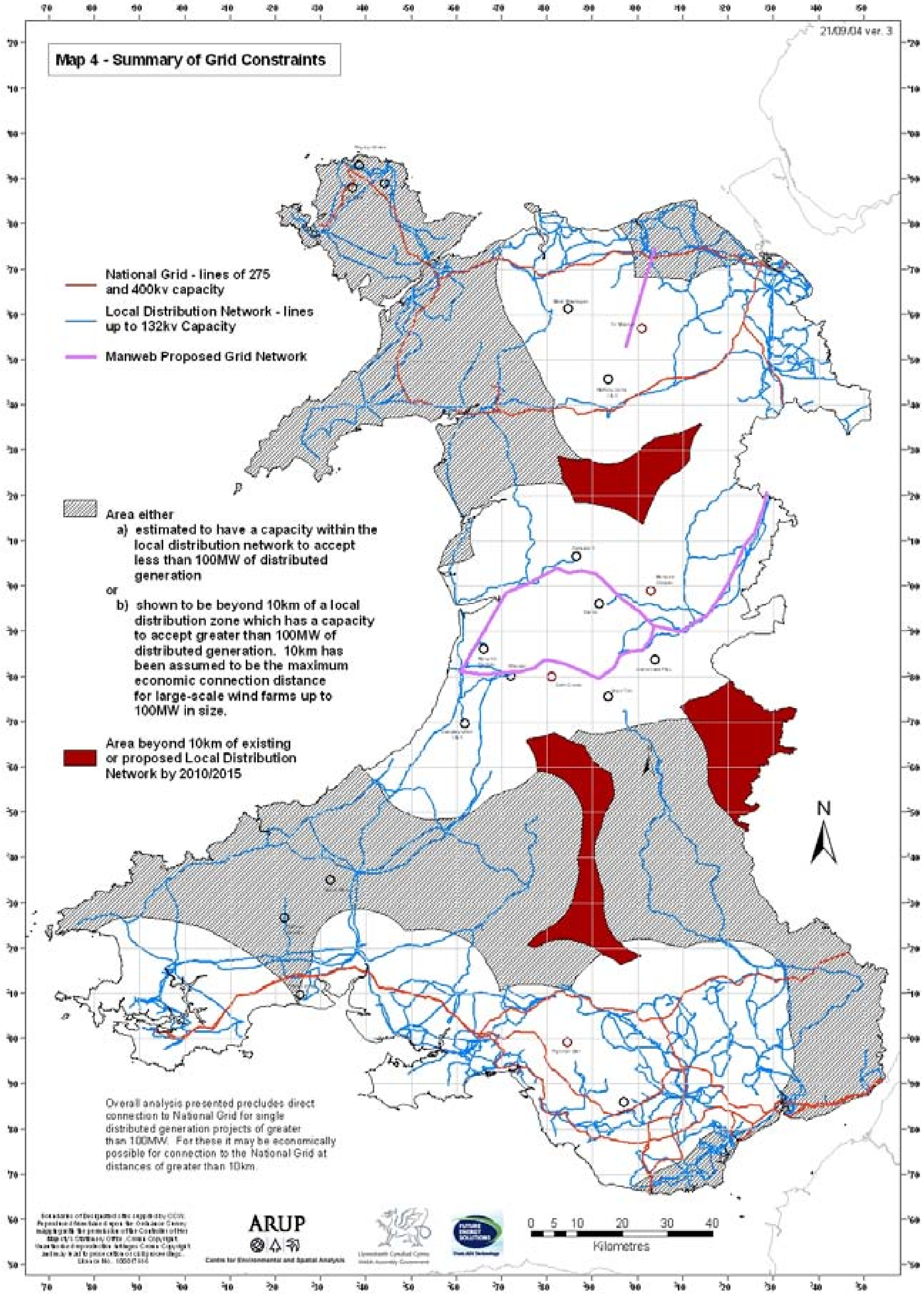
In summary those parts of Wales considered ‘unconstrained’ with respect to present or planned electrical capacity for strategic areas were only those with either

a) electrical capacity (existing or planned) ≥ 100MW or

b) were within sufficient economic connection distance (i.e. ≤ 10km) of a zone with an electrical capacity (existing or planned) ≥ 100MW.

These were taken forward for subsequent analysis and are shown graphically on **Figure 5.4** overleaf.

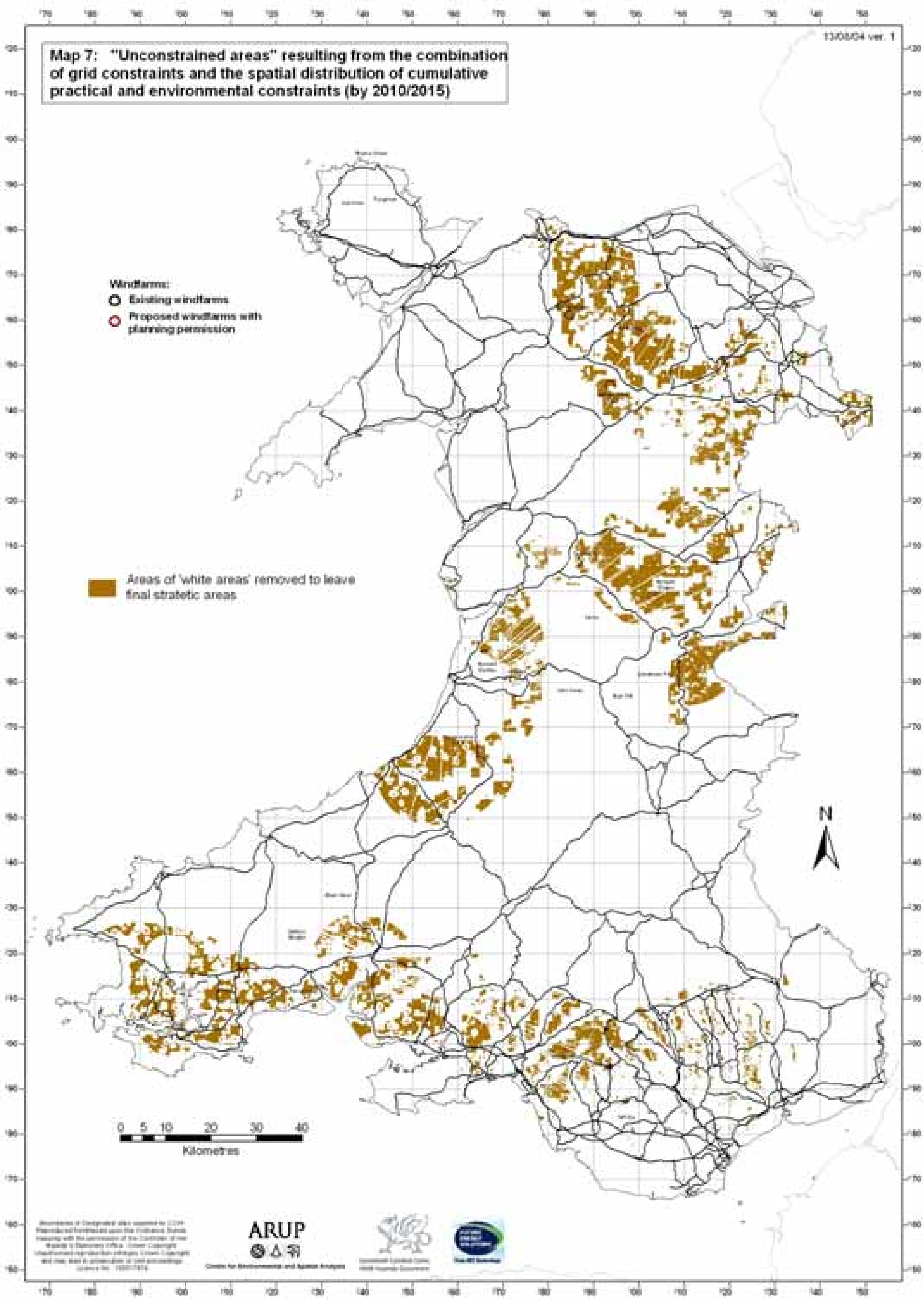
Figure 5.4 Summary of grid constraints (by 2010/2015)



5.3.5 Output from Part A – screening for strategic areas

A map was produced that indicated the spatial distribution of cumulative practical, environmental and grid constraints to large-scale wind energy development in Wales (the 'absolute' and 'variable' constraints together with areas of the grid network with a minimum capacity of 100MW). This map is reproduced in **Appendix H** but by definition is complex. Of more relevance is the 'inverse' of the map, i.e. those 'unconstrained areas' that are not covered by any of the other data (and are by definition 'white') and these are show on **Figure 5.5**.

Figure 5.5 "unconstrained areas" resulting from the combination of grid and cumulative practical and environmental constraints (by 2010/2015)

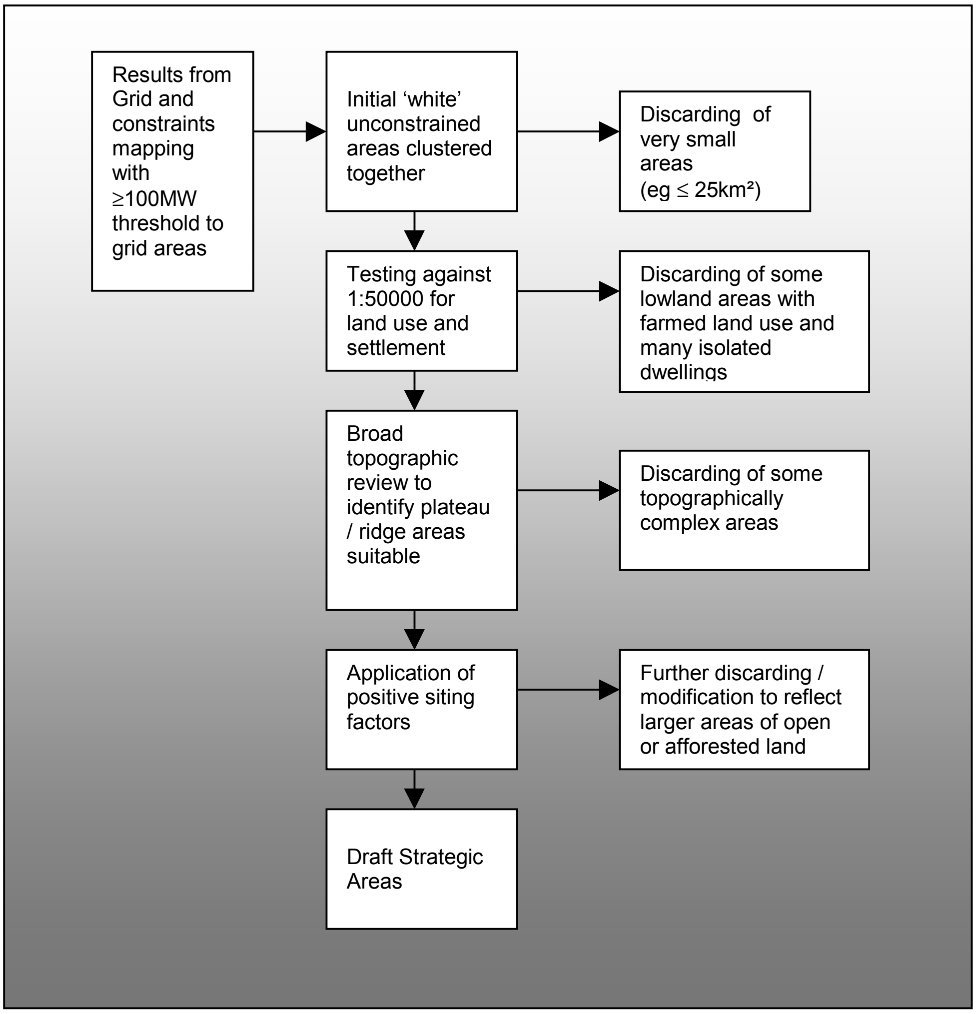


5.4 Part B – Refinement of strategic areas

5.4.1 Introduction

The initial scoping exercise detailed above proved to be extremely effective, reducing the area for further consideration to approximately 15% of the land area of Wales. Experience gained during Stage 1 suggested that this was still likely to be an overestimate of the potential land available and so a further refinement exercise was undertaken. The approach taken for this exercise is set out in **Figure 5.6** below.

Figure 5.6 - Refinement of strategic areas for onshore wind in Wales



The stages are described in greater detail below.

Review of 'white' unconstrained areas.

To allow for the scale of larger wind energy developments the smaller, isolated 'white areas' (i.e. those $\leq 25km^2$) were discarded or those of an awkward or linear shape. As a starting point the team were looking for areas up to $100km^2$ in size to give flexibility.

Testing against land use, settlement and topography

The identification of individual isolated properties and land uses (such as enclosed fields) which may well be incompatible with large-scale wind energy developments proved difficult with the GIS. Whilst data existed electronically which indicated individual postal address locations by grid reference, the datasets were understandably very large and effectively impossible to process at the scales required for such a strategic exercise. It was therefore necessary to pursue a manual selection approach which involved a team review of hardcopy 1:50000/1:25000 Ordnance Survey Landranger maps of the relevant areas.

This stage in the exercise is best illustrated by example.

Figure 5.7 and **Figure 5.8** overleaf are two extracts from the 1:50000 Landranger Ordnance Sheet 136, Newtown and Llanidloes. Both are 25km² in area. **Figure 5.7** indicates a sparsely populated area with very few isolated dwellings and a land use with a reasonable degree of coniferous plantation. The topography is relatively undulating in the range 300-400m AOD. This would fall through the refinement exercise.

Figure 5.8 shows an area with a greater density of isolated properties, minor roads and more complex topography, including several incised valleys. This is typical of much of eastern mid-Wales and would be discarded by the refinement exercise.

Most large-scale wind energy developments are located on elevated plateau or broad ridges, rather than in topographically complex terrain. It was possible therefore to discard some further smaller areas (such as some of the land to the South of the A5 near Pentrefoelas) from further analysis.

As a result of this stage, the following parts of the County Boroughs of Wales were discarded from further analysis:

Pembrokeshire,

South-Western Carmarthenshire,

North-eastern Powys,

Northern Conwy,

Western Wrexham and

Central Ceredigion.

Figure 5.7 – Extract from 1:50000 OS Landranger Sheet 136 (Newtown and Llanidloes) – low population density

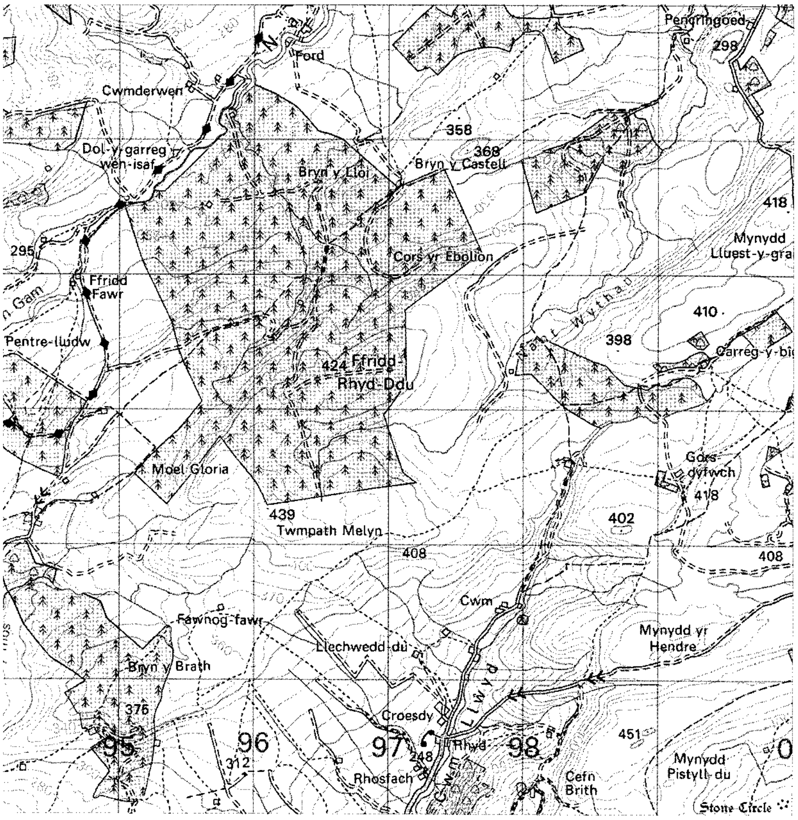
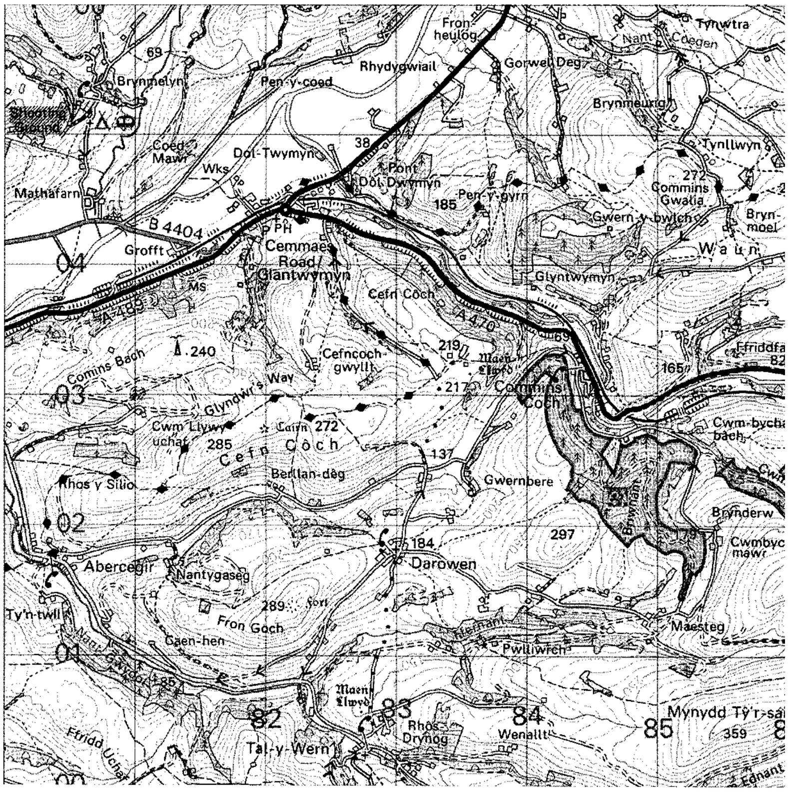


Figure 5.8 Extract from 1:50000 OS Landranger Sheet 136 (Newtown and Llanidloes) – moderate population density



Application of positive siting factors – land availability and access.

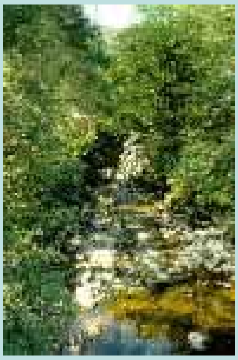
One of the most important factors in delivering a large-scale wind farm at the more local level is securing an appropriate leasehold or freehold of the land in question. With a very large-scale wind farm (i.e. 100MW) requiring up to 25km² in area, developers would need to be sure of securing agreements and access to all of the necessary land. One of the other important local factors is that of site access. Modern turbines have blades of up to 50m in length and thus specialist wide-load carrying vehicles are needed (together with suitable width access tracks) to enable erecting cranes and the turbines themselves to reach their ultimate point or erection.

Investigating land ownership and site access at the strategic level is considered practically impossible; CCW's Open Access Land (Open Country sub-set) and the Forestry Commission estate datasets were used as proxies for the issues.

Mapio Tir Mynediad
Mapping Access Land

Open Access Land (Open Country sub-set) – Access land is described in Section 1 of the Countryside and Rights of Way Act 2000[53] generally as either a) land mapped in conclusive form as open country or b) land mapped in conclusive form as common land. [Common land has been dealt with already and is considered a variable constraint (see previous)]. Open country is generally in the legislation and guidance described as Mountain, Moor, Heath and Down. The 'Moor' category included land of an open character with semi-natural vegetation such as rough unimproved acid grassland.

The Open Access Land (Open Country sub-set) does not include agriculturally improved or semi-improved grassland, which would imply a greater degree of land management and hence potential complex land-ownership issues. Thus the open country data layer was used to highlight larger areas of mostly un-enclosed land which were felt likely to be either of single or of very few different ownerships and hence attractive to potential developers. It is recognised however that open county has generally a higher recreational and ecological value than adjacent enclosed and grazed land and thus the identification of such areas as positive siting factors for this study does not indicate that large-scale wind energy developments are necessarily desirable within them.



Forestry Commission estate. The Forestry Commission is the Government Department responsible for forestry policy throughout Great Britain[54]. Forestry is a devolved matter and the Welsh Assembly Government has responsibility for forestry in Wales: the Forestry Commission estate in Wales is managed by Forest Enterprise Wales. The Forestry Commission estate is land within a single ownership (the Assembly Government) and is covered by a series of access tracks suitable for use by heavy plant for the extraction of timber. The Cefn Croes wind farm scheme near Aberystwyth, which has planning permission, will utilise areas of coniferous forestry, albeit not all part of the Forestry Commission estate.

[53] see www.countryside.gov.uk/assess/mapping
[54] www.forestry.gov.uk

It is possible to locate major wind energy developments in and around coniferous plantations, either on gaps between forestry blocks, on recently felled or planted land or even within mature plantations if the turbines are large enough (typically 100-130m to blade tip) although examples where the latter has been successfully achieved are presently few. Most areas have access roads that will be suitable for the delivery of wind turbines with only minor modification.

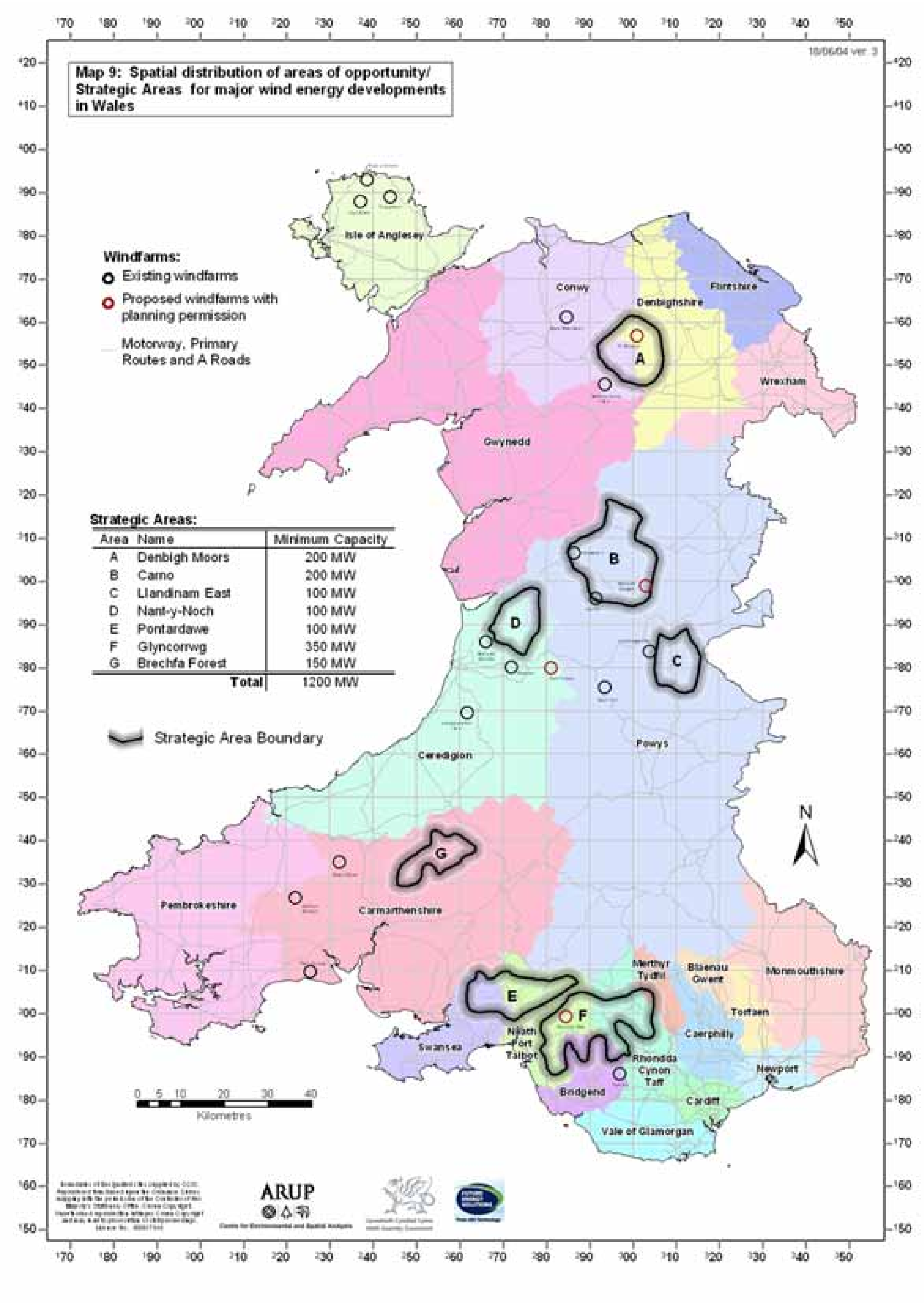
Unlike the open country dataset, there may also be environmental benefits from utilising land already affected by afforestation, particularly in terms of landscape and visual impact. This was not however the reason for the inclusion of the Forestry Commission estate as a positive siting factor, since all landscape and visual issues were taken out of the selection of strategic areas in the first instance.

5.5 Results

The result of the above analysis, together with a further review of the extent of variable constraints, was the derivation of seven strategic areas for large-scale onshore wind energy development in Wales. The extent of these is indicated on **Figure 5.9** overleaf. Working names for each are as follows:

- *A – Denbigh Moors*
- *B – Carno (the village is located broadly central to the area)*
- *C – Llandinam East*
- *D – Nant-y-Moch (the reservoir of the same name is located broadly central to the area)*
- *E – Pontardawe*
- *F – Glyncorrwg (the village of Glyncorrwg lies to the centre of the area but the area extends to the east to Merthyr Tydfil)*
- *G – Brechfa Forest*

Figure 5.9 Draft Strategic Areas



5.5.1 Presentation of results

Both Arup and the Welsh Assembly Government considered it inappropriate to present the strategic areas at any larger scale than 1:650,000 approximately (so that all Wales appears as occupying one A3 sheet). The reasons for this are as follows:

- The boundaries of the strategic areas were only defined, and more importantly digitised, at 1:250,000 scale (i.e. at 'road atlas' scale)
- There is a need to avoid giving the impression that the maps are suitable for use for the identification of individual sites.
- The exercise was strategic and the results of the study should reflect this.
- There should be flexibility for subsequent detailed modification of the strategic area boundaries via some form of consultation process, without necessarily undermining their strategic definition.

To reinforce the indistinctiveness of the strategic area boundaries, lines were 'buffered' both inside and out by some 2.5 km to give a broader band of some 5 km as shown on **Figure 5.9**.

6 Testing and validation of Strategic Areas

6.1 Introduction

Although landscape and visual issues (with the exception of National Parks and AONBs) were to be excluded from the identification of the draft strategic areas, it was considered appropriate to examine the draft strategic areas in relation to landscape and visual factors, as commentary would inevitably be sought on such aspects if the areas were to be more widely adopted.

Discussions and debate during Stage 1 of the research, together with literature research and field investigations, suggested that the following were the most relevant landscape and visual issues pertaining to the strategic development of large-scale onshore wind farms:

- Influence of other existing wind farms, i.e. cumulative visual and landscape impact
- Effects upon landscape 'character', considering a given landscape's sensitivity and capacity and the effects upon the 'wild land' resource of Wales
- Effects upon environmental designations with a strong landscape component, both direct and indirect.

Each of these is discussed below.

In addition the specialist grid study commissioned (included as **Appendix C**) indicates the economic importance of wind speeds greater than 6m/s in the successful development of large-scale wind farms, especially if such wind farms have to support considerable associated grid infrastructure. The draft strategic areas where therefore also examined with respect to higher wind speeds.

A final key test of the strategic areas was an evaluation of their ability to provide for the 800MW of onshore wind required by the Welsh Assembly Government. For this reason the last part of this chapter discusses the estimation of possible 'energy yields' from the areas through the assignment of potential national turbine locations within each area.

6.2 Influence of other existing wind farms.

The Landscape Architect profession is reaching consensus on how to assess the cumulative landscape and visual impacts arising from wind farm developments. The methodology has been recently summarised by Scottish Natural Heritage[55] and is included in **Appendix D**. The SNH paper deals with *how* to undertake a cumulative impact assessment, but does not offer any guidance on *thresholds of acceptability* i.e. at what point a particular combination of developments becomes unacceptable. This remains a matter for the professional judgement of the assessor. It can also move to the realms of a political decision.

There are only two overall potential approaches to dealing with cumulative impact with respect to onshore wind at an all-Wales level, namely whether to encourage the:

a) *Concentration of developments* in particular areas, essentially accepting local cumulative impact as several wind farms become visible from several others. This leads to the development of 'wind farm landscapes' where the overall character of an area changes. Whether this is viewed as positively or negatively is a matter for debate and relates to the wider issues of the acceptability of landscape change, or

[55] SNH, Guidance for the Assessment of cumulative Landscape and visual Impacts arising from wind farm developments. May 2004

b) *Dispersal of developments,* adopting a policy of attempting to avoid cumulative impact by keeping wind farms sufficiently far apart from each other such that particular areas are not able to experience visual impacts of any great magnitude (however defined in detail).

The option to adopt is as much a political decision rather than a technical one.

At present, the current approach of national, regional and local studies and policies within the UK is to encourage the dispersal of developments, whether expressed explicitly in such terms or not. Dispersal tends to imply the adoption of minimum separation distances between developments of particular scales or types. However, a policy of dispersal will eventually meet a point of saturation because of the lack of new developable land. It would not be possible to meet the 4TWh target with the dispersal approach.

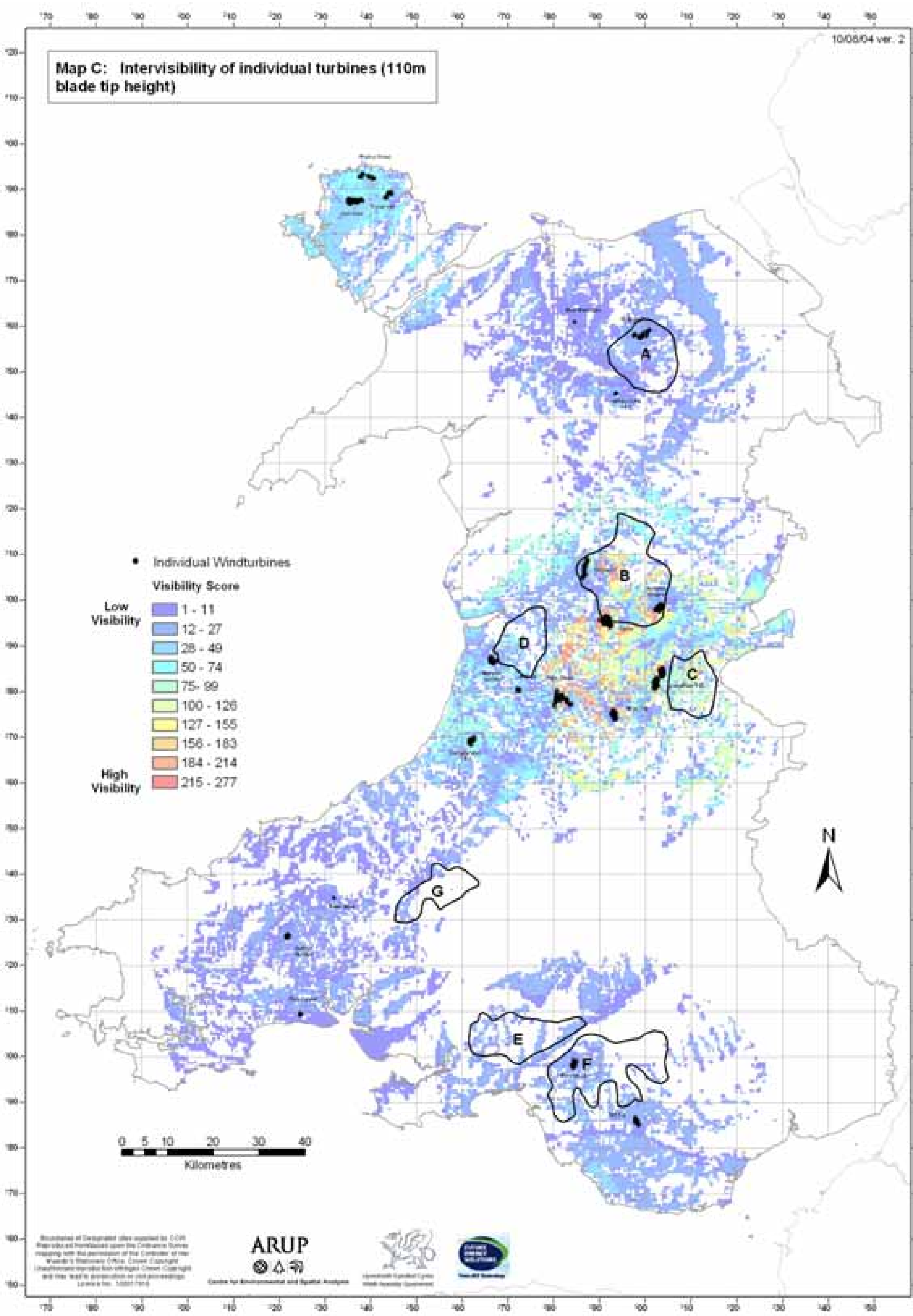
After much internal discussion, the Welsh Assembly Government decided that this research should consider a ‘concentration’ approach, to maximise the economies of scale of larger developments to help facilitate the provision of new electrical grid infrastructure. This has the effect of minimising the geographic spread of landscape and visual impacts. The logical conclusion of this is that within, and adjacent to, strategic areas cumulative impact considerations therefore assume far less importance in the planning process than at present.

Figure 6.1 below indicates the number of turbines (existing and with planning permission) that would be visible form the draft strategic areas. The detailed methodology for the calculation of visibility via the use of the Geographic Information System is set out in **Appendix H**.

This methodology applies to this testing exercise and those described in the remainder of this chapter.

A commentary on the results presented in **Figure 6.1** overleaf is provided in the table and text at the end of this chapter.

Figure 6.1 Intervisibility of individual turbines from the strategic areas



6.3 Landscape Capacity and Sensitivity

"Landscape capacity refers to the degree to which a particular landscape character type or area is able to accommodate change without significant effects on its character, or overall change of landscape character type. Capacity is likely to vary according to the type and nature of change being proposed"[56]

"Many Landscape Character Assessments will be used to help in decisions about the ability of an area to accommodate change, either as a result of new development or some other form of land use change, such as the introduction of new features, or major change in land cover such as new woodland planting. In these circumstances judgement must be based on an understanding of the ability of the landscape to accommodate change without significant effects on its character. Criteria for what constitutes significant change need to be identified in planning policies or landscape strategies, and will usually be informed by potential effects on character and /or particular features and elements."[57]

The published guidelines on Landscape and Visual Impact Assessment[58] tackle the subject of sensitivity at some length, but do not deal specifically with the topic of landscape capacity. It is, however, clear that there is much common ground between the thinking that is emerging on landscape sensitivity and capacity in Landscape Character Assessment work and the approach that is taken in Britain to Landscape and Visual Impact Assessment. This emerging common ground is summarised in the recent paper on the techniques and criteria for judging capacity and sensitivity[64] and this is included in **Appendix E**.

Turning a sensitivity study into an assessment of the capacity of a landscape to accommodate a particular type of change is difficult. The assessment of the sensitivity of different types or areas of landscape to the type of change in question must be combined with an assessment of the more subjective, experiential or perceptual aspects of the landscape and of the value attached to the landscape[60].

Weighing up such factors as landscape quality and condition; perceptual aspects such as scenic beauty, tranquillity, rurality, remoteness, or wildness; special cultural associations; the presence and influence of other conservation interests may allow the relative value of a particular landscape to be assessed as an input to judgements about capacity. However, reaching conclusions about capacity means making a judgement about the *amount* of change of a particular type (such as wind farm

[56] Carys Swanwick and Land Use consultants. Landscape Character Assessment Guidance. Countryside Agency and Scottish Natural Heritage. 2002.
[57] Carys Swanwick and Land Use consultants. Landscape Character Assessment Guidance. Countryside Agency and Scottish Natural Heritage. 2002.
[58] Landscape Institute and Institute of Environmental Assessment (2002) Guidelines for Landscape and Visual Assessment. Spon Press

[60] Cary Swanwick, Jan 2004, Topic Paper 6: Techniques and Criteria for judging capacity and sensitivity, Countryside Agency and Scottish Natural Heritage.

development) that can occur without having unacceptable adverse effects on the character of the landscape, or the way that it is perceived, and without compromising the values attached to it. Capacity is all a question of the interaction between the sensitivity of the landscape, the type and amount of change, and the way that the landscape is valued.

As with cumulative landscape and visual impact, there are no currently accepted thresholds of acceptable/ unacceptable change in landscape character in the UK, particularly in relation to wind energy developments.

For this reason, designations and data, which reflect aspects of this whole topic area, were omitted from the present research, namely:

- Landscapes of Special Historic Interest in Wales[61]
- Local authority landscape designations (e.g. Special Landscape Areas)
- LANDMAP data[62]

6.3.1 Wildlands

Wildlands are a relatively recent concept to describe remote areas which combine particular physical and perceptual characteristics which are becoming rarer in the UK and Europe. They are relevant to this study as these areas tend to be upland, have the highest wind speeds and are technically desirable for wind farms. Scotland has some of the most extensive 'remote' areas in Europe and has carried out some work on how to define both the term and the extent of wildlands (See **Appendix I** for further details).

Planning Policy Wales[63] states that 'the natural heritage of Wales… embraces the relationships between landform and landscape, habitat and wildlife, and their capacity to sustain economic activity and to provide *enjoyment and inspiration*' (para 5.1.1 p48) (emphasis added). A significant part of the Welsh landscape could be defined as wildlands.

In Wales, the scale of these wildlands and their distance from settled areas are less than in Scotland. The sense of wildness may, in many cases, also be less extreme (see photographs below).

Photo - between Devils Bridge and Tregaron, Mid Wales

[61] Cadw (2001) Register of Landscapes of Historic Interest in Wales – Volume 1, Parks and Gardens, Volume 2.1 – Landscapes of outstanding historic interest and Volume 2.2 – Landscapes of special interest
[62] Countryside Council for Wales (June 2003) The LANDMAP information manual
[63] Welsh Assembly Government (2002), Planning Policy Wales

However, this relative accessibility makes these areas valuable as many people can enjoy them. This makes wildlands an important landscape asset for Wales. The resource is finite and is under pressure from various forms of development and agricultural practices. Forestry also reduces the feeling of wildness of an area although it can still remain remote.

Photo -near Llyn Brianne, Mid Wales

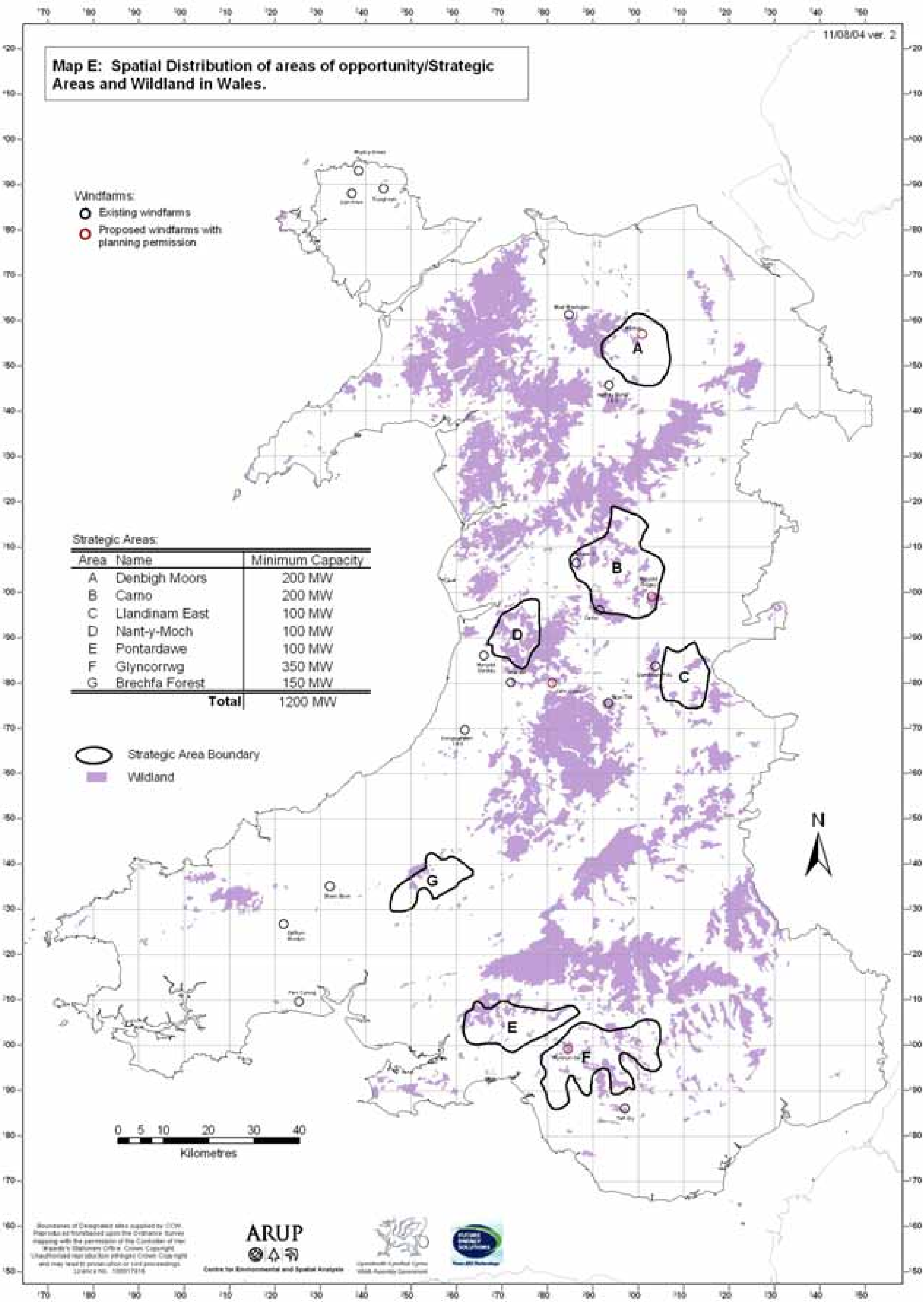
There are no maps of wildlands in Wales or national datasets that can easily and accurately define the resource. One early national dataset prepared by the former Welsh Office in the 1980's[64] was reviewed for applicability, but it was found to present a too analytical approach which ran counter to the wider perceptual elements needed for this purpose. Grade 5 Agricultural land Classification can act as a proxy (some 35% of Wales is covered by agricultural Grade 5 land classification) but the research has found that agricultural improvement, mapping inaccuracies and the presence of A and B roads and evidence of settlement all reduce its validity.

In practice the study team utilised a combination of the *Open Access Land (Open Country sub-set)* and *Common Land* datasets prepared by CCW for the Countryside and Rights of Way access land process (see previous chapter). Both include the majority of land within Wales of an open character with semi-natural vegetation such as rough unimproved acid grassland. The distribution of *Open Access Land (Open Country sub-set)* and *Common Land* and its relationship to the draft strategic areas is shown on **Figure 6.2** below.

It can be seen from **Figure 6.2** that less than 10% of the 'wildland' resource (as defined by the above datasets) falls within the draft strategic areas.

[64] Welsh Office Planning Services (1980) A Landscape Classification of Wales.

Figure 6.2 Spatial Distribution of 'wildland' and the strategic areas



6.4 Landscape and Visual Effects upon nationally designated sites / features

The third and final landscape / visual issue pertinent to the strategic planning of onshore wind energy developments is that of adjacent impacts upon National Parks, Areas of Outstanding Natural Beauty (AONB) and National Trails, in particular visual effects.

Planning Policy Wales[65] indicated "the duty to have regard to National Park and AONB purposes applies to activities affecting these areas, whether those activities lie within or outside the designated areas." (para 5.3.7). National Trails do not benefit from the same protective status as National Parks and AONBs, but nevertheless are designated under the National Parks and Access to the Countryside Act 1949.

Two issues are relevant. Firstly establishing whether existing or proposed wind farms can be physically seen from either relevant national designation, (a relatively objective matter to establish) and secondly what visual impact such a proposal has and how significant it is. As with landscape capacity/sensitivity, and cumulative impact, the latter is a complex and often subjective area.

The *significance* of visual impact is indicated as depending equally upon the *magnitude* of the visual impact (the human perception of the development) and the *sensitivity* to visual impact (of the human receptor e.g. resident or walker).

Both *magnitude* and *sensitivity* are influenced by distance from the development, but distance is indicated as an important factor in both.

Current best practice on the visual assessment of wind farms is contained within a recent report from the University of Newcastle.[66] The most relevant last two chapters of which are included as **Appendix F** and the key sections relating to the landscape and visual effects upon Nationally designated sites are summarised below.

Based upon an extensive study and field visits to eight constructed wind farms in Scotland, the study team concluded as follows. Their analysis applies to wind farms operating in Scotland and in landscape areas of a particular character. The detailed conclusions may or may not be directly applicable to other areas of the UK and to other landscape types, however it has been assumed that most of the work is applicable to Wales.

The size range of the wind farms examined was from 53.5 – 85.5m overall height but the majority were 53.5 – 65.5 m. However, a new generation of machines is now under development or construction with overall heights approaching 100 m. The team expected that their conclusions on distances or distance ranges would therefore need to be increased for these taller wind turbines.

[65] Welsh Assembly Government (2002), Planning Policy Wales
[66] University of Newcastle (2002). Visual Assessment of Wind Farms: Best Practice. Scottish Natural Heritage commissioned Report F01AA303A

In general the team found that the turbines are perceptible at a range of from 15 – 20 km from the wind farm and up to 25 km in specific cases and conditions[67]. They note that distance recommendations only apply in clear conditions and if one is specifically looking for the turbines and not just looking at the landscape. They consider it is likely that the turbines would be perceptible to a casual observer at distances of from 10 – 15 km, unless they were highly sensitive, or observant, or a resident.

The distance over which turbine detail is noticeable is indicated as about 5 – 8 km. At a distance of more than about 10 km they consider it is not possible to identify the taper of the turbine tower or identify nacelle detail. At distances up to approximately 12 km turbines are stated as perceived as individual structures that, dependant on layout, may or may not form a group. At a distance of more than about 10 km the turbines begin to be perceived as a group forming a wind farm, rather than as individual turbines.

Higher turbines are visible over a larger distance and this is reflected in the University of Newcastle team recommendations for zones of visual influence. Taking account of the distance ranges over which effects operate at the case-study sites, they judge that an increase in overall height to something approaching 100m for third generation turbines will result in these distance ranges increasing by around 20% in may cases. When the number of turbines is considered, the influence of a greater number of turbines on the visible distance is less certain, and probably depend on turbine layout, grouping, and the scale of the increase, but is not necessarily directly proportional to turbine number.

For turbines of a total height of 100m a recommended zone of visual influence is given as 30km.

The Arup research has therefore considered a distance of between 30 and 35km when evaluating whether any of the proposed strategic areas is likely to be visible from the National Parks, AONBs and National Trails.

With regard to at what distance (and hence, magnitude of impact) the effects become significant, there is a complete lack of statutory guidance. Until such time as robust consensus on significance based on detailed research, can be claimed with confidence, best practice requires that the bases for all judgements made are clear and explicit on a case-by-case basis. For this reason no specific distances have been identified as minimum separation buffers between National Parks, AONBs, National Trails and potential strategic areas.

Two figures are presented below **Figure 6.3** and **Figure 6.4** which show the relative visibility of the draft strategic areas from the National Parks, AONBs and National Trails of Wales. A commentary on the figures is provided in the table at the end of this chapter.

[67] University of Newcastle (2002). Visual Assessment of Wind Farms: Best Practice. Scottish Natural Heritage commissioned Report F01AA303A

Figure 6.3 Visibility of wind turbines from National Parks and AONBs, together with the strategic areas

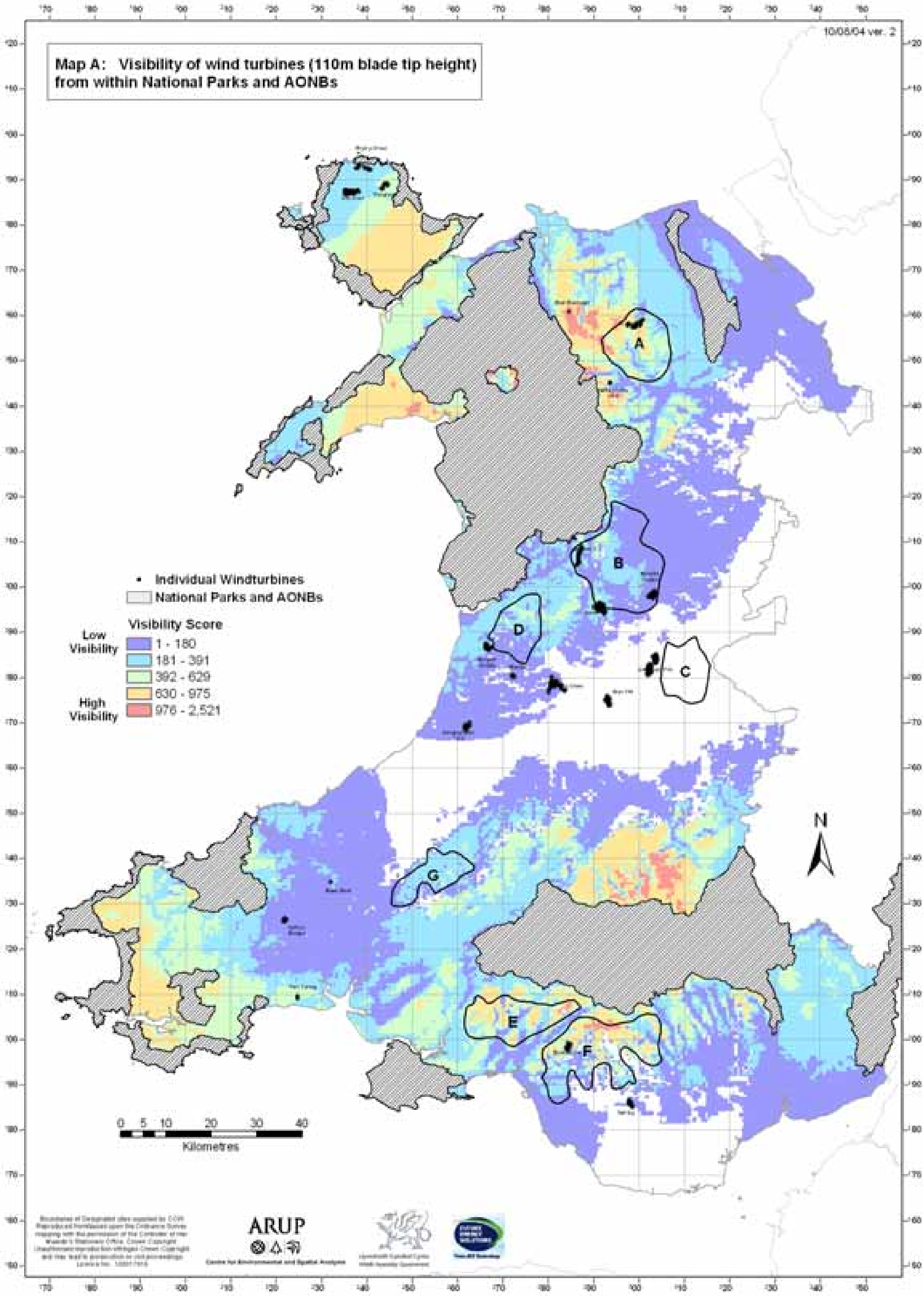
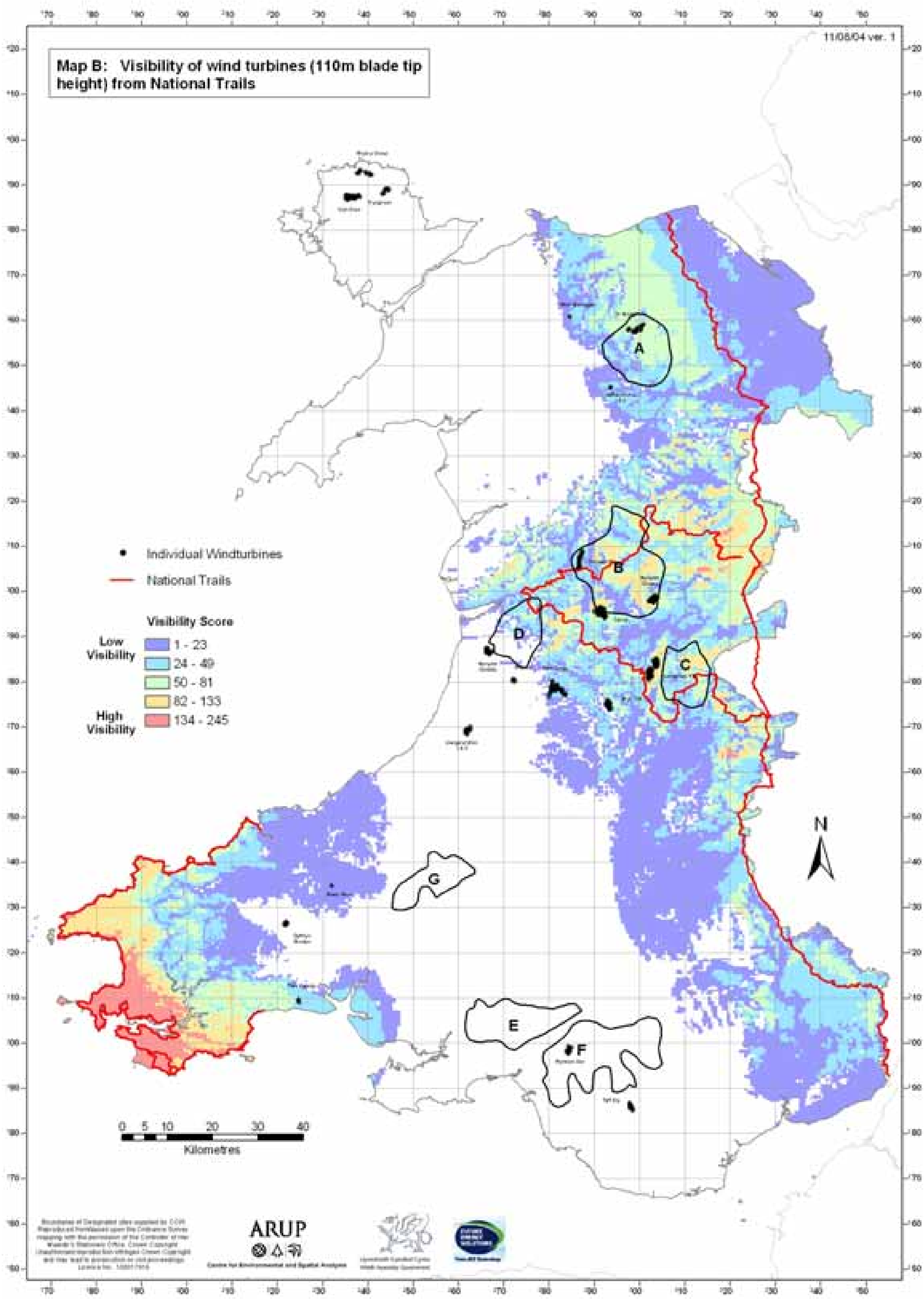


Figure 6.4 Visibility of wind turbines from National Trails, together with the strategic areas

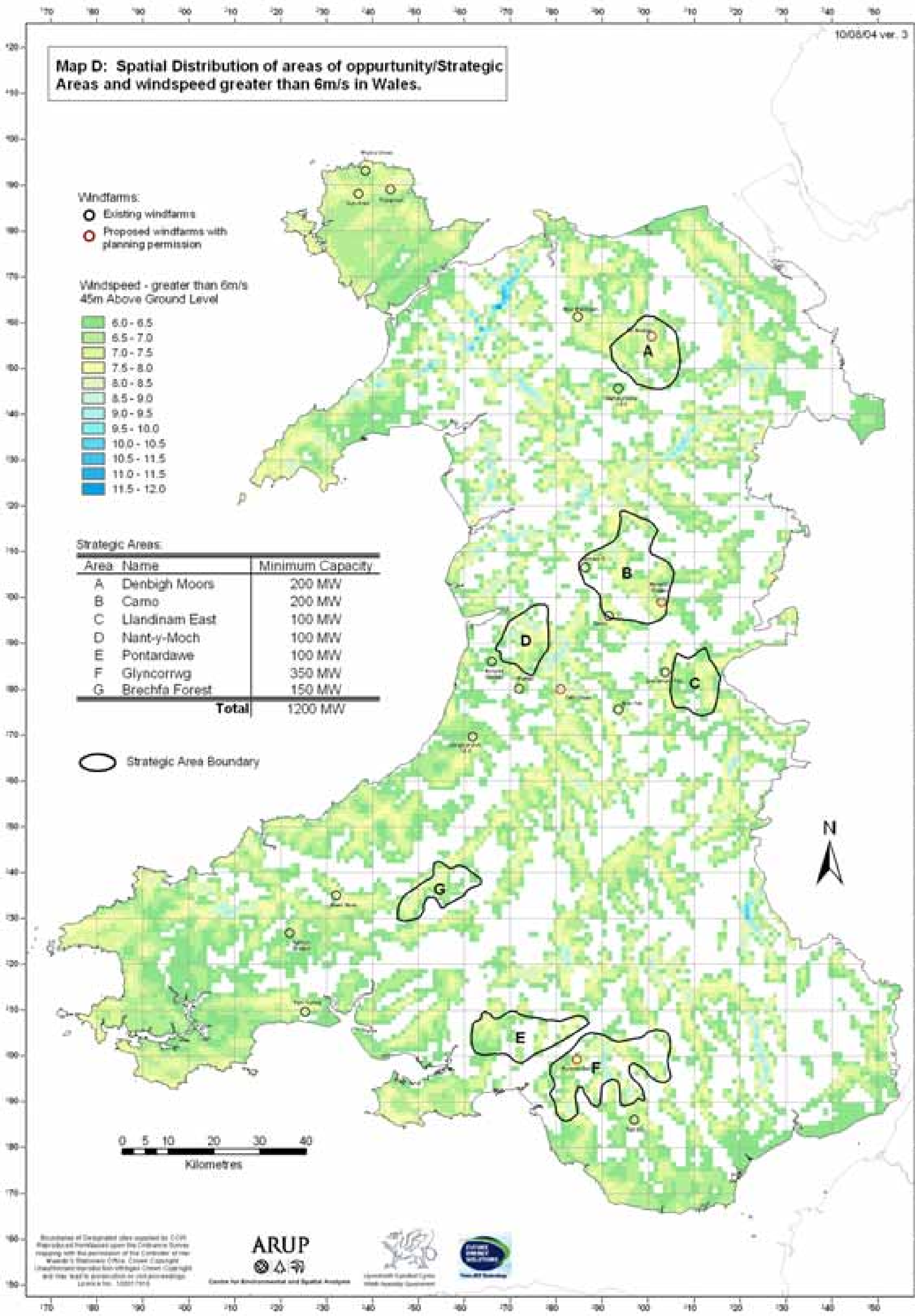


6.5 Higher Wind Speeds

In view of recommendations from the grid capacity study undertaken for this research[68], it was also felt prudent to examine the availability of wind speeds of ≥ 7 m/s within the strategic areas, as these locations are likely to be the most cost-effective to develop and most able to support the greatest amount of grid infrastructure (see **Appendix C)**.

[68] Figure 5.5 overleaf indicates the distribution of wind speeds greater than 6m/s at 45m above ground level within the draft strategic areas. A commentary on the figure is provided in the table at the end of the chapter.

Figure 6.5 Spatial distribution of windspeed >6m/s and the strategic areas



6.6 Summary of testing and validation of strategic areas

The results are discussed below in **Table 6.1** and in the text that follows.

Table 6.1 Commentary on the testing of the draft strategic areas

Draft Strategic Area	Visibility from National Parks (NPs)/AONBs/National Trails	Visibility of other wind farms from the strategic areas	Landscapes likely to be 'wild' in character: contribution to the strategic area	Wind speeds ≥ 7m/s: contribution to the strategic area
A Denbigh Moors	Highly visible from the National Park, due to elevated nature of the adjacent Snowdonia National Park, moderately visible from Offas Dyke National Trail.	Low (Tir Mostyn wind farm)	Less than 10%	Over 70%
B Carno	Moderately visible from Snowdonia NP, highly visible from parts of Glydwrs Way.	Very High (3 wind farms - Carno, Cemmaes II and Mynydd Clogau	Around 20%	Around 50%
C Llandinam East	Very low visibility from Snowdonia NP, highly visible from Glyndwrs Way.	Very High (Llandinam wind farm)	Less than 20%	Over 60%
D Nant-y-Moch	Moderately visible from Snowdonia NP, very low visibility from Glyndwrs Way.	Moderate (Mynydd Gorddu wind farm)	50-60%	Over 70%
E Pontardawe	Highly visible, due to elevated nature of the adjacent Brecon Beacons National Park. Not visible from any National Trails.	Negligible	20-30%	Around 30%
F Glyncorrwg	Highly visible, due to elevated nature of the adjacent Brecon Beacons National Park. Not visible from any National Trails	Very low	Less than 20%	Around 50%
G Brechfa Forest	Moderately visible. Not visible from any National Trails	Negligible	Less than 10%	Around 50%

Table 6.1 presents a complex picture and to a degree, it provides objective evidence for one of the main conclusions of the Stage 1 research, that put simply, some environmental assets would have to experience impacts resulting from the planned achievement of the 4 TWh target for renewable energy generation. It would not be possible to develop strategic areas and avoid (for example) the developments within such areas being seen from National Parks or National Trails.

The table also indicates it is difficult to 'rank' the draft strategic areas in order of either least or most environmentally desirable to develop first. Areas that have been identified (for example) with a low proportion of wildland are in some cases very visible from National Parks. Areas that are already experiencing cumulative impact from other wind farms (and hence might be desirable for further developments under the concentration approach) might not have the best distribution of higher wind speeds.

For these reasons all strategic areas have been treated equally with respect to their environmental performance.

6.7 Determining the potential energy yield from the strategic areas

Parts A and B of the methodology described previously determined the broad spatial extent of the proposed strategic areas. In order to determine if the areas were sufficient in extent to provide enough 'energy yield' to meet the aspirations of the Welsh Assembly Government it was necessary to determine the maximum generating ability of each with respect to onshore wind.

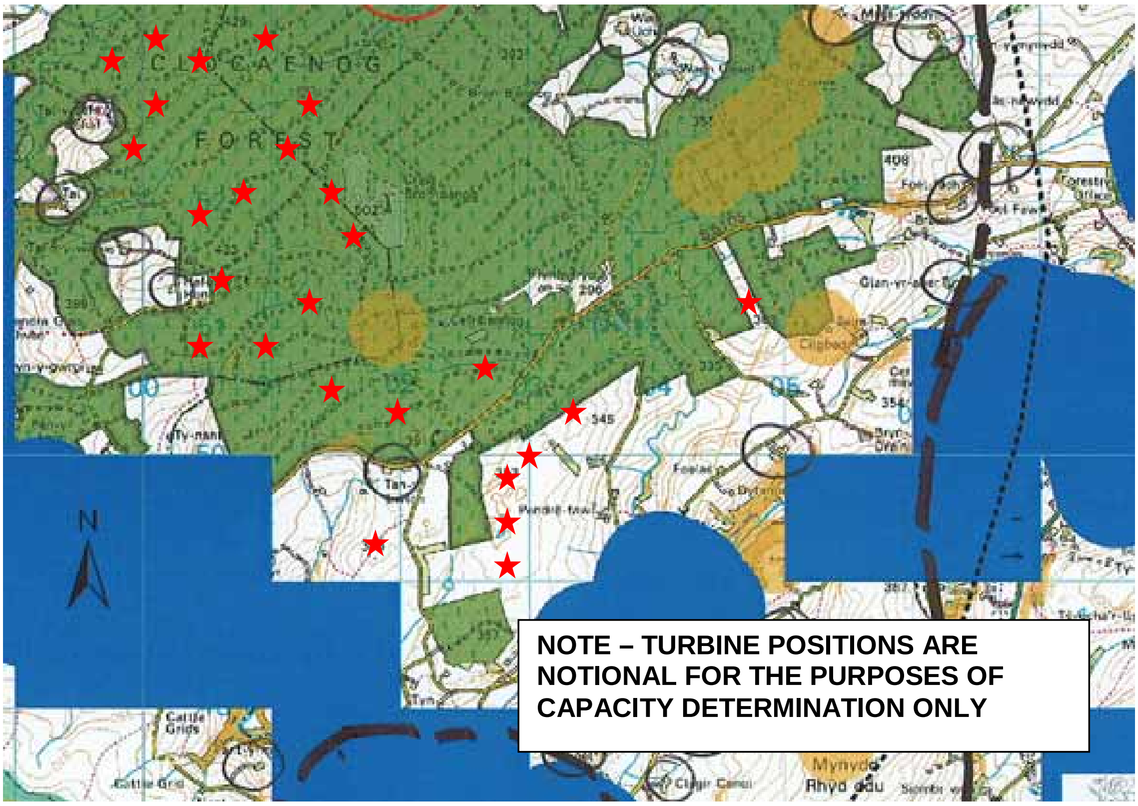
The '*Welsh Assembly Government is looking to achieve a minimum of 800 MW of installed capacity of onshore wind by 2010'* (previous chapters refer). It is generally accepted that with current technology an energy yield of between 5-9MW per square kilometre is possible, the range depending on turbine size, turbine electrical output and turbine layout. The market is currently favouring the development of larger onshore wind turbines with electrical capacities between 1.5MW and 2MW (although even larger machines are being developed for the offshore market, with capacities up to 5MW).

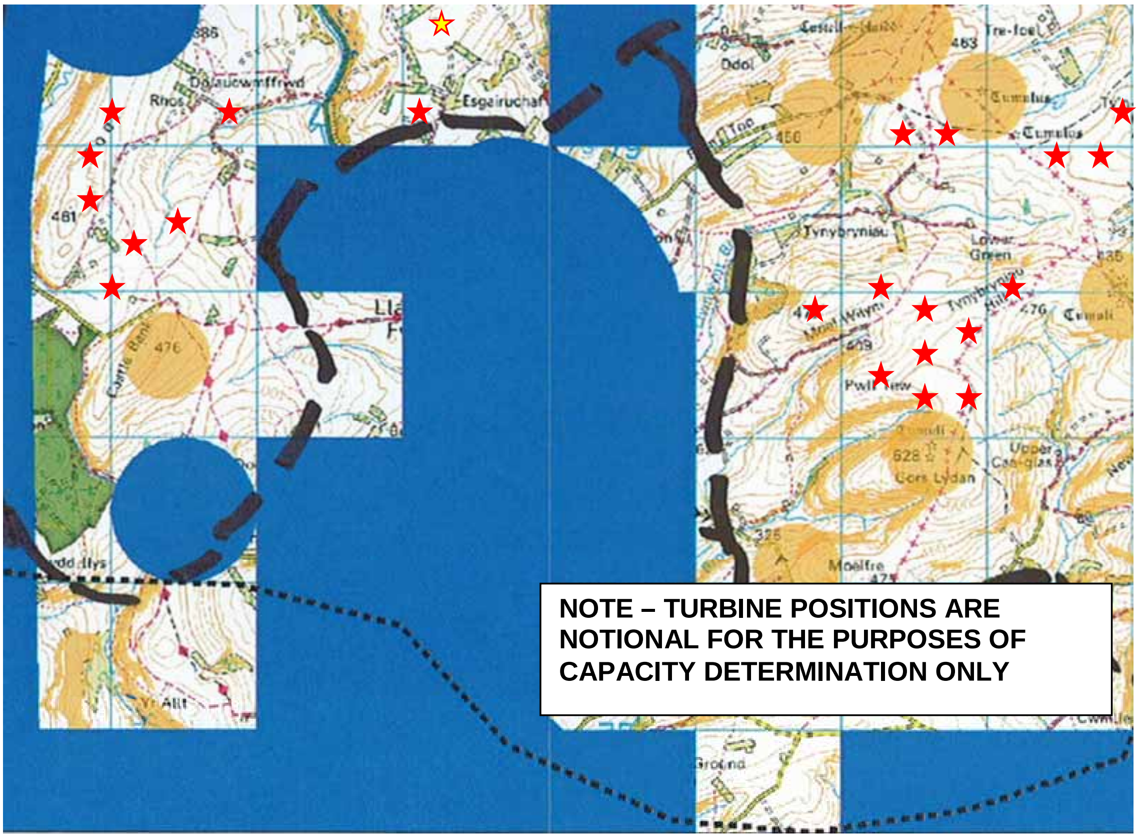
Rather than undertake a purely hypothetical calculation exercise involving the surface area of the strategic areas and a nominal energy yield per km², (based upon percentage land availability within the areas for wind turbines), it was decided that the only practicable way to proceed was to determine potential notional turbine locations within each area.

> Wind turbines typically need to be positioned so that the distances between them are around 3-10 rotor diameters (about 180-600 metres for a wind farm using 60m diameter, 1.3 MW wind turbines). This spacing represents a compromise between compactness, which minimises capital cost, and the need for adequate separations to lessen energy loss through wind shadowing from upstream machines.

The national turbine locations identification exercise was undertaken at 1:50000 scale, utilising maps generated from the GIS, of all available data, overlain on top of digital 1:50000 Landranger Ordnance Survey Mapping (see **Figure 6.6** below).

Figure 6.6 : Illustration of the capacity determination of strategic areas for onshore wind in Wales





It was recognised that such a process is very superficial and has the potential to either under or over-estimate likely energy yields. However by taking a conservative approach and generally utilising the lower end of possible turbine densities, it was possible to arrive at a general understanding of maximum capacities, to +/- 50MW.

Capacity or electrical yield data was added to the overall map of draft strategic areas. The data was presented as '*minimum capacities*' for the respective areas, even though the data presented is close (+/- 25MW) to the indicative maximum capacities determined.

There are three main reasons for this:

a) Arup have used a conservative estimate of electrical yield based upon a mid to lower range turbine density. It is therefore possible that a greater potential for generation in some or all of the strategic areas.

b) The scale of wind energy developments required to achieve target delivery by 2010 could be underestimated by third parties who are not familiar with the physical manifestation of 800MW of onshore wind. The use of a 'minimum' figure clearly sets out the magnitude of generation expected by the Welsh Assembly Government and the scale of development in the strategic areas. Insufficiently large developments have the potential to 'sterilise' parts of a strategic area, either a) directly via land acquisition, or b) indirectly via the using up of the perceived 'landscape capacity' for wind energy developments locally (however defined).

c) Minimum capacities will encourage developers with site-specific knowledge to engage in the debate about the likely yields from the strategic areas and thus reach a consensus about the most appropriate figures to use.

The minimum capacities are set out in **Table 6.2** below

Table 6.2. Indicative minimum capacities/electrical yield from the draft strategic areas.

Draft Strategic Area		Minimum Capacity (MW)
A	Denbigh Moors	200
B	Carno	200
C	Llandinam East	100
D	Nant-y-Moch	100
E	Pontardawe	100
F	Glyncorrwg	350
G	Brechfa Forest	150
Total		1200 MW

6.8 Overall Summary

The GIS established for this research project has been utilised to arrive at seven draft strategic areas for large-scale onshore wind energy developments. The draft areas are identified as having a minimum capacity of 1200 MW, approximately 50% greater than the 800MW required by the Stage 2 project brief, however it should also be noted that the Energy White Paper[69] aims for 20% of UK electricity to come from renewable sources by 2020 and that the identification of additional capacity for onshore wind energy developments at this stage may assist, in part, in target delivery for 2020.

The testing and validation exercise above indicates that the choice of some of these areas will be controversial due to such factors as their visibility from National Parks and the incorporation landscapes considered ‘wild’ in character. The review of higher wind speeds also suggests that there may be parts of the strategic areas will not be economic to develop at the present time, hence it may be possible that some of the areas reduce in size as a result of subsequent consultation.

[69] DTI (2003) Energy White Paper: Our Energy Future- creating a low carbon economy

Part D– Conclusions and Recommendations

This part of the report draws together the principal findings of the research and presents recommendations for the next steps to take the work forward.

7 Conclusions

The work of Arup and its sub-consultants to underpin the revised TAN 8 has lasted some 18 months. During this time the energy policies (and to a lesser extent planning policies) of the Welsh Assembly Government have evolved and the research has had to respond accordingly. There has been a growing realisation that up until 2010, onshore wind energy developments are the only renewable energy technology which can make a significant contribution to the delivery of the Welsh Assembly's 4TWh target. It has also been realised that the short time period to 2010 means that a more rapid approach to planning is required in order to meet UK/European Union obligations.

The research has developed a GIS, which has been used to assist in the formulation of TAN 8. However this GIS has not been used, as originally intended, to assist local planning authorities in making their own decisions regarding the planning of renewable energy. Instead the GIS has been used by the research team, in agreement with the Welsh Assembly Government, to identify strategic areas for the development of large-scale onshore wind farms. The areas identified by the study are the only areas that the study team believe are applicable to assist in meeting the 4TWh target; there are not enough areas to allow a choice.

The role for local planning authorities in the process of planning for renewable energy is to manage and monitor/control the strategic areas to accommodate developments of the scale indicated. Provided a broad consensus is reached regarding the validity of the strategic areas and their spatial extent, officers and members of local authorities need no longer make decisions on onshore wind in the absence of a national spatial framework.

Initial guidance for local planning authority officers in 'master-planning' the strategic areas is included as **Appendix J**, although it is anticipated that authorities will wish to develop their own in partnership with a wide range of bodies.

The use of strategic areas also heralds the end of cumulative impact criteria in Wales, which has to date to kept most wind farms greater than 15km apart centre-to-centre. Instead it allows the development of several discrete 'wind farm landscapes''. This approach safeguards our national environmental priorities, and will keep large-scale wind farms away from large parts of the countryside, including significant proportions of the Welsh 'wildlands'

The use of strategic areas sees a departure from the approach of England and Scotland, which are retaining more firmly criteria-based planning policies.

Whether this work facilitates the Planning for Renewable energy depends very much on how the results are received and the willingness to drive forward outcomes of the research.

8 Recommendations

This section sets out the principal recommendations for the Welsh Assembly Government which arise from the research, namely that:

1. The draft strategic areas be published for consultation with the revised consultation Draft TAN 8. The consultation should aim to elicit whether a) the principles of the designation of strategic areas are accepted and b) whether the boundaries of the strategic areas should be adjusted.
2. Draft TAN 8 give considerable weight to the delivery of the capacities indicated for each area in the planning process in order to meet the 4TWh target is to be met by 2010.
3. An extensive consultation process be conducted with those likely to be affected by the strategic areas involving a 'road show' or similar, explaining the definition of the areas and seeking views on how they might be refined. Local planning officers and the appropriate statutory consultees (e.g. CCW) should be key invitees to such 'road-shows'.
4. The Assembly Government begin to put pressure on the local distribution network operators in Wales to develop appropriate grid infrastructure proposals to facilitate the distributed generation that should be forthcoming from onshore wind in the strategic areas.
5. The Welsh Assembly Government further develops the draft strategic areas such that they are available at 1:50000 scale. It would aid the consultation process if they were also reviewed in relation to the local landscape and visual issues, particularly LANDMAP data and/or other county-level landscape data and assessments. This would assist with boundary refinement and justification and could form part of 3. above.
6. Thought is needed on how to treat wind energy developments which come forward outside the strategic areas; a criteria based approach may well be applicable which could include the scale of development generally considered acceptable.

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Appendix A

Offshore Wind and the Planning Process

Offshore Wind Energy and the Planning Process

Context

The UK land use planning system applies only as far as the mean low water mark. Beyond this, development consent for renewable energy schemes and other development within territorial waters is granted by the UK government (Secretary of State for the Environment or SoS for Trade & Industry, as appropriate). The Welsh Assembly Government is a consultee in the process. Its remit covers "the sea adjacent to Wales out as far as the seaward boundary of the territorial sea" (section 155 of the Government of Wales Act, 1998) However, it has no actual decision-making power.

The land use planning system in Wales has little scope to directly influence the strategic development of offshore wind energy generation schemes. However, planning authorities may receive applications for associated onshore infrastructure, and are likely to be consulted on offshore proposals adjacent to their local authority boundary. This chapter therefore presents some further guidance relating to the impacts of offshore wind energy development proposals.

Background: planning for wind energy developments in the offshore environment

The UK government's jurisdiction currently extends to its territorial waters: a cordon of twelve nautical miles offshore. The relevant authority for any wind energy schemes proposed beyond this limit is unclear. Within the 12-mile limit, the Crown Estate is responsible for leasing areas of the seabed to potential developers. Beyond the 12 mile limit, the Crown Estate has rights to explore and exploit natural resources on the continental shelf (excluding oil, gas and coal which are within the remit of the DTI), but there is no comprehensive legal framework for regulating renewables development in this area. A few such schemes are currently considered feasible where the technical and economic constraints can be overcome, so this is an issue which the wind industry and the DTI is keen to resolve in the near future. New legislation will be required. It is planned to produce legislation to control wind farm development beyond 12 miles in the next parliament.

Offshore renewable energy developers operating between the low water mark and the edge of territorial waters have two consent route options:

- licence from DTI under s36 of the Electricity Act 1989 and a licence under s34 of the Coastal Protection Act 1949
- licence from DTI under the Transport and Works Act

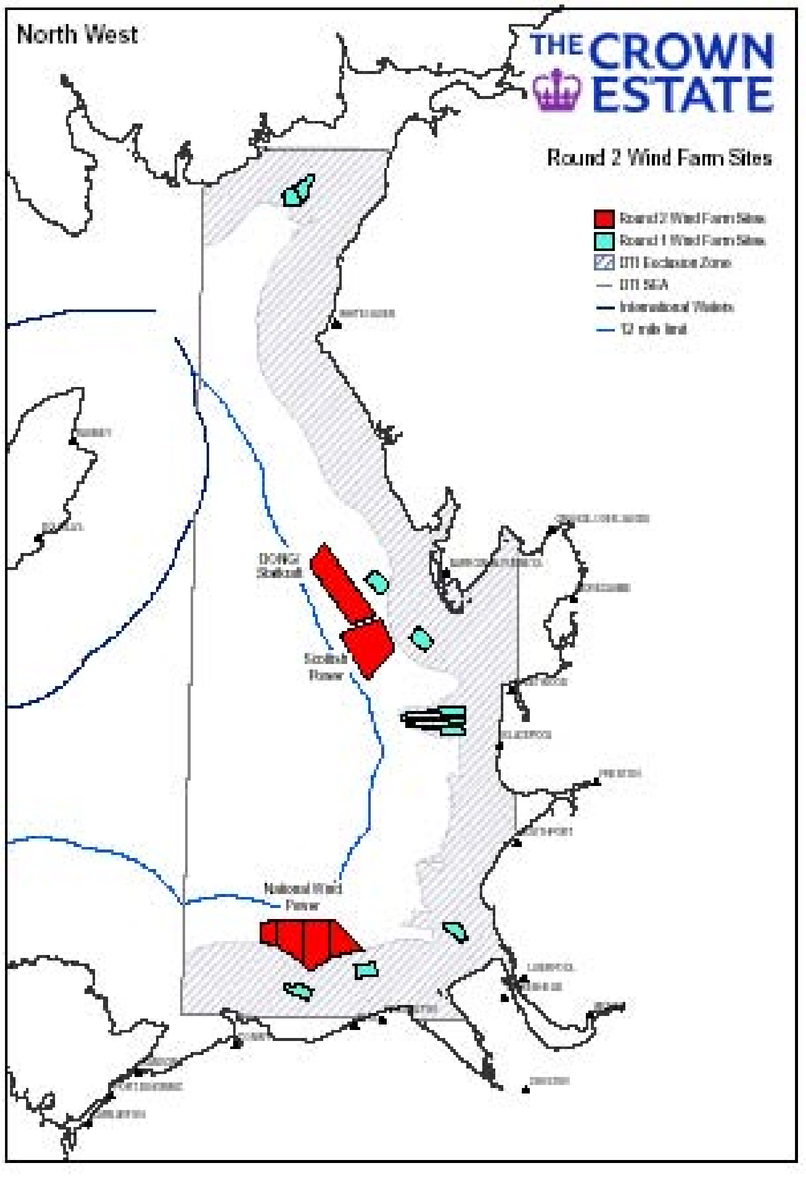
Future Offshore: a Strategic Framework for the Offshore Wind Industry
This consultation document was produced in November 2002 by the Department of Trade and Industry[1]. It was published in response to the view that the offshore wind industry is "poised for major and rapid expansion" (p8) with the release of the second round blocks and the enforcement of the Renewables Obligation from April 2002.

The DTI anticipates that offshore wind could contribute up to 40-50% of the 2010 renewables target (p8). An orderly approach to the exploitation of the wind resource is therefore desirable, and the DTI proposes that "applications for [seabed] leases should be invited in fixed rounds within defined strategic regions" (p41).

So far, there have been two rounds of leases: the first round (April 2002) included North Hoyle off Prestatyn, which was the first to be completed in 2003; Rhyl Flats (which has been consented) and Scarweather Sands (which is to be subject to a Planning Inquiry in autumn 2003) – See **Figure B.1** overleaf for locations

[1] (November 2002) Future Offshore: A Strategic Framework for the Offshore Wind Industry

Figure B1 Crown Estate Round Land 2 Offshore Wind Sites



For the second round, three large areas of the UK territorial waters have been identified: the Greater Wash; the 'North West' (Solway Firth to North Wales); and the Thames Estuary. These have been identified as the optimum locations for future offshore wind farms, and together they cover an area of some 16,696km^2 (DTI table 4.1). These areas were selected on the basis of provisional developer interest, which is closely correlated to the optimum bathymetric and other data contained within the Crown Estate's WindBase dataset.

There are significant implications of this offshore wind development for Wales: **if the DTI proposes to limit development to these strategic blocks, most of the Welsh coastline will be excluded from any further consideration**. In practice, there may be practical, economic or environmental reasons why areas of the Welsh coast may be unsuitable, but these are unlikely to be tested if future offshore development is to be limited to these blocks.

All second round block areas are subject to a strategic environmental assessment. These differ from traditional SEAs in that they do not assess alternative block locations but instead assess the relative advantages and disadvantages of specific areas within each of the three blocks.

Environmental Issues

The Strategic Environmental Assessment of the DTI's 'second round' blocks for offshore wind energy developments has recently been completed[2 3]. Further guidance on scoping Environmental Impact Assessments in relation to offshore wind farms is given by the Environment Agency[4]. As a result of the SEA, the headline significant impact risks were concluded to be as follows[5]:

- areas of high sensitivity to visual impact
- concentrations of sensitive seabirds
- designated and potentially designated conservation sites
- MOD practice and exercise areas (PEXA)
- main marine traffic areas.
- In addition, the SEA revealed some important data gaps, including –
- landscape / seascape issues (visibility, character, quality, value and capacity to accommodate change) and
- coastal tourism and recreation assessments
- specific marine ecological issues.

Landscape/Seascape issues are discussed further below

Seascape and visual impact issues

In addition to onshore infrastructure, the other key issue for local planning authorities relates to the seascape and visual impacts of offshore proposals. The seascape includes the coastline and the immediate onshore environment. CCW recommends[6] that

"15km is the boundary of a regional seascape unit and reflects the level of detail in the landscape visible to a receptor. It does not reflect the significance of visual impact of a wind farm or turbine, which clearly must depend on the scale of the individual development. … 0-8km, 8-13km and 13-24km should be used as distances/zones for high, medium and low significance of visual impact."

The key seascape issues of wind farm development at sea are:

- Visual effects of large wind turbines at various distances
- Lack of scalability of structures in open sea due to lack of reference points
- Sensitivity of coastal landscapes such as National Parks and Heritage Coasts
- Capacity of different types of sea including the marine, coastal and hinterland characteristics[7]
- The presence of islands or other visible coastlines
- Presence of sensitive receptors on land and at sea
- Enhanced effect of weather conditions

[2] BMT Cordah Ltd (2003) SEA (Phase 1) for offshore Wind Energy Generation: Scoping Report
[3] BMT Cordah (2003) Offshore Wind Energy Generation: Phase 1 Proposals and Environmental Report for consideration by the Department of Trade and Industry; page 12-1.
[4] Environment Agency (2002) Scoping Guidelines on Environmental Impact Assessment of projects – 17 Wind farms (onshore and offshore)
[5] BMT Cordah (2003) Offshore Wind Energy Generation: Phase 1 Proposals and Environmental Report for consideration by the Department of Trade and Industry; page 12-1.
[6] CCW letter in response to DTI Future Offshore consultation, page 7
[7] CCW Brady Shipman Martin & University College Dublin (2001): Guide to best practice in Seascape Assessment

Offshore wind turbines are very large structures (e.g. North Hoyle turbines are 107m to blade tip above mean sea level): combined with open views from the coast these structures are visible for long distances. The adverse visual effects have not been as well defined as for onshore schemes, because this type of development is still so new. Wind turbines will be most visible in sunny and clear weather conditions which is also the time when most visitors will be at the coast. Visitors to high quality coastal landscapes will be more sensitive than those who visit built up leisure resorts or areas with a lower quality landscape/townscape hinterland. Where other attractive coasts or islands are visible in the distance, such as in the Severn Estuary, the quality and scale of these elements will emphasise the scale and intrusiveness of the wind farm.

The visual impacts of offshore structures may be experienced for some distance inland. CCW recommends the use of the LANDMAP landscape information system as a source of baseline information on land, especially its “visual and sensory”, “tolerance to change” and “evaluation” sections. For land-based impacts, the methodological principles set out in Guidelines to Landscape and Visual Impact Assessment (GLVIA)[8] , are recommended.

The significance of impact is stated in GLVIA as the relationship between the magnitude of impact and the sensitivity of the receptor/receiving landscape. The greater the magnitude (and the more sensitive the receptor), the greater the significance and vice versa.

[8] The Landscape Institute/IEMA (2002) Guidelines for Landscape and Visual Impact Assessment (2nd Edition)

Appendix B

Review of minor or long-term Renewable Energy Technologies

B1.1 Biomass – woodfuel, especially small round wood

Biomass technology creates electricity or heat from vegetable matter or animal wastes. In the Welsh context, the key biomass technologies are those which convert vegetation into heat or electricity, as these are better understood and considered to be closer to commercial exploitation.

Biomass combustion systems (for electricity generation) involve the firing of biomass in large furnaces to raise steam for the direct propulsion of steam turbines. This type of scheme is relatively large-scale, its maximum size limited by the availability of fuel. Typically these schemes can generate 10-34MWe.

Biomass is unique among renewable energy technologies in that it requires the cultivation of its raw material. In Wales, there are several potential sources, including:

Short rotation coppice (SRC). These crops are grown specifically for the purpose of energy generation. Willow and poplar are considered possible, although recent research has identified willow as the more suitable for cultivation in Wales.

Small round wood and saw mill residue etc. This is a by-product of commercial forestry.

The source of fuel is a key consideration in the location of biomass plant. With current technologies, a biomass gasification plant generating 35MW would require some 7000 – 8000 hectares of SRC[9]. Unless the raw materials are already growing in an area, it will be necessary to cultivate these fuel crops 'from scratch'. This results in considerable lead-in periods before a biomass plant can become operational. However, if the raw materials are already grown in the area, they will already have a commercial value and the biomass plant will be required to compete for this resource on the open market.

As well as proximity to the fuel resource, the biomass plant used for electricity production must also be connected to the electricity distribution network. Although the two are not mutually exclusive, there are areas in Wales which have sufficient biomass resource but which lack the necessary electricity connections, and the cost of installing these is considered prohibitive to the development of such schemes.

There are currently no commercial biomass plants in Wales.

Commercial difficulties have hampered the development of biomass plants in the UK to date. The first to be proposed in the UK was the ARBRE project at Eggborough in Yorkshire. The ARBRE plant was designed to use integrated gasification combined cycle technology. To meet some of the fuel requirements, over 1350 hectares of willow coppice were planted within a 45 mile radius of the ARBRE facility. The ARBRE scheme was however declared insolvent in August 2002, following protracted delays to development, and Border Biofuels, the other major biomass interest in the UK is also experiencing financial difficulties. It was reported in 2002 that "the economic feasibility of substantial biomass generation is uncertain – it may rely on capital grants as well as the new market for renewable energy created by the Renewables Obligation[10]"

[9] ENDS Report, February 2002, Issue 325
[10] OXERA Environmental and Arup (2002) Regional Renewable energy assessments, page ii

In planning policy terms, biomass plant can be regarded as an industrial land use: its inputs, operations and outputs are assessed in the same way as one would assess other types of industrial units. The growth of fuel crops such as woody species does not require planning permission if it is on existing farm land. Landowners need to be satisfied that the demand for their wood will be sustained before they agree to plant new wood fuel crops.

The Cabinet Office Performance and Innovation Unit (PIU) does not expect energy crops to become a significant energy source until after 2010. However, it says that they "have an important role to play in the short to medium term and beyond" and could reach a capacity of up to 2,600MW by 2020[11].

It is not considered that a specific planning tool would be beneficial for this technology, for the following reasons:

- the planning system is adequately equipped to address applications for new biomass treatment facilities;
- the clearly defined geographical constraints for biomass plant mean that a national spatial strategy for biomass would be of little assistance: it is considered that a set of criteria would be sufficiently helpful for local authority planners when assessing applications for biomass plants and
- it is uncertain that biomass schemes in Wales for electricity generation will be economically viable over the forthcoming TAN 8 period, and therefore it is unlikely that a 'realistic planning pressure' will be experienced by local authorities in relation to this type of development.

B1.2 Tidal barrage or lagoon

This involves the construction of walls rising from an estuary or sea bed to the surface, and is therefore best suited to areas of shallow water which nevertheless have a high tidal range. The Severn Estuary is an obvious choice for tidal energy proposals, as the tidal range there is among the highest in the world at around 15 metres.

The barrage or lagoon walls impede the natural flow of the tide, forcing it through turbines to generate electricity. A tidal lagoon differs from a tidal barrage in that it does not require the obstruction of a whole estuary, but may be more resource intensive as it requires the developer to build a whole enclosure rather than a straight-line barrage across a watercourse. The ecological impacts of a barrage are likely to be even more significant than those of a lagoon.

An advantage of tidal energy is the near-constant supply - it is predictable, diurnal and available all year round. A Severn Barrage has been proposed by several developers during the past 30 years[12], and the Minister for Economic Development and Transport referred to it in his Cabinet response to the EDC final report on renewable energy (05.03.03) where he stated:

"in the longer term, special projects such as the Severn barrage may have tremendous potential. Barrages have environmental and economic implications and we see value in further studies. I will continue to press the importance of this on the Minister of State for Energy and Construction".

[11] ENDS Report, February 2002, Issue No. 325

[12] as stated in WAG Cabinet Response to the report of the Economic Development Committee on Renewable Energy, delivered by Andrew Davies AM, Minister for Economic Development, on 5th March 2003.

A barrage proposal has yet to be submitted for development consent (see box below).

Tidal Barrage[13]

A Severn Barrage could generate 17TWh of electricity per year. The 8.6GW barrage would avoid the release of 4.6 million tonnes of carbon per year - about 3% of current UK emissions - on the assumption that it displaces coal-fired generation. The consortium proposing the development claims that the barrage could be operational by 2014. It puts the capital cost at £10 - 14 billion, giving a "reasonable prospect" of achieving generating costs of £60/MWh in 2001 prices. The cost remains significantly above that of some other large-scale, low-carbon technologies, however: last year, the Government's Policy and Innovation Unit put the cost of offshore wind in 2020 at £20-30/MWh.

Tidal lagoons offer an alternative option to barrages for containing tidal waters and extracting energy. However, lagoons will also result in some adverse effects on the marine environment, and will require building aggregates. Careful consideration of such developments will be needed. For instance, where they are to be placed in relation to disturbance to marine habitats and species, disturbance to features such as the sea bed and tidal currents that may affect erosion of the shore would need to be considered through a detailed EIA study.

At least one (overseas-based) developer is investigating the feasibility of constructing a tidal lagoon off north Wales, as well as in the Severn Estuary (see box below). The technology has yet to be proven in a commercial development, however, and it is understood that until financial backing can be guaranteed, this scheme is still some way off development.

Tidal Lagoon[14]

Tidal Electric hopes to build a 30MW tidal lagoon scheme in Swansea Bay by 2006, followed by a 432MW plant at Rhyl Sands within two years.

The credibility of tidal lagoons was boosted last year by a report from AEA Technology which concluded that they could compete on price with conventional generation technologies and yield high rates of return under the renewables obligation.

It is not considered that a specific planning tool would be beneficial for this technology , for the following reasons:

- tidal power technologies are relatively constrained in terms of suitable location: more limited than offshore wind
- it is uncertain that tidal schemes in Wales will be economically viable over the forthcoming TAN 8 period, and therefore that a ‘realistic planning pressure’ will be experienced by local planning authorities in relation to this type of development.

[13] ENDS Report, January 2003, Issue 336
[14] ENDS Report, January 2003, Issue 336

B1.3 Active solar / solar thermal

Active solar power can be used to heat water or buildings, but is used to replace rather than to generate electricity. Typical methods involve passing a heat transfer fluid through a solar collector, such as a panel ('flat plate') or vacuum tube ('evacuated tube collector') placed on a south-facing roof. The scope for active solar heating in buildings is more limited, due to Wales' climate and latitude.

The contributions to individual homeowners in terms of utility bill minimisation may be significant, but these technologies are not generally a matter for strategic planning; development control officers may be required to grant planning permission for some external equipment, especially on historic buildings or in conservation areas, but in general this is not a strategic planning issue.

In summary as this technology generates heat and not electricity it is not considered relevant to this study.

B1.4 Solar PV

Photovoltaic (PV) panels convert solar power into electricity. They may contribute to the electricity grid but are more commonly used to recharge batteries such as those in standalone machinery, such as parking ticket machines in rural locations. For optimal performance, the panels should be south-facing and set at an angle of 30-60°.

Homeowners may be required to apply for planning permission before installing PV panels on their properties, but as with active solar power, this is an issue for individual planning authorities rather than a strategic concern.

B1.5 Passive Solar

Passive solar power is used to reduce fossil fuel consumption by creating buildings which maximise the benefits of the sun's rays, reducing the need for artificial heating and lighting. This is essentially a design issue and is not normally considered a renewable energy technology. As with active solar and PV above, however, local planning authorities may choose to promote this e.g. through design guidance as a means of reducing their overall dependence on fossil fuels.

B1.6 Energy from waste

Several processes have been developed which convert waste solids, sludges or gases into energy. For example, in 2001 there were seven landfill sites in Wales generating electricity from landfill gas[15]. Several Municipal Solid Waste (MSW) schemes are also proposed in Wales in response to the EU Landfill Directive which is imposing more stringent controls on the amount of waste which can be sent to traditional landfill sites. Most household waste can could theoretically be diverted from landfill, processed as Refuse Derived Fuel (RDF) and incinerated to generate heat and/or electricity.

However, these raw materials are wastes from other activities. It is considered more environmentally friendly to reduce the volume of waste we produce than to simply use it for energy generation once it has been discarded. Waste is not therefore considered to be a truly renewable source of energy.

[15] SEL (2001) The Potential for Renewable Energy in Wales, para. 3.12.1.2

The most recent Assembly Economic Development Committee report on renewable energy (January 2003) does not consider that energy from waste contributes to the 4TWh 'benchmark' for Wales.

B1.7 Tidal stream

As well as tidal lagoons and barrages, there are several other proposed technologies which harness the power of the tides.

Marine current turbines are designed to act in the same manner as wind turbines. Water turbines are anchored to the sea bed in areas of strong tidal stream flows, and the passing currents drive the turbine to generate electricity. Marine Current Turbines (MCT) formally announced the installation of the World's First Offshore Tidal Turbine to the Press at Lynmouth (off the North Devon coast) in June 2003. Tests are currently still underway, but the unit has already produced power, and the commissioning and initial test programme is running to plan. The intention is that fully automatic operation will be achieved by the end of 2003. This first unit is not grid-connected. It is purely a prototype and all the power generated will be dissipated through a 'Dump load'. It is intended that the next machine will be grid-connected.

Most recently, the Stingray has been trialled off Shetland. This device sits on the sea bed, weighed down by 160 tonnes of steel that form the base for a 10 tonne hydroplane. The hydrofoil oscillates some 20 metres in a similar motion to a whale's tail, generating electricity instead of forward motion[16]. One Stingray device is expected to have an installed capacity of 150kW. However, since the device remains submerged by at least 7 metres at low tide, navigation and visual impacts are virtually nil so it would be possible to install quite a number of the devices in clusters with a considerably greater combined output. The developer proposes to install a trial 5MW 'Stingray farm' in 2004, although this is also likely to be in the waters off Shetland. To date, it has not been raised as a possibility for Welsh waters.

B1.8 Wave

Harnessing the evident power of ocean waves would appear to be an attractive proposition, but this has proven very difficult in practice. Several types of scheme have been proposed to date, fixed to the shoreline or floating on the water surface. However, no commercial schemes have been proposed around the Welsh coast to date, and none are expected to come forward in the foreseeable future.

[16] New Civil Engineer (19 Sept 2002) – 'Call of the running tide'.

Appendix C

Grid Considerations Study

CONNECTION AREAS FOR WIND ENERGY IN WALES – GRID CONSIDERATIONS

Appendix to Arup Study

Report for the National Assembly for Wales

May 2004

Title	CONNECTION AREAS FOR WIND ENERGY IN WALES – GRID CONSIDERATIONS
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1. THE ELECTRICAL SYSTEM IN WALES

The grid schematic[1] shows the status of the England & Wales transmission system with 400/275 kV circuits and substations. In Wales the southern sector as expected with significant industry is quite robust between Pembroke and the English border whereas the northern sector is less developed. There is no direct grid linkage between north and south Wales

North Wales has significant transmission contracted generation that includes the Magnox site at Wylfa and the pump storage facilities at Dinorwig and Ffestiniog. This region generates more electricity than it consumes, with daytime exports to England and generally nightly importation because of the pumped storage facilities.

By contrast the system landscape in south Wales is significantly different and here consumption is greater than local generation. Although the grid is well developed between the English border and Pembroke, significant transmission contracted generation has been removed or mothballed over recent years.

2. WINDFARM CONNECTIONS

2.1. Existing WindFarms

Windfarm development in the SP MANWEB region of Wales is already substantial with significant amounts connected on Anglesey and along the north coast, around Aberystwyth and to the south of the grid supply point at Legacy. Table 1 gives the existing on shore status of operational wind farms in Wales. Generally the north and middle regions of Wales have the better wind resource, which is less so in the south.

Windfarm	Location	Network Region	Installed Capacity MW
Carno	Powys	SP MANWEB	36
Cefn Croes+	Ceredigion		60
Cemmaes	Powys		16
Llangwyryfon	Ceredigion		6
Llidiartywaun	Powys		20
Llyn Alaw	Anglesey		20
Mynydd Gorddu	Ceredigion		12
Penrhyddlan	Powys		13
Rhyd-y-Groes	Anglesey		7
Trysglwyn	Anglesey		7
Bryn Titli	Powys	WPD	10
Duffryn Brodyn	Dyfed		6
Taff Ely	Glamorgan		9
TOTAL			222

+Expected to generate 2004

[1] Grid schematic reference http://www.nationalgrid.com/uk/library/documents/sys_02/pdfs/FigA-2.pdf

Table 1: Existing Onshore Windfarm Development in Wales (over 5 MW)[2][3]

2.2. Connection Considerations

The existing network and connected generation in Wales mostly consists, as it does in the rest of the UK, of large scale conventional generation, such as nuclear, coal and gas stations connected to the national grid. This scene will slowly change as more sustainable relatively small-scale power stations come on line connected to the relatively lower voltages of the distribution network.

In general terms, although dependent on the effects additional generation will have on fault level, voltage limits and power flows, Table 2 show the approximate size of generation that is likely to be connected to the network line voltages.

Network	Line voltage	Approximate Connection Capacity
Grid	275/400 kV	+150 – 200 MW
Distribution Network	132 kV	50 – 100 MW
Distribution Network	33/66 kV	20 - 25 MW
Distribution Network	11 kV	1-3 MW

+Clearly the Grid could take larger capacities. Here typical NGC Severn Year Statement prospective wind connection sizes are given.

Table 2 Voltage Connections of Wind Farms

The Future Energy Solutions task 30 for the Assembly estimated the distances from substations at which windfarms are likely be connected. These calculations were based on the estimated costs of wind farm development (£600/kW- £700/kW) and the likely proportion of this that developers might be willing to spend on connection infrastructure estimated to in the region of 8%. Connection costs were based on the indicative pricing provided by network operator connection charging statements. Discussions with developers indicate that it is unlikely that connections in excess of 10 – 15 km from a substation or line (by teeing off) would be considered when the extra costs of planning, possible enquiries and way leaves are taken into account.[4]

3. THE WELSH DISTRIBUTION NETWORK

3.1. Introduction

[2] Data taken from the NGC SYS for 2003

[3] The BWEA web site shows a further number of small windfarms (less than 5 MW) totalling about 6 MW

[4] Note that task 30 estimated possible distances from sub stations to be between 18km – 30km. This included various caveats. Further consideration of these costs to include environmental statements, planning costs and wayleave issues has revised these likely distances to be more likely to be in the range between 10 – 15 km. Discussions since the issue of task 30 with windfarm developers supports this assessment.

The Welsh distribution network is operated by SP MANWEB in the north (this is only part of the SP MANWEB region which also includes the Chester and Merseyside regions of England) and Western Power Distribution (WPD) in the South.

3.2. The SP MANWEB Network

The north and mid Wales region of the SP MANWEB distribution network has 132 kV, 33 kV and 11 kV networks and is supplied by a small number grid supply points. A 132 network is maintained on the north coast and down through Wrexham to Newtown in the south east of the region. There are also isolated elements of 132 kV network on Anglesey, and into the Lleyn Peninsula. The remainder of the region is supplied by a 33 kV network, except in the Aberystwyth area, which has 132 kV links with the WPD network.

The SP MANWEB region is host to over 1000 MW of distributed generation (DG) and is one of the UK networks most affected by DG. This is largely due to the economic and topographical features of the region. The abundance of natural resource in Wales, and Non Fossil Fuel Obligation (NFFO) activity, has resulted in the connection of 183 MW of wind, small hydro generation and landfill gas generation. A further 133 MW of large hydro and significant combined heat and power gives a total of 1016 MW, which amounts to 30% of the net maximum demand of 3174 MW. Much of this successful deployment has been by SP MANWEB's adaptive and innovative approach to enable connection.

An extensive study of this network has been carried out for the DTI's New and Renewable Energy programme[5]. This study examined the voltage, fault level and power flow limitations of this part of the Welsh distribution network. It also considered the degree to which generator clusters effect the network, the solutions that should be deployed and the need for forward looking reinforcement plans in areas where generation clusters and the capability of the network is restricted.

The study concluded that there were high fault levels along the north Wales coast, from Bangor to Deeside and down to Wrexham and voltage constraints in the Aberystwyth, Machynlleth, Wrexham and Ffestiniog regions. In addition, as is likely to be the case on most networks, there exist reverse power flow limitations in the 132 kV network. The assessment highlighted areas of network with a clear need for significant reinforcement in order to accommodate the anticipated levels of generation after existing basic active management techniques were exhausted. It divided the region up into six regions and provided commentary on their ability to integrate distributed generation.

3.3. The Western Power Distribution Network

The South Wales network is supplied from a greater number of grid supply points than the SP MANWEB region providing power to the 132 kV system, which is then transformed down to 66 kV, 33 kV and 11 kV networks. Generally the South Wales network is more developed than that in the SP MANWEB region and reflects the higher concentration of industry and urban areas, particularly to the south east of the

[5] DTI New and Renewable Energy programme study: Modelling the Renewable Resource and the Electricity Network in North Wales: K/EL/00296/01/REP: URN 03/1299: Contractor EA Technology

region. The grid supply points run the length of the industrial southern areas from the English Border, through Cardiff and Swansea to Milford Haven.

In this southern part of the region there is also a strong 132 kV and 33 kV network. However above this southern strip it weakens quickly. In the western region there is a dual 132 kV line that runs to Lampeter and Llanarth and then into the SP MANWEB region with the remainder of this section reliant on a 33 KV infrastructure. The eastern upper region is sparsely populated being dependent on a 66 kV ring from Abergavenny to Llandrinodd Wells.

3.4. Welsh Distribution Network Connection Opportunities

Using material supplied by the network operators and available from their long-term development statements this study has divided Wales into 23 regions. This reflects the analysis by the network operators in their own assessments of their networks and their ability to integrate distributed generation. These 23 regions are identified, along with their incumbent networks (voltage) in Table 3. Although a fairly crude analysis these regions cover the Welsh land mass.

Zone	Approximate Geographical Zone Limits				Network kV
1	Brecon	Crickhowell	Buith Wells	Llandrindod	66
2	Lampeter	Llanarth	Llanfihangel Ystrad	Rhos	33 & 132
3	Brawdy	Fishguard	Cardigan	Blaenporth	33
4	Milford Haven	St Twynells	Tenby	Haverfordwest	33 & 132 and Pembroke GSP
5	Penblewin	Whitland	Pendine	Llanfyrnach	33 & 132
6	Cwmffrwd	Llandeilo	Llandovery	Llynbrianne	33
7	Llanelli	Crosshands	Swansea	Britton ferry	33 & 132 and Swansea & Baglan Bay GSPs
8	Pyle	Margam	Llynfi Valley	Caerau	33, 66 & 132 and Margam & Pyle GSPs
9	Ystradgynlais	Pontardawe	Abercrave	Pantyfynnon	33 & 132
10	Merthyr	Hirwaun	Mountain Ash	Upper Boat	33 & 132 and Cilfynydd GSP
11	Bridgend	Pontyclun	Talbot Green	Mill Street	33 & 132
12	Cardiff	Caerphilly	Cowbridge	Aberthaw	33 & 132 and Aberthaw , Cardiff East, Cowbridge & Upper Boat GSPs

13	Crumlin	Pengam	Ebbw Vale	Cwmfelinfach	33 & 132
14	Newport	Monmouth	Abergavenny	Pontypool	33, 66 & 132 and Rassau GSP
15	Magor	Caldicot	Sudbrook	St Arvans	33 & 132 and Uskmouth GSP
16[6]	Anglesey				33 & 132 and Wylfa GSP
17[7]	Aberdaron	Caernarfon	Conwy	Trawsfynydd	33 & 132 and Pentir & Dinorwig GSPs
18[8]	Llandudno	Rhyl	Connah Quay	St Asaph	33 & 132
19[9]	Conwy	Ruthin	Llanwddyn	Dolgarrog	33
20	Ffestiniog	Conwy	Llanwddyn	Borth	33 & limited 132 and Ffestiniog and Trawsfynydd GSPs
21[10]	Connah Quay	Legacy	Welshpool	Ruthin	33 & 132 and Legacy GSP
22[11]	Borth	Dolanog	Newtown	Aberaeron	33
23	Abergele	Connah Quay	Hope	Ruthin	33

Table 3: The 23 Regions and their Networks

Depending on the strength of the network, existing generation and remoteness to load centres these regions have differing capabilities to accept distributed generation. Table 4 estimates the amount these sectors could accept in terms of sizeable windfarm or other distributed generation development (mainly consideration has been given to larger 132 kV connections, crudely it is argued here that smaller 33 kV connections would equate in numbers to the 132 kV estimate). With the possibly of grid connection, GSP information has been included in the table.

Zone	Comment	Capacity
1	Sparely populated region with a 66 kV ring. Limited capacity with possible small connections near to Abergavenny of the 66 kV ring. Windfarms developed here would be within the acceptable range of the network but not necessarily the substations.	Small

[6] Zone D of the EA Technology study
[7] Zone C of the EA Technology study
[8] Zone E of the EA Technology study
[9] Zone B of the EA Technology study
[10] Zone F of the EA Technology study
[11] Zone A of the EA Technology study

2	Dependent on development of the southern section of MANWEB network. Windfarms developed here would be within the acceptable range of the network but not necessarily the substations.	50 MW
3	33 kV network aligned to the coast offers little connection opportunity coupled with limited local demand.	Small
4	Well-developed 132 kV network with significant load centre. Windfarms developed here would be within the acceptable range of substations. In principle the Pembroke GSP offers the opportunity to connect significant capacity directly to the grid, provided it is fairly local. Grid line to Pembroke to be downsized.	50 MW – 100 MW to the Distribution network. More if the grid could be utilised
5	No major substation available but teed to the 132 kV line between Haverfordwest and Carmarthen possible provided within about 10 km.	50 MW
6	33 kV network mostly to the south east of this zone offers little connection opportunity unless within 10 km of the Ammanford 132 kV substation.	Small
7	Significant 132 kV network and Swansea as a large load centre. 132 kV connection probable anywhere within this region. Also has the Swansea North and Balgan Bay GSPs gives potential for high capacity connection.	50 MW – 100 MW on the 132 kV network. More if the GSPs could be utilised
8	Although strong network and load centre, proposed United Utilities Scarweather Sands off shore windfarm project will 'bag' available capacity in this zone.	small
9	132 kV network and load centre but recent 50 MW connection offer made to developer is likely to reduce any additional opportunities.	small
10	132 kV network and load centre available to take output, connection possible but fault level head room will need to be extended with further generation connections. Upper Boat GSP accessible for higher capacities.	50 MW – 100 MW More if the GSP could be utilised
11	Good 132 kV interconnected network and load centre, but fault level head room will need to be extended to enable further generator connections.	50 MW – 100 MW
12	132 kV network and load centre but presence of the AES Barry generator connected to the distribution network (132kV), already subject to constraint will limit further connection. Three possible GSPs could be used for larger developments.	Small unless GSP can be utilised
13	Sizeable amount of 132 kV network and load centre. Possible grid connections to Rassau and Upper Boat if development is close.	50 MW – 100 MW More if the GSP could be utilised
14	132 kV network and load centre but with limited fault level. Rassau GSP offers potential high capacity connection. Connections to the east of this zone will be restricted to lower voltage network.	50 MW More if the GSP could be utilised

15	132 kV interconnected network with load possibly including demand from across the English border. North of this region restricted by remoteness of the network. Uskmouth GSP available to support higher capacity.	50 MW More if the GSP could be utilised
16	Isolated 132 kV line and significant existing windfarm development on Anglesey will restrict further connections. The EATL study indicates a small number of substations with spare capacity but not large. Wylfa GSP may offer high capacity connection to the grid	Small unless the GSP could be utilised
17	Lleyn Peninsula with isolated 132 kV line and little load centre will restrict further connections. However the Pentir & Dinorwig GSPs may offer high capacity connection	Small unless the GSP could be utilised
18	Significant 132 kV line and 33 kV infrastructure with demand along the north Wales coast. Possible to accommodate limited further connections. The EATL study indicates about nine substations with spare capacity.	30 MW
19	Limited network restricted to 33 kV and little local load.	small
20	33 kV and isolated 132 kV network with little local load but includes the Ffestiniog and Trawsfynydd GSPs which could offer sizeable connection opportunities if local. Windfarm linked to pump storage could provide interesting commercial approach.	Small unless the GSPs could be utilised
21	132 kV and 33 kV line through the urban areas of Wrexham and to the south offers some opportunity for local generation connection. The Legacy GSP could offer sizeable connection opportunities if local.	30 MW – 50 MW
22	Sizeable local generation causing export/import issues in this region although connected by 132 kV to the WPD network. Limited local demand.	Very small
23	Limited network restricted to 33 kV and little local load	Very small

Table 4: The 23 Regions and their Ability to Accommodate Further Distributed Generation

These comments need to be considered in light of the network within the 23 zones identified. As assessed in section 3.2 it is unlikely that connections in excess of 10 km – 15 km from a substation or line would be affordable by wind farm developers. These distances would more likely apply to larger proposed windfarms, typically 50 MW and above and might be less for small developments connecting to the 33 kV or 11 kV network.

4. DISTRIBUTION NETWORK DEVELOPMENTS

Based on the broad areas of renewable resource in Wales there are two areas of the SP MANWEB region that will need development if this resource is to be exploited. These are the Mid Wales area and Denbigh Moor to the north. Plans have been prepared by SP MANWEB for the progressive reinforcement of these networks and it is expected that any expansion will need to be matched to generation requirements in a co-ordinated manner.

The delivery of the proposed reinforcement will require Section 37 consents on approximately 200 km of new overhead line routes. This represents a significant risk to the availability of the reinforcement in a timeframe consistent with the targets of the Welsh Assembly. It is also important to note that the phasing of the proposed reinforcement is likely to accommodate distributed generation connections in the northern area of the mid Wales zone.

4.1. Network Requirements – Mid Wales Zone

Due to the way in which the Mid Wales area was electrified, the network capacity in this region is limited. Here the network was developed to supply remote load centres or generation projects. For example Welshpool and Newtown are supplied via long 132kV circuits from the Legacy GSP through Oswestry; and to the north, long 33-kV circuits connect with the Trawsfynydd GSP.

Limitations therefore apply not only to the ability to export generation but also to the expansion of load. The NFFO generation connected to this network has pushed the ability to apply basic active management techniques to the limit of practicability.

It has been anticipated that background load growth will lead to a reduced standard of security by 2009 and in order to ensure compliance with licence obligations, major reinforcement would be required by SP MANWEB. The scheme described here meets both generation and load requirements.

The total level of distributed generation that might be expected to connect to the Mid Wales network by 2010 could be as high as 600 MW, with a further 300 MW in Western Power Distribution's area linked to SP MANWEB's network. In order to accommodate all of this in an unconstrained fashion it would be essential to establish a new point of supply from the grid network somewhere in the mid Wales area. National Grid Transco have indicated that this connection is technically feasible.

In parallel with establishing a new GSP it is proposed by SP MANWEB to substantially reinforce the 132kV network to achieve two aims:

- Allow the phased expansion of the network in anticipation of the increase in generation[12]
- Provide a 'collector system' in the event that a new GSP is established.

The main elements of the proposed reinforcement are:-

- Construct a new 132kV infrastructure between Legacy GSP, Rhydlydan, Aberystwyth, Machynlleth and Carno.

[12] However it will not be possible to accommodate the proposed 220 MW site at Y Foel or the proposed 300 MW site at Tregaron, prior to the establishment of a proposed GSP. Should these projects be developed there will be a requirement to develop a suitable constraint management regime for their export.

- Establish and upgrade 132/33kV transformers at Llandinam, Carno, Welshpool, Aberystwyth and Machynlleth.
- Associated 33kV switchboard alterations.

A geo-schematic representation of the proposal is given in Annex 1. This schematic shows the existing network and how any re-enforcement would be phased. Construction of the full network would accommodate a maximum export capacity from additional generation as shown in Table 5 at winter maximum demand and system normal operating conditions. However under other loading and operating conditions it may be necessary to constrain generation. The exact capacity that can be connected will be subject to the location and capacity of the individual distributed generation connections.

Location	**Approximate new capacity MW**
Legacy	62
Between Oswestry and Carno	50
Carno	30
Machynlleth	12
Rhydlydan	140
Llandinam	90
TOTAL	**384**

Table 5: Mid Wales Generation Integration after the Proposed SP MANWEB Re-enforcement

As estimated in section 2.2 above wind farm connections might be economically acceptable to developers if made within 10 km –15km of these identified locations.

4.2. Network Requirements – Denbigh Moor

It is estimated that approximately 100MW of generation might require connection in this area. In order to accommodate this level of generation it will be necessary to reinforce the 132kV network around St Asaph near to the north coast of Wales. Here it is proposed to:

- Construct new circuit breaker bay at the St Asaph 132 kV substation.
- Construct approximately 40 km of 132kV overhead line
- Establish two 132/33kV transformers at Denbigh Moor

Here again wind farm connections might be economically acceptable to developers if made within 10 km –15km of these identified substations.

5. CONNECTING TO THE NATIONAL GRID

Larger capacity connections will need to be connected at higher voltages and the integration of large windfarms (or other generators), in excess of 100 MW would be connected directly to the 275 kV/400 kV grid lines that exist in Wales. Connection to the grid, at present, is treated very differently to that of a distribution network connection. In the case of grid connections a shallow charge is applied with use of system costs levied and of course the embedded benefits available to a distribution network connected generator are lost.

5.1. Opportunities for Connection

The National Grid's Seven Year Statement (SYS) provides information on opportunities for connection to the grid with guidance on where this might be achieved without major transmission reinforcements to enable an resulting change to national power transfers. The National Grid divides England and Wales into zones and provides an appraisal on each in terms its ability to accept new demand and generation.

In north Wales generation connection opportunities exist but not on Anglesey nor by the pumped storage facility at Dinorwig, both of which are exporting zones with very modest demands. The circuit connections here, the existing level of generation and grid security standard licence conditions would forbid further generation. Other than these grid supply points opportunities remain for the connection of additional generation in north Wales. The south Wales region is an importing zone with a strong internal transmission system. The Grid SYS defines this region as 'high opportunity' for appropriately sited new grid connected generation connecting to the grid supply points from Pembroke through to the English border.

5.2. Grid Connection Costs

It is difficult to estimate grid connection charges, as detailed in the National Grid Charging Statement[13] without reference to the specific connection site. These connection charges are based on a gross assess value, maintenance, and termination costs for the assets installed solely for the user connecting to the grid. Payment of this charge can be made annually on a decreasing asset value or as a firm price.

As previously stated 100 MW of capacity could be connected to a 132 kV distribution network, but should this not be possible or if a connection capacity in excess of 100 MW is needed then a connection directly to the grid would be most appropriate. Based on the grid statement of costs a new busbar bay onto an existing grid supply point reducing onto a new 132 kV or 33 kV busbar for the connection would have a gross asset value of several million pounds. For a 100 MW windfarm connection it is

[13] National Grid: Statement of the Connection Charging Methodology April 2004 available form the NGGC web site

estimated that this will increase the connection cost by a factor of two although this would be less for capacities in excess of 100 MW[14].

5.3. Grid vs Distribution Network Connections - Commercial Considerations

Connecting a windfarm to the grid will change a number of the commercial costs and benefits compared to a distribution network connection. Larger generators will require a generation licence[15] and with this will be a requirement to become party to the balancing and settlement code, and compliance with its rules and regulations, which involve costs. Smaller generators, without the need to become licensed, can avoid these costs, netting off their generation to a supplier demand.

At present (although this will change for the next distribution price control period) distribution network connections are at full cost (deep) with no use of system charging whereas grid connections costs are shallow with a then ongoing use of system charge.

The National Grid operates a connection incentive through its use of system charging[16] for generators. This charge can be negative in zones where the Grid would like generators to connect. For the north Wales zones generators pay the grid for use of system (2004/05 charging period is £4.12/kW excluding Anglesey and Dinorwig) in south Wales (2004/05 charging period is -£2.15/kW) the grid pays generators for use of the system.

For a grid connected generator the embedded benefits available to a generator connected to the distribution network are lost. These include the benefits that accrue not using the transmission system, such as avoiding use of system charging (although as described above this will be a dis-benefit in south Wales for the generator element of transmission use of system) and losses.

5.4. Grid Connection – Summary

The electrical system in England Wales is made up of the high voltage grid with large scale generator connections providing power to users through GSPs to the distribution network. To date renewable energy schemes, as relatively small generators (less than 100 MW) have been connected to the distribution network. As the size of renewable energy schemes increases these will need to be considered for grid connection. The National Grid's seven year statement indicates planning for large off shore windfarm connections to the grid, some as large as 200 MW.

For on shore windfarms each connection will need to be considered in the context of the local network conditions and possible constraints in terms of power flow, voltage

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[14] This estimate is based on the additional cost of providing a new grid/132 kV or grid/33kV transformer and associated infrastructure. It is assumed that the 'on' connection costs would then be as if the windfarm was to connected to the 132 kV or 33 kV distribution network. This would be necessary since windfarm generator output tends to be at a relatively low voltage typically 1 kV and below.

[15] With adherence to the grid code which imposes various operating conditions on the generator

[16] These charges contribute to the final price a consumer pays for electricity they are not however a significant proportion of this overall price.

conditions or fault level excesses. For windfarms up to 100 MW connection at the distribution level would be the first choice but where this maybe constrained the grid could be considered if local connection is possible. For windfarms in excess of 100 MW then probably the grid will be the only option to enable this sizeable power to flow to demand locations of an appropriate size. Grid connections will be more expensive and the commercial framework for the operator will be different as briefly explained in section 5.3

6. CONCLUSIONS

This brief analysis of grid capacity in Wales has estimated its current status and ability to integrate windfarms. It takes no account of town and county planning consents, DTI consent (section 36 & 37 if needed) or wayleave issues, only the existing electrical condition of the network. The conclusions are in distribution network terms:

- By dividing Wales into 23 regions only 11 of these could accommodate significant further generator integration.

- As expected much of this is in the south of Wales where the network is relatively strong, with the weaker northern network already absorbing sizeable wind energy connections. Large regions of Wales where it is believed that significant wind resource exists lacks the network infrastructure to accommodate further connections.

- The 11 regions identified that are able to accept more generation should integrate a further 510 MW to 780 MW. This is only based on an electrical appraisal of the network.

- The study has summarised SP MANWEB's outline plans for mid Wales and Denbigh Moor reinforcement. This could enable nearly a further 500 MW of connections. The mid Wales reinforcement plans are based on demand and possible generation connections and may include (although this is not a strong possibility) a new grid supply point. This development will need to take note of windfarm restrictions in mid Wales particularly in the MOD LFA7T.

- This report indicated the amounts of generation that the distribution network could accept and the zonal locations of the grid supply points. In mine of the opportunities (restrictions around Anglesey and Dinorwig) to connect to the grid at grid supply points this could double the overall connection cost.

- Further distribution network development will be dependent on the electricity regulator Ofgem and how it treats the network operators' requests for funds to develop their systems. During the next distribution price control period this will include an incentive arrangement to encourage the network operators to connect distributed generation.

7. POTENTIAL FURTHER STUDY

7.1 Location Factors that Influence Maximum Connection Distances

When assessing the constraints on the development of new wind farms in Wales, lack of a suitable grid connection within 10km was identified as a fixed constraint. For simplicity it was stated that this distance would be constant for a range of wind farms. This is because the size (rating) and complexity of the grid connection necessarily increases as the maximum output of the wind farm gets larger.

In reality, at the outset of a wind farm project grid connection costs will almost certainly be the most difficult costs to estimate. Distance from the wind farm to the connection is one factor, but the presence of fault level problems or outdated switchgear may require major refurbishment that could lead rapidly to multiplication of costs. These issues must be addressed on a site-by-site basis but a connection distance greater than 10km might not be a barrier to a wind farm with the right combination of characteristics.

One of the most important and obvious characteristics for a wind farm is mean wind speed. In the study, a mean wind speed of 6m/s was selected as the minimum required for a viable wind farm. At this speed a wind turbine such as the DeWind D8 – 2000kW will operate at around 15% of its rated capacity. Hence, it is unlikely that developers will be attracted to sites with mean wind speeds much lower than 6m/s.

On the other hand, the potential output from sites with mean wind speeds that are significantly higher than 6m/s is much greater and over a long period of time can transform the economics to make a longer grid connection seem much more attractive. Using the same DeWind D8 as an example, the manufacturer estimates that the annual yield on a site with a mean wind speed of 6m/s will be around 4.0GWh. If the mean wind speed is 7m/s the estimated yield increases to 5.7GWh, an increase in output of well over 40%. A wind speed of 8m/s increases the yield to around 7.1GWh, an increase of almost 80%.

The price for electricity generated from renewable sources is made up of two elements, the electricity price itself and the value of the Renewable Obligation Certificates (ROCs) that are collected. In our experience long-term agreements to sell the electricity at a combined (electricity + ROC) price of 6.5p/kWh are achievable. Hence, the potential increase in revenue for a single 2MW turbine on a site with a mean wind speed of 7m/s against the same turbine on a site with a wind speed of 6m/s is of the order of £110,000 per annum. For 8m/s the increase from 6m/s would be around £200k per annum.

If these levels of output are applied to a 50MW wind farm they are multiplied 25-fold giving additional revenue of approximately £2.75m per annum at 7m/s and £5m per annum at 8m/s. Figures such as these can alter the 15-20 year financial model for a wind farm very significantly indeed and could, if other circumstances are right, make grid connection distances of 20km or more feasible.

Table 6 indicates the estimated revenue against average mean wind speeds for wind farms of various sizes, assuming that all available electrical output is sold to the network at a fixed price of 6.5p/kWh:

Wind Farm Capacity	Specimen WTG sizes	AMWS 6m/s		AMWS 7m/s		AMWS 8m/s	
		Annual Yield (GWh)	Revenue £ x 10^3 (6.5p/kW)	Annual Yield (GWh)	Revenue £ x 10^3 (6.5p/kW)	Annual Yield (GWh)	Revenue £ x 10^3 (6.5p/kW)
5 MW	4 x 1.25MW	9.8	637	13.6	884	17.6	1144
10 MW	8 x 1.25MW	19.6	1274	27.2	1768	35.2	2288
25 MW	15 x 1.65MW	49.5	3217	68.7	4465	88.9	5778
50 MW	25 x 2MW	100.0	6500	142.5	9262	177.5	11537
100MW	50 x 2MW	200.0	13000	285.0	18525	355.0	23075

Table 6: Potential Windfarm Revenue against Average Wind Speeds

It can be seen from Table 6 that for every kW of installed capacity, each additional 1m/s of wind speed in the 6-8m/s range could theoretically increase revenue by around £50 per annum. However, it must be recognised that this is a general illustration only. Actual revenues will depend on the negotiated terms of the relevant power purchase agreements.

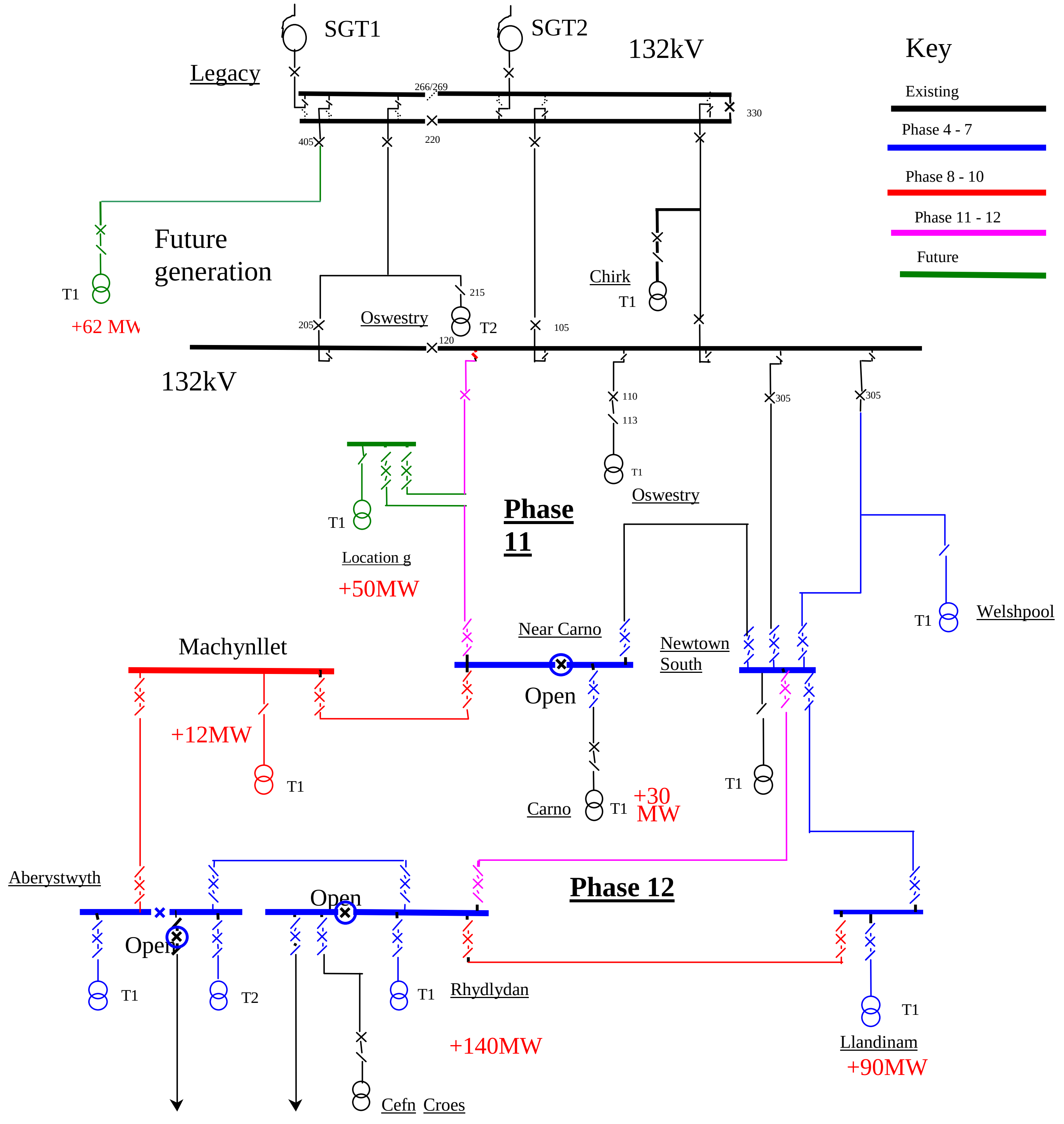
Another factor that might extend the grid connection to wind turbine generator envelope is the plan area and shape of the wind farm site. For example, a 50MW wind farm with an installation density of 8MW/km^2 might occupy a site with dimensions of 2.5km x 2.5km. The wind farm substation is normally constructed near the site boundary that is closest to the network connection point. Hence, although the primary connection might only be 10km long, the outermost turbines might actually be 12-13km from the network connection. For a wind farm that is less regular in shape, (e.g. on a ridge), the furthest turbines might be an even greater distance from the substation.

To illustrate this, a wind farm that we are familiar with in Portugal has 26 wind turbines spread over 8.6km in a linear formation along a north-south ridge. The existing grid connection is approximately 7km south of the southern end of the site. However, the northernmost turbine is located some 15km from the connection point.

7.2 Recommendations

The study carried out to date identified specific areas for wind farm development based on constraints such as a maximum grid connection distance of 10km and a mean wind speed of at least 6m/s. By assessing the characteristics of these areas in greater detail, it should be possible to identify sub-areas with mean wind speeds that are significantly in excess of 6m/s and topographic features that might lend themselves to wind farms extending well beyond the 10km envelope. As illustrated above, mean wind speeds of 7-8m/s can significantly increase the potential revenue of a wind farm. The objective of this exercise would be to reveal whether the true wind energy potential, in some areas at least, is greater than that suggested by the initial study.

Annex 1: MANWEB Mid Wales Reinforcement Proposal



Appendix D

Cumulative landscape impact guidance

Please note that the contents of the this appendix do not represent the Planning Policy of the Welsh Assembly Government

4th Version May 2004

GUIDANCE FOR THE ASSESSMENT OF CUMULATIVE LANDSCAPE AND VISUAL IMPACTS ARISING FROM WINDFARM DEVELOPMENTS

1.0 INTRODUCTION

This DRAFT guidance note seeks to define requirements for the assessment of significant cumulative landscape and visual effects under EIA regulations. It offers guidance on how proposed developments should be illustrated in landscape and visual analysis. Appendix A summarises the process advocated by this guidance note.

This is generic guidance only. The number of proposals in an area and the timing of applications gives rise to development scenarios of varying complexity. Professional judgement should inform the scope of the study to be undertaken. SNH and Planning Authorities may also require different or additional information to assist in their assessment of cumulative landscape and visual impacts.

Feedback on the contents of this note is welcome. Comments should be sent to frazer.mcnaughton@snh.gov.uk

2.0 GENERAL

The proposed windfarm should form the focus of the study. The CLVIA should describe, visually represent and assess the ways in which the proposal would have additional impacts when considered together with other existing, consented or proposed windfarms.

All cumulative landscape and visual impact assessment (CLVIA) shall be carried out in accordance with the methodology outlined in 'Guidelines for Landscape and Visual Impact Assessment' (LI and IEMA, 2002).

3.0 BASE PLAN OF ALL PUBLIC DOMAIN* PROPOSALS

The purpose of the base plan is to portray a clear picture of all the issues which are likely to be relevant for the subsequent CLVIA and to select those projects which will go forward to be considered in the subsequent assessment.

A suitably clear and legible base plan should be produced to show all proposals which are in the 'public domain'* and are located within 60 km from the windfarm under consideration.

* 'Public domain' for the purposes of this note is defined as:
- any constructed windfarm;
- any consented windfarm proposal;
- any undetermined windfarm application;
- any windfarm proposal which has been subject to an EIA scoping request to the relevant Planning Authority or the Scottish Executive; and
- any other windfarm proposal that the Planning Authority and/or SNH considers relevant for study and is within the public domain as a result of a public announcement or community meeting.

The 60km radius for the base plan is informed by University of Newcastle's *Visual Assessment of Windfarms: Best Practice* (where a radius of 30km is recommended for ZVIs in the LVIA of turbines of 100m and above). A 60km radius will enable the consideration of the scenario where, for example, an exceptionally important receptor is located midway between proposal A and proposal B at 30km from each.

The base plan should show, as a minimum, the footprint of all developments as shown by the relevant application or EIA scoping document. A 30km radius should be drawn around each proposal (these radii are best shown in different colours).

4.0 ZONE OF VISUAL INFLUENCE STUDIES

Cumulative ZVIs should be produced for all **existing** or **consented developments** or **undetermined Section 36 or planning applications** within a 30km radius from the centre point of the current proposal. SNH or the Planning Authority may request the inclusion of additional projects outwith the 30km limit.

Cumulative ZVIs should clearly show those areas from where one or more windfarms are likely to be seen. In the case of three windfarms it will be possible to illustrate the overlapping areas using e.g. red, blue and yellow shading to represent each development (with corresponding overlaps of orange, green, purple etc.). Where four or more windfarms are involved, ZVIs may become difficult to interpret and additional cumulative ZVIs may be required to show the cumulative effects clearly.

Early draft ZVIs can help the Planning Authority and SNH to advise on the selection of viewpoints for stationary cumulative impact assessment and routes for sequential cumulative impact assessment. These should be brought to pre-application meetings and included in scoping requests where possible.

5.0 THE SELECTION OF VIEWPOINTS AND STUDY OF FIXED POSITIONS FOR CUMULATIVE VISUAL EFFECTS

The selection of viewpoints should be based on an analysis of the draft cumulative ZVIs. They should be chosen to represent the following fixed position cumulative visual impact scenarios:

- *Combined or simultaneous visibility* occurs where the observer is able to see two or more developments from one viewpoint, without moving his or her head. A 90 degree arc of view should be shown and the effects represented as described below in section 5.0; and

- *Successive or repetitive visibility* occurs where the observer is able to see two or more windfarms from one viewpoint but has to move his or her head to do so. Visualisations, such as 180 or 360 degree arc of view wirelines, will be useful in assessing these effects. Supporting text or tables to describe the effects will be needed.

Exact locations for viewpoints should be agreed with the Planning Authority in consultation with SNH.

More detailed guidance on the general principles that SNH recommend for viewpoint selection is contained in *Guidance on Scoping Issues for EIA* (SNH 2003).

6.0 SEQUENTIAL VISUAL ASSESSMENT AND SELECTION OF ROUTES FOR ANALYSIS

Sequential effects on visibility occur when the observer has to move to another viewpoint to see other developments or a different view of the same development.

The study of such effects is a new and emerging field of EIA. The following suggests a framework to allow such effects to be consistently described and the significance of impact determined.

Routes to be assessed should be defined and agreed with the Planning Authority. The extent of these study routes should be informed by the 60km baseplan drawing and the cumulative ZVIs.

The assessment should clearly describe the baseline conditions and then describe to what extent the proposal would add additional visual impacts. This information could be presented in a table or other suitably clear presentation. The description should be informed and depicted by supporting wireline drawings and, where relevant, photomontages. Computer generated moving images or videomontage techniques may also be appropriate. Alternatively, a series of static images could be produced and viewed in time sequence.

The "journey scenario" should clearly describe the notable points along the route where impact occurs and should be described and assessed in terms of:

- direction of view ('direct', 'oblique', 'aligned on route', or 'looking NW of route' etc.);
- distance from nearest turbine;
- the number of turbines visible at each windfarm development; and
- which parts of the turbines are visible at each development (e.g. blade tips, hubs, upper towers or full towers).

The duration of effect should also be described. For example, 'assuming an average driving speed of 'x', this effect will be apparent for approximately ten minutes between 12 and 8 km from the nearest turbine'. Whether views are aligned on direction of travel or oblique to the development also needs to be made clear.

7.0 PHOTOMONTAGE AND WIRELINE REPRESENTATION

The visual effects should be clearly portrayed in accordance with GLVIA guidelines and informed by existing and forthcoming University of Newcastle studies. Developments at different stages in the planning process should be shown in the following way:

- For Section 36 and planning applications that have been **installed, consented or are undetermined as applications** in advance of the proposed windfarm, <u>the turbines</u> from the previously submitted layout drawings shall be shown on the photomontages and/or wireline views (in addition to those turbines proposed[**]). The drawings should be clearly

[**] For existing, approved or undetermined application sites it is usually a realistic requirement to generate photomontage when the site is within 15km of the viewpoint, beyond this distance these 'other' windfarms should be shown as an annotated array.

annotated to interpret the different proposals. The dimensions of the "existing" turbines [hub and blade] should also be clearly stated.

- For Section 36 and planning proposals which have been **subject to a formal scoping request**, <u>the likely extent of the array</u> of turbines shall be shown in addition to those turbines forming the detailed development proposal. Again, clear annotation of the wireline drawings will be needed. The extent of the array should be based on the footprint of the development as submitted in the scoping information. Where known, the dimensions of proposed turbines should be given. Additionally, an image of a single turbine, positioned centrally or prominently on the site, will assist in the portrayal of likely effects.

For all wireline and photomontage representations the following information should be clearly stated:

- arc of view (in degrees);
- dimensions (in metres) of all turbines;
- distance of site[s] from viewpoint (in metres or kilometres);
- status of "existing" developments i.e. installed / consented / scoping etc.; and
- camera format, focal length and viewing distance[***].

Numbering of all proposed turbines or annotation of key turbines or clusters of turbines on the wireline drawing is strongly recommended. However, annotation should be carefully executed in order not to become so complex as to obscure the clarity of the image. A separate appendix showing wirelines with numbered turbines may be appropriate.

*To allow adequate assessment and interpretation of the photomontages and wireline images it is likely that it will be desirable to produce images at **larger** than standard A3 size**.** Such images should usefully be included in loose leaf format in plastic pockets within the EIA or in 'fold out' format.*

8.0 DESCRIPTION AND ASSESSMENT OF CUMULATIVE LANDSCAPE EFFECTS

The study of potential cumulative landscape impacts should include the description and assessment of the following issues:

Effects on landscape designations
Effects of additional development on the qualities and the integrity and objectives of any relevant landscape designation should be analysed and described.

Effects on designed landscape interests
Effects of additional development on the character and integrity of any relevant designed landscape interest should be considered. Issues such as the landscape setting of the designed landscape and the impact on key views from the designed landscape will be important considerations requiring analysis

[***] Viewing distance of the photomontage and wireline is 'most comfortable' at between 30 and 50 cm.

Effects on landscape character
The effect of development on existing landscape character should be described. It is likely that as more windfarms are developed and at closer distances to each other they will begin to be perceived as a key landscape characteristic and will therefore change landscape character. These effects should be objectively assessed in accordance with standard landscape character assessment guidelines (LUC for SNH and CA, 2002, GLVIA 2002).

Effects on sense of scale
Tall structures are likely to dominate and alter the perception of vertical scale in the landscape. This will be the case particularly when larger turbines are seen in comparison with developments using smaller turbines or when proposed turbines are viewed in comparison with other landscape features.

Effects on sense of distance
Effects on distance may be distorted with additional windfarm development. For example, if larger turbines are located in the foreground of smaller turbines or vice versa.

Effects on existing focal points in the landscape
An existing windfarm development may act as a focal point in the landscape and the effects of other windfarm development on this should be considered.

Effects of skylining
A viewer's eye tends to be drawn towards the skyline. Where an existing windfarm is already prominent on a skyline the introduction of additional structures along the horizon may result in development that is proportionally dominant. The proportion of developed to non-developed skyline is therefore an important landscape consideration.

Effects on sense of remoteness or wildness
The existing experience of remoteness and wildness should be described and the cumulative effects of development analysed. Useful reference can be made to SNH's policy on Wildness in Scotland's Countryside (SNH, 2003).

Effects on other special landscape interests
Effects of additional development on other interests in the landscape should be considered. For example, this may include consideration of the effects on the landscape setting of settlement or other cultural interests and associations with the landscape (LI and IEMA, 2002).

Other issues that are not identified above may be relevant for assessment of cumulative landscape effects.

9.0 TIMING OF STUDIES

The above requirements for cumulative landscape and visual assessment of all public domain proposals shall run until the application is lodged. It is SNH's recommendation that any planning *application* <u>will</u> be required to be assessed against any other constructed or consented windfarm *or any other undetermined planning application*.

10.0 OTHER NOTES

Information on other sites subject to applications and scoping opinions should be obtained from the relevant planning authority and/or the Scottish Executive. SNH may be able to help identify such projects but cannot guarantee the accuracy of the information provided. SNH encourages Local Authorities and the Scottish Executive to log all existing, consented, applied for or formally scoped windfarm proposals on a GIS system. This should allow public domain information to be readily copied and handed over to developers and/or neighbouring Planning Authorities to allow for study and consideration of cumulative effects.

Visual impact assessment best practice guidelines are in preparation by the University of Newcastle in association with the Scottish Renewables Forum and SNH. When finalised they should be used in conjunction with this guidance note.

References

Land Use Consultants on behalf of SNH and the Countryside Agency (2002) *Landscape Character Assessment: Guidance for England and Scotland*

Scottish Executive Development Department (revised 2002) PAN 45 *Renewable Energy Technologies*

Scottish Natural Heritage (2001) *Guidelines on Environmental Impacts of Windfarms and Small-Scale Hydro Electric Schemes*

Scottish Natural Heritage (2003) Staff guidance note: *Cumulative Effect of Windfarms*

SNH (2003) Policy Statement 02/03: *Wildness in Scotland's Countryside*

SNH (Nov 2003) *Guidance on Scoping Issues for EIA 3rd draft*

The Landscape Institute and Institute of Environmental Management and Assessment (2002) *Guidelines for Landscape and Visual Impact Assessment* 2nd Edition Spon Press

University of Newcastle (2002) Visual Assessment of Windfarms: Best Practice. *Scottish Natural Heritage Commissioned Report F01AA303A*

University of Newcastle (in preparation) Visual Impact Assessment Guidance *Scottish Natural Heritage Commissioned Report*

APPENDIX A

BASE PLAN
[section 3]

60 km radius Study Area
Showing all **built**, **consented** and **undetermined applications** and all other **public domain*** wind farm proposals with 30km radius drawn for each.

This BASE PLAN can usefully be taken to early meetings with SNH and Planning Authority

CUMULATIVE ZVI(s)
[section 4]

ZVIs for all **built, consented** and **undetermined applications <**30km from proposal.

In addition: any projects **>**30km which are requested by SNH &/ Planning Authority

STATIC CUMULATIVE VISUAL IMPACTS ASSESSMENT
[section 5]

Assessment of combined/simultaneous visibility and successive/repetitive visibility

Viewpoint selection based upon Cumulative ZVI(s)

SEQUENTIAL CUMULATIVE VISUAL IMPACTS ASSESSMENT
[section 6]

Assessment of cumulative visual impact along a route

Route selection based upon Cumulative ZVI(s) and with reference to the 60km ‘bigger picture’.

CUMULATIVE LANDSCAPE IMPACTS ASSESSMENT
[section 8]

Assessment of cumulative landscape impacts upon:
landscape designations
designed landscapes
sense of scale
sense of distance
focal points
skyline
wildness and remoteness
special landscape interests
etc.

* ‘Public domain’ for the purposes of this note is defined as:

- any constructed windfarm;
- any consented windfarm proposal;
- any undetermined windfarm application;
- any windfarm proposal which has been subject to an EIA scoping request to the relevant Planning Authority or the Scottish Executive; and
- any other windfarm proposal that the Planning Authority deems relevant for study and is within the public domain as a result of a public announcement or community meeting.

Appendix E

Landscape Capacity/ Sensitive Guidance

Please note that the contents of the this appendix do not represent the Planning Policy of the Welsh Assembly Government

LANDSCAPE CHARACTER ASSESSMENT GUIDANCE FOR ENGLAND AND SCOTLAND

TOPIC PAPER 6 : TECHNIQUES AND CRITERIA FOR JUDGING CAPACITY AND SENSITIVITY

An exploration of current thinking about landscape sensitivity and landscape capacity, to stimulate debate and encourage the development of common approaches.

Carys Swanwick

January 2004

FINAL DRAFT

Version 4.1

Produced for The Countryside Agency & Scottish Natural Heritage

1. INTRODUCTION

1.1 The Countryside Agency has recently published a report [1] that looks forward to the way that the countryside might evolve up to the year 2020. It makes it clear that change in English rural landscapes is inevitable in the next 20 years, as a result of a variety of social and economic forces, including food production, housing needs, transport issues, and energy requirements. At the same time the Agency published the results of a public opinion survey suggesting that 91% of English people want to keep the countryside exactly as it is today. Clearly the two are not compatible and hard decisions are inevitably required about how the many different demands that society makes on the land can be accommodated while also retaining the aspects of the environment that we place such high value on. Although there have been no exactly parallel studies of future landscapes in Scotland and of attitudes to them, the recent report on change in Scotland's rural environment [2] shows that similar issues also arise there. Indeed Scotland has been at the forefront of efforts to consider the capacity of Scotland's landscapes to accommodate change of various types.

1.2 In both England and Scotland, Landscape Character Assessment is being widely employed as a tool to help guide decisions about the allocation and management of land for different types of development. It is being used particularly to contribute to sensitivity or capacity studies dealing with the ability of the landscape to accommodate new housing, wind turbines and other forms of renewable energy, and new woodlands and forests, as well as locally significant types of development such as, for example, aquaculture schemes in Scotland. Work of this type inevitably involves consideration of the sensitivity of different types and areas of landscape and of their capacity to accommodate change and development of particular types. If carried out effectively, Landscape Character Assessment can, in these circumstances, make an important contribution to finding solutions that allow essential development to take place while at the same time helping to maintain the diverse character and valued qualities of the countryside. Making decisions based on sensitivity and capacity is a difficult and challenging area of work and also one that is developing rapidly as more and more studies of this type are carried out. The terms themselves are difficult to define accurately in a way that would be widely accepted.

1.3 This Topic Paper provides an overview of current thinking about landscape sensitivity and landscape capacity in terms of both the concepts involved and the practical techniques that are being used. It is not intended to provide a definitive method for assessing sensitivity and capacity but rather to help those involved in such work by setting out some of the key principles, clarifying some of the issues, helping with definitions of key terms and providing examples of the approaches that are currently being used. In this way the intention is to encourage greater transparency in the thinking applied to these issues and to promote consistency and rigour in such work. The content of the paper is based on a workshop involving a small group of practitioners involved in work of this type and review of a small selection of recent studies. It was not the intention, and nor were the resources available, to carry out a comprehensive review of published reports or work in progress in this area, or a wide ranging consultation exercise.

2. WHAT EXISTING GUIDANCE DOCUMENTS SAY ABOUT SENSITIVITY AND CAPACITY

2.1 The topic of landscape sensitivity and capacity proved one of the most difficult to deal with in the main Landscape Character Assessment (LCA) guidance. This was due to both the new and rapidly developing nature of much of this work and also to the great variation in the approaches being applied and the terminology being used. In addition there were some concerns about the need for compatibility with the definitions of sensitivity being developed in the separate 'Guidelines for Landscape and Visual Impact Assessment' [3] which was due to be published at the same time. As a result the published version of the LCA guidance omitted specific reference to landscape sensitivity and instead contained only a few short paragraphs on the topic of landscape capacity on the basis that the issues would be dealt with more fully in a later Topic Paper. For convenience, the current wording of the LCA guidance is summarised in **Box 1**.

Box 1 : What the existing guidance says about capacity

"Landscape capacity refers to the degree to which a particular landscape character type or area is able to accommodate change without significant effects on its character, or overall change of landscape character type. Capacity is likely to vary according to the type and nature of change being proposed"

"Many Landscape Character Assessments will be used to help in decisions about the ability of an area to accommodate change, either as a result of new development or some other form of land use change, such as the introduction of new features, or major change in land cover such as new woodland planting. In these circumstances judgement must be based on an understanding of the ability of the landscape to accommodate change without significant effects on its character. Criteria for what constitutes significant change need to be identified in planning policies or landscape strategies, and will usually be informed by potential effects on character and/or particular features and elements"

Carys Swanwick and Land Use Consultants. Landscape Character Assessment Guidance. Countryside Agency and Scottish Natural Heritage. 2002.

2.2 The published Guidelines on Landscape and Visual Impact Assessment [3] tackle the subject of sensitivity at some length, but do not deal specifically with the topic of landscape capacity. It is, however, clear that there is much common ground between the thinking that is emerging on landscape sensitivity and capacity in Landscape Character Assessment work and the approach that is taken in Britain to Landscape and Visual Impact Assessment. It is therefore particularly important to understand the links between the two and to try, as far as possible, to achieve consistency in the approaches used and particularly in the terms and definitions used. On the other hand it must also be recognised that LCA and LVIA are not the same processes and there must also be clarity about the differences between them.

3. CONCEPTS OF SENSITIVITY AND CAPACITY

3.1 The terms sensitivity and capacity are often used more or less interchangeably. Others treat them as opposites, in the sense that low sensitivity is taken to mean high capacity and vice versa. Indeed the earlier versions of the Landscape Character Assessment guidance used the term sensitivity in the definition given above but this was changed to capacity in the published version to avoid confusion with the guidance on landscape and visual impact assessment. However, as experience of the issues involved has developed, it has become clearer that the two are not the same and are not necessarily directly related. A clearer distinction therefore needs to be drawn between them. Definitions vary among those actively engaged in this work and opinions vary about the acceptability and utility of different definitions. The box below contains just two examples of current ideas of sensitivity, in the words of the authors.

Box 2 : Examples of definitions of landscape sensitivity in current use

"Landscape sensitivity... relates to the stability of character, the degree to which that character is robust enough to continue and to be able to recuperate from loss or damage. A landscape with a character of high sensitivity is one that, once lost, would be difficult to restore; a character that, if valued, must be afforded particular care and consideration in order for it to survive."
The model for analysing landscape character sensitivity is based on the following assumptions:

i) Within each landscape type certain attributes may play a more significant role than others in defining the character of that landscape.
ii) Within each landscape type, certain attributes may be more vulnerable to change than others.
iii) Within each landscape type, the degree to which different attributes are replaceable, or may be restored, may vary.
iv) The condition of the landscape - the degree to which the described character of a particular landscape type is actually present 'on the ground' - will vary within a given area of that landscape type.

By being able to appreciate and assess the significance, vulnerability and replaceability of different attributes, the relative stability or resilience of the various attributes within given landscape types can be assessed. Then, taking into account condition, or representation of character, the sensitivity of a particular area of landscape can be determined.

Chris Bray. Worcestershire County Council. Unpublished paper on a County Wide Assessment of Landscape Sensitivity. 2003.

Landscape sensitivity... is a property of a thing that can be described and assessed. It signifies something about the behaviour of a system subjected to pressures or stimuli. One system, when stimulated might be robust and insensitive to the pressure, whilst another may be easily perturbed. The system might also be thought of in a dynamic way - the pressure could send the system off into a new state or the system might be resilient and bounce back rapidly and be relatively insensitive to disturbance. Sensitivity is related here to landscape character and how vulnerable this is to change. In this project change relates to wind energy development and any findings on landscape sensitivity are restricted to this (landscapes may have different sensitivities to other forms of change or development). Landscapes which are highly sensitive are at risk of having their key characteristics fundamentally altered by development, leading to a change to a different landscape character i.e. one with a different set of key characteristics. Sensitivity is assessed by considering the physical characteristics and the perceptual characteristics of landscapes in the light of particular forms of development.

John Benson et al. University of Newcastle. Landscape Capacity Study for Wind Energy Development in the Western Isles. Report commissioned by Scottish Natural Heritage for the Western Isles Alternative Renewable Energy Project. 2003

3.2 These two examples highlight one of the main debates about landscape sensitivity, namely whether it is realistic to consider landscapes to be inherently sensitive or whether they can only be sensitive to a specific external pressure. This paper argues that both are valid and useful in different circumstances. Looking at the way that the word sensitivity is used in other contexts, for example in describing the character of people, it is common and seems quite acceptable to describe someone as 'a sensitive person', without necessarily specifying what they are sensitive to. Landscape can quite reasonably be treated in the same way.

3.3 There is a greater degree of agreement about definitions of capacity with broad acceptance that it is concerned with the *amount* of change or pressure that can be accommodated. There is therefore a quantitative dimension to it and it needs to reflect the idea of the limits to acceptable change. The main debate here is about whether aspects of landscape value should or should not be incorporated into considerations of capacity. In general there appears to be some acceptance that it should, although some argue that this is a retrograde step and could lead to an over reliance on existing designations, which is widely recognised as an overly simplistic approach. There is also some disagreement about where visual aspects should be considered, whether as a component of landscape sensitivity, or wholly as a contributor to landscape capacity, or both.

3.4 In this paper an attempt has been made to weigh up the different arguments and as a result it is suggested that three terms can usefully be adopted as shown below. Further details of the definition and use of these terms are in the later sections of this paper.

i) **Overall landscape sensitivity:** This term should be used to refer primarily to the inherent sensitivity of the landscape itself, irrespective of the type of change that may be under consideration. It is likely to be most relevant in work at the strategic level, for example in preparation of regional and sub-regional spatial strategies. Relating it to the definitions used in Landscape and Visual Impact Assessment, landscape sensitivity can be defined as embracing a combination of:

- the sensitivity of the landscape resource (in terms of both its character as a whole and the individual elements contributing to character)

- the visual sensitivity of the landscape, assessed in terms of a combination of factors such as views, visibility, the number and nature of people perceiving the landscape and the scope to mitigate visual impact.

ii) **Landscape sensitivity to a specific type of change:** This term should be used where it is necessary to assess the sensitivity of the landscape to a particular type of change or development. It should be defined in terms of the interactions between the landscape itself, the way that it is perceived and the particular nature of the type of change or development in question.

iii) **Landscape capacity:** This term should be used to describe the ability of a landscape to accommodate different *amounts* of change or development of a specific type. This should reflect:

- the inherent sensitivity of the landscape itself, but more specifically its sensitivity to the particular type of development in question, as in (i) and (ii). This means that capacity will reflect both the sensitivity of the landscape resource and its visual sensitivity;

- the value attached to the landscape or to specific elements in it.

The meanings of these terms and the types of factors that need to be considered in each case are summarised in **Figure 1 (a) and (b)**.

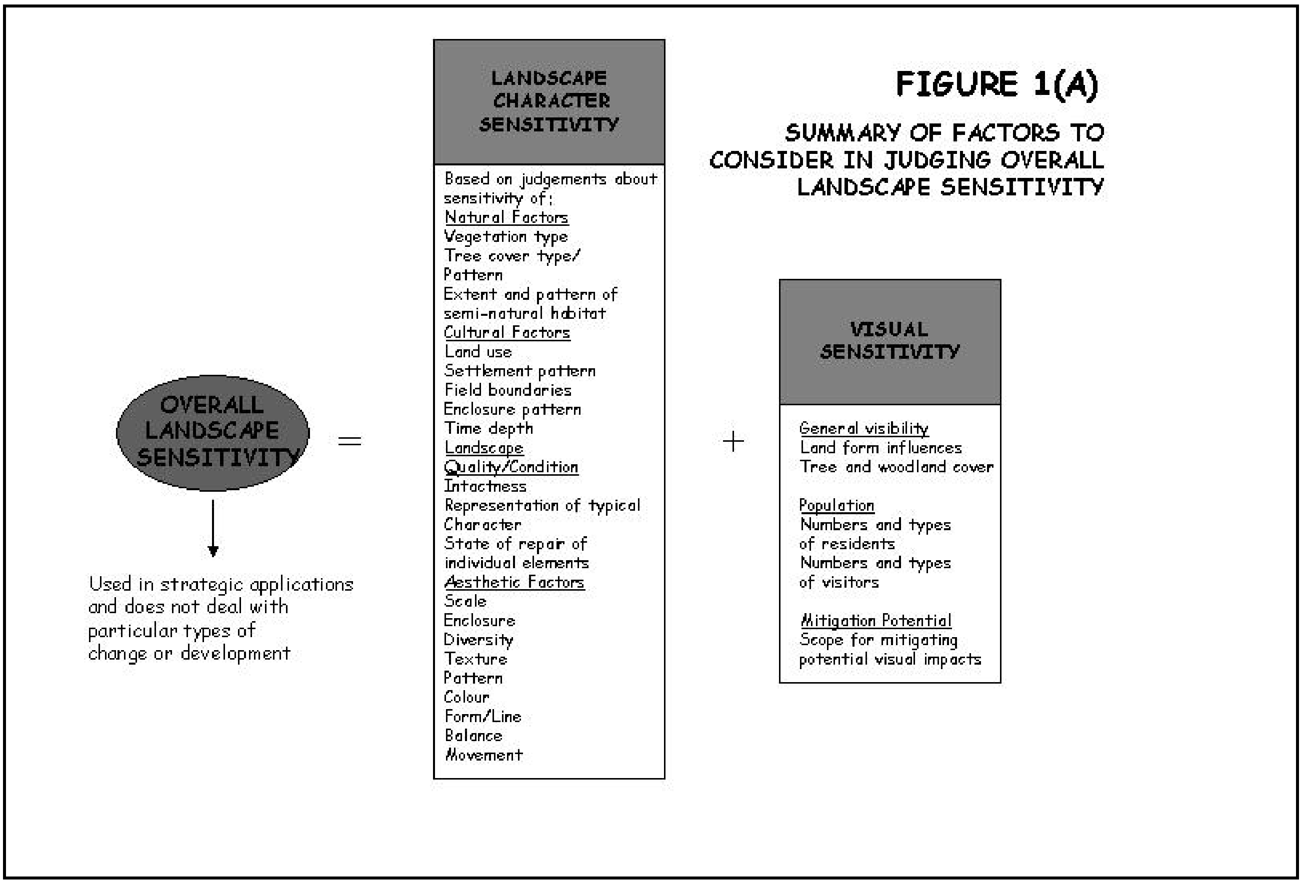


FIGURE 1(A)

SUMMARY OF FACTORS TO CONSIDER IN JUDGING OVERALL LANDSCAPE SENSITIVITY

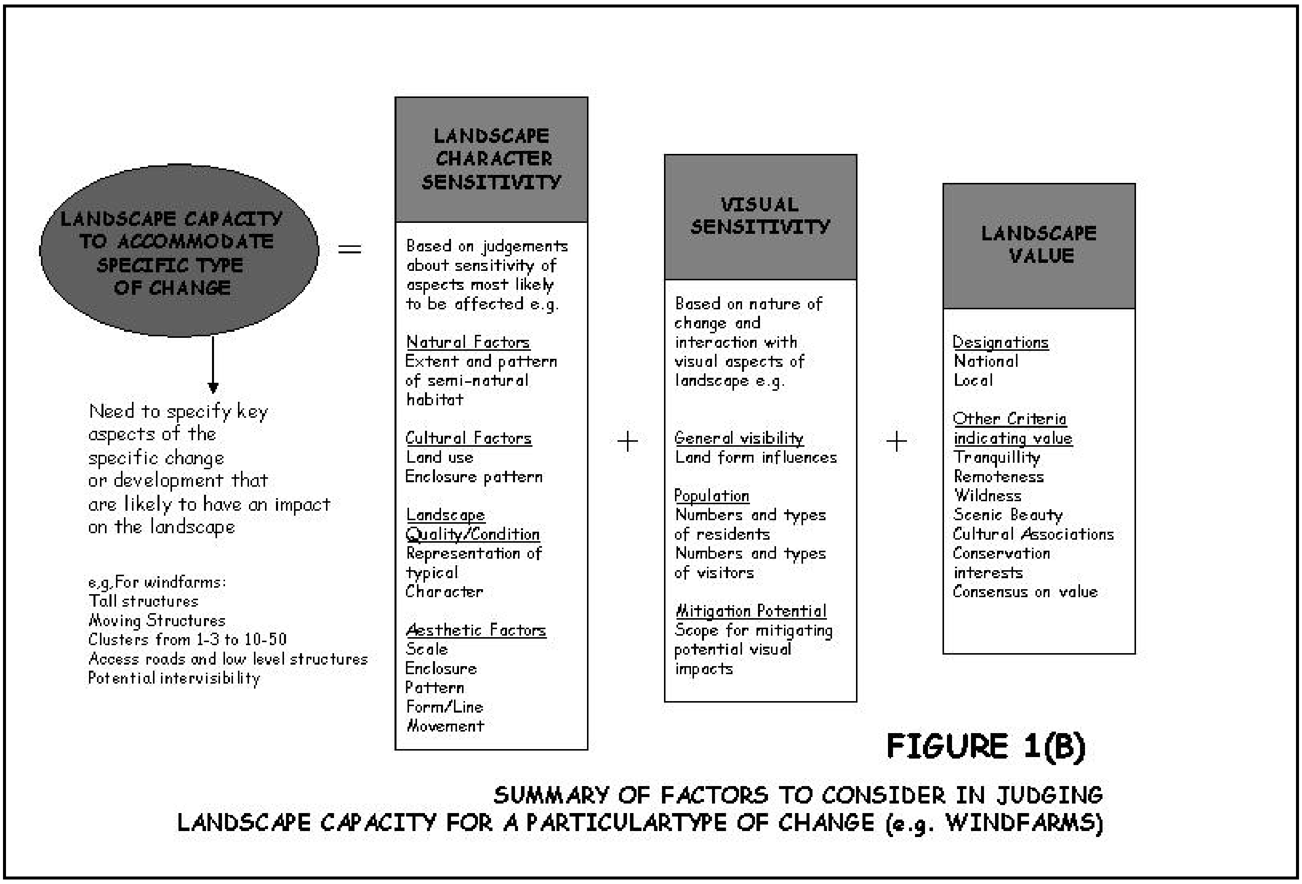


FIGURE 1(B)

SUMMARY OF FACTORS TO CONSIDER IN JUDGING LANDSCAPE CAPACITY FOR A PARTICULARTYPE OF CHANGE (e.g. WINDFARMS)

3.5 The implication of this is that capacity studies must be specific to a particular type of change or development. At a strategic level, for example in work relating to regional and sub-regional spatial strategies, this means that it might be appropriate to produce a single map of general landscape sensitivity. Maps of landscape capacity, however, need to be specific so that, for example, a map showing an assessment of wind turbine capacity could be produced but would almost certainly be different from a map showing capacity for housing development or for new woodland and forestry planting. Some capacity studies are very specific in their purpose, seeking for example to assess capacity to accommodate a 1000 home settlement at a particular density of development.

4. JUDGING OVERALL LANDSCAPE SENSITIVITY

4.1 In making judgements about the overall landscape sensitivity of different landscape types or areas, without reference to any specific change or type of development (for example in work relating to regional and sub-regional spatial strategies), careful consideration needs to be given to two aspects:

- Judging the sensitivity of the landscape as a whole, in terms of its overall character, its quality and condition, the aesthetic aspects of its character, and also the sensitivity of individual elements contributing to the landscape. This can be usefully referred to as **landscape character sensitivity**;

- Judging the **visual sensitivity** of the landscape, in terms of its general visibility and the potential scope to mitigate the visual effects of any change that might take place. Visibility will be a function particularly of the landform of a particular type of landscape and of the presence of potentially screening land cover, especially trees and woodland. It will also be a reflection of the numbers of people who are likely to perceive the landscape and any changes that occur in it, whether they are residents or visitors.

Landscape character sensitivity

4.2 Judging landscape character sensitivity requires professional judgement about the degree to which the landscape in question is robust, in that it is able to accommodate change without adverse impacts on character. This means making decisions about whether or not significant characteristic elements of the landscape will be liable to loss through disturbance, whether or not they could easily be restored, and whether important aesthetic aspects of character will be liable to change. Equally, consideration must be given to the addition of new elements, which may also have a significant influence on character. These decisions need clear and consistent thought about three factors:

- the individual elements that contribute to character, their significance and their vulnerability to change;

- the overall quality and condition of the landscape in terms of its intactness, representation of typical character and condition or state of repair of individual elements contributing to character;

- the aesthetic aspects of landscape character, noting that in Scotland these are usually referred to as the 'landscape experience' or the 'scenic qualities' of the landscape. As indicated in the LCA Guidance, aesthetic factors/scenic qualities can still be "recorded in a rational, rigorous and standardised, if not wholly objective way". They include for example the scale, level of enclosure, diversity, colour, form, line, pattern and texture of the landscape. All of these aesthetic dimensions of landscape character may have significance for judgements about sensitivity. They are also distinct from the perceptual aspects of landscape character, which are much more subjective and where responses to them will be more personal and coloured by the experience and the preferences of the individual. These are also important dimensions of character and influence the ability of landscapes to accommodate change but they are best dealt with as part of the consideration of value to be incorporated in the final step of assessing capacity, as discussed in **Section 7**.

4.3 Different methods have been used to judge landscape character sensitivity in recent work. Each has its merits and it is not the role of this topic paper to advocate one approach or another. There is also much common ground between them and they are not therefore alternatives but rather different explorations of a similar approach. A common feature of these approaches in England is the analysis of landscape character in terms of firstly the natural and ecological, and secondly the cultural attributes of the landscape. Landscape sensitivity is in these cases equated broadly with ideas of ecological and cultural sensitivity and deliberately does not embrace either aesthetic aspects of character or visual sensitivity. Three recent examples illustrating this approach are summarised in **Boxes 3 and 4**.

4.4 There are few if any examples of studies of overall landscape sensitivity that incorporate assessment of the aesthetic dimensions of landscape character, although it would be technically possible to do this. Such considerations are more likely to be found in studies of sensitivity to particular forms of change or development and are discussed in **Section 5**.

Box 3 : An approach based on ecological and cultural sensitivity

The Countryside Agency's work on traffic impacts on the landscape required a desk based rather than a field assessment using Staffordshire as the test area. The main concern was with the impact of the road network on landscape character. The Countryside Agency's National Landscape Character Types, and the Land Description Units (LDUs) on which they are based, both derived from the National Landscape Typology, were used as reporting units. The attribute maps from the national typology also provided much of the source data for the analysis. In this work landscape sensitivity is defined as the degree to which the character of the landscape is likely to be adversely affected or changed by traffic levels and network use. It is considered to consist of a combination of ecological sensitivity and cultural sensitivity where:

- **ecological sensitivity** is based on identification of areas where there are ecologically significant habitats likely to be at risk, reflecting combinations of agricultural potential, related to ground type, together with agricultural use and woodland pattern;

- **cultural sensitivity** is based on identification of areas where culturally significant elements of the landscape will be at risk, reflecting a combination of settlement pattern, land cover and the origins of the landscape in terms of whether it is 'planned' or 'organic'.

These two aspects of sensitivity are mapped using GIS and combined into an overall sensitivity matrix. Data on the road hierarchy and road 'windy-ness' was then combined with the sensitivity classes to give an overall assessment. This desk study proves successful in highlighting areas of concern that could then be examined in more detail if required.

Babtie Group and Mark Diacono. Assessing Traffic Impacts on the Countryside. Unpublished Report to the Countryside Agency. 2003

Box 4 : Approaches based on vulnerability, tolerance and resilience to change

Work carried out recently for structure plan purposes by Herefordshire and Worcestershire County Councils working in partnership, focuses on landscape character sensitivity rather than visual sensitivity. The work is at the detailed level of Land Description Units (the constituent parts or building blocks of Landscape Character Types and Areas). These studies also focus on individual landscape indicators and attributes - meaning the factors that contribute to character, grouped together under the headings of ground vegetation, land use, field boundaries, tree cover character, tree cover pattern, enclosure pattern, settlement pattern, spatial character and additional characteristic features, such as parkland or rivers.

These studies use a combination of several different aspects of the character of the landscape to reach an assessment of overall sensitivity, based on analysis of these attributes. The definitions of the component parts can be summarised as follows:

Vulnerability: This is a measure of the significance of the attributes that define character, in relation to the likelihood of their loss or demise. This combines assessment of the significance of an attribute with assessment of its functionality and of the likelihood of future change based on apparent trends.

Tolerance: This can be defined as the degree to which change is likely to cause irreparable damage to the essential components that contribute to landscape character. It is a measure of the impacts on character of the loss of attributes, reflecting the timescale needed for their contribution to character to be restored. This combines assessment of the replaceability of individual attributes with their overall significance in the landscape and also takes account of the potential for future change based on apparent trends.

Resilience: This combines tolerance with vulnerability to change. It is a measure of the endurance of landscape character, representing the likelihood of change in relation to the degree to which the landscape is able to tolerate that change.

Sensitivity: relates to the resilience of a particular area of landscape to its condition.

Each of these aspects of sensitivity is assessed from a combination of desk and fieldwork. The assessments of each factor are then progressively combined in pairs using matrices, until the final assessment of individual areas emerges. In general three point numerical scores are used to combine the various aspects in pairs.

The published Herefordshire work focuses on landscape resilience , which is mapped for landscape types and forms the key summary map in the published Supplementary Planning Guidance document, leaving a final assessment of sensitivity to a more detailed stage based on individual land cover parcels, which is the fine grain at which condition has been assessed in this work. The Worcestershire work is not yet published but will take a similar approach once the County survey of condition has been completed.
Worcestershire County Council. Unpublished paper on a County Wide Assessment of Landscape Sensitivity. 2003.
Herefordshire Council. Landscape Character Assessment. Supplementary Planning Guidance. 2002.

Visual sensitivity

4.5 In a comprehensive study of landscape sensitivity account would ideally also be taken of the visual sensitivity of the landscape. This requires careful thinking about the way that people see the landscape. This depends on:

- the probability of change in the landscape being highly visible, based particularly on the nature of the landform and the extent of tree cover both of which have a major bearing on visibility;

- the numbers of people likely to perceive any changes and their reasons for being in the landscape, for example as residents, as residents staying in the area, as travellers passing through, as visitors engaged in recreation or as people working there;

- the likelihood that change could be mitigated, without the mitigation measures in themselves having an adverse effect (for example, planting trees to screen development in an open, upland landscape could have as great an effect as the development itself).

4.6 In practice visual sensitivity can be difficult to judge without reference to a specific form of change or development and that is no doubt why there are few examples of strategic assessments that incorporate this dimension. Herefordshire and Worcestershire initially intended to incorporate such considerations into their strategic work but abandoned the attempt on the basis that it was more realistically considered for specific proposed developments or change. Work by Staffordshire County Council does, however, provide a working example of an approach that combines judgements about landscape character sensitivity (as outlined above) with consideration of the issue of visual sensitivity. It is summarised in **Box 5**.

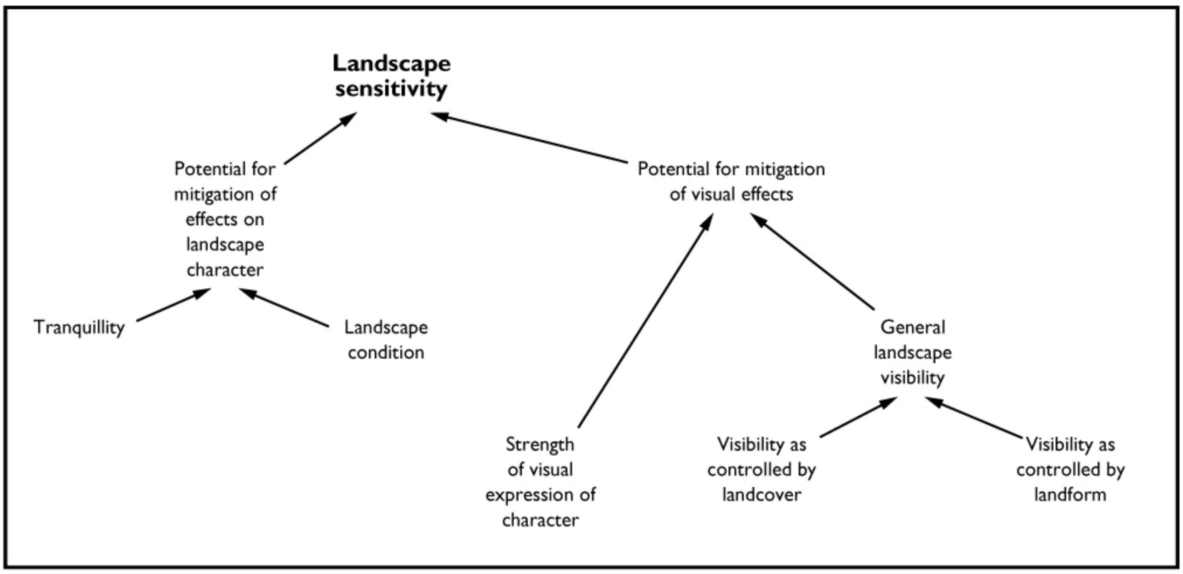
Box 5 : Staffordshire County - An approach that combines landscape character sensitivity and visual sensitivity

Work carried out by Staffordshire County Council, published as Supplementary Planning Guidance to the Staffordshire and Stoke on Trent Structure Plan , approaches landscape sensitivity by working at the Land Description Unit level and addressing the three aspects of landscape character listed below. In this work the first stage in addressing landscape sensitivity is to consider the quality (as defined in the LCA guidance, meaning condition and expression of typical character in specific areas) of individual areas of landscape in relation to their character. This is achieved by asking a series of questions about the three aspects of character:

- **Visual aspects**, dealing with the spatial distribution, pattern and condition of landscape elements. The questions cover: the presence of characteristic features for the landscape type; the absence of incongruous features for the type; and the visual and functional condition of the elements contributing to character of that particular type.

- **Cultural aspects**, which are determined by the history of human activity and are reflected in the patterns of settlement, land use, field enclosure and communications. The questions cover: demonstration of a clear and consistent pattern of landscape elements resulting from a particular course of historical development contributing to character; and the extent to which the area exhibits chronological continuity or 'time depth' in the landscape.

- **Ecological aspects**, relating to the pattern and extent of survival of the typical semi-natural vegetation and related fauna. The questions cover the presence and frequency of semi-natural vegetation characteristic of the landscape type; and the degree of fragmentation and the pattern of the semi-natural habitats.



The Staffordshire approach notes the strong relationship between the quality and sensitivity of the landscape in that one of the effects of disturbance can be the removal of characteristic landscape features. In dealing with the potential impacts of change on landscape character it asks how likely it is that significant features or characteristics of the landscape that contribute to its quality will be lost through disturbance. It also asks whether perception of landscape quality will be adversely affected.

The Staffordshire example is one of the few cases where landscape character sensitivity and visual sensitivity have been combined in an integrated approach. In terms of visual impact this work asks two questions:

- How likely is it that the effects of a given amount of disturbance will be visible?
- What is the potential for negating or minimising adverse visual impacts of disturbance through mitigation and compensation measures?

The idea of general visibility is used and is defined in terms of the likelihood that a given feature, randomly located, will be visible from a given viewpoint, also randomly located. It was determined in this case by theoretical and field based analysis of landform and tree and woodland cover and the way that they interact.

All these different factors, relating to both landscape character sensitivity and visual sensitivity are then combined by judging each on a 5 level scale and combining them sequentially, in map form, through the use of GIS, to produce a final map of landscape sensitivity.

Staffordshire County Council 1999. Planning for Landscape Change. Supplementary Planning Guidance to the Stoke on Trent and Staffordshire Structure Plan. 1996-2011

5. JUDGING LANDSCAPE SENSITIVITY TO A SPECIFIC TYPE OF CHANGE

5.1 In many studies judgements must be made about the ability of the landscape to accommodate particular types of change or development. This is where sensitivity and capacity are most often used interchangeably but it is suggested that, in line with the definitions set out above, sensitivity is the most appropriate word to use. When judging how sensitive a landscape is to some specified type of change it is essential to think in an integrated way about:

- The exact form and nature of the change that is proposed to take place;

- The particular aspects of the landscape likely to be affected by the change, including aspects of both landscape character sensitivity and visual sensitivity, as described in **Section 4**.

5.2 Understanding the nature of the agent of change is like specifying or describing the development project in an Environmental Impact Assessment, except that it is a generic rather than a project-specific form of change. The focus must be on identifying key aspects of the change that are likely to affect the landscape.

5.3 Defining the particular aspects of the character of the landscape that are likely to be affected by a particular type of change (landscape character sensitivity) means careful analysis of the potential interactions. These might include: impacts upon particular aspects of landscape character including landform, land cover, enclosure and settlement pattern; and impacts on aesthetic aspects such as the scale, pattern, movement and complexity of the landscape. In Scotland, for example, the wide range of capacity studies that have been carried out , although varying in their approach, usually incorporate consideration of the key physical, natural and cultural characteristics of the landscape, but also take into account the aesthetic/scenic dimensions of the landscape in judgements about the ability of different landscapes to accommodate change. So, for example, the Stirling Landscape Character Assessment, which includes consideration of a locational strategy for new development, includes criteria related to the 'landscape experience'. It considers that scale, openness, diversity, form and or line, and pattern are the most relevant aspects for this task (see **Box 6** in Section 7 for fuller examples).

5.4 Similarly the visual sensitivity of the landscape with respect to the specific type of change or development needs to be assessed. This means that the potential visibility of the development must be considered, together with the number of people of different types who are likely to see it and the scope to modify visual impacts by various appropriate forms of mitigation measures.

5.5 An overall assessment of sensitivity to the specific form of change or development requires that the four sets of considerations summarised above should be brought together so that the sensitivity of individual types or areas of landscape to that particular form of development can be judged and mapped. They are:

- impacts upon particular aspects of landscape character including landform, land cover, enclosure and settlement pattern;

- impacts on aesthetic aspects such as the scale, pattern, movement and complexity of the landscape;

- potential visibility of the development and the number of people of different types who are likely to see it;

- scope to modify visual impacts by various appropriate forms of mitigation measures.

In most cases, this is likely to be a precursor to further judgements about capacity. Studies specifically of sensitivity to a particular type of development, without proceeding to an assessment of capacity, are not likely to be common.

5.6 The outcome of a study of landscape sensitivity to a specific type of change or development would usually be a map of different categories of sensitivity, usually with either three (for example low, medium and high) or five (for example very low, low, medium, high, very high) categories of sensitivity. Such a map provides an overview of areas where there is relatively low sensitivity to the particular type of change or development but does not indicate whether and to what extent such change or development would be acceptable in these areas. This requires consideration of other factors and is best tackled through a landscape capacity study.

BOX 5 : South West Region Renewable Energy Strategy – an example of using landscape sensitivity to forms of renewable energy development to inform draft targets

This is a consultant's study, carried out by Land Use Consultants for the Government Office for the South West. It focussed on providing information on the sensitivity of different landscape character areas to wind turbines but also assessed whether a similar approach could be used for biomass crops. Key features of this work, which is still in progress, are:

- It is a strategic study of landscape sensitivity to a specific type of change/development. The Countryside Character Area framework is adopted as suited to the needs of regional scale work, though there has also been subsequent discussion of the scope to use the new National Landscape Typology to provide a more refined level of assessment.

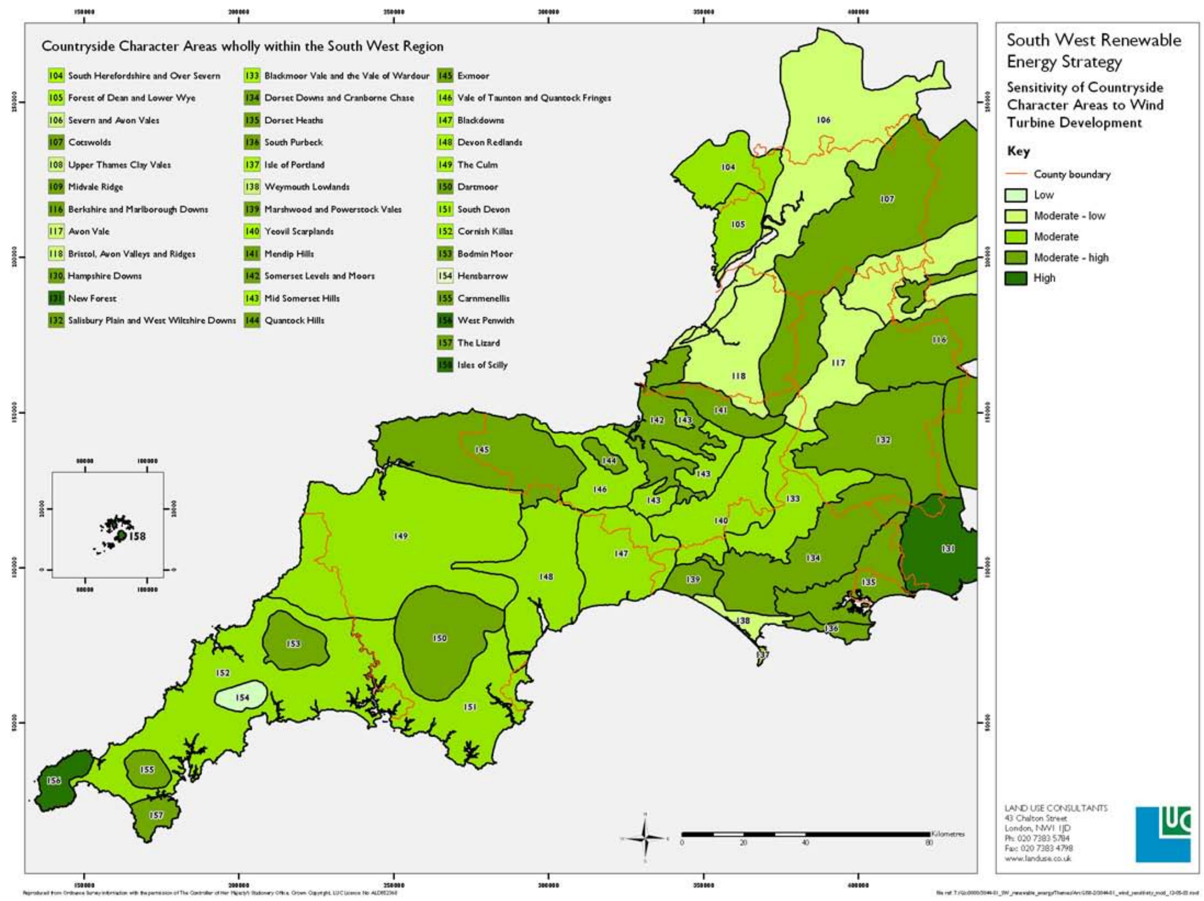
- A range of attributes contributing to landscape character are identified as likely to indicate suitability to accommodate wind turbines. Scale and form of the landscape, landscape pattern, settlement pattern and transport network relate to the elements and attributes giving character to the landscape; skylines and inter-visibility relate to the visual sensitivity of the landscape; sense of enclosure, sense of tranquillity and remoteness relate to perceptual aspects and value; while sensitive/rare landscape features relates to aspects of landscape value. These distinctions are not referred to in the study where all are referred to simply as 'landscape attributes'.

- A shorter list of attributes is considered to indicate suitability of a landscape to accommodate biomass crops. They are: landscape pattern, land cover/land use, sense of enclosure and settlement pattern/transport network.

- Using these attributes, a series of sensitivity classes are defined in relation to both wind turbines and biomass crops. In each case a five level verbal scale of sensitivity is used – low, moderate/low, moderate, moderate/high and high.

- For each level of sensitivity the influence of the landscape attributes in relation to that type of development is summarised. For example, landscapes judged to be of low sensitivity to wind turbines are "likely to have strong landform, a strong sense of enclosure that reduces visual sensitivity, to be already affected by man made features, to have reduced tranquillity, little inter-visibility with adjacent landscapes and a low density of sensitive landscape features. Similarly, for biomass crops, areas of high sensitivity are defined as those where monocultures of biomass crops would prejudice landscape pattern, where transport infrastructure is dominated by narrow rural lanes (or is absent), and where buildings are uncharacteristic of the landscape (e.g. moorland). The scale of possible wind turbine development is considered, predominantly in relation to landform scale, though it is acknowledged that at more detailed levels of assessment other factors such as landscape pattern and enclosure will also be relevant.

Overall the assessment of landscape sensitivity is considered to provide just one 'layer' of information relevant to the process of regional target setting. The study is clearly based on professional judgement within a clear and reasonably transparent framework. There is no explicit scoring or use of matrices but rather a common sense approach to combining the nature of the landscape with the nature of the development to derive sensitivity classes.



Land Use Consultants. South West Renewable Energy Strategy : Using Landscape Sensitivity to set Draft Targets for Wind Energy. Unpublished report to the Government Office for the South West. 2003.

6. JUDGING LANDSCAPE CAPACITY

6.1 Turning a sensitivity study into an assessment of capacity to accommodate a particular type of change means taking a further step. The assessment of the sensitivity of different types or areas of landscape to the type of change in question must be combined with an assessment of the more subjective, experiential or perceptual aspects of the landscape and of the value attached to the landscape. There are, perhaps inevitably, some reservations amongst practitioners about the incorporation of value in work on landscape sensitivity and capacity because this is seen as the return to the now largely discredited thinking about landscape evaluation. It cannot be denied, however, that society does value certain landscapes for a variety of different reasons and this has, in some way, to be reflected in decision making about capacity to accept change.

6.2 As the Landscape Character Assessment guidance indicates (Paragraph 9.5), value may be formally recognised through the application of some form of national landscape designation. Where this is the case the implications of the designation need to be taken into account. This means, in particular, understanding what aspects of the landscape led to its designation and how these might be affected by the proposed change. The consultation draft of Planning Policy Statement 7, which is due to replace Planning Policy Guidance Note 7, requires that Local Planning Authorities no longer refer to local landscape designations in Development Plans. Local landscape designations are proposed to be replaced by criteria-based policies, underpinned by robust Landscape Character Assessments.

6.3 The absence of designation does not mean that landscapes are not valued by different communities of interest. This means that in such cases other indicators of value will need to be considered to help in thinking about capacity. Judgements about value in such cases may be based on two main approaches. One is to address value by means of the Quality of Life Assessment approach, seeking to address the question of 'What Matters and Why?' (see Topic Paper 2 – 'Links to Other Sustainability Tools'). In this approach value will be judged in an integrated way, with considerations of landscape and sense of place set alongside other matters such as biodiversity, historic and cultural aspects, access and broader social, economic and environmental benefits.

6.4 Alternatively judgements can be made in terms of the relative value attached to different landscapes by a range of different communities of interest. This can be based on the range of criteria set out in the Landscape Character Assessment guidance (**Paragraphs 7.8 and 7.22)**. These include landscape quality and condition; perceptual aspects such as scenic beauty, tranquillity, rurality, remoteness or wildness; special cultural associations; the presence and influence of other conservation interests. There may also be a long established consensus about the importance of particular areas. Weighing up all these factors may allow the relative value of particular landscapes to be assessed as an input to judgements about capacity.

6.5 Reaching conclusions about capacity means making a judgement about the *amount* of change of a particular type that can be accommodated without having unacceptable adverse effects on the character of the landscape, or the way that it is perceived, and without compromising the values attached to it. This step must clearly recognise that a valued landscape, whether nationally designated or not, does not automatically, and by definition, have high sensitivity. Similarly and as already argued in Section 3, landscapes with high sensitivity do not automatically have no, or low capacity to accommodate change, and landscapes of low sensitivity do not automatically have high capacity to accept change. Capacity is all a question of the interaction between the sensitivity of the landscape, the type and amount of change, and the way that the landscape is valued.

6.6 It is entirely possible for a valued landscape to be relatively insensitive to the particular type of development in question because of both the characteristics of the landscape itself and the nature of the development. It may also be the case that the reasons why value is attached to the landscape are not compromised by the particular form of change. Such a landscape may therefore have some capacity to accommodate change, especially if the appropriate, and hopefully standard, steps are taken in terms of siting, layout and design of the change or development in question. For example, a capacity study may show that a certain specified amount of appropriately located and well-designed housing may be quite acceptable even in a highly valued and moderately sensitive landscape. This is why capacity is such a complex issue and why most capacity studies need to be accompanied by guidelines about the ways in which certain types of change or development can best be accommodated without unacceptable adverse effects.

6.7 Clearly at this stage of making judgements about capacity there can be considerable benefit in involving a wide range of stakeholders in the discussions since there is likely to be a strong political dimension to such judgements. On the other hand clear and transparent arguments are vital if decisions are to be well founded and this is where well constructed professional judgements about both sensitivity and capacity are extremely important.

6.8 In Scotland a wide range of capacity studies have been carried out to look at the ability of different areas to accept development of different types. They have covered housing and built development in general, as well as wind turbines and aquaculture. The detailed approach taken varies as the studies have been carried out by different individuals or consultancies working to different briefs for different clients. **Box 6** contains a summary of the approach taken in a recent example.

7. RECORDING AND PRESENTING INFORMATION

7.1 Approaches to judging sensitivity and capacity can be made at different levels of detail. Much depends on the time and resources available and on the problem to be addressed. For example, capacity studies for housing may need a finer grain of assessment because of the particular nature of the development. Where time and resources are limited quick assessments are needed and it is likely that overall judgements will need to be made about the whole of a landscape type or area without necessarily making

BOX 6 : Stirling Landscape Capacity Assessment for Housing and Small-scale Industrial, Retail and Business Development

Carried out by David Tyldesley Associates for Scottish Natural Heritage and Stirling Council in 1999, this study seeks to ensure that development around Stirling is directed towards those landscapes which can best accommodate it. The work developed an approach pioneered at St Andrews in 1996 and also ran in parallel with a settlement capacity evaluation in the neighbouring area of Clackmannanshire. The Stirling study assessed 15 specific locations of settlements and their settings and three larger general areas of search. The purpose of the study was to define: settlements and areas of high landscape sensitivity judged to have little capacity to accommodate growth; settlements and areas judged to be able to accommodate minor growth and settlements or areas judged to be suitable for major settlement expansion or new settlement. The work assumed that the buildings in question would be well-designed and would use traditional building techniques and materials. It also assumed that it would include a strong framework of structural landscape treatment including ground modelling where appropriate and tree planting of appropriate scale, area, design and species composition to ensure that the development achieves a good fit in the landscape. This study embraces both sensitivity and capacity, as defined in this Topic Paper, although they are not separately considered. The assessment is clearly made with respect to particular specified forms of development. The assessment is based on five criteria which are applied to the landscape types previously identified in a Landscape Character Assessment. The five criteria address aspects of Landscape Character Sensitivity, Visual Sensitivity and Landscape Value, as discussed in this topic paper. The criteria are derived from the key characteristics and features of the landscape character types and can be grouped as follows in relation to the structure of this Topic paper:

Related to Landscape Character Sensitivity

Effects on the Landscape Resource: examines the effects of development on the key physical features and characteristics and judges whether that development of the kind described could be accommodated and whether the character of the landscape would be sustained, enhanced or diminished. Only the important characteristics relevant to the type of development are assessed.

Effects on the landscape experience: assesses the potential effects of development on aspects of landscape experience relating to scale, openness, diversity, form and/or line and pattern and makes an overall assessment of whether these aspects would be affected positively or negatively.

Related to Visual Sensitivity

Visual effects: considers possible visual effects of the forms of development on: views and approaches to the settlements from the principal approach roads; possible effects on strategically significant outward views from the settlements; potential effects on distinctive skylines; and potential effects on visually conspicuous locations such as open, flat ground or open, high or rising ground.

Mitigation: considers whether the development would require long-term mitigation to reduce the effects of the development. It also considers how feasible any desirable mitigation would be and whether the mitigation itself would be appropriate.

Related to Landscape Value

Other Important Effects: considers whether the development would affect the integrity of an important designed landscape or its setting and whether the development would affect the amenity of other important cultural or historical elements or features of the landscape, including their settings.

The criteria under these five categories are applied systematically to each settlement and area of search in terms of the different landscape character types that occur. Professional judgments are made and for each criteria a three point graphical scale is used to express the findings. An overview is taken of the judgments for each of the criteria for each landscape type, and an overview assessment is made of the whole. The three point scale applied to each criteria covers: no impact or positive enhancement; neutral or average effect; and significant negative effect or diminishing of landscape character. An overall judgment is then made based on the profile of the area/settlements and relevant landscape type based on a table of judgments under each criteria.

David Tyldesley Associates. Stirling Landscape Character Assessment. Report for Scottish Natural Heritage and Stirling Council. 1999

individual assessments of the constituent aspects of sensitivity or capacity. Consultants working to tight timescales and with limited budgets often carry out short sharp studies of this type. In such cases it is rarely possible to assess each of the relevant factors individually in great detail and the emphasis is often on overall judgement of sensitivity. It is nevertheless still extremely important that the thinking that underpins these judgements is clear and consistent, that records of the field judgements are kept in a consistent form and that the decisions reached can be explained easily to an audience of non-experts.

7.2 Local authorities carrying out such work in house are likely to work in a different way and may sometimes have longer periods of time for desk study, survey and analysis. Permanent staff can be more fully involved in such studies and have a greater opportunity to become familiar with and to understand their landscapes and to develop real ownership of the work. In these cases it may be possible to take a much more detailed and transparent step-by-step approach to assembling the judgements that ultimately leads to an overall assessment of landscape sensitivity or capacity. The Staffordshire, Worcestershire and Herefordshire studies, for example, provide demonstrations of what can be achieved by officers working on assessing their own areas, often over a reasonably long period of time.

7.3 Whoever carries them out, all assessments of sensitivity and capacity inevitably rely primarily on professional judgements, although wherever practically possible they should also include input from stakeholders. The temptation to suggest objectivity in such professional judgements, by resorting to quantitative methods of recording them is generally to be avoided. Nevertheless dealing with such a wide range of factors, as outlined in the paragraphs above, does usually require some sort of codification of the judgements that are made at each stage as well as a way of combining layers of judgements together to arrive at a final conclusion.

7.4 The first step is to decide on the factors or criteria that are to be used in making the judgement and to prepare a clear summary of what they are and what they mean. The second step is to design record sheets that allow the different judgements that need to be made to be recorded clearly, whether they are to be based on desk study or field survey. The time and resources available will influence the level of detail of this record sheet and the level of detail required of the work. Ideally separate records should be made of each component aspect of the final judgement. So for example in the case of a comprehensive capacity study for a particular type of change or development, a record should be made of the judgements made about:

i) the **Landscape Character Sensitivity** of each landscape type or area to that type of change, which will reflect the sensitivity of individual aspects of landscape character including landform, land cover, enclosure form and pattern, tree cover, settlement form and pattern, and other characteristic elements, and the aesthetic aspects of landscape character, including for example, its scale, complexity, and diversity;

ii) the **Visual Sensitivity** to that type of change, which will reflect, for each landscape type or area; general visibility, influenced by landform and tree and woodland cover, the presence and size of populations of different types, and potential for mitigation of visual impacts, without the mitigation in itself causing unacceptable effects.

iii) the **Value** attached to each landscape, which will reflect:

- National designations based on landscape value;
- Other judgements about value based either on a 'Quality of Life Assessment', or on consideration of a range of appropriate criteria relating to landscape value.

7.5 These different aspects need to be judged on a simple verbal scale, either of three points - high, medium or low, or of five points – for example very high, high, medium/average, low and very low, or equivalents. A three point scale is much easier to use but a five point scale allows greater differentiation between areas. These scales can easily be translated into shades or colours for graphic display and are well suited to use as layers within a GIS of the type now widely employed in landscape character work.

7.6 The question remains of how layers of information can then be combined to arrive at a final assessment of either sensitivity or capacity, depending on which is required. There are three possible methods: firstly the construction of an overall profile combined into an overall assessment of sensitivity and capacity; secondly the cumulative assessment of sensitivity and capacity by sequential combination of judgements; and thirdly a scoring approach. They are briefly outlined below.

An overall profile

7.7 In the first approach individual assessments are made of the constituent aspects of sensitivity or capacity using a three or five point verbal scale, as outlined above. The amount of detailed assessment that goes into the judgements of each of these factors will depend on the time and resources available and the overall approach taken. These assessments are arranged in a table or matrix to provide a profile of that particular landscape type or area. An overview is then taken of the distribution of the assessments of each aspect and this is used to make an informed judgement about the overall assessment of sensitivity or capacity. **Figure 2** gives a hypothetical example:

Figure 2 : Building up the overall profile

Landscape Type/Area	Landscape Character Sensitivity	Sensitivity of Individual Elements	Sensitivity of Aesthetic Aspects	Visual Sensitivity	LANDSCAPE SENSITIVIY	Value of Landscape	LANDSCAPE CAPACITY
Type 1	High	Medium	Medium	High	HIGH	Low	MEDIUM
Type 2	Low	Medium	Low	Low	LOW	Low	HIGH
Type 3	High	High	High	Medium	HIGH	High	LOW
etc							

Cumulative assessment

7.8 In the second approach individual assessments are similarly made but in this case the more detailed lower-level assessments are combined in pairs sequentially until an overall assessment is reached. The number of layers combined in this way depends upon the level of detailed information collected in the survey. This must of course be done for each landscape type or area being assessed. Based on the framework and definitions set out in this paper some simplified and purely illustrative possible combinations (and there are of course others) might be:

- Sensitivity of ecological components + Sensitivity of cultural components = Landscape character sensitivity

- General visibility (related to land form and land cover) + Level and significance of populations = Visual sensitivity

- Landscape character sensitivity + Visual sensitivity = Overall landscape sensitivity

- Presence of designations + Overall assessment of value against criteria = Landscape value

- Overall landscape sensitivity + Landscape value = Landscape capacity

7.9 The difficulties with this approach are that it may be somewhat cumbersome and time consuming to apply, especially for large areas, and that decisions must be made about how the individual assessments are to be combined. So, for example, while two HIGHS clearly give a HIGH in the matrix, what about a HIGH and a MEDIUM? Is the highest level used in which case the answer is also HIGH, or is a judgement made on the combinations? There is no single answer but again the emphasis must be on transparency. **Figure 3** illustrates this process for two hypothetical combinations. Both could also be shown with a five point scale, as discussed above, to give a more refined assessment.

Figure 3 a) Combining Landscape Character Sensitivity and Visual Sensitivity to give overall Landscape Sensitivity

Landscape Character Sensitivity				
	High	HIGH	HIGH	HIGH
	Medium	MEDIUM	MEDIUM	HIGH
	Low	LOW	MEDIUM	HIGH
		Low	Medium	High
		Visual Sensitivity		

Figure 3b) Combining overall Landscape Sensitivity and Landscape Value to give Capacity

Landscape Sensitivity				
	High	MEDIUM	LOW	LOW
	Medium	MEDIUM	MEDIUM	LOW
	Low	HIGH	MEDIUM	MEDIUM
		Low	Medium	High
		Landscape Value		

Scoring

7.10 In this type of approach the word scales must be combined in a consistent way with appropriate rules applied as to how the combined layers are further classified. This may require that they are converted into numerical equivalents for ease of manipulation. Shown graphically, these 'scores' will take the form of different colours or shades, which is generally preferable to presenting the numerical figures themselves. There are certainly examples of work that do take a scoring approach to the layers of information in the assessment, although they may not appear in the final published material.

7.11 While scoring overcomes the difficulty of how individual assessments of each aspect are combined (for example by multiplication within matrices and by adding different matrices) and makes the process transparent, it does lead to a greater emphasis on quantitative aspects of such work. If overemphasised as an end in itself rather than as a means to an end, numerical representation may run the risk of generating adverse reactions because it suggests something other than professional judgement and can suggest a spurious scientific rigour in the process. It was, after all, the overly quantitative nature of landscape evaluation in the 1970s that led to a move away from that approach.

The role of Geographic Information Systems

7.12 Today most sensitivity and capacity studies, whichever approach they take, are likely to rely on Geographic Information Systems (GIS) to manipulate the layers of information. This brings several advantages and notably:

- Consistency of approach, in that appropriate matrices or algorithms can be defined once and then applied consistently throughout a study;

- Transparency, in that it is easy to interrogate the base datasets used and also to visualise and communicate intermediate stages of the process if required;

- Efficiency and effectiveness in the handling of data, allowing explorations of the information and alternative approaches to combining it which would simply not be achievable in a manual paper based exercise.

8. CURRENT PRACTICE AND ISSUES IN ASSESSING SENSITIVITY AND CAPACITY

8.1 There is a wide range of work, either in progress or completed, which tackles the issues of landscape sensitivity and capacity. Most of it is quite complex and difficult to summarise meaningfully in a short paper like this and there are few if any examples as yet which demonstrate all the principles set out here. Where possible examples have been included in the boxes in the text to illustrate particular aspects of such work, including examples of overall landscape sensitivity studies carried out by local authorities, studies to assess sensitivity to particular types of change or development and capacity studies aimed, for example, at exploring wind turbines or housing, among other types of development. It is hoped that more examples may be available in future and may be included on the Countryside Character Network website (www.ccnetwork.org.uk).

Transparency and Presentation

8.2 It is clear from examination of the strategic studies of overall landscape sensitivity, such as those conducted by Herefordshire, Worcestershire and Staffordshire, that they are enormously detailed and very transparent in describing the approach to analysis and judgements. It is also apparent that they are very detailed and demanding of time and resources, and also quite complex because of the desire to explain each step in the process. However, even experienced practitioners who have not been involved in this work may struggle to understand fully the terminology used, the subtleties of the definitions and the judgements that are made at every level of the assessment, as well as the way that the different factors are combined. They may also disagree with some of those definitions – replaceability, for example, is in itself a very complex term open to different interpretations, especially when used in relation to ecological habitats. A lay audience could well be completely baffled by the complexity of the whole process. So although the arguments are logical, consistent and fully explained this can in itself open up potentially important areas of misunderstanding or debate.

8.3 On the other hand some of the consultants' studies of sensitivity and capacity are often short on transparency and rely on professional judgements, the basis of which is often not clear. It could be argued that there has to be a trade-off between complete transparency in the methods used and the accessibility of the findings to a non-specialist audience. Reasoning must always be documented as clearly as possible and the reader of any document should be able to see where and how decisions have been made. Different content and presentation techniques may be needed to tailor the findings of studies for particular audiences. Officers of Worcestershire County Council, for example, intend ultimately to produce the findings of their overall sensitivity analysis in a more accessible form for a wider audience. The complexities in the full explanation of the method are considered necessary to provide the essential degree of transparency and justification but it is recognised that this is only likely to be suited to a specialist audience.

Continuing debates and questions

8.4 Whatever the approach adopted there are likely to be continuing debates on several questions. The main ones that require further exploration as experience grows are:

a) Is it reasonable to make assessments of overall landscape sensitivity without considering sensitivity to a specific type of change? In what circumstances will this approach work?

b) To what extent should considerations of 'value', as discussed in **Section 6** of this paper, be taken into account in landscape capacity studies? This paper argues that they should be, provided that these considerations are clearly thought through and appropriately incorporated in the judgements that are made. Simply relying on designations is to be avoided as this is an oversimplification of complex issues but the issue remains of whether there is agreement about the way that value can be defined. At present it seems that this approach to defining capacity, by combining sensitivity and aspects of value, is reasonably well accepted in Scotland, particularly in recent wind farm capacity studies, but less so in England.

c) How can transparency about the approach to making judgements be achieved without the explanations becoming unnecessarily complex and inaccessible?

d) To what extent is quantification of assessments of sensitivity or capacity either necessary or desirable, as discussed in **Paragraph 7.11**? Both quantification and consideration of value suffer from the spectre of the 1970s approaches to landscape evaluation which hangs over them. This needs to be recognised when deciding on and presenting an appropriate approach, in order to avoid unnecessary arguments about its suitability.

Future developments

8.6 This Topic Paper is not intended to be a definitive statement about issues of landscape sensitivity and capacity. Nor is it the intention to recommend or promote a single method. This is a rapidly developing field in which practitioners are actively exploring different approaches in different circumstances. The Topic Paper may be amended in future as experience accumulates and the strengths and weaknesses of different approaches become more apparent as they are applied in practice. In the meantime comments on the content of the Topic Paper are invited to assist in this evolutionary process. The discussion forum on the Countryside Character Network website should be used for this purpose if you want to share your views with the wider practitioner community. Alternatively you can send your views by post to the coordinators of the network. Web site address and network contact details are provided in the 'Further Information' section.

References and Further Information

[1] Countryside Agency (2003) *The State of The Countryside 2020*. CA 138. Countryside Agency. Cheltenham.

[2] Scottish Natural Heritage (2001) *Natural Heritage Trends - Scotland 2001*. Scottish Natural Heritage. Battleby, Perth.

[3] Landscape Institute and Institute of Environmental Management and Assessment (2002) *Guidelines for Landscape and Visual Impact Assessment.* Spon Press, London.

Useful Web Sites

Countryside Character Network
www.ccnetwork.org.uk

Landscape Character Assessment Guidance (available on line)
www.countryside.gov.uk/LivingLandscapes/countryside_character
or www.snh.org.uk/strategy/LCA

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Appendix F

Visibility and Visual Effects Guidance

Please note that the contents of the this appendix do not represent the Planning Policy of the Welsh Assembly Government

Visual Assessment of Windfarms: Best Practice

Report No. F01AA303A

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This report should be quoted as:

University of Newcastle (2002) Visual Assessment of Windfarms Best Practice. *Scottish Natural Heritage Commissioned Report* F01AA303A.

COMMISSIONED REPORT
Summary

Visual Assessment of Windfarms: Best Practice
Report No: F01AA303A
Contractor : University of Newcastle

BACKGROUND

The development process for many windfarms requires formal environmental impact assessment (EIA) and the incorporation of the results into an environmental statement (ES). SNH's experience is that there can be a great deal of variation in the way that visual impact assessment (VIA) is dealt with in EIA. This project involved: a review of relevant guidance, research and development work on visibility, visual impact and significance; an investigation of the visibility of eight existing Scottish windfarms; a comparison between as-built visibility and estimates of visibility in the ESs; evaluation of Zone of Visual Influence (ZVI) and other assessment tools; and generation of Best Practice Guidelines for VIA of windfarms.

MAIN FINDINGS

- Many guidelines on windfarm development appear to be based on first generation windfarms and need to be revised for second and third generation turbines.
- There is some research and a wide and diverse range of guidance and opinion on the detailed issues of ZVI, distance, visibility and significance for windfarms, explained by the complexity and the subjectivity of the issues, the desire of one set of windfarm interests to minimise the political, professional and public perception of the visual (and landscape) effects of windfarms and an opposing desire by another set of interests to maximise these perceptions.
- The magnitude or size of windfarm elements, and the distance between them and the viewer, are basic physical measures that affect visibility, but the key issue is human perception of visual effects, and that is not simply a function of size and distance.
- The influences on apparent magnitude are reviewed, including factors that tend to increase it and factors that tend to reduce it. A new conceptual model and schema for assessing visual effects is provided.
- Based on survey work at eight sites - Beinn An Tuirc, Beinn Ghlas, Deucheran Hill, Dun Law, Hagshaw Hill, Hare Hill, Novar and Windy Standard - an overall analysis is provided of the effects on visibility of the Size and Scale of the Development, Proportional Visibility, Lighting, Movement and Orientation, Distance, Colour and Contrast, Contrast, Skylining and Backclothing, Elevation of Windfarm and Human Receptor and Colour and Design.
- Zones of Visual Influence (ZVI) are never wholly accurate and other tools such as photomontage are never wholly realistic. Suggestions are made of ways to address these issues.

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For further information on the SNH Research & Technical Support Programme contact ascg@snh.gov.uk

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1 INTRODUCTION

1.1 Concern for the landscape, visual and other environmental effects of tall, industrial or technological structures in the landscape is not new (e.g. Goulty, 1990). In the case of windfarms, however, there is universal acknowledgement that the potential landscape and visual effects are among the most important and to some extent the most intractable issues for obvious and well-rehearsed reasons (e.g. Coles & Taylor, 1993; Lindley, 1994).

1.2 Strategic approaches to the siting of windfarms are advocated through the use of tools such as Geographical Information Systems (GIS) (e.g. Sparkes & Kidner, 1996) and there are commercial software packages such as WindFarmer (Garrad Hassan, no date), WindPRO (EMD, no date) and WindFarm (ReSoft, no date) that combine GIS with procedures for calculating Zones of Visual Influence (ZVI) and producing photomontages. It is not clear if such software is in widespread use in the UK. Ultimately, however, the assessment of all but the smallest individual development project for a windfarm requires formal environmental impact assessment (EIA) and the incorporation of the results of that assessment into an environmental statement (ES).

1.3 Under the EIA Regulations, effects on landscape must be assessed. Established guidance (LI-IEA, 1995 and LI-IEMA, 2002) makes a distinction between landscape effects and visual effects, the latter being considered a specific subset of the former. *"Landscape effects derive from changes in the physical landscape which may give rise to changes in its character and how this is experienced. This may in turn affect the perceived value ascribed to the landscape. … Visual effects relate to the changes that arise in the composition of available views as a result of changes to the landscape, to people's responses to the changes, and to the overall effects with respect to visual amenity"* (LI-IEMA, 2002). In this report the focus is mainly on the visual effects for the reasons discussed below.

1.4 Scottish Natural Heritage's (SNH) experience is that there can be a great deal of variation in the way that assessment of both visual impact and the significance of visual impact are dealt with in EIA documents, including the appropriate distance for Zone of Visual Influence (ZVI) surveys. The latter attracts a degree of contention amongst some developers and landscape professionals. There is therefore a need for some independent opinion on all these aspects.

1.5 The brief for the current study (Appendix 4) therefore required that it address the following aims:

- to identify any relevant work on visibility, visual impact and significance
- to investigate visibility of existing windfarms
- to compare as-built visibility with estimates of visibility in ESs
- to draw conclusions about appropriate distances for ZVI in different circumstances

1.6 A series of research questions has therefore been posed in order to address these aims:

- What research, policy, guidance and opinions exist on issues related to the assessment of the magnitude and significance of the visual effects of windfarms?
- Is this literature consistent, and if not, what are the sources of and details of any differences?
- What are the key factors that affect visual effects and the assessment of those effects?
- What is the visibility of existing windfarms, and is this real-life visibility as predicted by the literature and as predicted in EIA? If not, why not?

- Based on the answers to those questions, can recommendations be made for best practice with regard to visual impact assessment within EIA?

1.7 This report is divided into six main sections as follows:

- The methodology and approach used for the study are described in section 2.
- Background research is described in section 3.
- Survey and analysis of eight case-study sites are described and analysed in section 4.
- An analysis of the overall survey is described in section 5.
- Discussion of the overall findings of the study appears in section 6.
- Recommendations for Best Practice Guidelines are summarised in section 7.

Table 1: Case Study Windfarms

Windfarm *	Local Planning Authority	SNH Office	OS Sheet/ Grid Reference	Location
(1) Beinn an Tuirc, Kintyre (2001)	Argyll & Bute Council	Argyll & Stirling	68/NR 753361	Centre/East of Kintyre
(2) Beinn Ghlas, Oban (1999)	Argyll & Bute Council	Argyll & Stirling	49/NM 980257	5km south of Taynuilt, 10 km east of Oban
(3) Deucheran Hill, Kintyre (2001)	Argyll & Bute Council	Argyll & Stirling	62/NR 760440	Centre/East of Kintyre
(4) Dun Law (Soutra Hill), Borders (2000)	Scottish Borders Council	Forth & Borders	66/NT 465575	South of Soutra and north west of Lauder
(5) Hagshaw Hill, Douglas (1995)	South Lanarkshire Council	Strathclyde & Ayrshire	71/NS 790307	4km west of Douglas
(6) Hare Hill, Ayrshire (2000)	East Ayrshire Council	Strathclyde & Ayrshire	71/NS 655098	Near New Cumnock
(7) Novar, Dingwall (1997)	The Highland Council	East Highland	20/21/NH 555715	6km north west of Evanton
(8) Windy Standard, Galloway (1996)	Dumfries & Galloway Council	Dumfries & Galloway	77/NS 615015	9km north east of Carsphairn and east of Loch Doon

* The date given is when the windfarm was built and/or commissioned.

2 METHODOLOGY

2.1.1 The project has followed the requirements and guidance of the brief in all key respects and proceeded as follows (Figure 1).

2.2 Background Research

2.2.1 Both published and grey literature[1] on relevant topics was reviewed. The World Wide Web was searched for access to a wide range of unpublished guidance, opinion and comment. Although the primary focus was on Visual Impact Assessment (VIA), there are many other sources concerning renewable energy or wind energy that refer indirectly to technical detail concerning VIA and these have been included wherever relevant.

Figure 1: Project Methodology

Background Research

Including published, refereed and "grey" literature, via systematic searches of bibliographic data-bases and using search engines.

To include ZVI, visual impacts of windfarms, distance-visibility-perception issues, selection of viewpoints, distance-significance issues, "Guidelines" and Environmental Statements for windfarms.

Consultation

Request for information using short telephone questionnaire to SNH regional-local offices.

↓

Case Study Windfarms

(1) Beinn an Tuirc, Kintyre (2) Beinn Ghlas, Oban (3) Deucheran Hill, Kintyre (4) Dun Law, Borders (5) Hagshaw Hill, Douglas (6) Hare Hill, Ayrshire (7) Novar, Highland (8) Windy Standard, Galloway

↓

Review of Environmental Statements

For the selected windfarms, to include evaluation of methods used (ZVI, wireframe, photomontage), definitions of significance, methods of determining significant viewpoints, and predictions of visibility and significance.

↓

Survey of Windfarms

Site visits to compare predictions made in ES with results on site. Two visits to be made to each site, to capture diverse weather-visibility conditions. Visits to be to selected key viewpoints for each site. Time constraint will restrict assessment to accessible viewpoints (by car or short distances on foot i.e. excluding remote vantage points on e.g. Southern Upland Way or the islands). Identification of any visibility issues omitted (based on site visit supplemented by advice from SNH).

↓

Analysis

Of accuracy of ES predictions, including evaluation of significant factors:
Observer factors - sight, perception, opinion
Windfarm factors – size, number of turbines, movement-flicker effects
Landscape factors – topography, land-cover
Meteorological factors – season, light, weather
Other factors – intervisibility, cumulative impacts

↓

Conclusions & Recommendations

Regarding "Best Practice Guidelines" for developers (and others) on the environmental assessment of the visibility and visual impacts of windfarms.

2.3 Case Study Sites

2.3.1 The character of the landscape, weather and other environmental effects are important and so the study was required to focus mainly on Scotland. Selection of case study sites was iterative. A first short list was compiled from those windfarms built and operating in Scotland (Appendix to Brief), concentrating on the larger windfarms (in terms of numbers of turbines). Next, the age of the windfarms, the landscape character and the availability of Environmental Statements were examined. A final selection of eight sites was chosen, all in Scotland (Table 1). The ES for each windfarm was obtained through SNH[2] (Appendix 1).

2.4 Case Study Survey and Analysis

2.4.1 An identical survey and analytical procedure has been used at each case study site. First, the Environmental Statement and related or supplementary documents (Appendix 1) were analysed to extract basic information (if present) on the ZVI, viewpoints, visualisations (including photomontages) and terms used to define visual significance. The main focus was on the key elements of the Visual Impact Assessment (VIA) and not on the broader Landscape (including landscape character) Assessment.

2.4.2 Next, a contact within SNH (including some advisors who have since left the organisation) was telephoned to ask about the process of environmental assessment for each case study and to discover information not available from the ES, such as whether a public inquiry was held. Although we began asking for detailed recollection from each contact (for example: Did SNH advise on the precise radius of the ZVI? Were all viewpoints identified by SNH included or were any excluded?), this proved an unrealistic expectation. Contacts quite reasonably could not recall case details from several years previous and were only able to give general comments and recollections. Whilst case details could be extracted from archived SNH files, we did not pursue this due to time constraints. The contacts were able to comment on changes made between the windfarm *"as assessed"* and *"as built"*, but again could not provide site-specific details on turbine re-locations and similar adjustments. In some cases there are significant differences between *"as assessed"* and *"as built"* that have affected our ability to test the accuracy or otherwise of the ES.

2.4.3 Finally, site visits were made during which as many viewpoints as practicable were visited and a comparison made between the appearance of the windfarm on site and the verbal description and photomontage (if any) presented in the ES. Records of the weather, time of day, light levels, visibility etc were made. The site survey protocol was devised and field tested at Dun Law windfarm by all three surveyors, and then revised and refined before being applied at the remaining seven sites. Each site was visited by one of the professional landscape surveyors accompanied by an assistant. The numbers of visits to each viewpoint are noted in Section 4.

2.5 Timetable

2.5.1 Site visits to the case study sites were made on the dates shown in Table 2. Two visits were made to each windfarm, except at Novar where one visit was made.

2.6 Limitations

2.6.1 The study was constrained by time, and by time of year, and these factors must be borne in mind in the interpretation of the results. The whole project was executed over a short period of approximately 8 weeks. Field work was completed during January and February 2002 and so was not able to compare visibility or visual effects over four seasons and during a wide range of light and weather conditions. Although most sites were seen in contrasting weather conditions, it was not possible to ensure that every viewpoint at every case study site was observed in contrasting conditions (for example, overcast and clear skies).

Table 2: Fieldwork Timetable

DATE	DAY	KES	SPJ	JFB
30 Jan	Wednesday	Dun Law	Dun Law	Dun Law
3 Feb	Sunday	Beinn Ghlas		
4 Feb	Monday	Deucheran Hill Beinn An Tuirc		
6 Feb	Wednesday		Hare Hill Hagshaw Hill	
7 Feb	Thursday		Windy Standard	
9 Feb	Saturday			Novar
13 Feb	Wednesday		Windy Standard	
14 Feb	Thursday		Hare Hill Hagshaw Hill	Dun Law
17 Feb	Sunday	Deucheran Hill Beinn An Tuirc		
18 Feb	Monday	Beinn Ghlas		

2.6.2 It was not practical to visit every viewpoint in every ES; inaccessible or remote viewpoints (such as on islands, at the tops of mountains or hills or in remote walking terrain) were in general omitted from the study. Particular case study site limitations are mentioned in section 4 and may affect the comprehensiveness of the diagnosis for individual windfarms. Adverse weather conditions were a significant constraint in Kintyre. However, overall the study team assessed 70 viewpoints and made 113 individual viewpoint assessments; the more generalised diagnoses and conclusions from these pooled results are therefore more robust, limited only by the seasonal constraints.

3 BACKGROUND RESEARCH

3.1 Guidelines on Windfarm Development

3.1.1 We have reviewed a range of guidelines on windfarm development. There is universal acknowledgement that visual effects are important, that they depend on distance, size, visibility and other factors, and on both landscape and visual receptors. Whilst there is some evidence to suggest a degree of professional landscape consensus on VIA and significance, there is extremely diverse and subjective opinion among other stakeholder groups. Some guidelines quote specific distances for recommended ZVI or for the relative impacts (and by implication significance) of visual effects in relation to distance. Some guidance appears to be re-cycling guidance from other sources and justification for any specific distances quoted in these documents is rare. In most cases any distance-effect guidance is not related directly to or varied with the size or height of turbine towers, but appears to be based on first-generation windfarms with tower heights (to hub/nacelle) of 25-30 m approximately (40 – 55 m overall).

3.1.2 The latest version of National Planning Policy Guidance 6: Renewable Energy Development (Scottish Executive, 2001) sets out broad policy but contains no detailed technical advice concerning the assessment of landscape or visual effects (but see below). Similarly, Department of the Environment (1993)(Planning Policy Guidance 23) is generic but non-specific, although it does recommend light grey/white colours as most suitable for towers, nacelles and blades in Northern Europe. Department of the Environment (1995) quotes as an example that the zone of visual influence for a particular windfarm development in Britain has been calculated to be approximately 10 miles (16 km), but without any detail. Scottish Executive (2002)(Planning Advice Note 45) offers the following general guide (Table 3) to the effect that distance has on the perception of a windfarm development in an open landscape (without relating this to tower height, but having earlier referred to turbines of tower height >70m and rotor diameters of >80m):

Table 3: General Perception of a Wind Farm in an Open Landscape

	Perception
Up to 2 kms	Likely to be a prominent feature
2-5 kms	Relatively prominent
5-15 kms	Only prominent in clear visibility – seen as part of the wider landscape
15-30 kms	Only seen in very clear visibility – a minor element in the landscape

Source: PAN 45 (revised 2002): Renewable Energy Technologies.

3.1.3 A similar table appeared in the Draft NPPG6 Consultation Document (2000), and the comments made on that Draft are of interest. For example, the British Wind Energy Association (BWEA) asked for the term *"impact"* to be replaced by *"effect";* argued that the table of perceptions of impact was prejudicial and asked for its removal; and offered that *"significant visual effects of wind turbines are only experienced within 5 km; beyond 15 km wind turbines can generally only be seen in very clear visibility and even when visible are likely to be a minor element in the landscape"* (Powergen Renewables made essentially the same argument).

3.1.4 Other consultees referred to the fact that turbines are increasing in size; that the Novar windfarm is clearly visible at 30 km; preferred a recommendation of semi-matt to matt surfacing for towers; and raised the issue of cumulative effects. Several consultees referred to the Sinclair-Thomas Matrix (see section 3.7 and Table 4) without identifying its source, pedigree or publication. As a result of these consultations, almost all reference to particulars was removed from the final version of NPPG6. Some details do however reappear in PAN45, but the word *"dominant"* which appeared in the table in NPPG6 Consultation Draft is changed to *"prominent"* in the table in PAN45 (above).

3.1.5 Scottish Natural Heritage (2001) is the most detailed of any statutory agency guidance available or published. Whilst it contains detailed information on issues of siting and design, and the processes of site planning, it also contains a specific recommendation that a ZVI should usually extend to at least 25 km. The Countryside Council for Wales (1999) specifies a ZVI of at least 10 km from the site (for wind turbine proposals) and up to 20 km on the fringes of National Parks and Areas of Outstanding Natural Beauty (AoNB) and in areas likely to be seen from such distances. Countryside Commission (1991) suggests an outer limit of 10 – 15 km for ZVI. There is no up-to-date Countryside Agency guidance in existence but we understand it is in preparation.

3.1.6 It is likely that much local government guidance exists, but a comprehensive review would have required letters or questionnaires to each organisation; a small selection available on the www is noted here. Cornwall County Council (no date) is general development guidance and is based on Landscape Institute - Institute of Environmental Assessment (LI-IEA)(1995). It combines the concepts of impact magnitude and receptor sensitivity (both *"landscape"* and *"viewer"* for landscape and visual respectively) and then offers two matrix tables for evaluating landscape and visual significance.

3.1.7 Specifically for windfarms, Moray Council (2001) recommends the use in EIA of a ZVI map and viewpoint analysis based on wireline diagrams and photomontage without specifying any distance or technical detail for these. Cornwall County Council (1996) (Appendix A: Visual Impact Assessment of Delabole Wind Farm) describes how this project (which began operation in December 1991, comprising 10 No 400 kW turbines, each 40.4 m high inclusive), was assessed using a ZVI of 7.5 km and based on the nacelle height only (32 m).

3.1.8 South Norfolk District Council (2000) (Supplementary Planning Guidance) is more explicit, and contains the following specific guidance (extract)(although the South Norfolk topography and landscape character are very different to much of Scotland): *"The following seven general principles … should be met if the visual impact of any proposal is to be minimised: … ii) Where a proposal lies within 5km of the Broads Authority Executive Area boundary, it would only be acceptable if it was demonstrably capable of locating without visual intrusion to the Broads; … vi) Proposals should be spaced at not less than 5km intervals from each other in order to prevent substantial adverse cumulative impacts which might exceed the capacity of the landscape to accommodate wind developments; …".* The SPG also recommends that any visual assessment is made on a 20km radius of the proposed large turbines in its zone of visual influence.

3.1.9 Cumbria County Council (1999) is the most detailed local government guidance we have identified. It is based on turbine heights to a maximum of 60 m and recommends a basic ZVI of 20 km and the visualisation of key viewpoints within 10 km. It also addresses cumulative effects, recommending such assessment for windfarms within 20 km of each other, and contains a range of further detailed guidance on both landscape and visual impact assessment.

3.1.10 The British Wind Energy Association (1994) suggests that the ZVI should be defined within a radius agreed with the local planning authority but contains no specifics concerning ZVI or other visual assessment tools.

3.1.11 The Campaign for the Protection of Rural Wales (CPRW)(1999) draws attention to the progressive increase in installed capacity and size of individual towers between 1991 to 1998 of from around 300 kW (41.5 m) to 600 kW (60 m) and notes that future increases will come from higher capacity machines of 1.5 MW (c 95 m) or more and that due to their extended threshold of visual intrusion, their impact would not be correspondingly diminished and would be considerably intensified at closer range. CPRW has argued that 95 m turbines could be visually intrusive at a 12 km radius and readily discernible at 22 km (Sinclair, 2001, discussed further at sections 3.7 and 6.2) so that CPRW recommend a *"radius of visual impact analysis of 30 km compared with 20 km for the current typical 55 m turbines".* They note the potential siting of turbines offshore and call for this to be at non-intrusive distances from the coast (more than 10 km and preferably 15 km). CPRW state that 60 m turbines can be visually significant within a 15 km radius and forecast 20 km for 95 m turbines. Thomas (1996) argues for 20 km or more (ZVI) for large-scale developments and the landscape terrain of the Mid Wales upland plateaux.

3.1.12 Although the project has not been able to review international guidance, we did note that guidance from New Zealand (EECA, 1995) explicitly omits detailed recommendations for assessing visual effects and argues that *"each development will need to be considered on its merits in terms of site and locality-specific considerations such as distance, back-drop, landscape scale and number of potential viewers".*

3.2 Research and Development Studies

3.2.1 Reference to ZVI and visual significance is contained in several national, supra-national and international research and development reports, some focused on wind power and some considering renewables in general.

3.2.2 AEA Technology plc (AEAT)(1998) is part of a study attempting to produce an overall valuation (or cost-benefit analysis) for the whole wind fuel cycle, including monetary estimates of the aggregate visual amenity damage of windfarms. It offers an *"Impact Pathway for Visual Intrusion"* and refers to the *"visual burden"* and the *"objective impact*" of that burden, and then contrasts this with the *"perceived impact"* which is influenced by attitudes and the existing land form and scenery. It refers to ZVI as zones of visual intrusion and notes that *"It can be concluded that there is unlikely to be any significant visual impact at a range of greater than 6 km",* although this conclusion is not justified.

3.2.3 The International Energy Agency (IEA)(1998) uses similar language to AEAT (1998), emphasising the difference between the visual burden (comprised of the height, shape, form, colour and number of turbines themselves) and human responses to it. It goes on to state that beyond 20 km the turbines will not be visible to the human eye (apparently based on towers of *"40 m height with the blades adding another 20 m*") and that in practice there are very small or negligible effects on visual amenity beyond 12 km. *"Between 6-12 km, the towers are indistinct and the rotor movement will be visible only in good conditions. Therefore, the visual amenity effects are generally concentrated within 6 km of the wind farm"* (the latter conclusions appear to be based on Eyre, 1995).

3.2.4 The European Commission (EC)(1997) (also based extensively on Eyre, 1995) states that *"a 1.5 MW turbine looks little different from a 500 kW machine, so the continuing trend towards larger wind turbines may, paradoxically, reduce the subjective visual effect of a given installed capacity".* Although not explained, this may be a reference to the suggestion that any enlargement is very difficult to perceive if there are few comparable scale indicators in the landscape, although this ignores the effect of height on the visibility distance and also ignores the effects of magnitude near to a tower. It notes that *"two bladed rotors appear to tilt with respect to the horizon whereas three bladed rotors appear to revolve and are therefore more calm and pleasant to view"* but it makes no reference to distance effects.

3.2.5 Soerensen & Hansen (2001) focus on offshore windfarms and note that it is assumed that the visual impact to viewers at sea level is negligible when the farms are located more than 8 km from shore. With distances larger than 45 km, the visibility will be almost zero due to the curvature of the earth's surface. These distances will be greater where there are elevated viewpoints but may also be severely reduced depending on the atmospheric clarity. They quote a study in Germany where visual impact would not be regarded as a problem at all if the farms were placed 15 km from shore. CADDET (2001) reports briefly on studies for two offshore windfarms in Denmark. The Horns Rev windfarm (eighty 2 MW turbines in a grid pattern 14-20 km offshore) *"will be visible from shore on a very clear day"* but *"the dominance of the windfarm in the landscape as viewed from the shore will be so modest that the impact is likely to be minimal".*

3.2.6 Quantitative research on ZVI, distance and visual impacts appears less common. Hull & Bishop (1988) examined the effects of electricity pylons on the landscape and in particular the relationship between distance and scenic impact. Based on the use of photographs and a rating of *"scenic beauty"* on a ten-point scale, they found that the visual impact decreases rapidly as distance increases. Most of the impact occurred in the 100 m to 1 km range, and the impact at 500 m was about 25% of the maximum, whilst at 1km it was 10%. The tower's scenic impact was also influenced by the landscape surrounding the tower. It appeared that towers had less impact in more complex scenes, especially at larger distances, presumably because the tower becomes less of a focal point and the observer's attention is diverted by the complexity of the scene.

3.2.7 Recent research by Bishop (in press) used animated computer simulations in paired comparisons of scenes, with and without a wind turbine, to test the ability of respondents (students) to first detect, then recognize, and then judge the impact of the turbine in relation to distance, contrast and atmospheric conditions (drawing on detailed equations from Shang & Bishop, 2000). The test turbine was 63 m in height (to rotor tip). His key conclusions (drawn from a Draft report by the Windfarm Steering Committee, Victoria, Australia, supplied by Nigel Buchan) are that:

- Recognition was only made by 5% of respondents at 30 km distance
- Recognition was only made by 10% of respondents at 20 km distance
- The most significant drop in recognition rates occurred at 8-12 km in clear air
- The most significant drop in recognition rates occurred at 7-9 km in light haze
- Visual impact drops rapidly at approximately 4 km and is <10% at 6 km in clear air
- Visual impact in light haze is not greatly different. A rapid decrease in visual impact begins at under 4 km and is <10% at 5 km
- Low contrast in light haze reduces the distance thresholds by 20%
- High contrast can dramatically increase the potential impact of white towers
- Ratings are highly sensitive to changing atmospheric conditions.

Given the size of the test turbine, these controlled and simulated findings are not dissimilar to the empirical results reported in Stevenson & Griffiths (1994) and Turnbull Jeffrey Partnership (1997)(Appendix 5), discussed below.

3.2.8 Research has been carried out, mainly in the USA and Denmark, into observer attitudes to the symbolism and meaning of wind energy (e.g. Thayer & Freeman, 1987; Wolsink, 1989, 1990), and into design issues such as scale, visibility, dominance, coherence, diversity, and the effects of site layouts (e.g. Bergsjo et al, 1982), but this research does not contain details that would inform the present study. For example, in some research smaller turbines appeared to have a lower effect than larger turbines, but this was a small preference compared to the effect of the number of units, so that people preferred fewer larger turbines. One potentially contradictory piece of research evidence is that on the one hand people find moving rotors more attractive than static ones, so that motion has been equated with lower perceived visual impact by some commentators, whilst elsewhere there appears to be agreement that movement makes the turbines more conspicuous than they would otherwise be.

3.2.9 Atkins Planning (1986) carried out a scoping study for the Energy Technology Support Unit on the visual impact of large wind turbines (up to 50 m high), which contains a range of sound, general observations and conclusions, although the penetration of such commissioned reports into wider circulation and practice is less clear. For example, we found no reference to that report, or Stevenson & Griffiths (1994), discussed below, in any of the ESs examined for the current study (except for an indirect reference to Stevenson & Griffiths in the Dun Law ES).

3.2.10 Stevenson & Griffiths (1994) carried out a comprehensive post-development audit of eight windfarms in England and Wales, visiting each windfarm on up to four occasions throughout the year. Six viewpoints were analysed at each site at distances up to 20 km, although in practice topography and visibility restricted views from 10 km and prevented views beyond 16 km for all sites. Photographs used a medium format camera (image area 4.5 x 6 cm) and a 80 mm focal length lens *"to provide an image closest to that of the human eye"*. The case study sites included turbines ranging in maximum height from 40.0 to 61.5 (but six were within the range 40.0 – 43.5 m) and in a variety of landscape settings.

3.2.11 Drawing on previous literature, and their own judgements, they devised an impact-zoning schema as follows:

> *"i) Visually dominant – the turbines dominate the field of view and appear large scale. The character of the immediate area is substantially altered and the movement of the rotor blades is obvious.*
>
> *ii) Visually Intrusive – The turbines appear fairly large in scale, and an important element in the landscape. However, they do not necessarily dominate the field of view. Blade movements are clearly visible and can attract the eye.*
>
> *iii) Noticeable – The turbines are clearly visible but not intrusive. The windfarm is noticeable as an element in the landscape. Movement is visible in good visibility but the turbines appear small in the overall view. Some change to the landscape setting is likely.*
>
> *iv) Element within Distant Landscape – Turbines are indistinct and form minor insignificant elements within a broader landscape. Movement of blades is generally indiscernible. The apparent size of the turbines is very small".*

3.2.12 Their main conclusions are that

- *In most situations turbines dominated the view up to a distance of 2 km (zone (i)).*
- *Turbines appear visually instrusive at distances between 1 and 4.5 km in average to good visibility (zone (ii)).*
- *Turbines are noticeable, but not intrusive, at distances between 2 and 8 km, depending on atmospheric conditions and other factors (zone (iii)).*
- *Turbines can be seen as indistinct elements within the distant landscapes at distances of over 7 km (zone (iv)).*

3.2.13 They also include further analysis and discussion concerning the effects of atmospheric conditions and seasonal variations, before analysing a number of VIA techniques. For ZVI, they recommend 10 km as suitable in most conditions. For photomontages, they make a number of straightforward recommendations, but in particular note that the size of the original photograph will affect the apparent size of the turbine image, stating that *“where photographs smaller than A3 are used, the turbines on the photomontage appear smaller than in reality”* and *“An A3 size print viewed from approximately 8 “ [20 cm] gives an accurate rendition of scale”.*

3.2.14 A recent study on ZVI, distance and visibility has been carried out at Hagshaw Hill windfarm for Scottish Power plc, as part of the preparation of the Beinn an Tuirc ES (Turnbull Jeffrey Partnership, 1997). Although we have not been able to examine the full report, we have reproduced a summary of it in Appendix 5 (from Scottish Power, 1997) because it covers similar issues to the present study.

3.2.15 It is evident that there is some research and a wide range of guidance and opinion on the detailed issues of ZVI, distance, visibility and significance for windfarms. Some of the differences identified might be explained by much of the early work having been based on first generation windfarms of a maximum height of from 40 to 55 m. Other differences can be attributed to both the complexity and the subjectivity of the issues, especially concerning visibility, perception and significance. A final influence is probably the desire of one group of windfarm interests to seek to minimise the political, professional and public perception of the potential visual (and landscape) effects of windfarms, and an opposing desire by another group of interests to maximise these perceptions. In practice, those differences must be resolved and decisions made.

3.3 Visual Effects and Design Issues

3.3.1 IEA (1998) notes that stroboscopic effects are minimised by keeping rotation rates below 50 rpm for three-bladed machines (75 rpm for two-bladed machines). The flicker effect (from the effect of sunlight streaming past the rotating turbine blades) has only a short potential duration each day and depends on a number of other criteria. In any event, effects should be minimal at distances greater than 300 m. It also states that *“Visual impacts are only normally important for residents and tourists up to a distance of about 10 km, with the main effects on amenity being concentrated within a few kilometres of the wind farm”.*

3.3.2 The Danish Wind Industry Association (2000) offers some simple suggestions regarding design issues, similar to but much less comprehensive than SNH (2001). SNH (no date) remarks that *“experiments in blade colour have shown that pale blue, brown and grey rather than white appear to be more recessive, whilst a matt surface reduces the amount of glint”*, whilst Stanton (1996) argues that the colour used should be white rather than off-white or grey, arguing that this (white) represents a forthright design statement, rather than off-white or grey which may be seen as a form of deception. Stanton argues that white is associated with purity and neutrality, whilst grey appears technically primitive, linked with other industrial elements. Gipe (1995) reviews public opinion surveys and a range of design guidance, based on North American and European experience, to arrive at conclusions not dissimilar to the guidance contained in SNH (2001).

3.3.3 A recent study (European Wind Energy Association, 2000) has examined the colour issue afresh and has explored a wide range of colours, combinations and design approaches – including camouflage, blending and articulation – but the work was restricted to explorations using photomontage and we are not aware of any field testing of different colour combinations. *“The overall conclusion was that graduated colour schemes worked well in all situations, especially helping to "root" the turbines in their setting. In terms of actual colours, "earthy" colour schemes - browns, greens and oranges – were found to tie the turbines to their surroundings more effectively than "airy" blues and greys. Schemes using a range of different grey shades on different turbines in a group, and an idea for "false shadows" – three or four shades of grey in vertical irregular stripes up the tower - were both* *considered visually confusing".* It is not clear from this report whether the issue of visibility and perception in relation to distance was included in this study of colour.

3.4 Visibility and Perception

3.4.1 Viewed by the human eye 1.8 m from the ground across a *"flat"* surface such as the sea, the horizon will be of the order of 6 km distant, due to the curvature of the earth. Viewed at an elevation of 60 m, the horizon will be of the order of 32 km distant and from the top of a 1000 m mountain the horizon will be at a distance of approximately 113 km. A tall structure standing above the horizon would of course increase these distances significantly; for example, for an observer at 1.8 m who is viewing a man-made structure 50 m tall, the effective distance to the horizon is 34 km and for a 100 m structure the distance is 46 km (Miller & Morrice, no date).

3.4.2 However, actual human perception is affected by the acuity of the human eye. In good visibility (visibility is meteorologically defined as the greatest distance at which an object in daylight can be seen and recognised), a pole of 100 mm diameter will become difficult to see at 1 km and a pole of 200 mm diameter will be difficult to see at 2 km. In addition, mist, haze or other atmospheric conditions may significantly affect visibility (Hill et al, 2001). Assuming this relationship is linear, and assuming absolute clarity of view, this suggests that the outer limit of human visibility in clear conditions of a pole (e.g. a notionally cylindrical wind turbine tower) 5000 mm (5 m) in diameter (a representative figure for a 60+ m high tower) will be of the order of 50 km; and the absolute limit of visibility imposed by the limit of the horizon viewed across a flat plane is similar at approximately 46 km.

3.4.3 Although there is frequent reference in ESs to the effect of reduced visibility caused by atmospheric or weather effects, data is rarely used to quantify this effect (the Hare Hill ES is an exception among the case study sites, and Stevenson & Griffiths (1994) also use such data). Such data is available from the Meteorological Office.

3.4.4 Physical visibility is not, of course, the only issue. Human perception is equally important in considerations of if and how a windfarm will be seen. Whole branches of medicine, ophthalmology, psychology and many applied sciences are concerned with perception. Numerous text books provide illustrations of the complexity of perception, including many familiar optical illusions. These issues are critically important in areas such as the design of roads and signage, in the training of airline pilots, the analysis of accidents and the design of machinery. Whilst the thrust of much research is concerned with how people can be deceived or make perceptual misjudgements, there are several key points that we believe may be material to VIA for windfarms.

3.4.5 People perceive size, shape, depth and distance by using many cues, so that context is critically important. When people see partial or incomplete objects, they may mentally *"fill in"* the missing information, so that partial views of turbines may have less effect than imagined. Although people may be able to physically *"see"* an object, inattentional *"blindness"* caused by sensory overload, or a lack of contrast or conspicuousness, can mean they fail to *"perceive"* the object. In a contrary way, large size, movement, brightness and contrast, as well as new, unusual or unexpected features, can draw attention to an object. In all these effects, issues such as experience, familiarity and memory may have an important role to play. Therefore, perception depends on experience, the visual field, attention, background, contrast and expectation, and may be enhanced or suppressed.

3.4.6 Two important issues, depth perception and size constancy, deserve further discussion. At least six monocular cues (cues dependant on one eye only, compared to binocular cues that require both eyes) are recognized as being used in the perception of depth and relative distance. These include (i) interposition (one object partially obscuring another appears nearer), (ii) the relative size of the retinal image (an object of known size is perceived to be further away if the image is smaller), (iii) the height of an object relative to other objects (an object at a lower level is perceived to be nearer), (iv) objects that appear clearly visible are judged to be nearer than others which are less clear, (v) linear perspective (converging lines in the landscape can create this effect), and (vi) movement cues (fast movement is judged nearer than slow movement by a stationary observer). We can therefore surmise that these phenomena will act to increase or decrease the apparent distance of a windfarm from the observer in the landscape.

3.4.7 Constancy is the phenomenon in which the properties of familiar or well-known objects appear to be constant and stable irrespective of the circumstances in which they are viewed. In size constancy, objects are perceived as the same size even when viewed from different distances. This is often illustrated using photographs containing people, but applies with any familiar object – the perception of the size of the people is quite different to their actual size on the photograph. This effect appears to be based on factors such as the relative size of other objects, textures and familiarity (the phenomena of shape, colour and brightness constancy are also well-recognised). We can therefore surmise that on viewing a windfarm in the landscape, a human observer could perceive the turbines to be the same size over a potentially long distance range as their familiarity increases, even if the image sizes (on either the retina or a photographic film) are very different.

3.4.8 The general conclusions to be drawn are that the magnitude or size of windfarm elements, and the distance between them and the viewer, are basic physical measures that affect visibility, but the real issue is human perception of visual effects, and that is not simply a function of size or distance. We say more on factors that we believe increase perception of *"apparent size",* and factors that decrease it, in sections 5 and 6.2.

3.5 Zone of Visual Influence[3] (ZVI)

3.5.1 The visibility of a windfarm is of course also affected by topography. The concept of the ZVI[4] in professional landscape work originated in the 1970s. Typically, topographic sections would be plotted and sight lines analysed at, say 10^0, intervals. This manual process was and is crude, slow and laborious. Faster and more refined manual techniques were developed using contour maps and templates or overlays. By the mid-1980s, Jarvis (1985) is describing the use of custom-written computer programs to produce ZVI and related visual assessment tools, but one is a program that takes six hours to execute 100,000 sections checking intervisibility; he gives an example of a ZVI covering 20 km^2 based on a 150 m grid.

3.5.2 The rapid development of computing power and capacity, and a parallel decline in relative costs, is of course familiar, so that a typical desk-top personal computer today might have many times the power of the Jarvis machine. However, the programs needed for calculating visual or landscape impacts over large areas have fallen into a no-man's land between Computer Aided Design (CAD) and GIS so that some companies such as TJP Envision (Turnbull Jeffrey Partnership, 1995; McAulay, 1997) have invested much in-house research and development effort in this area. The results are that today such ZVI calculations can be executed rapidly and relatively cheaply in terms of program costs and computing time (although it should be noted that program running times for ZVI calculations are counted in hours, not minutes, and these times increase linearly with the number of turbines and by the square (or worse) as the area of the ZVI increases).

3.5.3 The basic modules needed to calculate a ZVI are now an increasingly standard feature of much GIS software and integrated links to programs for producing wireframes and photomontages are commonplace. Use of a 50m grid, producing greater refinement and resolution, now appears common and standard. However, the rapid changes in the technology and tools that have taken place during the last 10 years inevitably means that some of the early ZVI in windfarm assessment (including the case study sites) are not as sophisticated or extensive as those appearing in current assessments, and this needs to be borne in mind in assessing aspects of the case study sites analysed later.

3.5.4 Hankinson (1999) describes three possible stages or components of a ZVI. First, a desktop study during which an experienced assessor can usually read the local contours from a 1:25,000 or 1:50,000 plan and gain a good idea of the likely extent of visibility. Next, an analysis (computer based) using a digital terrain model (DTM), cross-sections etc is carried out. Finally, site evaluation. She emphasises the distinction to be made between the ZVI (from the desk study and site evaluation) and what she terms the Zone of Theoretical Visibility (ZTV) derived from computer modelling (Hankinson, Box 16.7, page 367). There are two main sources of error in any ZTV.

3.5.5 First, data errors built into the computer program used include the contour intervals in the baseline data, which affect the degree of interpolation used in the program; and the accuracy and reliability of that data (other error refinements include whether the program takes account of the curvature of the earth etc)(Hankinson, Box 16.8, page 369). For example, a ZTV derived from a DTM based on 1:50,000 contour information (10 m contour interval) may be interpolated and rounded to the nearest metre in the program. The *"1 m interpolation"* assumes a straight-line slope between two contours and cannot take account of rocky terrain that can vary by up to 9.9 m without appearing on the 10 m contour base. Purchased data (from Ordnance Survey) and data digitised in-house also all contain inaccuracies or errors.

3.5.6 The second source of error arises because the ZTV is theoretical, that is it usually assumes a perfectly bare and smooth terrain unencumbered by houses, buildings or other structures, vegetation, hedges, woodland and forests. The site evaluation is the opportunity to take account of landform features that do not appear on the ZTV and landscape features that affect visibility such as trees, hedgerows, fences and buildings. Some programs are being developed that allow the introduction of surface features such as tree cover into the computation of ZVI (e.g. Turnbull Jeffrey Partnership, 1995 and illustrated in the Beinn An Tuirc ES). The key conclusion offered by Hankinson is that users and readers of ZTV/ZVI in environmental statements need to be alert to and explicit about the inherent sources of error, assumptions and limitations of the tools.

3.5.7 Current EIA DTM and ZVI calculations appear to be based on the use of Ordnance Survey (OS) topographic information, which is available for commercial and business use as Land-Form PROFILE (from 1:10,000 scale) or Land-Form PANORAMA (from 1:50,000 scale). The degree of detail, error and cost (at February 2002) of these products are significantly different. PANORAMA is available as 20 km x 20 km tiles (812 tiles cover Great Britain) that cost £10 each. Hence the digital or contour data for a windfarm in the centre of a tile might cost only £10 (to produce a 20 x 20 km ZVI), or £40 in the event that the proposed site fell at the corner of a tile. However, it should be noted that contour intervals are at 10 m and the error is ± 3 m, with a 50 m cell size. When details are stated in the case study ESs, the data set most commonly used is 1:50,000.

3.5.8 PROFILE has contour intervals at 5 m (±1 m) or 10 m (±1.8 m)(cell size 5 m) but each tile only covers 5 x 5 km and more than 10,000 tiles cover Great Britain. The cost per tile varies depending on quantity (e.g. decreasing from £100 - £70 - £42 - £25 per tile). The result is that 9 tiles cover an area 15 x 15 km, 16 tiles cover 20 x 20 km, 25 tiles cover 25 x 25 km and 36 tiles cover 30 x 30 km. The raw data costs are then, respectively, £900 - £1120 - £1750 - £2520. The practical result of this is that we are not aware that PROFILE data is used in ZVI for windfarms.

3.6 The Accuracy of ZVI Predictions

3.6.1 Fisher (1995) has analysed the effects of data errors on viewsheds calculated by GIS programs and shown that the calculations are extremely sensitive to small errors in the data, and to the resolution of the data and errors in viewer location and elevation. Other studies have shown that a viewshed calculated using the same data but with eight different GIS programs can produce eight different results. The direction of such errors – to either over or underestimate the ZVI – is unclear and is not obviously unidirectional. Such errors and effects are well researched and familiar in the detailed GIS technical literature but may not be highlighted in commercial programs or reported in practice reports, which reinforces the conclusion that the ZVI reported in most studies should be described as the Zone of Theoretical Visibility or the *"probable viewshed"*[5], and be subject to subsequent field testing and verification.

3.6.2 Prediction is at the heart of EIA and the general scarcity of detailed post-development audits by which the accuracy of impact predictions might be judged is surprising and regrettable, although some studies are now appearing. A general study by Wood et al (2000) across a range of project types and all (EU Directive) impact categories found that for landscape and visual effects, 40% of predictions were accurate, almost 40% were nearly accurate and approximately 20% were inaccurate.

3.6.3 Wood (1999) has made a detailed audit of the accuracy of a number of EIA predictions, including a ZVI for a clinical waste incinerator in Leeds. He discovered that for the incinerator stack, the ZVI overestimated the spatial extent of project visibility, due mainly to the use of a worst-case and simple topographic model that took no account of the heterogeneous and complex natural and man-made elements in the surrounding landscape.

3.6.4 In a further study (Wood, 2000) he audited the ZVI for four developed projects, including the Ovenden Moor windfarm near Halifax (ES dated 1991) in which the ZVI was determined by desk-study and not by the use of a topographic model or DTM. Overall he found a relatively close match between the predicted and actual ZVI, but including many errors of detail (large discrepancies were revealed for the other projects he analysed). He attributes the detailed errors in part to the fact that the ZVI was based on the tower height excluding the rotors, so that there was systematic under-prediction of visibility at the fringes of the ZVI; however, the general accuracy achieved using a coarse technique based on terrain only is probably due to the homogeneous landscape of the windfarm, dominated by open moorland with virtually no screening vegetation or buildings.

3.7 Visual Effect, Distance and Impacts

3.7.1 The most explicit and structured recommendations on the specific issue of the potential visual impact of wind turbines in relation to distance appears to be the self-styled Sinclair-Thomas Matrix (CPRW, 1999; Sinclair, 2001). This has its origins in a table produced in 1996 by a planning officer of Powys County Council (Thomas) and since revised and updated by a consultant (Sinclair). Assuming unimpeded, good visibility, Thomas defined 9 distance bands (A-I) and classified these with a visual impact rating from *"dominant"* (A) to *"negligible"* (I). This initial table was devised based on the 25 and 31 m hub machines built at Cemaes and Llandinam (Wales) in 1992. At that time, Thomas concluded that *"15 km is considered to be the appropriate radius distance for study"* and according to Sinclair, this became recognised as the norm for ZVI in EIA (apparently irrespective of turbine size).

3.7.2 Sinclair repeated the analysis, concluded that the Thomas distance bands were *"rather conservative",* and revised them upwards. Sinclair then extended the approach to viewpoints around other windfarms, including larger (72 m) turbines at Great Eppleton (Durham), and also projected or extrapolated the recommendations to encompass 90-100 m turbines. Both authors acknowledge that the Matrix is a general guide, especially at the margins of each band, and recognise the important influences of local conditions, viewing direction, turbine angle and the scale and nature of the landscape context. The resulting Sinclair-Thomas Matrix is reproduced in Table 4 (from Sinclair, 2001)(it is repeated in slightly different form in CPRW, 1999).

3.7.3 We have not been able to determine if this Matrix is in widespread use, or if it has been accepted, challenged or revised at public inquiries (although we are aware that it has been presented and used at public inquiries). It is not referred to in any ES we have examined (although many of these pre-date production of the Matrix) and it is not referred to in any of the literature we have examined, barring its citation in CPRW (1999) and Sinclair (2001) and mention in the consultation responses to Draft NPPG6.

3.7.4 Our initial diagnosis is that the Matrix raises several issues and difficulties of interpretation, including the fact that it is based on the professional (if experienced) opinion of two people, and that it sometimes conflates two separate points – magnitude and significance – for example in using the value-laden word *“intrusive”* in Band C. Such

Table 4: The Thomas and Sinclair-Thomas Matrices

THE THOMAS AND SINCLAIR-THOMAS MATRICES (section A) to estimate the potential visual impact of different sizes of wind turbines					
Overall height of turbines (m) >>>		41-45	41-48	53-57	72-74
Descriptors	Band	Thomas Matrix		Sinclair-Thomas Matrix	
		Original	Revised		
		Approximate distance range (km)			
Dominant impact due to large scale, movement, proximity and number	A	0-2	0-2	0-2.5	0-3
Major impact due to proximity: capable of dominating landscape	B	2-3	2-4	2.5-5	3-6
Clearly visible with moderate impact: potentially intrusive	C	3-4	4-6	5-8	6-10
Clearly visible with moderate impact: becoming less distinct	D	4-6	6-9	8-11	10-14
Less distinct: size much reduced but movement still discernible	E	6-10	9-13	11-15	14-18
Low impact, movement noticeable in good light: becoming components in overall landscape	F	10-12	13-16	15-19	18-23
Becoming indistinct with negligible impact on the wider landscape	G	12-18	16-21	19-25	23-30
Noticeable in good light but negligible impact	H	18-20	21-25	25-30	30-35
Negligible or no impact	I	20	25	30	35
Suggested radius for ZVI analysis		15	At least Junction of Band F and Band G; extended to reflect local circumstances or if cumulative impact may be involved		

THE SINCLAIR-THOMAS MATRICES (section B) Potential visual impact matrix for wind turbines of 72-74m overall height (field observation) and 90-100m (extrapolated). Distances in km					
Band		72-74m	90-100m	Magnitude	Significance
				(subject to other factors)	
A	Dominant impact due to large scale, movement, proximity and number	0 - 3	0 - 4	High	Potential for independent significant impact
B	Major impact due to proximity: capable of dominating landscape	3 - 6	4 - 8	Medium/High	
C	Clearly visible with moderate impact: potentially intrusive	6 - 10	8 - 13	Medium	Potential for contributory significant impact
D	Clearly visible with moderate impact: becoming less distinct	10 – 14	13 - 18		
E	Less distinct: size much reduced but movement still discernible	14 – 18	18 - 23	Low/Medium	Potential for ancillary non-significant impact: only becoming significant if numerous or cumulative with other installations
F	Low impact, movement noticeable in good light: becoming components in overall landscape	18 – 23	23 - 30	Low	
Approximate recommended threshold for ZVI analysis					
G	Becoming indistinct with negligible impact on the wider landscape	23 –30	30 - 38	Negligible	
H	Noticeable in good light but negligible impact	30 -35	38 - 45		
I	Negligible or no impact	35+	45 +		

Source: Sinclair (2001)

confusion persists in the tables because Table section A does not have the same columns as Table section B, where in the latter, magnitude and significance are separated. However, we have attempted to apply the Matrix during the case study visits and this is discussed further at section 6.2.

3.8 Photomontage

3.8.1 The illustration of potential landscape or visual impacts using photographs, wireframes and photomontage is now commonplace and expected in EIA, and videomontage may soon become more widespread. The development of these and related visual or virtual reality techniques is now an area of major research and development interest. The issues are inevitably complex. Perkins (1992), for example, asks what influences *"perceived realism"*? Whilst image quality may be important, he points out that realism may be affected by the context or content of the image portrayed. A technically accurate and precise photomontage that placed Edinburgh Castle on Kintyre will not be perceived as realistic for obvious contextual reasons. Although less extreme, a proposed windfarm placed in a remote landscape may be perceived by a viewer as containing an element of incongruity and inappropriateness that will affect their evaluation of the visualisation.

3.8.2 It should also be obvious that the human eye sees differently than a camera lens, both optically and figuratively. The focusing mechanisms of human eyes and camera lenses are different; human eyes move, and the brain integrates a complex mental image; human vision is binocular and dynamic, compared to a camera that tends to flatten an image. These and related issues of perception have already been referred to in section 3.4.

3.8.3 It therefore follows that when the common recommendation is made that a 50mm standard lens (35mm camera) most closely approximates to the human eye, this *"standard"* or *"normality"* is relative and qualified (and this definition of *"normality"* is challenged in some specialised photographic literature). If a wide-angle lens is used, for example for panoramic effect, the size of the subject in the foreground will increase in relation to the background; in the case of windfarms in a landscape scene, the effect will be to under-represent the relative size of the towers and under-estimate their visual magnitude.

3.8.4 Cornwall County Council (1996) (Appendix A: Visual Impact Assessment of Delabole Wind Farm) notes that *"for photographs taken within 500 m of the site, a standard (75 mm) lens was used on a medium format camera. For all the others, a 200 mm lens was used. The combination of the two sizes of lens seemed to provide the most realistic image of the turbines/wind farm in the landscape".* This is an unusual set of conclusions that we have not been able to verify.

3.8.5 Shuttleworth (1980) is a relatively early example of a continuing body of work using photographs as surrogates for real landscapes, although the work is mainly concerned with landscape character and quality assessment, and not visualisation and realism *per se*. He points out the obvious differences and distortions between the two-dimensional image and the three-dimensional perception of a scene or viewpoint by a human observer. He stresses the need to insert aids in photographs to provide constancy scaling and perspective resolution. Perceptual ambiguity can be reduced if the field of view is as large as possible and if depth cues (paragraph 3.4.6) are deliberately included in the photograph. Interestingly, Shuttleworth found that photographic simulation was most reliable in dealing with the overall perception of the landscape, but less reliable when dealing with perception of detailed elements and characteristics in the landscape.

3.8.6 LI-IEA (1995)(and updated in LI-IEMA, 2002) contains general guidelines on photomontage (and CAD, including ZVI) but contains little technical detail for photographs or

ZVI. Sparkes & Kidner (1996) remark that photomontages are not cheap to produce, are fundamentally inflexible and of course cannot depict movement. They also suggest they can give a pessimistic impression of a development because for the turbines to be visible on the photograph, they tend to be painted in white or given a black outline, resulting in them having a high degree of contrast compared to expectations in reality. This was not our experience during the case-study research (paragraphs 6.1.16-6.1.21).

3.9 Significance

3.9.1 Prediction and then evaluation of significance are at the heart of EIA. All developments produce effects, which may be positive or negative. All developments produce effects which vary in size or magnitude and such variation may be spatial or temporal or both. It may or may not be feasible, technically or economically, to reduce or mitigate such effects. After mitigation, an effect may still be significant because of size, location, type, risk or related factors. Such significance may be temporary or permanent, reversible or irreversible. Significance is therefore always relative and context-specific, which may be local, regional, national, supra-national or international.

3.9.2 Ultimately, significant is whatever individuals, people, organisations, institutions, society and/or policy say is significant – it is a human evaluative and subjective judgement on which there may or may not be consensus. It is therefore important that two separate but critical characteristics of all effects – magnitude and significance – are clearly distinguished.

3.9.3 The wide diversity of opinion evident on the merits or otherwise of windfarms, including their visual effects, and the implicit expression of opinion on significance within that diversity of opinion, should not be surprising. It is therefore also important that in any ES, the foundations and assumptions on which significance is based must be clear and explicit.

3.9.4 Remarkably, perhaps, significance is little researched in relation to visual impacts. Exceptions are Bishop (in press), referred to at paragraph 3.2.7, and Stamps (1997), who offers a detailed review of the issue (including the related issues of design guidance and design review) and a theoretical and methodological model for assessment based on a statistical analysis of human preference ratings for before and after scenes. However, his focus, and his case-studies, are based on urban design issues in California.

3.9.5 The legal and regulatory starting points in Scotland are the Environmental Impact Assessment (Scotland) Regulations 1999 (Circular 15/1999) which require that *"the aspects of the environment likely to be significantly affected by the development"* are included in the ES, but offer no specific guidance on definitions of significant. The guidance states that impacts are more likely to be significant in sensitive locations, examples of which are listed. In the case of windfarms, the *"likelihood of significant effects will generally depend upon the scale of the development, and its visual impact … EIA is more likely to be required for commercial developments of five or more turbines, or more than five MW of new generating capacity".* The complementary PAN58 (Environmental Impact Assessment)(Scottish Executive, 1999) does not offer specific guidance on definitions of significance.

3.9.6 Specifically for landscape and visual effects, the LI-IEA Guidelines (LI-IEA, 1995) are widely referred to and appear to have achieved status as a de-facto national standard. However, the Landscape Institute has produced an advice note[6] that emphasises that the Guidelines are general, non-prescriptive, and were not intended to offer a preferred methodology. In particular the note is at pains to point out that the examples given (Figure 3.1 [classification of sensitive landscape/visual receptors and impact magnitude] and 3.2 [the relationship between sensitivity and magnitude in defining significance thresholds]) are illustrative only. *"On no account should they be linked and then applied in the assessment of a proposed development. As paragraph 3.62 states: "… it must be stressed that this is only* *an example. Every project will require its own set of criteria and thresholds, tailored to suit local conditions and circumstances …"".*

3.9.7 In the second edition of this guidance (LI-IEMA, 2002), the advice given is less prescriptive and stress is laid on "*informed and well-reasoned judgement supported by thorough justification*" as well as the need to consider issues, including significance, on a case-by-case basis (Box 7.3, LI-IEMA, 2002). Broad professional landscape consensus does exist, as the similarities in the examples given in Appendix 6 of LI-IEMA (2002) show, but detailed differences of interpretation are inevitable. Despite arguments to the contrary that appear in some of the ESs we have examined, there appears to be no statutory guidance on a definition or definitions of significance. Guidance states that potentially significant effects may occur in some sensitive locations (landscapes), with the implication that an effect of a defined magnitude in one location could be significant but that the same effect in another, less sensitive, location would not.

3.9.8 The value judgement of significance is played out through development control and the public inquiry system, in that decisions of re-design, re-siting of turbines, planning conditions and even refusal of permission can be said to be the result of statutory, public and political debate on which visual effects are and are not judged to be significant. It would be an interesting and informative study to test these ideas through a detailed examination of development control and public inquiry case-law, but this was beyond the scope of the current study.

3.9.9 It therefore follows that the definitions and judgements of significance contained within an ES are ultimately those of the developer and/or the consultant, even allowing for the existence of a degree of consensus among landscape professionals who would be expected to share some common standards and norms. Whilst no criticism of the honesty or professional integrity of the parties is intended concerning the case study examples in this project, it is a truism that a developer must want to minimise the number of significant impacts identified, and that a professional is torn between their role as an expert and their role as an advocate. Whilst there are examples in existence of patently biased and promotional Environmental Statements that developers have treated as little more than public relations documents, even in ostensibly fair, balanced and unbiased statements there can exist more subtle and entirely understandable nuances and judgements that can be challenged. Statutory consultees, other professionals and decision-makers are therefore free to accept or reject many definitions and judgements, unless consensus exists.

3.10 Public Attitudes

3.10.1 There is a little research, some survey and much anecdotal evidence that public attitudes to renewable energy, wind energy and windfarms are complex and dynamic. Krohn & Damborg (1998) review a range of international studies and show that (a) there is broad public support for renewable energy in general, (b) there is high (around 80%) public support for wind power, including similar levels of support in the UK based on thirteen surveys conducted between 1990 and 1996, but that (c) there are important and significant differences in attitudes and opinions in the particulars. In other words, there may be a significant difference between attitudes expressed (positively or negatively) in a general way, and actual behaviour in terms of opposition to new developments.

3.10.2 Whether such differences are labelled NIMBYism or invested with more subtle attempts to explain an apparent contradiction is a matter for research and debate (Wolsink, 1994, 2000). At a simplistic level, windfarms are not different from other developments such as hospitals, roads and waste disposal sites, in that the majority of the public accepts the necessity for these but may be vociferous opponents of local developments. Also, studies for windfarms show that human perceptions of potential noise and potential landscape or visual effects are the key issues. Windfarm interests have been interested to summarise and promote the results of such studies (e.g. BWEA, 1996), although it is worth stressing here that such summaries may show evidence of selectivity in interpretation, and most surveys have been of a type best described as general public attitude and opinion surveys that have not focused on the more detailed questions being examined in the current study.

3.10.3 Duddleston (2000) reports on a post-development survey (by telephone) of public attitudes and opinions concerning the Beinn Ghlas, Novar, Hagshaw Hill and Windy Standard windfarms. Residents within a 20 km radius of each site were sampled (the study used the following zonal definitions: 0-5 km – high proximity zone; 5-10 km – medium proximity zone; 10-20 km – low proximity zone). Perversely at first sight, perhaps, a slightly higher proportion of respondents in the medium and low proximity zones (11% and 12% respectively) said that they disliked the windfarm because it was unsightly or spoiled the view compared to those (8%) in the high proximity zone, but this bald result ignores detailed local visibility issues (for example, the Novar site is essentially invisible in the high proximity zone, except for specific and limited localised viewpoints, but more visible beyond this zone). This point is elaborated by Duddleston (Table 4, page 12), where she shows that a higher proportion of respondents in the medium proximity zone see the windfarm from their home or garden or when travelling on local roads compared to those in other zones, and they also see the windfarm more frequently (every day or most days). The survey then asked people to compare their anticipated and actual problems. For all effects including *"look of the landscape being spoilt",* the results show actual effects to be around 15-20% of anticipated effects.

3.10.4 Whilst windfarm interests are keen to offer these (and other) results from public attitude surveys as evidence that public reaction and opposition to windfarms is exaggerated, it could equally be interpreted as evidence that detailed attention to the planning, impact assessment, siting and design processes is successful in minimising effects or mitigating potentially significant impacts. The Duddleston survey did not address specific visual questions, such as whether the windfarm as built appeared more or less prominent than they (the public) had expected or had judged from inspection of pre-project visualisations (the main sources for pre-project information were local newspapers, other media and word of mouth, with some consultation by developers in the high and medium proximity zones). It therefore offers no results to inform the detailed questions being asked by the current project.

3.10.5 We have not discovered any public attitude or opinion surveys that address the specific issue of the relationships between turbine size, distance, visibility and impacts.

3.11 Cumulative Effects

3.11.1 This general phenomenon is flagged or raised in many discussions and policy documents as an important issue. A relatively recent report is Energy Technology Support Unit (2000). This is generic guidance on principles and processes but contains little specification or technical detail on issues of magnitude, distance and significance.

3.11.2 Piper (2001) has analysed three cases of the cumulative effects of two or more projects, including windfarms in Holderness (Yorkshire) and Kintyre. In Holderness (study for East Riding of Yorkshire Council), the boundary of the study area was seen as the maximum distance (about 20 km) from which the windfarms might be seen (in a coastal region of very flat topography). The basic approach involved defining landscape character and determining the sensitivity of the landscape (based on potential change, intrinsic character and potential visibility). The study defined several visibility thresholds as follows: 0-2 km: turbines a prominent element in the local landscape – high visual impact; 2-5 km: turbines would appear as clearly visible element in landscape – high-medium or medium visual impact. In terms of best practice for cumulative effects assessment, Piper rates the Holderness study as limited and partial; for example, no cumulative zone of visual influence map was produced to show overlapping affected areas within different dominance thresholds. For the Kintyre project (study for Scottish Natural Heritage) the study area was defined as a radius up to 30 km, assuming turbine heights to blade tip of up to 68 m, and based on five projects or potential projects at various stages of resolution. As for Holderness and in terms of best practice for cumulative effects assessment, Piper also rates the Kintyre study as limited and partial; for example, landscape character assessment was not used and no explicit assessment of significance in relation to distance is made.

3.11.3 MosArt Associates (2000) have prepared an analysis of landscape character and sensitivity to windfarm development for Cork County Council, but this was an area based study akin to the similar capacity studies being carried out in Scotland and elsewhere, and contains few detailed technical recommendations on aspects of VIA. With regard to cumulative effects, however, it recommends the use of overlapping ZVI and, pending a further study, that the outer limit of cumulative effect is set at 10 km separation, with any larger separation not considered as having a cumulative effect. For individual applications, it recommends a basic ZVI of 20 x 20 km and, for large turbines (a height of more than 60 m), a ZVI of 30 x 30 km.

3.11.4 Information on a current research study on cumulative impact of wind turbines, commissioned by the Countryside Council for Wales, is at Macaulay Land Use Research Institute (2002). At present the material available here is largely literature review, much of which is general and non-specific for windfarms. For example, it reviews controversies over the differences between professional and lay public preferences for landscape and scenic quality; it reviews several studies (largely drawn from the USA and the Netherlands and much from the late 1980s) on perceptual studies of windfarms (but much of this is focused on attitudes and symbolism, and general design issues) and it reviews a familiar range of tools for VIA, including ZVI and viewpoint analysis.

4 CASE STUDY SITES

4.1 Introduction

4.1.1 The following sections provide a short description of each windfarm, followed by a condensed analysis of each Environmental Statement (Appendix 1), concentrating on key aspects of the VIA [7]. For each viewpoint visited we provide a brief summary of the prediction or judgement made in the ES, and then a brief comment based on our site appraisal. An overview of the site appraisals is then presented, followed by some brief conclusions.

4.2 Beinn An Tuirc

The Windfarm

4.2.1 The windfarm was constructed in 2001. The original proposal was for 50 turbines with a hub height of 40.5 m and a total height of 62.5 m. As built the windfarm consists of 46 turbines with height to hub of 40.5 m and total height of 62.5 m. Viewpoints were selected by negotiation with the local planning authority and SNH. The site moved south during negotiations because of ornithological interests and the layout also changed for this and visual reasons. There are significant locational differences between as assessed and as built.

The Environmental Statement

4.2.2 The ES material available to us was varied and complex and it proved difficult to cross-match, collate and test the documentation. The main statement (no date) is based on layout G (layouts D, E, F and G are referred to). The ZVI radius (study area) is declared as 15km, but is actually 16.6 km to accommodate the spread of the windfarm layout of 3.3 km. Chapter 9 in the ES includes a detailed discussion of the basis for the selection of 15 km. The basic ZVI is a zone of theoretical visibility (bare-ground or worst-case scenario). Computer calculations are also made of the zone of actual visibility taking account of trees rendered in the program as standardised forestry blocks. Relative visibility in the ZVI is based on a hub height of 40.5 m, not the maximum height, but this decision is not explained.

4.2.3 Eighteen viewpoints were selected based on site survey and consultation with SNH, Argyll & Bute Council and North Ayrshire Council (Arran). Site assessments were made based on visualisations (photographs and wireframes), not photomontages. The effects on both stationary viewers and moving viewers are distinguished and analysed and a long list of factors considered in assessment is provided. Orientation of the turbines in relation to the prevailing winds is considered. Separate reports exist containing *"Wireframe Overlay Illustrations"* (May 1998)(viewpoints 1, 2, 5, 11, 12, 13 and 15 only) and *"Photomontages"* (no date)(prepared for viewpoints 2, 5, 11, 12, 13 and 15 only). The recommended viewing distance for visualisations is 24 cm. It is not clear if these separate reports refer to the 18 viewpoints in the main ES.

4.2.4 At the end of each viewpoint assessment (descriptive), a statement is made as to the anticipated effect (e.g. *"moderate adverse effect on visual amenity"*) and the significance (e.g. *"significant"*). The ES makes reference to the Environmental Assessment Regulations and concludes that minor effects are not significant, but moderate and major effects are significant. The basis for the assessment of significance does not appear in the main ES (layout G), but is described and discussed in detail in a supplementary report, *"Assessment of Landscape and Visual Effect Layout F, Draft 2"* (1997), as is the technical detail of the ZVI, DTM etc. We also obtained a packet of visual material (ZVI, site layout, wireframes) dated 1999 that in one case referred to layout H. We assume that layout H is close to the as built windfarm.

4.2.5 Although based ultimately on professional judgements by more than one assessor, this ES is explicit in listing and discussing the factors taken into account in judging very significant, significant and not significant or no effect. The details in the ES are long and relatively complex and are not repeated here for that reason. The supplementary report (1997) is effectively a second version of the ES, based on Layout F, but concerned only with the landscape and visual effects. A full set of ZVI, visualisation, photomontage and related materials is presented.

Site Survey

4.2.6 There are 19 viewpoints in the ES. Seven are on the islands of Gigha or Arran and 2 are in the sea; these were not visited during this study. Of the 10 remaining, 5 were not visited due to their remoteness. To assess them would have involved some hill walking which may have been feasible in better weather but was not practical due to the time constraints of the project and the poor weather conditions. Therefore only five out of 19 viewpoints were assessed.

4.2.7 We made a total of 9 visits to the 5 viewpoints (viewpoint 6 involved walking 2 miles so we visited it only once when the weather was good) but were only able to make 5 useful assessments of 4 viewpoints due to the weather.

Table 5: Viewpoint Analysis for Beinn an Tuirc

VP	Distance (km)	No of Visits	ES Description (main ES)	Site assessment	Photomontage/wireframes (main ES)	Wireframes (supplementary)
1	5.85	2	States 11 turbines visible.	None visible. This may be due to layout changes.	Totally inaccurate, looks like layout change.	
2	4.35	2	States 35 turbines visible over 2 hills. States ‘moderate adverse impact’.	23 then 11 visible over 1 hill. Although the number and layout were not accurate, ‘moderate adverse impact’ is correct.	Inaccurate in number and position. Turbines looked bigger in reality than in photomontage.	Called viewpoint 1. Wireframe shows 23 turbines with extreme tips of three more (which were obscured by vegetation in reality). The individual positions are reasonably accurate. The overall position and size of the farm is accurate.
3	7.8	2	States 30 turbines visible. States ‘new visual focus’ and ‘moderate adverse impact’.	15 visible. “Moderate adverse impact’ may be too strong as there are already many manmade elements in this landscape.	Not accurate in position or number. Size looked bigger in reality.	Called viewpoint 2. Two wireframes, one without vegetation and one with blocks of trees. The former shows 15 turbines with the tip of one more. The overall position and size is accurate. The latter wireframe shows only 11 turbines and the tip of one. As we saw more it would appear that the screening effect of the trees has been overestimated.
6	6.6	1	ES states 21 turbines visible and ‘low adverse impact’.	7 visible (although light conditions poor). ‘Low adverse impact’ is correct.	Not accurate in number or position.	Called viewpoint 5. Shows 8 turbines.

4.2.8 There were substantial changes in layout between the ES and construction, accounting for the major discrepancies we found. We do know that the number of turbines was reduced by 4 and the whole position was shifted south because of ornithological interests. Apart from the numbers and positions, we generally agreed with the assessments of impact and significance and there was only one disagreement where we felt that the impact had been slightly overstated, but again layout change may have affected this assessment.

Conclusions

4.2.9 Full technical details of the VIA are provided and justified in the ES and potential errors are acknowledged. Magnitude, sensitivity and significance are separated, justified and discussed in detail and in a balanced way. Major changes between assessment and construction mean that this ES is not strictly accurate. The turbines look bigger in reality than in the photomontages. The newer wireframes to accommodate the layout changes are generally accurate regarding the positioning and overall impact of the windfarm with minor inaccuracies regarding individual positions of turbines and screening effects of trees.

4.3 Beinn Ghlas

The Windfarm:

4.3.1 The windfarm was constructed in 1999. The original proposal was for 16 turbines with a hub height of 40 m and a total height of 61.5 m. A total height of 65m was used in the ES landscape assessment for reasons that are not explained, which might have resulted in over-prediction of the ZVI. As built the windfarm consists of 14 turbines with a height to hub of 35 m and a total height of 57 m. SNH judge that all the main or significant viewpoints were covered, although views from roads to the west (leading to Loch Awe) were ignored or underestimated, and emphasis was perhaps not placed on views by walkers on nearby hills. Although 2 turbines were removed, we understand that the other 14 locations were not changed.

The Environmental Statement

4.3.2 The ZVI is shown for an area of 30 x 30 km, distinguishing the differing numbers of turbines to be seen. However, the resolution is crude and it is not overlain onto an OS map, making locational referencing difficult. This was produced using a DTM (worst-case conditions, ignoring structures, forests etc) of the 1:25,000 OS map, but no details of potential errors are given. The VIA then uses photographs for 17 viewpoints using a wide panoramic format camera and wireline visualisations. Five views are illustrated using photomontage.

4.3.3 Significance (Volume 1) is based on LI-IEA (1995). First, magnitude was defined as:

> *High – Notable change in landscape characteristics over an extensive area ranging to intensive change over a more limited area.*
> *Medium – moderate changes in local area*
> *Low – virtually imperceptible changes in any components*

4.3.4 And then sensitivity was defined as:

> *High – important components or landscape of particular distinctive character susceptible to relatively small changes*
> *Medium – landscape of moderately valued characteristics reasonably tolerant of changes*
> *Low – a relatively unimportant landscape. The nature of which is potentially tolerant of substantial change*

4.3.5 These were then combined into a classification as:

> *Significance Substantial – the product of high sensitivity and high magnitude, or medium sensitivity with high magnitude*
> *Significance Moderate - the product of medium sensitivity and medium magnitude, or low sensitivity with high magnitude*
> *Significance Slight - the product of low sensitivity or low magnitude*

4.3.6 This schema is essentially similar to LI-IEA (1995), but in this case it is logically flawed and incomplete, in that in a 3 x 3 matrix (magnitude versus sensitivity) there must be 9 classes, but only 6 are referred to in the ES (and only 6 examples are illustrated in the detailed technical appendix (Volume 3)). No distinctions are made between magnitude, sensitivity and significance for landscape impacts as opposed to visual impacts. For each viewpoint, a description leads to categorisation of significance, although the authors then introduce terms such as very slight (presumably lower than slight). The significance terminology then changes in a later summary table to minor-moderate-significant. Although not explained, the implication is that only substantial impacts are judged to be significant. Four additional viewpoints (using a Linhof panoramic format camera giving 90^0 field of view) were produced to give further wirelines and photomontages. This supplementary report to the ES does explain sources of discrepancy between the ZVI predictions and on-site evaluation (including data interpolation errors).

Table 6: Viewpoint Analysis for Beinn Ghlas

VP	Distance (km)	No of Visits	ES Description	Site assessment	Photomontage
4	9	2	ES states 13 turbines visible and that "they would not be conspicuous in most lighting conditions".	Only 4 visible but weather conditions poor. We could still distinguish them clearly and they stood out more than was suggested in the ES.	The turbines seemed about twice the size in reality. There were fewer visible but these stood out more on the skyline.
5	13	2	ES states 10 visible and described as minute elements in the landscape and impact 'slight'.	10 visible. Assessment correct.	The turbines look much taller in reality and more spread out than in the photomontage.
6	10	1	ES states that no turbines would be visible from the road.	None visible.	N/A
7	-	1	This was a viewpoint chosen to evaluate the access track and substation.	We could not make out any track or locate the substation.	N/A
10	8	2	States 10 turbines would be visible and would be inconspicuous in most lighting conditions and impact 'slight'.	10 visible on each visit. Description incorrect. Underestimates appearance and impact.	N/A
11	11	2	States that towers of 10 and rotors of a further 4 would be visible. States "barely discernible in most lighting conditions" and "slight impact".	We saw only 3 but the cloud was low. Assessment correct but in better weather conditions this could be an underestimate.	N/A
13	13	2	States all turbines visible and "barely discernible in most lighting conditions" and "slight significance".	All turbines visible. Incorrect that turbines would be "barely discernible in most lighting conditions" as we saw them clearly in poor light. "Slight significance" correct.	N/A
B	14	2	States all (14) turbines visible and "barely discernible in most lighting conditions" and "significance slight".	13 visible but weather poor. Incorrect that "barely discernible in most lighting conditions" as we saw them very clearly in poor light. "Significance slight" correct.	Turbines seem much more noticeable and distinct than on PM. They seem bigger and more spread out.

Site Survey

4.3.7 There are 17 viewpoints in the ES. Three were not visited because they were remote. Out of 26 visits to 14 viewpoints we were only able to make 9 useful assessments of 8 viewpoints due to weather conditions.

4.3.8 Although we generally thought that the number of turbines and the impact/significance ratings were accurate (bar one underestimate), we thought that the descriptions of visibility were on the whole an underestimate. The photomontages also appeared to underestimate size and the positions seemed inaccurate.

Conclusions

4.3.9 The technical details of the VIA in the ES are not provided in full, nor are they justified, and potential errors are not always acknowledged. There is no explanation given on the potential accuracy (or otherwise) of the photomontages. Magnitude, sensitivity and significance are separated, justified (very succinctly) and discussed, but not separately for landscape and visual effects, and there is some inconsistency of terminology.

4.4 Deucheran Hill

The Windfarm:

4.4.1 The windfarm was constructed in 2001. The first proposal that was given the name Deucheran Hill was for 12 turbines with the height to hub not stated but a total height of 76 m. As built the windfarm consists of 9 turbines with height to hub of 46 or 60 m and total height of 62.5 or 76.5 m. Viewpoints were selected after consultation.

The Environmental Statement

4.4.2 There is some complexity and lack of clarity within this ES because a separate ES (not examined in this study) was prepared for an earlier proposal (named Cruach nan Gabhar) with 24 (and then 15) turbines. The proposal was later modified, the turbines reduced to 12 (and then 9) and the name was changed to Deucheran Hill. In the Deucheran Hill ES, visual re-assessments are restricted to those 3 viewpoints (from an original 14) where an increase over the Cruach nan Gabhar proposal(s) is expected. For other viewpoints, the (now pessimistic) assessments based on Cruach nan Gabhar are used in the Deucheran Hill ES. A table (Table 5.1) compares the number of turbines visible for each windfarm, distinguishing between (rotor) tips and hubs. Towers are to be coloured off-white/ pale grey with a semi-matt surface.

4.4.3 The ZVI is a worst-case survey (bare ground), but the screening effect of conifer plantations is noted. The data used and resolution are not stated. The distance used is 15 km (overlain on 1:50,000 OS map (reduced)) but this distance is not justified. A revised ZVI is then produced (supplementary drawings) for 7 x 79 m and 2 x 93 m turbines (as built).

4.4.4 Visualisations use wireframes and it is emphasised that these are not photomontages. The camera was at a height of 1.8 m using a 50 mm focal length lens and a recommended viewing distance of c23 cm. The ES draws attention to the limitations of the visualisations and stresses that the graphics (dark delineation of towers on a white background) can over-represent the true width and impression of the towers. Accordingly, it is stated that whilst the height representations are correct, at distances beyond 4-6 km the width is over-represented.

4.4.5 This ES adopts a common methodology for assessing significance for each impact category (based on LI-IEA (1995) and Department of the Environment (1995)). The landscape and visual assessment methodology is explained in detail in Appendix E and magnitude (for visual receptors) was defined as shown in Table 7.

Table 7: Magnitude of Impact – Visual Receptors (Table F3 from Deucheran Hill ES)

MAGNITUDE OF IMPACT	
HIGH	Major change in view: change very prominent involving total or partial obstruction of existing view or complete change in character and composition of view through loss of key elements or addition of uncharacteristic elements.
MEDIUM	Medium change in view: which may involve partial obstruction of existing view or alteration to character and composition through the introduction of new elements. Change may be prominent but not substantially different in scale and character from the surroundings and the wider setting. Composition of the view will alter. View character may be partially changed through the introduction of features which, though uncharacteristic, may not necessarily be visually discordant.
LOW	Minor change in view: change will be distinguishable from the surroundings whilst composition and character (although altered) will be similar to the pre-change circumstances.
NEGLIGIBLE	Very slight change in view: change barely distinguishable from the surroundings. Composition and character of view substantially unaltered.

4.4.6 Sensitivity was defined as the *"importance of the individual element being assessed e.g. the landscape type or location …",* categorised as Low, Medium or High. The sensitivity of visual receptors is defined and considered in detailed evaluative tables – tourists (high sensitivity), travellers (low), local recreation (high), walkers and climbers (high), estate workers/farmers (medium), residents (high) – with both landscape and visual effects being assessed. These were then combined as shown in Table 8.

Table 8: Impact Matrix (Table 1.2 from Deucheran Hill ES)

MAGNITUDE			
HIGH	Moderate	Moderate/Major	Major
MEDIUM	Low/Moderate	Moderate	Moderate/Major
LOW	Low	Low/Moderate	Moderate
NEGLIGIBLE	Negligible	Negligible/Low	Low
	LOW	MEDIUM	HIGH
		SENSITIVITY	

Note: *"shaded boxes are not considered significant in terms of the Regulations".*

4.4.7 This schema is essentially identical to LI-IEA (1995). Significance is explained and justified. The authors state that only Moderate/Major and Major impacts are judged (by them) to be significant.

4.4.8 There is discussion of cumulative issues in relation to this and other proposals in the area. A cumulative ZVI is included as are 7 wireframes (representing the three windfarms considered) and to justify the conclusion of (cumulative) insignificance.

Site Survey:

4.4.9 There are 14 viewpoints in the ES. Five are on Arran or Gigha and were not visited. Of the 9 on the mainland, 2 were remote. We made a total of 12 visits to 7 viewpoints (2 viewpoints were quite remote so we had time to visit them only once) and were able to make only 6 useful assessments of 5 viewpoints due to weather conditions.

4.4.10 From the few viewpoints we had to go on, we conclude that this ES was quite accurate both in the visualisations and in the descriptions and conclusions. Discrepancies we found were very slight (both in underestimating and overestimating impact) and possibly caused by unavoidable differences in perception between individuals and interpretation of terms such as slight, moderate etc.

Conclusions

4.4.11 The technical details of the VIA in this ES are provided (if not always justified) but potential errors are not acknowledged. Magnitude, sensitivity and significance are separated, justified and discussed. There is much explicit advocacy and argumentation in this ES, in addition to objective impact assessment. Whilst this may appear to run counter to any general best practice guidance that an ES should as far as possible be objective, fair, balanced and not a public relations document, the ES does take space to explain the basis of the arguments. Irrespective of whether one agrees with this argumentation, the separation of objective and subjective assessment, and advocacy, is generally clear.

Table 9: Viewpoint Analysis for Deucheran Hill

VP	Distance (km)	No of Visits	ES description	Site assessment	Photomontage
3	8.9	1	Stated that the tip of 1 turbine would be visible.	Nothing visible but the light was low.	The turbine shown on the visualisation was not visible so cannot comment on the accuracy of positioning
4	16.2	2	States no turbines visible	Accurate, no turbines visible	
5	10.3	2	States no turbines visible	Accurate, no turbines visible	
6	5.4	1	States no turbines visible	Accurate, no turbines visible	
8	13.3	2	ES states 9 hubs visible. States that the scale would remain subordinate to the underlying landform.	1 and 9 were visible on different visits due to varying weather conditions. Correct that the scale would remain subordinate to the underlying landform, but this underestimated the effect of character change in the landscape. Conclusions of impact significance etc correct.	Very accurate in positioning but turbines seem much larger than in the visualisation.

4.5 Dun Law

The Windfarm

4.5.1 The windfarm was constructed in 2000. The original proposal was for 34 turbines with a hub height of 35-46 m (but 45 m is used in the VIA) and a total height of 54.5-68 m (but 66.7 m is used in the VIA). As built the windfarm consists of 26 turbines with height to hub of 40 m and total height of 63.5 m. SNH judge that all potentially significant viewpoints were covered, including some recommended by SNH. There was some adjustment of tower positions between as assessed and as built, partly in response to SNH concerns with the risk of in line views of rows of turbines from key viewpoints, but SNH were not fully involved in these detailed adjustments between an outline permission and construction.

The Environmental Statement

4.5.2 This ES is in parts complex, confused and confusing and it is difficult to tease out the elements of the VIA (for example, pages are not numbered, contradictory but unexplained details appear in different sections, and cross referencing to photomontages is erratic). For the ZVI, radii of 7 and 20 km appear to have been used at one stage (ignoring vegetation, structures etc). One ZVI shows the number of nacelles (hub) visible, but the scale is hard to interpret. Figure 4 in the main report shows a mapped ZVI (called Visual Analysis) of up to 8 km (concentric rings are drawn at 2, 4 and 8 km), overlain on a 1:50,000 map of 14 x 16 km. Figure 5 is a theoretical ZVI of up to 16 km. No technical detail is provided, nor is the varied menu of ZVI explained.

4.5.3 Eight viewpoints are examined, all from publicly accessible locations, chosen after consultation with SNH and Borders Regional Council. There is a wireline for each viewpoint, and a photomontage for seven viewpoints (based on photographs using a 50 mm lens in 35 mm format). In a supplementary report, alternative layout options are examined, and Option E (which appears to be close to the as built windfarm) is analysed using wirelines and additional photomontages for viewpoints 2, 4, 6, and 7.

4.5.4 The evaluation of significance is in part contained within each written viewpoint analysis. The ES states that Energy Technology Support Unit guidelines were used (i.e. Stevenson & Griffiths, 1994) as follows:

Dominant	*< 2 km*
Visually intrusive	*1.0-4.5 km*
Noticeable	*2.0-8.0 km*
Elements in the landscape	*7 km and above*

4.5.5 These guidelines do not actually distinguish magnitude and significance, except implicitly. However, it is hard to determine how these were used, and the ES then proceeds to discuss views and viewpoints in bands of 0-2, 2-4, 4-8, and 8-16 km in order to assess visibility and hint at significance. Words such as dominant, prominent, intrusive, conspicuous are used, but an explicit declaration of significance is not always applied.

Site Survey

4.5.6 There are 12 viewpoints in the ES. One is remote and one is on private land with hostile signage; neither was visited. Of the 10 remaining, we made a total of 19 visits to 10 viewpoints and were able to make 19 useful assessments. This ES makes no explicit prediction of the numbers of turbines visible from each viewpoint and is erratic in offering a judgement of significance.

4.5.7 Assessing the accuracy of the ES is impossible because few exact predictions are made. Allowing for some post-assessment design changes, visualisations were reasonably accurate in positioning but not an accurate representation of the windfarm in reality.

Conclusions

4.5.8 All the key elements of VIA are present in this ES – ZVI, wirelines, photomontage – and some technical detail is provided - but there is a lack of clarity and limited justification for judgements made. Magnitude, sensitivity and significance are not clearly separated, justified and discussed.

Table 10: Viewpoint Analysis for Dun Law

VP	Distance (km)	No of Visits	ES Description	Site assessment	Photomontage
A	0.2 - 0.48	2	States "dominant element in view".	17 turbines visible to W of A68, including overhead power line. Large vertical elements in bare moorland plateau. Constantly changing perspective from fast moving cars. Other turbines largely hidden behind shelter belt to E.	Largely accurate, but wide angle lens used which produces distorting effect.
B	1.2 – 2.4	1	States "dominant and prominent".	26 turbines are visible, context as for viewpoint A.	Same comments as for viewpoint A.
C	1.15	2	States "prominent and intrusive, conspicuous and significant".	26 turbines are visible. At this distance, differences between skylining and backgrounding are irrelevant.	Largely accurate, some small differences probably due to post-ES relocations.
D	1.95	2	States "prominent".	14 turbines are visible. Forestry and other elements in middle and foreground reduce effect of windfarm, and forestry will screen view in time.	PM3 is reasonably accurate, but three turbines at extreme left are missing, whilst PM4 is more accurate.
F	4.2	2	States "prominent on the horizon".	11 turbines are visible but partly screened by foreground hedge.	8 turbines shown on PM but 11 visible on site and PM gives impression much smaller than reality.
H	4.75	2	States visibility "limited to the tips of the blades of 6 turbines". Impact "not significant".	Windfarm is invisible at this point	N/a.
I	9.0	2	States "very small and distant element in view".	13 turbines are visible but are not easy to count with the naked eye and movement not visible. Moving along road ± 0.5 km, turbines much more conspicuous. Effect appears due to complex middle and foreground elements at viewpoint I.	N/a.
J	5.8	2	Impact "slight".	4 turbines just visible above trees, but only with aid of binoculars. Windfarm is effectively invisible. Overhead power line and pylons dominate the view; background tree growth may have screened turbines.	N/a.
K	7.0	1	"Visibility limited to the upper parts of towers and glimpsed views of rotating blades silhouetted above the horizon". Impact "not significant".	23 turbines are visible. Movement clearly visible to naked eye.	Not accurate; the PM mis-labels Dun Law which lies to extreme right of PM.
X	4.3	2	"Prominent on the horizon".	16 turbines visible but movement scarcely visible because of orientation of rotors at 90^0 to viewer.	Largely accurate.

4.6 Hagshaw Hill

The Windfarm

4.6.1 This was Scotland's first windfarm, constructed in 1995. The original proposal was for 30 turbines with a hub height of 35 m and a total height of 55.5 m. As built the windfarm consists of 26 turbines with height to hub of 45 m and total height of 65.5 m. There is therefore a significant difference (in height of the turbines) between as assessed and as built.

The Environmental Statement

4.6.2 The ZVI is a worst case analysis for a radius of 12 km from the centre of the site, shown on a reduced 1:50,000 OS base map, but the choice of distance is not explained. The data used to generate the ZVI are not stated and potential errors are not acknowledged. The ZVI map only shows visibility as present/absent and does not show visibility varying in relation to the numbers of turbines.

4.6.3 There is discussion and argumentation concerning the diversity of opinion concerning the visual and landscape effects of windfarms, drawing from other public opinion surveys. Concerning significance, there is some generalised but inconclusive argumentation to the effect that many factors affect visibility, perception and significance. Within the text, evaluative statements such as marginal significance and relatively insignificant component are used freely. The issue of visibility is introduced by the use of photographs (some panoramic, but by splicing photographs taken with a 50 mm lens) of Delabole and Carland Cross windfarms (of similar height to the Hagshaw Hill proposal), and there is extensive discussion of the relative effects of these at varying distances. Based on this review, the ES states that *"we consider that significant visual impacts, if they exist, will in our opinion only be experienced within a range of up to 1.5 km from the turbines. However, we have allowed a margin of 0.5 km and extended the range to up to 2 km".* The ES then allows that other factors may need to be considered in restricted circumstances, so that *"we do not consider that at a distance greater than 6 km to 6.5 km that the proposal, if seen, would be significantly adverse in views for those who might adopt a negative stance towards them".*

4.6.4 Sixteen visualisations are provided using a mixture of photomontage or photographs with wireline illustrations or wirelines only. Some of these are large panoramas (14 x 96 cm) and all have a recommended viewing distance of 9.5 inches (24 cm). These locations were agreed with SNH, who also represented the interests of Clydesdale District Council. The limitations of these are stressed, including a statement that they (the photomontages) over-represent the appearance of the turbines at distances beyond 4 km to 6 km. Each visualisation is accompanied by discursive text that interprets the view but does not lead to a precise declaration concerning significance. A summary is then provided, leading to a more general appraisal of effects in relation to landscape character (zones).

4.6.5 This detailed Landscape and Visual Assessment (Appendix B, Volume 3) is then translated into the main statement (Volume 1) in a general overview that offers the broad conclusion that *"although the windfarm may be seen over a wide area, there will be few views that will perceptibly change from their present overall character to any significant extent".* It states that the height of the turbines has been reduced from 64 m to 55.5 m (as a result of internal and external consultations). However, the as assessed height (Volume 3) was 55.5 m and the as built height is 65.5 m. We do not understand the reasons for these differences. It might be expected that this discrepancy of 10 m would have introduced error into both the ZVI and the visualisations.

Table 11: Viewpoint Analysis for Hagshaw Hill

VP	Distance (km) - Direction	ES assessment	Site observations	Photomontage
1	3.25	Bare exposed landscape setting above gentler wooded landscape with AGLV to east in view. Conspicuous in certain conditions.	26 turbines visible. Conspicuous in bare landscape. Appears closer because of low light levels and orientation of the development which is in a horizontal plane to the viewer.	Layout of turbines accurate. 30% are lower than on pm.
2	4.5	Waste disposal heaps to W substantially influence view. Substantially screened by topography and development	20 turbines visible. Waste disposal heaps do not substantially influence view as they are below the ridgeline. No topographical screening from the road. Dominant feature as there are minimum number of detractors.	Reasonably accurate. Wider development area than shown.
3	4	Edge of Douglas Conservation Area. Majority of turbines are screened from view. Relatively small and more distant component. Not a significant adverse effect.	11 turbines visible. No towers are visible. Not a dominant feature on the skyline.	Much lower levels of development than shown.
4	4	Influence of the development encroaches into the setting of the AGLV. Will not dominate or significantly affect the quality of the landscape.	22 turbines visible. Does not dominate the scene owing to the landscape character of the valley, but it is a visible feature on the skyline.	Differences in the clustering of the turbines from this viewpoint add to the impact in the centre of the scene. More turbines shown with towers than actually appear on site. Deciduous valley- side trees and conifer blocks limit visibility by acting as detractors.
6	14	Urban environment. Near detractors. Relatively insignificant component with little influence on the urban experience.	24 turbines visible. Strong vertical elements and foreground topography add interest and detract from development. Scale of windfarm small in the scene. Movement only detectable in sunny conditions by glinting off blades.	Individual turbines on pm appear smaller than on site
7	8	Substantially screened by topography. Not a significant change	5 turbines visible. Indistinct over shoulder of hillside. Contrast low.	
8	8	Urban environment seen over conifer plantation and street lights are detractors. Marginal change No real visual significance	24 turbines visible. View of development framed by houses, lines of which lead the eye to Hagshaw Hill, therefore because of this more impact in the view 'No real visual significance' incorrect.	More obvious in view than in wireframe
9	7.75	Fleeting views.	16 turbines visible.	In wireframe the

		Discernible, but not significant adverse effect.	Discernible. Visible but of similar scale to trees and smaller than other more dominant elements closer to the road. Fast speed of travel means windfarm is less obvious. Much more noticeable from junction 12 on M74.	elements appear smaller in scale than in reality
10	8	Turbines are not the highest or most extensive landscape elements in view. Strong horizontal lines.	24 turbines visible. Visual interest in the foreground. Moderately dominant in this sensitive landscape.	Turbines appear taller and more evenly spaced than in pm.
11	2.5	Detractors in view. Will add feature of visual interest	Tip of only 1 turbine blade visible. No significant effect.	N/A
12	12	The nature of the change will not significantly adversely affect either the context of the view or the quality of the wider view.	26 turbines visible. Situated on the highest land in view. Movement attracts attention and increases visibility and intrusion.	
13	12.5	Small and relatively insignificant. Discernible only on clear days. Limited degree of visual influence. No significance. Adverse impact for negative viewers.	26 turbines visible. Clearly visible on skyline to SSW spread across hilltop. Larger in view than any other vertical element in landscape, but not dominant.	Elements appear smaller in wireframe than with naked eye but suspect this is the effect of the moving image.

Site Survey

4.6.6 All viewpoints (listed) were visited twice each except 3, 7 and 12, which were visited once each.

4.6.7 From the site observations the ES is accurate in its predicted assessment in 8 out of 12 of the view points. The photomontages were accurate in 2 out of 11 cases. Of the 9 that were inaccurate, three showed the windfarm larger than it appeared on site and in six of the illustrations the windfarm appears larger as built than in the photomontages. The viewpoint selection provided good coverage of the area with the exception of travel towards the site in a south west direction from Rigside to Douglas on the A70 and particularly around junction 12 on the M74 where the impact was higher and the development has a more significant visual impact than VP 9 (along the northbound carriageway of the M74).

Conclusions

4.6.8 The technical details of the VIA are mostly provided in this ES (if not always justified) but potential errors are not acknowledged. A significant (10 m) discrepancy between the height of the turbines as assessed and as built raises serious doubts about the accuracy of the ZVI and visualisations. The landscape and visual effects are not clearly distinguished, but are interwoven. Magnitude, sensitivity and significance are separated, justified and discussed, but the treatment is extremely discursive so that it is difficult to separate the inherent complexities of the issues. There is also much explicit advocacy and argumentation in this ES, in addition to objective impact assessment.

4.7 Hare Hill

The Windfarm

4.7.1 The windfarm was constructed in 2000. The original proposal was for 20 turbines with a height to hub of 40 m and total height of 60 m. As built the windfarm consists of 20 turbines with height to hub of 62 m and total height of 85.5 m, a dramatic difference that might have resulted in under-prediction in the ZVI. Viewpoints were selected after consultation. This proposal went to a public inquiry through written representation. Although approval was given, the siting of individual towers was a reserved matter that was not followed through fully by further consultation with SNH, and there are significant differences between as assessed and as built.

The Environmental Statement

4.7.2 The ZVI is based on a 20 x 20 km grid centred on the site. The shortest distance from the edge of the site to the limit of the ZVI is 8.5 km and the longest distance is approximately 13 km. The ZVI is the zone of theoretical visibility (worst case scenario). No explicit calculation is made of the zone of actual visibility taking account of ground cover or structures, but it is mapped according to the number of turbines visible (1-7, 8-13 and 14-20). Eight viewpoints were selected based on consultation with Cumnock & Doon Valley DC, SNH and New Cumnock Community Council (shown on Map 14, Main Report), and these are shown as 8 photomontages in the Main Report (prepared using a 50 mm lens and a recommendation that these be viewed from 17 cm).

4.7.3 Impact assessment is based on the number of turbines visible and distance. The ES states that the windfarm would be clearly visible at distances less than 1 km, distinct at 1 – 3 km and less dominant at 3 – 6 km. Beyond 6 km the prediction is that the turbines are increasingly indistinct. The sensitivity of receptors (residents, travellers etc), the degree of screening, visibility effects (eg weather) and field of vision are also considered and discussed. Meteorological data for a distant but comparable weather station is used to estimate and quantify the effects of cloud cover on visibility.

4.7.4 There is a complex but clear and explicit manipulation of several criteria to produce impact rating scales and then an integrated evaluation of both magnitude and significance based on a combination of receptor sensitivity, screening, distance and visibility, with significance classes described as none-minor-moderate-significant. Reference is also made to mitigation by choice of rotor blades (3 not 2) and colour (non-reflective finishes and pale colour).

Site Survey

4.7.5 All viewpoints listed were visited twice.

4.7.6 From the site observations the ES is accurate in its predicted assessment in 5 out of 8 viewpoints. The photomontages showed 50% accuracy in their predicted visual impact (2 out of 4), the inaccuracy representing an under estimate in the visual impact on site. Hare Hill occupies a dominant hill top location visible in particular from directions south clockwise to north east. The siting and topography restricts views from the closest housing at New Cumnock, but views of the windfarm are apparent along the majority of the Glen Afton road, a scenic drive. The ES provides predictions on the anticipated level of impact based on criteria of significance. These criteria were sensitivity of different receptors, extent of screening and or backgrounding of the development by landform or vegetation, distance of the development and the visibility as measured by the field of vision. These were found to be accurate. Visual effects not predicted by the Environmental Statement include: the impact of the views from the A76 travelling south east from Cumnock to New Cumnock which is increased by intervisibility with Windy Standard (the two windfarms occupy the highest ridges in the view), although at this distance the significance of intervisibility is limited. However, the experience for the driver is of windpower as a noticeable feature in the landscape. The implication of this is for the effects of intervisibility on any future windfarm development.

Table 12: Viewpoint Analysis for Hare Hill

VP	Distance (km) - Direction	ES assessment	Site observations	Photomontage
1	4.5	Significant impact.	5 turbines visible. Vertical interference in view from telegraph poles which are more dominant than the turbines	
2	3.5	9-11 turbines visible. Significant impact increased by the heritage associated with the Glen and the sensitivity of the human receptors.	12 turbines visible. Wind farm covers undulating tops of hills and the variety of heights of the turbines and the variation in topography provides some lessening of effect, but it is the only major development in this area of the attractive valley.	Reasonably accurate. (on 13 Feb Light and contrast in the sun make the turbines more obvious and it appears closer in sunlight.)
3	5.5	Significant impact. Comments as viewpoint 2	16 turbines visible. Bulk of hills and rock faces are greater in scale than the turbines and this lessens the visual intrusion. Moderate element in the landscape made more dominant by movement and skylining	Towers appear taller and less clustered than in p.m
5	6.0	Moderate impact Approximately 8 turbines visible	12 turbines visible. Intricacy of the landscape receptors reduces impact	
6	8.0	Moderate impact. Significance reduced by being greater than 5 km.	14 turbines visible on the skyline. Inter-visibility with Windy Standard increases the perception of the scale of the development.	Reasonable accuracy, but towers do not appear tall enough as the blades in the p.m appear to go down to the ground.
7	4.2	9 turbines on average in view. Farmsteads and dwellings highly sensitive to change and have a wide angle of view, but this would be moderated by distance and screening.	14 turbines occupy a wide angle of view on the hillside in a horizontal plane to the viewer. Screening by topography and the horizontal banding in the view provides an acceptance of the development width.	Reasonable accuracy. Turbines are lower to the E and higher to the W than shown.
8	8.5	Minor impacts. Average of 8 turbines visible, but impacts substantially reduced by distance and effects of atmospheric conditions which would reduce visibility throughout much of the year.	9 turbines visible. Foreground urban and rural detractors reduce the apparent impact of the development.	Pm. Does not link to location plan.

4.7.7 The number of view points chosen was limited and a particular omission was from B741 travelling north east just to the west of Knockburine where 16 turbines at a distance of 10km appear suddenly over the ridgeline and the impact increases as the driver travels towards the windfarm before it becomes obscured by vegetation and topography.

Conclusions

4.7.8 The technical details of the VIA are provided in this ES although potential errors are not acknowledged. The recommended viewing distance for photomontages is extremely short. Magnitude, sensitivity and significance are separated, justified and discussed in an explicit and balanced way.

4.8 Novar

The Windfarm

4.8.1 The windfarm was constructed in 1997. The original proposal was for 34 turbines, but height to hub and total height are not stated in the ES (landscape section), which casts doubt on the accuracy of the VIA. As built the windfarm consists of 34 turbines with height to hub of 35 m and total height of 55.5 m. SNH judge that all the main or significant viewpoints were covered, in consultation with Highland Council, including addition of a viewpoint from Ben Wyvis. There was some (but not major) adjustment of tower positions between as assessed and as built, and there were larger changes regarding ancillary works (access tracks etc) during construction, but these were not considered in the present study.

The Environmental Statement

4.8.2 It is stated that the ZVI was supplied to the landscape consultants by National Wind Power Ltd and no technical detail is provided, nor is the ZVI presented in the ES. The radius used was 10 km *("the turbines would be inconspicuous beyond that distance although they may be visible"*), plus two selected viewpoints beyond 10 km. No explicit calculation is made of the zone of actual visibility taking account of landform, ground cover or structures, and no account is taken of the spatial distribution of individual turbines, which covers approximately 3 km.

4.8.3 Thirteen viewpoints were selected based on site survey and consultation with SNH and Highland Regional Council. Each view was used to assess landscape character, then for impact assessment. Photographs were taken with a wide panoramic format camera. Wirelines are referred to but not shown. Photomontages are shown for 5 viewpoints, but no details of their preparation, limitations or recommended viewing distance are provided (except that they are shown as before and after images, based on the original photographs taken with the wide panoramic format camera). These photomontages are never referred to in the detailed VIA.

4.8.4 The ES refers to the amount of change in assessing impact but there is no reference to character or the concept of capacity. The issues of magnitude and significance are merged and drawn from the Department of Transport Design Manual for Roads and Bridges. Volume 11 – Landscape Assessment as follows:

> *Substantial – where the proposals would cause a significant change in the existing view.*
> *Moderate - where the proposals would cause a noticeable change in the existing view.*
> *Slight - where the proposals would cause a barely perceptible change in the existing view.*
> *No change – where no change would be discernible.*

4.8.5 Only substantial impacts are regarded as significant. This scale is applied at each viewpoint, related to human receptors (e.g. travellers, residents, walkers) and summarised in a table. Reference is also made to mitigation by colour of tower *("a light hue of neutral colour*").

Table 13: Viewpoint Analysis for Novar

VP	Distance (km)	ES Description	Site assessment	Photomontage
1	8.5 – 9.75	Predicts 17 turbines visible and quality "pleasant" and impact "slight to moderate".	23 are visible on site. Turbines are inconspicuous unless you actively search for them. However, 10 were backclothed against snow covered hills giving weak contrast (would be stronger against vegetation).	Difficult to check accuracy of PM at this distance (Ben Wyvis in cloud and so not seen in PM). Panoramic lens completely misrepresents scene.
2	6	Predicts 25 turbines visible and quality "very pleasant" and impact "moderate".	22 are visible on site. Turbines clearly visible in good light.	No PM.
3	5-6	Predicts 24 visible in part and quality "pleasant" and impact "moderate".	22 are visible on site but part-screened by row of trees in middle-foreground.	No PM.
4	4 - 6	Predicts 20 visible in part and quality "pleasant" and impact "substantial".	17 are visible on site.	PM is largely accurate representation of turbines in two groups but wholly underestimates visual effect due to use of panoramic lens.
5	2	Predicts 12 visible in part and quality "pleasant" and impact "substantial".	13 are visible on site.	No PM.
8	6.5	Predicts 13 (part) visible and quality "very pleasant", compromised by overhead power lines directly over viewpoint and impact "slight".	12 visible on site. Overhead power line not strictly "in view". Perception of turbines constantly changing as they are lit-unlit by movement of sun in and out of cloud. In photograph, use of panoramic lens "shrinks" centre hills to give very misleading impression.	No PM.
9	10.5	Predicts all 34 visible in part, and that quality is "pleasant" and impact "slight to moderate".	Fewer visible (13) than predicted but visibility poor. House now constructed in immediate foreground.	No PM.
10	15	Predicts 27 visible in part and quality "very pleasant" and impact "slight".	26 turbines visible, but not clear with naked eye and binoculars needed to check. Movement not detectable at this distance. Those backclothed were clearer but those skylined much less distinct.	Visibility on site much clearer than when PM photograph taken. Hills behind windfarm not an indistinct blur in reality.
11	3	Predicts 10/11 visible and quality "high" and impact "substantial".	11 turbines visible on site.	No PM.

Site Survey

4.8.6 There are 13 viewpoints in the ES. Three were not visited because they were too remote and one because it was on private land. Out of 9 visits to 9 viewpoints we were able to make 9 useful assessments.

4.8.7 The predictions of the numbers of turbines visible were generally very accurate or accurate, and differences may be as much to do with re-siting decisions after assessment as with any errors in the VIA. The photomontages were seriously misleading for two reasons; first, their small size and secondly the use of a panoramic lens camera.

Conclusions

4.8.8 The technical details of the VIA are not provided in full in this ES, nor are they justified, and potential errors are not acknowledged. The ZVI is not provided. There is no explanation given on the potential accuracy (or otherwise) of the photomontages and in fact they are never referred to (we did not have access to the main statement, Volume 1, where such reference may appear). Magnitude, sensitivity and significance are identified but not separated with any clarity, nor are landscape and visual effects clearly distinguished.

4.9 Windy Standard

The Windfarm

4.9.1 The windfarm was constructed in 1996. The original proposal was for 40 turbines with a height to hub of 40 m and total height of 60 m. As built the windfarm consists of 36 turbines with height to hub of 35 m and total height of 53.5 m, which might have resulted in over-prediction in the ZVI. Viewpoints were selected after consultation with SNH and local authorities.

The Environmental Statement

4.9.2 The ES states that a *"computer based study was used to delineate areas of potential visual access within a radius of 16 km"* but such a ZVI does not appear in the ES. Figure 8 shows circles at radii of 5 km and 10 km plus selected viewpoints beyond 10 km drawn on a 1:100,000 scale OS map, but there is no indication of relative visibility in relation to topography and this is not a ZVI. There is a note that *"normally the radius of the search area is 10 km, on the basis that the largest features, the turbines, are generally inconspicuous beyond this distance although they may be visible".* Significance is not treated explicitly. It is stated that *"the assessment of impact is the description of the amount of change within the landscape in conjunction with a consideration of the landscape character"* (sic). Passing reference is made to the Department of Transport Design Manual for Roads and Bridges Volume 11: Landscape Assessment. Elsewhere in the ES, summary tables bring all impacts to a common scale of minor, moderate and significant, although these terms are never explained or justified.

4.9.3 Twenty viewpoints were selected, mostly within 15 km of the centre of the site. A table provides, for each viewpoint, a location, short description, distance, note on predicted visibility (number and effects) and a declaration of significance. Although never justified, the significance terms used are slight, moderate and significant, despite the fact that the DoT Design Manual referred to earlier uses the terms no change, slight, moderate and substantial. Wireline diagrams are referred to but not shown. These viewpoint descriptions are repeated in the text. For six viewpoints, selected after discussion with the Regional Council, photomontages are produced, but these are never referred to in the assessment of viewpoints and no technical details on their production or use are provided. The summary section uses the terms moderate and substantial. There is acknowledgement of the existence of a parallel proposal for a windfarm at Harehill and potential issues of intervisibility and cumulative effect are noted but not analysed.

Site Survey

4.9.4 All the listed viewpoints were visited twice

Table 14: Viewpoint Analysis for Windy Standard

VP	Distance (km)	ES assessment	Site observations	Photomontage
1	9.5	Nil	Not visible	
2	13.5	Impact slight	Not visible, obscured by foreground vegetation	
3	13	Turbines skylined in distance. Impact slight.	27 turbines in centre of view. The only obvious development.	Turbines appear smaller and less as individual units in the pm than in reality.
7	13	Nil	Not visible, but Hare Hill is	
8	11.5	Nil	Not visible, but Hare Hill is	
9	11.5	Nil	Not visible, but Hare Hill is	
10	11	Possibly views of parts of the turbines	Not visible	
11	4.5	Nil	Not visible	
12	13.5	Turbine development would be indistinct. Turbines in view would be set against the hillside and within the cover of Carsphain forest. Impact slight	26 turbines visible in the distance. Smaller in scale than Hare Hill, which can be clearly seen nearer to the viewer.	
13	13	Impact slight compared with the already approved Hare Hill wind farm.	Not visible	
15	7	Nil	4 turbines visible along the river valley. The bulk of the hillsides in this location decreases the turbines apparent size.	
16+17	4	6 turbines would be visible on top of very dominant hills. Significant change in view.	4 turbines visible. Steep sided valley with conifer plantations in a range of topography. Turbines are seen as large-scale skyline elements. Drama of the site appears to reduce impact.	Accurate for the 4 largest turbines. Two above nacelle cannot be seen.
18	5.5	?????	Dodd Hill obscures views	
19	10	Nil	Nil	

4.9.5 From the site observations the Environmental Statement is accurate in its predicted assessment of 9 out of 13 cases. Of the photomontages assessed, one was accurate and one showed the windfarm larger than it appeared on site. There were insufficient photomontages within this ES to comprehensively illustrate the visual effects of the windfarm as built. Visual effects not predicted by the Environmental Statement include: the impact of the views from the A76 travelling south east from Cumnock to New Cumnock is increased by intervisibility with Hare Hill (the two windfarms occupy the highest ridges in the view), although at this distance the significance of intervisibility is limited. However, as mentioned previously, the experience for the driver is of windpower as a noticeable feature in the landscape and the implication of this is for the effects of intervisibility on any future windfarm development. Although the statement refers to the approval of permission for the Hare Hill windfarm there is no information on intervisibility. This is a key feature in long distance views from A76 travelling south east from Cumnock and minor roads (VP 12). This is considered as a major shortcoming, but we understand that commercial confidentiality restricted availability of information to carry out a cumulative assessment.

4.9.6 The topography of the site severely restricts the visibility of the windfarm from close range. The choice of viewpoints close to the development gave an assessment of no effect in 7 of the 20 viewpoints. This could have been picked up as a desk study by a theoretical ZVI to which topographical data had been applied.

Conclusions

4.9.7 The technical details of the VIA are not provided in this ES and potential errors are not acknowledged. There is no ZVI and no wireframes. The photomontages are never analysed or discussed. The landscape and visual effects are not clearly distinguished. Magnitude, sensitivity and significance are not distinguished, justified and discussed and there is inconsistency in the terminology used. Although there is reference elsewhere in the ES to effects on landscape, people, recreation etc, the overall structure of the ES makes it difficult to locate and link each of these elements of a comprehensive VIA.

4.10 Other Windfarms and Environmental Statements

4.10.1 Access to some further ESs was possible (Appendix 3), in hard copy or via the www, and key data on ZVI and distances has been extracted from these (and included in Table 16). A more systematic review of a wider selection of ESs was considered in the original plan for the project, but time limitations, compounded by the fact that a comprehensive collection of ESs for Scottish windfarms is not available in either SNH or the Scottish Executive Library, means that such further research has been restricted.

5 OVERALL ANALYSIS

5.1 Introduction

5.1.1 We now analyse a range of generic issues concerning visual impact assessment, based on a consideration of the evidence gathered from all the assessments made at all the viewpoints visited, and considering the literature examined and the environmental statements reviewed. We concentrate on visual effects and leave the key issues surrounding technical visualisation to the final discussion.

5.1.2 Although it is tempting to try to offer specific and conclusive diagnoses or prescriptions, it is clear that the wide variety of factors that influence the core issues under investigation – magnitude, distance and visibility – are such that any generalisation is dangerous. On the other hand, practice cannot proceed effectively if the conclusion is that there are so many variables that nothing useful can be said. An attempt is therefore made to strike a balance between definitive conclusions and an acknowledgement of the context-specific issues that can affect these conclusions. Whenever we make a comparison – for example, that movement increases apparent size or visibility – this is always assuming that other factors are held constant (e.g. light, distance etc).

5.1.3 This analysis applies to windfarms operating in Scotland and in landscape areas of a particular character. The detailed conclusions may or may not be directly applicable to other areas of the UK and to other landscape types.

5.1.4 The size range of the windfarms examined was from 53.5 – 85.5 m overall height but the majority were 53.5 – 65.5 m. However, a new generation of machines is now under development or construction with overall heights approaching 100 m. It is expected that our conclusions on distances or distance ranges would therefore need to be increased for these taller wind turbines.

5.2 Influences on Visibility

General Visibility

5.2.1 In general we found that the turbines are perceptible at a range of from 15 – 20 km from the windfarm and up to 25 km in specific cases and conditions. These distances only apply in clear conditions and if you are specifically looking for the turbines and not just looking at the landscape. It is likely that the turbines would be perceptible to a casual observer at distances of from 10 – 15 km, unless they were highly sensitive or observant or a resident.

5.2.2 The distance over which turbine detail is noticeable is about 5 - 8 km. At a distance of more than about 10 km it is not possible to identify the taper of the turbine tower or identify nacelle detail. At distances up to approximately 12 km turbines are perceived as individual structures that, dependant on layout, may or may not form a group. At a distance of more than about 10 km the turbines begin to be perceived as a group forming a windfarm, rather than as individual turbines.

5.2.3 Higher turbines are visible over a larger distance and this is reflected in our recommendations for ZVI in Table 17. Taking account of the distance ranges over which effects operate at the case-study sites, we judge that an increase in overall height to something approaching 100 m for third generation turbines will result in these distance ranges increasing by around 20% in many cases. When the number of turbines is considered, the influence of a greater number of turbines on the visible distance is less certain, and probably depends on turbine layout, grouping, and the scale of the turbines/windfarm relative to the scale of the landscape. Impact diminishes as distance increases, but is not necessarily directly proportional to turbine number.

Proportional Visibility

5.2.4 Sometimes the whole structures (tower, nacelle and blades) are visible, fully or predominantly, above the horizon. Sometimes the view includes a mixture of elements – the whole structure of some, the upper part of the tower or the extreme tips of rotors of others. In extreme cases, the only elements visible are rotors. The first case is more visually coherent and the eye sees the structures with clarity. The appearance of just the rotors, or the nacelle and rotors, above the horizon produces a disconcerting effect when they are moving that we would describe as less visually coherent, although the observer may mentally fill-in the missing elements. The former appearance can have less impact than the latter at the same distance, because the latter effect is unusual and disturbing even when it is familiar.

5.2.5 The visual layout of turbines in relation to the horizon and skyline profile is therefore an important factor for consideration when assessing the effect at a viewpoint. The extent, pattern and proportions of structures in the view in relation to the scale and form of the landscape and the skyline are all important.

Lighting

5.2.6 We observed that direct sunlight shining on the turbines, either intermittently as the sun moves in and out behind clouds, or for longer periods in bright clear conditions, has the effect of increasing the prominence of the structures and this effect operated over a wide middle distance range. Viewpoints to the south of a windfarm (in the arc from east through south to west) experience this effect whereas back-lit effects occur at viewpoints to the north (in the arc from east through north to west).

5.2.7 Glinting, as the sun is reflected directly into the eye of the observer, can occur over long distances, at least up to 12 km, but is very occasional and is also sensitive to very small changes in angle of view. A flickering effect as the movement of the blades casts a shadow on the tower can occur in bright sunlight and can attract the eye at relatively short distances of from 3 - 5 km; this effect is most marked when the angle of the sun is low in the sky. These potential effects should be considered for viewpoints involving residents or motorists.

5.2.8 The seasonal effects of light (linked with weather and cloud cover) should be considered in relation to human receptors. For residents, year-round conditions are relevant. For tourists and other recreationists, winter conditions will affect fewest people and summer conditions will affect most.

Movement and Orientation

5.2.9 The movement of the blades, in all cases where this is visible, increases the visual effect of the turbines because it tends to draw the eye. We could detect movement with clarity at distances up to 15 km in clear conditions or conditions of strong contrast between the rotors and the sky, but only if you are specifically looking for the windfarm. On occasions, movement was not visible at 6 km in weak contrast. At a distance of more than about 12 km blade movement can become hardly perceptible and we judge that blade movement is perceptible to the casual observer at up to approximately 10 km. Movement was more perceptible when backdropped against dark vegetation compared to grey sky.

5.2.11 Since windfarm rotors are designed to move, the only significant circumstance when a static illusion will result in a generally lesser effect is at viewpoints oriented at 90^0 (± a small deviation of perhaps 10^0) to the prevailing wind direction. Because the prevailing wind in the UK is generally from the south west, viewpoints in the quadrants from south through south west to west, and from north through north east to east, will experience the longest periods of exposure to visible movement. Viewpoints in the opposite quadrants will experience more static effects and we observed this effect at relatively short distances of 2-5 km. We also judged that rotors seen in the plane oriented at 180^0 to the viewpoint appear relatively nearer. It was difficult to assess whether the visibility of movement is affected significantly by the diameter of the rotors or the height of the structures.

Distance, Colour and Contrast

5.2.12 At short distances the colour is clearly seen and colour and light do not have a dramatic modifying effect on visibility, except in extreme overcast conditions or at dawn or dusk. As distance increases, the eye cannot distinguish colour and all structures are seen as grey (this effect would apply whether the turbines were pale grey, yellow or blue). Light coloured (lit) turbines appear closer than grey (unlit) turbines at similar distances. Seen against a blue or pale sky, but not sunlit, grey turbines appear dark. As the sky darkens, because of cloud cover or time of day or season, the contrast between sky and turbines decreases and at long distances (e.g. over approximately 10 km) the turbines may become indistinct because of this. Turbines can appear white against a dark sky if they are lit by sun through patches of cloud. At shorter distances, the contrast between sky and turbines still decreases, but the reduction in visibility is much less because the eye and brain use more linked cues including colour and form and texture as well as contrast.

Contrast, Skylining and Backclothing

5.2.13 The recommendation to use off-white or pale-grey for each element of the structures is because the majority of views by the majority of people are of skylined structures seen against a blue or grey sky. This is because sites for windfarms to date are elevated relative to the majority of receptors. In fact the majority of the viewpoints assessed in the study were middle to long range (5 – 15 km) and skylined. The commonest appearances were dark (grey) turbines seen against a lighter sky and light (grey) turbines seen against a darker sky.

5.2.14 Backclothing is a more frequent phenomenon for viewpoints at elevations higher than the windfarm, although there are a few examples from the case-study sites of backclothing against distant hills and mountains, such as at Novar clearly seen at 15 km against the backcloth of Ben Wyvis, and some against middle-distance hills such as at Dun Law from close-range viewpoints. In winter, backclothing can be against snow-covered hills. Because our surveys did not cover many viewpoints of this type, our site appraisals on this issue are more limited.

5.2.15 As the sky darkens, those turbines seen against the darkening sky become more difficult to perceive, and the ones which are seen against a backcloth of landform and vegetation become relatively more prominent. It is clear from some photomontages and some viewpoints assessed that off-white or pale-grey structures seen against a backcloth of moorland vegetation, including heather, semi-natural grassland and conifer plantations, are much more prominent than when seen against either clear or grey skies. This suggests that the effect of backclothing against vegetation is to extend the visible distance considerably. We observed at a few locations when backclothed turbines were lit by sunlight that they were much more conspicuous than when lit but skylined.

Elevation of Windfarm and Receptor

5.2.16 The area occupied by windfarms is sometimes large and several important effects need to be considered from high-elevation viewpoints. Walkers and others at higher elevations will be within sight of the windfarm for longer periods of time. Visual detractors and man-made elements will be more limited and, apart from the mass of the landform, will be smaller in scale. The turbines will also be backdropped to a greater extent than from lower elevations and the colours of the turbines and vegetation types will have an effect of increasing relative visibility. Air clarity may also be higher at elevation. From higher sites with their long distance views of the landscape beyond the windfarm, there is an effect that can appear to make the turbines look closer than those at the same distance but skylined, and intervisibility as a visual factor can increase in importance.

Colour and Design

5.2.17 All of the case study turbines appeared to be off-white or pale-grey and the current study was not able to explore what additional influences colour might have on VIA, nor have we examined other detailed design factors that may also be relevant to VIA, including tower shape and individual turbine design. As noted earlier, colour effects are mainly important for skylined views at close range but could be more important at longer ranges for backclothed views.

Landscape character and receptors

5.2.18 The character of the landscape and especially elements within it affect perceptions of magnitude. In landscapes that were free of man-made elements the turbines were sometimes much more conspicuous in the middle and long-distance ranges and this affected our judgements of their magnitude. Windfarms or turbines framed by other developments sometimes had a greater apparent impact than those with no framing, because the other elements provided visual cues for judging size, depth and distance.

5.2.19 In the south west region of Scotland the character of the southern uplands is of long ridges, which are a strong horizontal element in the landscape. Other horizontal features, river valleys and their vegetation, hedges and walls, built development and coniferous plantings, often increase this horizontal effect. The windfarms seen during this research can create the impression of another horizontal band at middle range and longer distances, especially where intervisibility between two windfarms occurs.

5.2.20 Consideration needs to be given to the heights, layout and numbers of turbines in a windfarm because the visual impact of a larger number of smaller turbines may be lower (as they are in a scale related to the landscape character) than a windfarm with a smaller number of larger turbines which may in turn be perceived as having a higher visual intrusion level owing to their lack of apparent size-similarity with the horizontal bands in the landscape into which they are to be inserted.

5.2.21 The influence of character will vary for different landscape types, although this is not an issue explored in detail in the current project. However, the technology and economics of turbine design will probably be a more important driver of turbine design and tower height.

5.2.22 Cumulation and intervisibility can be important issues, owing to the breadth of some developments on the skyline, as well as proximity. The orientation of windfarms with respect to others in the visual field needs to be considered to lessen the apparent scale of development. This observation arose especially in the south west region.

5.3 Assessment of Visibility

5.3.1 We discuss this broad issue in greater detail in Section 6. Here, three general points can be made.

5.3.2 We found that there was a general tendency to underestimate the magnitude of visibility in the ES descriptions compared to our judgements on site. This may be related to the frequent under-representation seen in photomontages (paragraphs 6.1.16 – 6.1.17). No doubt consultants use these for evaluation as much as other parties. If this tendency to underestimate magnitude is widespread, for whatever reasons, it does suggest that much of the published guidance and some of the implied judgements on significance in relation to distance will tend to be conservative. Many anecdotal and derivative distance-significance judgements may therefore need to be lengthened to compensate for underestimation caused by reliance on photomontage. In addition, earlier field studies (e.g. Stevenson & Griffiths, 1994) devised distance bands based on first generation turbines, and our conclusion is that these bands need to be increased for second and third generation structures.

5.3.3 We judged that wireframes *tended* to cause less under (or over) estimation of visibility and visual effect, compared to photomontages, perhaps because they do not purport to be other than indicative of potential visibility. Wireframes are used more as a working tool for VIA whereas photomontages are also used to simulate realism. In other words, whilst both wireframes and photomontages are required to be (and generally are) accurate in terms of the positioning, spatial distribution and size (especially height) of the towers, wireframes (unlike photomontages) are not expected to offer a *realistic* visualisation or impression of the on-site view that will exist after construction of the windfarm.

5.3.4 This may also be an appropriate point to raise a subtle presentational point about visibility assessment. Because many factors act to decrease or increase apparent magnitude (and therefore potential significance), there is a tendency in all the ESs examined (and in guidance such as is shown in Table 3) to adopt what might be termed the *"half-empty"* rather than the *"half-full"* approach to assessment. For example, guidance and assessment often emphasises the factors that decrease visibility ("*only prominent in clear visibility*") rather than the factors that increase visibility ("*always prominent in clear visibility*"). Although both statements are in one sense identical, a different adverb produces a different impression.

6 DISCUSSION

6.1 Visual Impact Assessment

Zone of Visual Influence

6.1.1 It proved impossible to carry out comprehensive tests of the accuracy of the ZVI in the case-studies for two main sets of reasons. First, the area covered by a typical ZVI is very large, for example 225 km^2 for a 15 x 15 km ZVI, and a systematic checking of such a large area would have required intensive, time-consuming site visits. Also, almost all ZVI were based on topographic worst case scenarios, making site survey difficult when the bare terrain of the ZVI is in reality populated by vegetation, buildings and other structures and elements (Wood, 1999, 2000). Second, many windfarms were significantly different in the details as built compared to as assessed; such differences included changes in the numbers of turbines, changes in the overall height of turbines, and changes in the site-specific locations of individual turbines. For these reasons, our diagnoses concerning ZVI are largely based on the literature described in the background research.

6.1.2 ZVI are never accurate (Hankinson, 1999). They contain several sources of error and it may not always be feasible to separate these errors or to estimate their size and potential effects. If the errors are known, this should be stated. The existence of error should always be acknowledged. Such errors may matter less if the purpose of the ZVI is to compare the relative effects of two or more sites or to compare alternative layouts, where it is the comparison which is being evaluated, and not the precision of specific locations. They are not necessarily a reliable basis for predicting visibility from exact locations, which must always rely on additional pre- and post-ZVI desk and site assessment. They are a useful basis for selecting potential viewpoints for consideration (but must be subjected to detailed site testing), perhaps using wireframe or photomontage techniques.

6.1.3 Most ZVI examined are worst case, based on a topographic digital terrain model only. Increasing sophistication by the addition of data on forests, woodlands and other elements in the landscape is at the same time both desirable and subject to the introduction of further errors of detail and interpretation.

6.1.4 All ZVI examined are not distance-sensitive, that is they do not attempt to combine the effects of distance and visibility to generate what has been termed a fuzzy viewshed. This is sensible, given the subjectivity and complexity of this factor, which is best considered as a separate and distinct exercise in any assessment.

6.1.5 The presentation of the ZVI in some ESs could be improved. Overlaying the ZVI onto an OS base map (at 1:50,000 or 1:100,000 scales) is essential to help the interpretation of the ZVI and is also necessary in the initial stages of selecting representative or key viewpoints.

6.1.6 Where the degree of visibility is illustrated using a graded tone or a range of colours, careful thought on presentation and explanation is required to minimise the risk of creating a distorted impression. This can arise because the number of turbines visible sometimes increases as the distance increases, due to topography, whilst the relative size or visual effect decreases in parallel. A shaded ZVI that uses denser tones for areas where the number of visible turbines is greater can create an impression that is diametrically opposed to the probable magnitude and significance of the visual effects. One solution might be to adopt the use of the term ZTV (Zone of Theoretical Visibility) for what is now commonly referred to as the ZVI in order to emphasize the theoretical, potential and limited nature of the information shown in such a map. Another solution might be to produce a second map (perhaps called the Zones of Visual Effect: ZVE) where the predicted magnitude of the effects (Table 18 and Section 6.2) is translated onto the ZTV to illustrate the effects that distance (and other factors) are expected to have on the size and intensity of the visual effects. Finally, a composite map (perhaps called the Zones of Visual Significance) could be considered which combines the ZTV and the ZVE with the thresholds and criteria used for assessing significance, to illustrate graphically what is now only explored using a limited number of key viewpoints. We are not aware that such presentation techniques have been attempted experimentally, nor have we explored fully the potential conceptual, technical and interpretational difficulties, but this may be an area for further research and development in the application of CAD and GIS tools.

Table 15: Published Technical Recommendations for Visual Impact Assessment

		ZVI (distance in km)	ZVI	ZVI	Visualisations	Photomontage
Tower height →		*Not specified*	*c60 m*	*c95 m*		
CC (1991)		10-15				
BWEA (1994)		-	-	-	Recommended but non-specific	Recommended but non-specific
Stevenson & Griffiths (1994)		10			Recommended and specified	Recommended and specified
LI-IEA (1995) & LI-IEMA (2002)		-	-	-	Recommended but non-specific	Recommended but non-specific
Thomas (1996)		-	20	-	-	-
TJP (1997)			15			
CuCC (1999)			20		Key viewpoints within 10 km radius	
CPRW (1999)*			20	30		
CCW (1999)		10-20				
SNDC (2000)		20				
MAA (2000)			20	30		
SNH (2001)		25			Key viewpoints up to 10 km radius	
SE PAN45 (2002)		-	-	-	Recommended but non-specific	Recommended but non-specific

* Sinclair-Thomas recommendations (Table 4).

6.1.7 On the question of a recommended radius for a ZVI in relation to the proposed overall height of towers, we have reviewed the recommendations that appear in published guidelines (Table 15) and the practices in the case-study and other ESs (Table 16). In no case-study has a developer used the recommended radius contained in Sinclair-Thomas (Table 4), and whilst there is a suggestion in Table 16 of a trend for the radius to increase in size as the height of towers increases, this is by no means clear.

Table 16: ZVI in Environmental Statements in Relation to Number and Size of Towers.

	Windfarm	Date of ES	Height of Tower (maximum including rotor)(m)*	Number of Towers*	ZVI (km) **	Viewpoints (number)
1	Delabole	1991?	40.4	10	7.5	Not known
2	Burnt Hill	1993	60	19	17	27
3	Hare Hill	1994	60 (85.5)	20	10 (8.5-13)	8
4	Hagshaw Hill	1994	55.5 (65.5)	30 (26)	12	16
5	Novar	1995	? (55.5)	34	10	13
6	Windy Standard	1995	60.0 (53.5)	40 (36)	16 (10?)	20
7	Dun Law	1996	66.7 (63.5)	34 (26)	8 (16)	8
8	Beinn Ghlas	1997	65 (57)	16 (14)	10	13
9	Beinn An Tuirc	1997?	62.5	50 (46)	15	18
10	Gartnagrenach	1998	63	24	15	9
11	Deucheran Hill	1999	76 (76.5 & 62.5)	12 (9)	15	14
12	Meikle Carewe	1999?	78	14	25	22
13	Kielder	2000	82	107	20	Not known
14	Black Law, Carluke	2001?	90?	70	23	Not known

* First quoted figure is as in ES. As-built height and number may differ and figures in parentheses are as-built if known to differ from as-assessed in ES.
** Two figures are quoted where there is a lack of clarity or contradiction in the ES.

6.1.8 Based on our diagnoses concerning the effects of distance, our arguments that relatively small effects could be significant for highly sensitive receptors, the precautionary principle which is now widely established as best practice in environmental policy, and taking account of the increasing sizes proposed for new developments, we recommend the general guidelines shown in Table 17.

Table 17: Recommendations for ZVI in Relation to Overall Height.

Height of turbines (total including rotors)(m)	Recommended ZVI distance (km)
50	15
70	20
85	25
100	30

6.1.9 The figures in Table 17 are approximate and should be adjusted either upwards or downwards to suit local circumstances and in the context of local or regional landscape character and landscape or visual sensitivity. Despite the trend towards larger and taller structures, it is unclear what ultimate limits might exist, because optimum tower height depends on an integration of economic, meteorological, technological and environmental factors. The recommendations in Table 17 would need to increase for heights greater than 100m, although at distances much greater than 30 km the limit of visibility to the human eye is being approached.

6.1.10 The cost of digital data is very low but computation times will increase for ZVI for larger radii. The calculation of line-of-sight from a digital terrain model (DTM) in GIS is therefore still computationally intensive (Kidner et al, 1997) and such costs may be one reason for developer or consultant reluctance to extend the radii of ZVI. However, we judge that this cost is still a relatively small element of an overall EIA. A further reason for resistance to larger radii might be tactical and psychological, in that increasing even a ZTV increases the likelihood that designated or valued landscapes will appear on the zonal map at the margins, so perhaps fuelling fears among developers that an increase in potential significance will be perceived if the radius is increased. We have commented on this and related issues, and possible ways to address it, at paragraph 6.1.6.

Viewpoints

6.1.11 The general result from our brief interviews with SNH project officers was that they felt that developers had listened and accepted SNH recommendations concerning the selection of viewpoints. Whilst hindsight might occasionally suggest a key viewpoint that was omitted, we judge that any significant underestimation of visibility is often due to post-ES siting and design changes rather than to any key omissions at the scoping stage. For some case study sites, additional post-ES visualisations had been prepared. However, there are occasional instances of omission, an issue that arises particularly in the south west region where intervisibility and cumulative effects were sometimes acknowledged but not analysed and assessed.

6.1.12 From our analysis of the case study sites, we can detect no clear rationale for the number of viewpoints selected that might lead to recommendations. For example, Table 16 shows a wide variation in the number of viewpoints selected, unrelated to the size or number of turbines or the size of the ZVI. The number selected is a result of negotiation between the developer or the consultants and statutory consultees, especially the local planning authority and SNH. Whilst there may be some developer-resistance to producing very large numbers of visualisations on the grounds of time or cost, additional influences must also be the landscape character within the ZVI and the probability or potential significance of visual effects based on the density of human habitation, transport or recreational routes, strategic recreational sites or scenic viewpoints and so on. Local Plans and related Supplementary Planning Guidance may also influence the selection of viewpoints, although we have not examined this issue. A case-by-case approach to viewpoint selection through negotiation is therefore the only feasible option.

6.1.13 We did note that in some ESs, viewpoints are described as being selected to show a *"representative"* range of visual effects. We also noted a frequent tendency for several *"not visible"* viewpoints to be selected for assessment. By way of contrast, the Harehill windfarm is visible at seven of the eight viewpoints assessed (and probably visible at the eighth), but the Windy Standard windfarm is invisible at nine of the 15 viewpoints assessed. Whilst acknowledging that the ZVI, used for identifying potential viewpoints, will contain errors, this phenomenon appears at first sight to be odd. The ES is required by law and regulation to assess potential significance, and if the ZVI predicts invisibility, then detailed assessment seems unnecessary. Although we have not explored the possible reasons behind this, it may be that consultees wish to see further proof of invisibility beyond the ZVI, and that there is deep distrust of the accuracy of ZVI.

6.1.14 The choice of precise viewpoints in the case-study ESs sometimes seemed less than ideal. There were occasions when we assessed a viewpoint and noticed that a very short distance nearer to or even further away from the windfarm the turbines were more prominent. We found this at Dun Law and Deucheran Hill and Beinn an Tuirc. There were some viewpoints for Deucheran Hill from which the windfarm was not visible, but from the same location Beinn an Tuirc was very visible or even dominant. Perversely, this viewpoint was not used in the Beinn an Tuirc ES, but a viewpoint nearby selected for Beinn an Tuirc demonstrated a much reduced or zero impact.

6.1.15 If visualisations are therefore being used for what are effectively three separate purposes, (a) to test the ZVI, (b) to provide a representative selection of visual effects (essentially this is visual survey and not assessment), and (c) to assess the potential significance of effects at key viewpoints, then these three purposes should be distinguished. Although mixing these purposes might appear harmless, it can result in an ES that contains potentially and superficially very misleading information. For example, statements to the effect that *"the windfarm would only be visible from three of the fifteen viewpoints assessed"* can be inserted freely and truthfully, without acknowledging that twelve of these may have been selected specifically to show just such a non-visible and therefore non-significant effect.

Wireframe and Photomontage

6.1.16 Photographs (and therefore photomontage) are subject to a range of limitations. They may not reproduce small objects or texture, rendering of colour is variable, light levels are not reproduced accurately, the small scale can tend to distort, and contrast is generally lower than in reality. However, and accepting these limitations, they are useful and essential tools in VIA. Our own view is that wireframes can be as useful as photomontage in many circumstances, because they are cheaper to produce, so more can be requested, and because they do not purport to be other than indicative of potential visibility.

6.1.17 The accuracy of photomontage has at least two dimensions. First, a photomontage can and should be accurate in the sense that the positioning, spatial distribution and size (especially height) of the towers is accurate in relation to the landscape and other elements or structures in the picture. This is achieved by meticulous attention to a number of detailed requirements that are familiar in photomontage (and wireframe) technology. Second, the accuracy of a photomontage can be judged on the degree to which it creates a realistic visualisation or impression of the on-site view that will exist after construction of the windfarm. This consideration is more subjective and impressionistic, but realism can be enhanced by avoiding obvious distortions caused by some lenses, and by considering size and viewing distance, discussed below.

6.1.18 A photomontage can imply a degree of realism that may not be robust, and can seduce even a critical viewer into investing more faith in that realism than may be warranted. Certainly our case-study analyses confirm a widespread belief that photomontages almost always underestimate the true appearance of a windfarm from most viewpoints. This is in contrast to statements in some ESs that overestimation occurs because of the technique used to produce the photomontage.

6.1.19 There can be several causes of this underestimation. The most obvious is the use of panoramic or wide angle lenses that produce subtle and sometimes not so subtle distortion. Wide angle lenses in particular have the effect of enlarging the foreground and reducing or receding the background in a manner that directly under-represents the apparent magnitude of windfarms in landscape scenes. We therefore endorse the general use of the 50 mm lens on a 35 mm format camera. For photomontage, the focal length of the lens used and other relevant technical detail should always be quoted.

6.1.20 A second reason is the common submission of visualisations that are relatively small, often accompanied by a recommendation to view them from an unnaturally short distance. For example, some case-study ESs suggested viewing distances of 17, 23 or 24 cm. Our judgement is that this configuration is a strain on the eyes, is difficult or impossible to use and fails to capture any semblance of realism. Because most viewers will in practice observe these images from longer distances, a subtle but powerful under-representation of the visual effect is introduced.

6.1.21 A typical, comfortable viewing distance for reading A4 pages is 30-40 cm, and a typical, comfortable viewing distance for larger images at either A4 or A3 held at arm's length is 50-60 cm. We therefore recommend that what is comfortable and natural for the viewer should dictate the technical detail and not *vice versa*. This means that visualisations should be designed for typical viewing distances of 30 – 50 cm and that most visualisations should be correspondingly larger (a recommendation also made in Stevenson & Griffiths, 1994). A full image size of A4 or even A3 for a single frame picture, giving an image height of approximately 20 cm is therefore to be preferred, rather than the common use of images with a height of approximately 10 cm.

6.2 Effects of Distance

The Sinclair-Thomas Matrices

6.2.1 We tested the Sinclair-Thomas Matrices (Table 4) during our site visits and found them difficult to use because of the imprecision of the terminology used, and because the separation between magnitude and significance was not always clear or was mixed. In addition they take no account of the influences of different landscape character or visual context. Whilst there is probably not much controversy over a judgement that the visual effect is dominant close to a windfarm and indistinct or negligible at long distances, the matrices lack clear differentiation in the middle-distance zones. It is here, of course, that most debates and controversies over magnitude and significance exist. In general our on-site assessments were in agreement with Sinclair-Thomas at viewpoints near to a windfarm and at long distances, but we consistently rated the visual effect as either much less or lower in the middle-distance zones, or we were unable to reach a robust judgement because of a lack of differentiation in definition between distance classes. For example, we were never able to distinguish the difference between Band C *("Clearly visible with moderate impact: potentially intrusive"*) from Band D *("Clearly visible with moderate impact: becoming less distinct* ") on visual grounds.

An Alternative Schema

6.2.2 We have therefore devised the following schema as an alternative to the Sinclair-Thomas or other distance-magnitude guidelines, based on the results from the current research project. This schema is offered as a suggestion for testing and further evaluation, and our earlier comments on issues of magnitude and significance should underline the inherent difficulties in devising any schema that is likely to enjoy universal consensus, even among trained professionals. We suggest that the following approach might at least help clarify the issues sometimes hidden within the generalised statements that appear in some literature.

6.2.3 First, we suggest use of the conceptual model shown in Figure 2. The issues are complex and this cannot be wished away. The first factor to be considered is physical form of the development, which varies with the windfarm structures, their number and layout. The second factor to be considered is visibility in a physical sense, including distance to the viewpoint, weather effects and the seasons – what we have termed the ambient conditions in Figure 2. The third consideration in terms of magnitude (left side of Figure 2) is a large number of factors that modify the visual effect, some related to human perception and some related to physical elements and design of the environment. We believe that this is a structured and enlightened approach to the assessment of magnitude.

6.2.4 Second, we suggest that magnitude be described as shown in Table 18. The terms large, small etc are used because magnitude means size. For each size class, we offer a single keyword descriptor, which is then qualified with other words to try to paint a verbal picture of the size effect. Each class is a range, and the boundaries are explicitly not fixed or defined. It is important to emphasise that no judgement of significance is implied in this table and the words have been chosen to describe size only, in so far as this is possible.

6.2.5 Our judgement is that in the very large, large and negligible distance zones, there are very few factors that modify the physical visual effects to any great extent, although all will have some slight modifying effect. However, a host of modifying factors needs to be considered in the broad middle distance zones. These are listed in Figure 2, divided into those that tend to increase the perception of magnitude and those that tend to reduce it. In judging the appropriate size class for any predicted visual effect at a particular viewpoint, these factors need to be considered explicitly.

6.2.6 It is important to stress that the critical classification is the visual size class and not the distance. Three examples emphasise this point. It is the size class descriptor *prominent* that is important visually, not whether the viewpoint happens to be at 1 km or 2 km from the turbines. If the prevailing wind is such that the turning rotors will appear directly facing the viewer for most of the time, the turbines will appear more visible than if the prevailing view is to blades at right angles to the viewer; in this case, it is perfectly feasible for the perceived magnitude to be judged as *conspicuous* rather than *apparent*. If meteorological data shows that aerial visibility will be low for a high proportion of the year, the average magnitude of the visual effect will be correspondingly lower; in this case, it is perfectly feasible for the perceived magnitude to be *apparent* rather than *conspicuous*.

6.2.7 Magnitude must then be linked with sensitivity to seek evaluation of significance, discussed in the next sections.

6.3 Receptor Sensitivity

6.3.1 For sensitivity (right side of Figure 2), we recommend use of the words high and low, rather than large and small, because the words high and low imply a level of intensity rather than a size associated with magnitude. Both the sensitivity of the human receptor and the interaction with their location or the type of viewpoint may need to be evaluated.

6.3.2 Whilst there appears to be a general consensus, expressed in much guidance (e.g. LI-IEA, 1995; LI-IEMA, 2002)) and in ESs and elsewhere, that assessing sensitivity is subjective and depends in the end on experience and balanced professional judgement, we suggest that this consensus should apply mainly to landscape assessment. For the related but distinct area of visual assessment, it seems to us that this is as much a matter for people as for professionals. When a landscape or other professional writing in an ES identifies a range of human receptors – residents, walkers, tourists etc – and then categorises their visual sensitivity as high or medium or low - it needs to be acknowledged that this is the professional acting as a representative or surrogate; they are not applying professional experience and judgement, *per se*.

6.3.3 Although this type of human sensitivity categorisation seems intuitively reasonable, we know of no detailed evidence to support it. Also, of course, people's perceptions, attitudes, preferences and sensitivities are known to be highly diverse and variable. Further, people are not either residents or walkers; most people may be both of these things, and other things, at different times of the day, or seasons, or through their behaviour, lifestyles or lifetimes.

6.3.4 We therefore recommend that in any ES there is an explicit description of who the human receptors are, and a description of their suggested sensitivity, with further detailed justification if possible, including their number, mobility, exposure time etc. If and when detailed research is carried out to test the range and diversity of such sensitivities, then this information can be used directly in EIA.

Figure 2: Conceptual Model for Visual Impact Assessment

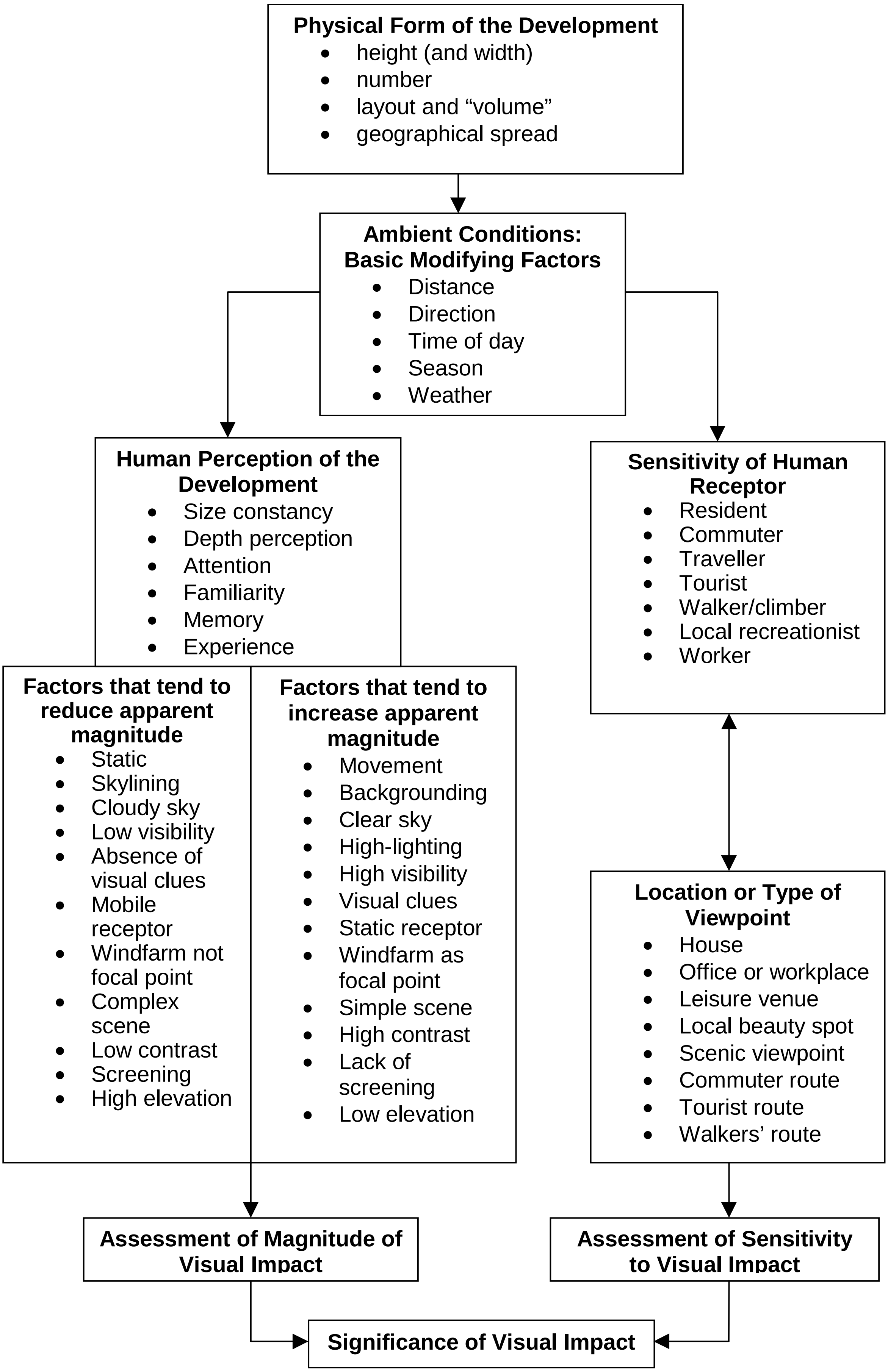

Table 18: Size Classes, Names and Descriptors for Visual Effect (Magnitude)

Size Class	Name	Descriptors – appearance in central vision field	Modifying Factors (Figure 2)
Very Large	Dominant	Commanding, controlling the view	Few
Large	Prominent	Standing out, striking, sharp, unmistakeable, easily seen	Few
Medium	Conspicuous	Noticeable, distinct, catching the eye or attention, clearly visible, well defined	Many
Small	Apparent	Visible, evident, obvious	Many Limit of Potential Visual Significance ↓
Very Small	Inconspicuous	Lacking sharpness of definition, not obvious, indistinct, not clear, obscure, blurred, indefinite	Many Limit of ZVI ↓
Negligible	Faint	Weak, not legible, near limit of acuity of human eye	Few

6.4 Significance

6.4.1 Of all the issues surrounding VIA, significance is the most subjective and intractable. We therefore recommend that the link between magnitude and sensitivity is made explicit to arrive at judgements of significance. The use of simple matrices is, we believe, a helpful tool for mapping and explaining the basis for the judgements made. However, as LI-IEA (1995) has stressed, the matrices in those guidelines are indicative suggestions only, and a case-by-case approach is required in assessing significance for individual windfarm proposals. The LI-IEA (1995) model matrix of three classes on each axis producing 9 cells, only 3 of which are typically judged as significant, is in our view simplistic and unrefined and quite unsuitable as a tool for widespread use. In particular it implies a degree of certainty about a very restricted definition of significance that we do not believe is justified. Expanding a 3 x 3 (9 cells) matrix to 4 x 4 (16 cells) or even 5 x 5 (25 cells) is much more representative of the diversity of size and sensitivity found in visual impact assessment. These matrices do not appear in LI-IEMA (2002), perhaps because of the risk that they will be applied indiscriminately. Instead, LI-IEMA (2002) emphasises that *"Significance is not absolute and can only be defined in relation to each development and its location. It is for each assessment to determine the assessment criteria and the significance thresholds, using informed and well-reasoned judgement supported by thorough justification for their selection …."* and goes on to give several examples (Appendix 6) of criteria, definitions of magnitude and interpretations of significance used by different landscape practices for different project types and landscape settings. There is a lack of statutory guidance on the definition and evaluation of significance and this may be one reason for some simplistic approaches to a complex and difficult issue.

6.4.2 We are not persuaded by the common declaration or assumption found in some of the ESs examined that a medium effect imposed on a medium sensitivity receptor is necessarily insignificant, nor that a small effect on a high sensitivity receptor is also insignificant. For example, LI-IEMA (2002) states that *"in wilderness landscapes the sensitivity of the people who use these areas may be very high and this will be reflected in the significance of the change*". It therefore appears to us feasible that a small change for a highly sensitive receptor could be judged to be significant. An example of the problem of interpretation of significance appears in the ESs for the Beinn an Tuirc and Deucheran Hill windfarms. Both declare they are based on the EIA Regulations, but the former concludes that moderate and major effects are significant, whilst the latter concludes that only major and moderate-major effects are significant. However, ultimately this is just playing with words, and as we have already pointed out, the law, regulations and statutory materials offer no unequivocal guidance. Until such time as robust consensus on significance, based on detailed research, can be claimed with confidence, best practice requires that the bases for all judgements made are clear and explicit on a case-by-case basis.

6.5 Conclusions

6.5.1 VIA is complex. All the issues surrounding magnitude and visualisation (e.g. factors affecting visibility, human perception, ZVI, camera specifications for photomontages), and all the issues surrounding significance (e.g. the sensitivity of human receptors, and the meanings of words such as material change and fundamental change), are subject to complexity, controversy and uncertainty. This research and report has reviewed, examined and explored these issues in detail. It has tried to explain the influence of different issues and effects and to offer guidance on their interpretation and application to VIA.

6.5.2 VIA requires an explicit recognition of this complexity, controversy and uncertainty. The provision of detailed technical information is essential in any VIA to ensure that the issues can be understood and sound judgements made. The overriding consideration is that the quality of the VIA needs to be high if the evaluation of impacts is to be sound.

6.5.3 Given the wealth of research, guidance and experience revealed by this study (even if some of it is contradictory), we were surprised at the general lack of reference to and use of this material in the ESs examined. This apparent failure of research and even practice-based research to penetrate quickly into EIA and VIA practice is an issue that may need to be examined and addressed.

7 RECOMMENDATIONS FOR BEST PRACTICE FOR VISUAL IMPACT ASSESSMENT

In this section our detailed recommendations are presented and summarised as concise bullet points. Their justification is contained within the preceding review, analysis and discussion. Although some may seem obvious or even trivial, there is such variation in the content of the VIA in the Environmental Statements examined that even these simple points need emphasis in the interests of best practice.

7.1 General

- Generic Best Practice Guidance on EIA should also be followed for VIA, including the requirements for assessment to be rigorously documented and explained, integrated, consistent, balanced and objective and for presentation to be logical, clear and well-structured
- Cumulative effects and the cumulation of windfarm projects should be considered and assessed whenever relevant
- Comprehensive scoping based on consultation should be carried out
- Clear distinctions should be made between magnitude, sensitivity and significance
- The inherent complexity, controversy and uncertainty in VIA should be acknowledged and addressed
- High quality VIA depends on a detailed and explicit declaration of the basis upon which all aspects of the VIA have been made, especially magnitude, sensitivity and significance
- Significant post-assessment changes should be re-assessed, re-visualised and re-evaluated
- Wider use should be made of the existing wealth of research, guidance and practice experience

7.2 Landscape and Visual Assessment

- Visual Impact Assessment is an integral but distinct part of Landscape and Visual Assessment and should be distinguished from Landscape Assessment, including Landscape Character Assessment, Landscape Sensitivity and Landscape Significance
- The *"Guidelines on the Environmental Impacts of Windfarms and Small Hydroelectric Schemes"* (Scottish Natural Heritage, 2001) and *"Guidelines for Landscape and Visual Impact Assessment"* (LI-IEMA, 2002) should be used.

7.3 Zone of Visual Influence

- A ZVI should appear in any Environmental Statement, superimposed on an OS base map at 1:50,000 or 1:100,000 scales
- The data used to calculate the ZVI should always be described. The use of OS Panorama Data and a 50 m cell size is recommended
- The existence of error should always be acknowledged and if possible the errors should be assessed and discussed
- A theoretical (computer generated) ZVI should always be tested and verified by desk and field study and the results of those tests should be described
- Distance for ZVI should be based on the recommendations in Table 17 and should be justified, including any alternative distance used
- Distance for ZVI where cumulative effects is an issue should be adjusted, extended and justified

- ZVI should assess the degree of visibility based on the numbers of turbines visible, at least to the maximum height and if possible based on nacelle/hub height and on total height
- Any extensions to a worst-case (bare ground) ZVI to include computer modelling of built and landscape elements should be subject to these same recommendations

7.4 Viewpoints

- Viewpoints should be selected by negotiation with statutory consultees, including the Local Planning Authority and Scottish Natural Heritage, and public consultation and participation should be considered
- The number should be selected to achieve an effective assessment of key viewpoints and an effective assessment of representative viewpoints, as two distinct considerations
- Viewpoints should be selected in order to identify both potentially sensitive receptors and potentially significant views or locations or landscapes
- Precise selection on site should be made to avoid detailed positioning which underestimates the visual effect by the judicious positioning of screening objects
- If used to verify the accuracy of any ZVI, such verification should be distinguished from its use to assess potential sensitivity and significance
- If viewpoints are also used as part of any landscape assessment, this should be clearly distinguished from the visual assessment
- The precise location (including OS grid reference point), orientation to the proposed development, date, time of day and weather conditions should be stated for each viewpoint

7.5 Visualisations

General

- The focal length of the lens and camera format used for photographs (and derived visualisations) should always be stated
- Use of a 50 mm lens in a 35 mm format is recommended, or equivalent combinations in other formats
- Panoramas should be produced by splicing standard photographs and not by the use of specialist cameras, in order to minimise distortion

Wireframes

- Wireframes should be used in an appropriate combination with photographs and photomontage, as both working and presentation tools
- Wireframes may occasionally be preferred to photomontage because they reduce the risk of implying a false realism

Photomontages

- The limitations of photomontage should be recognised and acknowledged, especially a tendency for photomontage to consistently underestimate the actual appearance of a windfarm in the landscape
- A natural viewing distance of 30-50 cm should dictate the technical detail of their production
- A full image size of A4 or even A3 for a single frame picture, giving an image height of approximately 20 cm, is required to give a realistic impression of reality

7.6 Magnitude

- Magnitude (size) of visual effects should be described and the categorisation justified
- Terminology such as large – small should be used
- The use of the size classes and descriptors in Table 18 is recommended
- Distance should not be used mechanistically to predict magnitude at a particular viewpoint because of the potential effects of other modifying factors

7.7 Environmental Conditions and Human Perception

- The specific environmental conditions at or affecting each viewpoint should be stated and analysed, including factors such as season and weather, air clarity, movement, orientation to prevailing winds, visual cues, screening and elevation of the wind farm in relation to the viewer (Figure 2), as well as the detailed design and layout of the windfarm
- Available data should be used wherever possible (e.g. meteorological data)
- Specific aspects of human perception at or affecting each viewpoint should be stated and assessed, including factors such as size constancy, depth perception, attention, familiarity and experience (Figure 2)

7.8 Receptor Sensitivity

- Different human receptors should be distinguished and described (Figure 2)
- Terminology such as high – low should be used
- Their characteristics and behaviour, including factors such as mobility, should be distinguished
- Their number, degree and time of exposure and other relevant factors should be analysed, using available data wherever possible
- Their assumed sensitivity should be described and justified
- Distinctions should be made between assumed human receptor sensitivity and that based on landscape professional experience and judgement

7.9 Significance

- The basis upon which significance and non-significance has been assessed should be described and justified
- Significance (and sensitivity) is highly context and project specific and this needs to be recognised and addressed
- Every project requires its own set of criteria and thresholds, tailored to suit local conditions and circumstances

7.10 Conclusion

- The increasing development pressures for windfarms require that VIA is approached in a comprehensive, explicit and systematic way and that the inherent complexity, controversy and uncertainty are addressed.

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10 APPENDICES

Appendix 1: List of Environmental Statements and Related Documents Used for Case Study Sites

CRE Energy (Scottish Power plc)(no date). Beinn An Tuirc Windfarm. Environmental Statement. Document No 4906/018/ES/97/7505.

CRE Energy (Scottish Power plc)(no date). Beinn An Tuirc Windfarm. Photomontages. No reference.

Scottish Power (1997). Propopsed Windfarm at Beinn An Tuirc, Kintyre. Assessment of Landscape and Visual Effect, Layout F, Draft 2. Turnbull Jeffrey Partnership, Edinburgh.

Scottish Power (1998). Beinn An Tuirc Windfarm. Wireframe Overlay Illustrations. Prepared as supporting information for Argyll and Bute Council.

National Wind Power Ltd (1996). Proposed Windfarm at Beinn Ghlas, Barguillean Farm, Taynuilt, Argyll & Bute. Environmental Statement Volume 1. Perth.

National Wind Power Ltd (1996). Proposed Windfarm at Beinn Ghlas, Barguillean Farm, Taynuilt, Argyll & Bute. Environmental Statement Volume 3: Technical Reports. Bioscan Report No E0510V3, Bioscan (UK) Ltd, Aberdeen.

National Wind Power (1997). Beinn Ghlas Windfarm, Taynuilt, Argyll. Additional Viewpoint Assessment. Derek Lovejoy Partnership, Edinburgh.

National Power Consultants Ltd (1999). Proposed Wind Farm at Deucheran Hill, Kintyre: Environmental Statement. Volume 2. Glasgow (and revised drawings dated November 2000).

Renewable Energy Systems Ltd (1996). The Dun Law Wind Farm: Environmental Statement. RES Ltd, Hemel Hempstead.

Renewable Energy Systems Ltd (1996). Dun Law Wind Farm: Responses to Statutory Consultees and Further Assessment. RES Ltd, Hemel Hempstead.

TriGen Windpower (1994). Environmental Statement Project Summary for Proposed Windfarm at Hagshaw Hill, Clydesdale. TriGen Windpower Ltd, Truro, Cornwall.

TriGen Windpower (1994). Environmental Statement for Proposed Windfarm at Hagshaw Hill, Clydesdale. Volume 1. TriGen (Hagshaw Hill) Ltd, Glasgow.

TriGen Windpower (1994). Environmental Statement for Proposed Windfarm at Hagshaw Hill, Clydesdale. Volume 2. TriGen Windpower Ltd, Truro, Cornwall.

TriGen Windpower (1994). Environmental Statement for Proposed Windfarm at Hagshaw Hill, Clydesdale. Volume 3. TriGen (Hagshaw Hill) Ltd, Glasgow.

Natural Resource Consultancy (1994). Environmental Statement Summary. Wind Farm at Hare Hill, New Cumnock, Ayrshire. NRC, Ayr for Dalhanna Farming Company.

Natural Resource Consultancy (1994). Environmental Statement. Wind Farm at Hare Hill, New Cumnock, Ayrshire. NRC, Ayr for Dalhanna Farming Company.

Natural Resource Consultancy (1994). Environmental Statement Appendices 3-7. Wind Farm at Hare Hill, New Cumnock, Ayrshire. NRC, Ayr for Dalhanna Farming Company.

National Wind Power (no date). Novar Windfarm Limited. Environmental Statement Volume 2: Figures and Illustrations. National Wind Power, Bourne End, Buckinghamshire.

National Wind Power (1995). Proposed Windfarm, Novar Estate, Evanton, Ross & Cromarty. Environmental Statement Volume 3: Technical Reports. Bioscan Report No E481V3ES, Bioscan (UK) Ltd, Aberdeen.

National Wind Power & Fred Olsen Ltd (1995). Windy Standard Windfarm Environmental Statement. National Wind Power, Bourne End, Buckinghamshire & Fred Olsen Ltd, Castle Douglas.

Appendix 2: Additional Data Sources for As-built Case Study Sites

Beinn An Tuirc: http://www.tjp.co.uk/eia_files/beinn-an-tuirc.html (accessed 15 February 2002)

Beinn Ghlas: http://www.natwindpower.co.uk/beinnghlas/index.htm (accessed 15 February 2002)

Deucheran Hill: http://www.pgen.com/news/default.asp?display=detail&News_ID=294&Category=16 (accessed 15 February 2002)

Dun Law: http://www.geo.ed.ac.uk/scotgaz/features/featurefirst7717.html (accessed 15 February 2002)

Hagshaw Hill: http://www.ecogen.co.uk/hagshaw.htm (accessed 15 February 2002)

Hare Hill: http://www.scottishpower.com/newsdesk/pr113010_23_10_2001.htm (accessed 15 February 2002)

Novar: http://www.natwindpower.co.uk/novar/index.htm (accessed 15 February 2002)

Windy Standard: http://www.natwindpower.co.uk/windystandard/index.htm (accessed 15 February 2002)

Appendix 3: List of Other Environmental Statements and Related Documents

AMEC (AMEC Border Wind). Kirkheaton Wind Farm: Appeal Decision. http://www.borderwind.co.uk/sites/kirkheaton/appeal.htm (accessed 15 February 2002)

Atlantic Energy (1998). Gartnagrenach Windfarm Proposal: Environmental Statement.

EcoGen (no date). Kielder Windfarm Campaign Update: Text of Our Environmental Statement 18 April 2000: 5.1 Landscape and Visual Assessment. http://www.ecogen.co.uk/bw-dti-sub%20s0006.htm (accessed 15 February 2002)

RES (RenewableEnergy Systems Ltd)(no date). The Non-Technical Summary of the Environmental Statement for a Proposed Wind Farm at Meikle Carewe. http://www.res-ltd.com/meikle (accessed 15 February 2002)

Scottish Power plc (1993). Burnt Hill Windfarm. Landscape and Visual Assessment. Final Report, Turnbull Jeffrey Partnership, Edinburgh.

Appendix 4: Project Brief

Visual Assessment of Windfarms - Best Practice

Background

In reviewing Environmental Impact Assessments (EIAs) for windfarms it is apparent that there is a great deal of variation in the way that assessment of both visual impact and the significance of visual impact are dealt with in these documents. There is also a degree of contention amongst landscape professionals about the appropriate distance for Zones of Visual Influence (ZVI) surveys and a corresponding need for some independent opinion on all the above aspects.

Aims of study

- to identify any relevant work on visibility, visual impact and significance
- investigate visibility of existing windfarms
- to compare as-built visibility with estimates of visibility in EIAs
- draw conclusions about appropriate distances for ZVI in different circumstances

Method

It is anticipated that the study will begin with a brief literature review to identify any relevant work previously carried out on visibility, visual impact, zones of visual influence (ZVI) and criteria for assessing significance of visual impact. This review may include published EIAs. Some consideration of other types of development (such as transmission towers) may be required, where the methods used are relevant to the current study.

A selection of 10 existing windfarms would be visited. Several visits will be necessary to embrace a variety of lighting and weather conditions. These conditions should be documented as part of the assessment.

The selection would be agreed at the inception meeting, but would be drawn from developments located in N England and mainland Scotland. A list of existing windfarms in Scotland is included at Appendix 1 (not attached).

Using the EIAs for each of these developments, consultants would check the visibility from each of the viewpoints identified, comparing actual visibility with that anticipated by the EIA. Consultants would need to liase with the relevant SNH contact and the competent authority concerned to obtain the most recent EIA, establish the degree to which this reflects the as-built development, verify whether the selection of viewpoints took into account SNH comments, and any other relevant background information. Note that consultants must contact the appropriate SNH Area office in order to obtain permission before entering private land. Contact details will be provided at the inception meeting.

Consultants may need to identify and assess further viewpoints, where for example, SNH had requested other viewpoints but the request was ignored, or where an overly restrictive ZVI may have excluded others.

In reviewing EIAs for existing developments, consultants should also review the reliability of wireframe and photomontage representations of proposals and draw conclusions about their accuracy. It is not envisaged that photography will be required as part of this study.

Using all the information gained above, consultants should draw conclusions about:

- whether there is any published best practice guidance available on the topic
- the visibility of existing windfarms in different conditions
- whether this was anticipated by the EIA and accurately portrayed in wireframes and photomontages
- whether the ZVI was broad enough to include all viewpoints with significant visibility

Best practice recommendations should then be made on the basis of these conclusions.

Project outputs

Written report, maps, tables, including extracts from EIAs.

Programme

Project initiation	w/c 17 December 2001
Draft report	15 February 2002
Final report	8 March 2002

References

- Guidelines on the Environmental Impacts of Windfarms and Small Scale Hydro-electric Schemes
- Guidelines for Landscape and Visual Impact Assessment

Appendix 5: Summary of Findings from a Study of Hagshaw Hill Windfarm (Turnbull Jeffrey Partnership, 1997).

"As light conditions change, particularly the colour and nature of the sky backcloth, the perceptibility of the turbines changes. When turbines are perceived against a white or light sky backcloth, they appear dark. As the sky backcloth darkens, those turbines seen against the darkening sky backcloth become more difficult to perceive, and the ones which are seen against a backcloth of landform become more prominent. Also, when sunlight shines on the turbines, they become more prominent.

The turbines are perceptible at a range of more than 20 km from the windfarm (two researchers identified them in excellent visibility conditions at about 29 km). This range only applies if you are specifically looking for the turbines, not just looking at the landscape. It is likely that the turbines would be perceptible to a "casual" observer at a distance of up to approximately 17-20 km.

Blade movement is an important consideration, as it tends to draw the eye towards the turbines. Blade movement is perceptible at a range of about 15-17 km, but only if you are specifically looking for the windfarm. At a distance of more than about 15-17 km, blade movement is not perceptible. Blade movement is perceptible to the casual observer at 10-15km.

At a distance of more than about 12 km, the turbines are perceived as a group forming a windfarm, rather than as individual turbines. At a distance of less than 12 km, turbines are perceived as individual structures which, dependant on layout, may or may not form a group. The distance at which turbine detail becomes noticeable is about 8 km. At a distance of more than about 8 km, it is not possible to see the taper of the turbine or identify nacelle detail.

Turbines generally appear more visually satisfying when they appear fully or predominately above the skyline, rather than partially above the skyline. Where only the turbine blades are visible above the skyline, this looks very unusual.

Visual layout of turbines in relation to the skyline profile in an important factor to consider when assessing the impact on a viewpoint. The issue of the extent and pattern of turbine layout in relation to the scale and form of the skyline is important.

Where the windfarm and viewpoint occur in the same area of landscape character, the potential for a higher impact on the viewpoint is increased. Where they do not occur in the same area, the potential is reduced.

Analysis of the research findings leads to the conclusion that there are a large number of inter-related factors which need to be considered when selecting an appropriate cut-off radius, and that no exact figure can be arrived at with any degree of certainty. Relevant considerations are the size, colour, layout and number of turbines, weather conditions, the type of landscape in which the windfarm and viewpoint are located and whether blade movement is perceptible. Professional experience of siting similar objects in the landscape leads to the belief that use of higher turbines certainly results in a greater cut-off radius. However, when the number of turbines is considered, the influence of a greater number of turbines on the radius is less certain, and probably depends on turbine layout, grouping, and the scale of the turbines/windfarm relative to the scale of the landscape. Certainly, impact diminishes as distance increases, but is not necessarily directly proportional to turbine number.

In considering the above points in relation to the proposed Beinn an Tuirc windfarm, professional judgement has concluded that 15 km is a reasonable ZVI cut-off radius to use for practical assessment purposes as the distance beyond which there is unlikely to be a significant adverse landscape and visual effect because: movement of the blades would generally not be perceptible; the proposed windfarm would appear as a small-scale element in the landscape beyond such a distance ; it is unlikely that the windfarm site would occur in the same area of landscape character as viewpoints which are more than 15 km away from the windfarm; beyond this distance, the turbines would be perceived as a group forming a windfarm, rather than individual turbines. This 15 km radius accords with Argyll & Bute Council's opinion of long and short-range visibility expressed in their Windfarm Policy document: "The choice of representative viewpoints should reflect long and short-range visibility (15 -0.5km)……" [Reference 3, Appendix D].

It is acknowledged that there remains a degree of uncertainty in adopting this distance. It is also acknowledged that, depending on weather and lighting conditions, the windfarm would be visible from greater distances. However, given the range of variable factors which require consideration to determine such a radius, it is considered that a 15 km cut-off radius is a reasonable distance to adopt in this situation in relation to the likelihood of a significant adverse landscape and visual effect occurring."

11 NOTES

[1] "Grey literature" is a term used to describe documents, reports, policy guidance and so on that are not officially published in the sense of having an ISBN or ISSN number and which are therefore not certain to be accessible through official library cataloguing sources.

[2] Environmental Statements are an important resource and data-base for policy development, research and case work (for all project types). We noted that there is no central system within SNH for cataloguing and storing ESs, and apparently no systematic policy of retention in area offices. Considerable effort was needed to obtain the requisite ESs for this project, mainly by the landscape team in headquarters. We strongly recommend that SNH consider establishing a recording and retention system for such documents. In fact there is no centralised and reliable system for ES storage in the UK generally or in Scotland. The Scottish Executive Library in Edinburgh is apparently charged with their retention, at least for a period (lists appear in PAN58: EIA), but enquiries reveal that their collection is partial.

[3] Therivel (2001) and others sometimes refer to the Zone of Visual Intrusion and LI-IEMA (2002) refers to the Visual Envelope Map (VEM).

[4] Other terms used include viewshed, visual envelope and intervisibility maps.

[5] The literature also refers to "fuzzy viewsheds" to describe the degree to which the target might be distinguished given such phenomena as atmospheric conditions, the eyesight of the observer and the object-background contrast etc.

[6] Landscape Institute Advice Note 01/99: Guidelines for Landscape and Visual Impact Assessment. London.

[7] It should be noted that this analysis of the ESs was confined to the VIA elements only and any positive or negative comments do not imply any judgement on the overall quality of the ES or the overall quality of any combined Landscape and Visual Assessment. Research (e.g.Glasson et al, 1997) shows the overall quality of ESs in the UK to be highly variable, based on a wide range of criteria including both technical content and presentation.

Appendix G

Review of Multi-criteria Analysis

Multi-criteria Analysis

Providing decision support – options considered

Decision support tools can range from the provision of simple maps, guidance notes and technical advice through to sophisticated tools developed using spreadsheets and Geographical Information Systems (GIS). One of the subtle, but most important distinctions between the various approaches is the degree of prescription the tool offers the end user with respect to the decision being made.

Hard copy maps, linked to guidance tend to offer the user fairly fixed advice. An organisation has prepared the map/guidance based on research or expert opinion and it represents only a limited range of policy choices for the user. GIS-based decision support tools, based usually on some form of Multi-criteria analysis (MCA) tend to offer the user of the system considerable scope to manipulate the data and apply their own user driven weightings and scores to the data, thus generating a whole range of possible outputs and hence policy outcomes.

Multi-criteria analysis (MCA)

Multi-criteria analysis is a technique which allows an organisation or individual to establish preferences between options (e.g. where in Wales to locate wind energy developments) by reference to an explicit set of objectives that the decision-making body has identified . The purpose is to serve as an aid to thinking and decision-making, but not to take the decision itself. It has the goal of providing an overall ordering of options from the most preferred to least preferred option. It is a plausible way of measuring the extent to which options achieve objectives and of weighting the objectives in order to discover the more preferable of the options. A standard feature of the MCA is a performance matrix, in which each row describes an option (such as to develop within a particular designated area or not) and each column describes the performance of the options against the criteria. A full application of the MCA normally involves the eight steps identified overleaf. Although the process is outlined as a step by step decision-making process, this is not the case, as steps can be revisited and revised at any time in the exercise.

Steps in a Multi-criteria analysis

1. Establish the decision context. What are the aims of the MCA, and who are the decision-makers and other key players?
2. Identify the options.
3. Identify the objectives and criteria that reflect the value associated with the consequences of each option.
4. Describe the expected performance of each option against the criteria. (If the analysis is to include steps 5 and 6, also ‘score’ the options, i.e. assess the value associated with the consequences of each option.)
5. ‘Weighting’. Assign weights for each of the criteria to reflect their relative importance to the decision.
6. Combine the weights and scores for each of the options to derive an overall option
7. Examine the results.
8. Conduct a sensitivity analysis of the results to changes in scores or weights.

A multi-criteria approach (MCA) was not considered appropriate for our current research for several reasons:

- Consultation visits held with Local Authority planning officers in Wales with responsibility for renewable energy planning revealed that most did not welcome the possibility of having to undertake the MCA and make appropriate spatial and policy decisions on an authority by authority basis
- a tool would need a sophisticated weighting system that all the stakeholders bought into, and this proved impossible to achieve via the steering panel meetings for Stage 1.
- The variability inherent in the MCA approach and the degree to which political factors could be used to alter the outcomes within individual authorities could lead to very different outputs. This might not be a problem with some types of planning development, but the scale and strategic nature of larger onshore wind energy developments requires a cross-authority approach.
- a multi-criteria analysis approach is not able to represent the full range of considerations that are required for a mature discussion on wind energy generation opportunities. The less tangible elements of decision-making, including the background knowledge of local authority planners, the variability in the electricity distribution network, and the need for third party involvement from an early stage in discussions, must not be overlooked.

- The datasets would require frequent updating. Issuing updated versions of the GIS decision support tool to the local authorities would involve ongoing resource commitments over an unspecified time period requiring considerable ongoing costs.
- Whilst the GIS data could be used by the research team to develop the study under Welsh Assembly copyright licences, there would be considerable intellectual property issues associated with issuing the data within a decision support tool for wider use by stakeholders in the onshore wind development process.
- There is a real danger with MCA, especially when using GIS, that one ends up “valuing what is measurable rather than measuring what is valuable”.

Appendix H

Report on the development of the GIS

Please note that the contents of the this appendix do not represent the Planning Policy of the Welsh Assembly Government

The Development of a National Geographical Information System for Facilitating Renewable Energy in Wales: Meeting the Target

Contact Number 269/03

ARUP

northumbria UNIVERSITY

Centre for Environmental & Spatial Analysis

The Development of a National Geographical Information System for Facilitating Renewable Energy in Wales: Meeting the Target

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CONTENTS

APPENDICES

List of Tables and Figures

1 Introduction

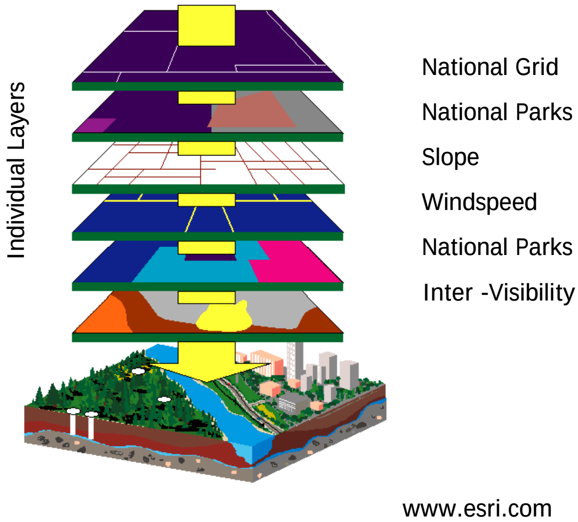
Principal Aim:

- To develop a National Geographical Information System (GIS) that can be used to identify strategic areas to facilitate the development of Renewable Energy in Wales: Meeting the Target.

This document supports the work of Arup in undertaking Contract 269/2003 on behalf of the Welsh Assembly Government, driven by the need to reach the UK Governments target of achieving 10% of electricity supplies from renewable sources by 2010 throughout the whole of the United Kingdom. Given the existing level of windfarm development already within Wales the identification of new sites raises a number of planning issues that need to be considered together. These include windspeed, grid infrastructure, radar, communications, military training and operations and the cumulative impact of new developments with existing windfarms.

A National GIS has been compiled to inform this decision making process. Using a GIS cartographic model (Figure 1), the data will be used to generate and test options for the location of strategic areas for windfarm development. A cartographic model allows the combination of 'layers' of information containing data relating to constraints or restrictions on windfarm development. The resulting gaps are those areas that are considered potentially suitable for windfarm development, based on the criteria provided. This study is strategic in nature and does not focus on specific local site constraints such as landownership, site access or proximity to roads.

Figure 1: Conceptual diagram of a Cartographic Model



Layers of data used within the national cartographic model used to identify strategic areas can be split into two components:

- Grid Study of infrastructure and capacity
- GIS constraints model

As a point of GIS terminology constraints describe layers that impose restrictions on location, turbines cannot be located within national parks due to planning restrictions.

This document presents the methods and techniques used to generate and combine the data in order to compile the National GIS and to cartographically model scenarios of windfarm development. This data was then used by Arup to identify/define strategic areas - the methodology adopted by Arup is outlined in the main report.

The strategic areas were then tested and validated using a series of datasets requested by Arup. Methods and techniques used to generate these datasets are presented here, for more information upon how they were used in the validation process please see main report.

2 Study Area and Data Collection

Data has been compiled for the whole of Wales from a number of different sources listed below.

- CartoGraphics: The National Assembly for Wales (includes supply of Ordnance Survey data)
- Countryside Council for Wales (CCW)
- CADW
- Future Energy Solutions (FES)
- National Grid (NG)
- Ordnance Survey
- http://www.bwea.com
- http://www.bbc.co.uk/reception/tv_transmitters/region_wales.shtml
- http//www.torfaen-objectiveone.org.uk/bil/site/site.htm
- http://www.homepages.mcb.net/bones/06airfields/UK/uk.htm,

Sources of data and its metadata (information about the data) are given in Appendix C. Please note that all maps produced in this report are based upon the Ordnance Survey mapping with the permission of the Controller of Her Majesty's Stationary Office. Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Welsh Assembly Government O.S. Licence No. 100017916.

3 Mapping Grid Infrastructure/Grid Capacity

Grid capacity issues have important implications for the identification of strategic areas. These are:

Temporal: grid infrastructure and capacity given at 2004 and at 2010/2015.
Spatial: - the geographical variation of capacity controlled by the distribution of grid infrastructure and distance away from the grid network.

There are two scenarios of grid infrastructure and grid capacity to consider – the spatial distribution of Electricity Capacity for wind energy development in Wales spring 2004 and by 2010/15. For more information on grid capacity and connection for wind energy in Wales please see the document 'Connection Areas for Wind Energy in Wales – Grid Considerations – Contract 218/2001, Future Energy Solutions (2004) for the Welsh Assembly Government'.

The existing grid network within Wales, as shown in Map 1 in Appendix B, has been divided spatially into twenty-three approximate geographical zone limits. These areas summarise the spatial extent and capacity of network operators, such as *SP Manweb Plc* (for Scottish Power Manweb) and Western Power, and the existing network infrastructure. Each area is placed into a category representing its grid capacity as summarised in table 1.

Table 1: Categories of Grid capacity

Key: (Increasing Capacity ↓)	Code	Grid Capacity	Scenario
	A	Very small and small	2004 and 2010/15
	B	Small but with National Grid possibility	2004 and 2010/15
	C	30MW -50MW without National Grid	2004 and 2010/15
	D	30MW -50MW with National Grid	2004 and 2010/15
	E	50MW - 100MW without National Grid	2004 and 2010/15
	F	50MW - 100MW with National Grid	2004 and 2010/15
	G	50MW - 150MW	2010/2015 only
	H	250MW - 300MW	2010/2015 only

In addition, areas 10 kilometres away from the existing grid network, for each scenario, have been identified (Map 2 and Map 3 in Appendix B). Please note that areas assigned with the code A (that represent those areas with very small and small capacity) and areas identified as greater than 10 kilometres away from the grid network are used in the GIS cartographic model as described in the next section.

4 GIS Cartographic Model

4.1 Introduction

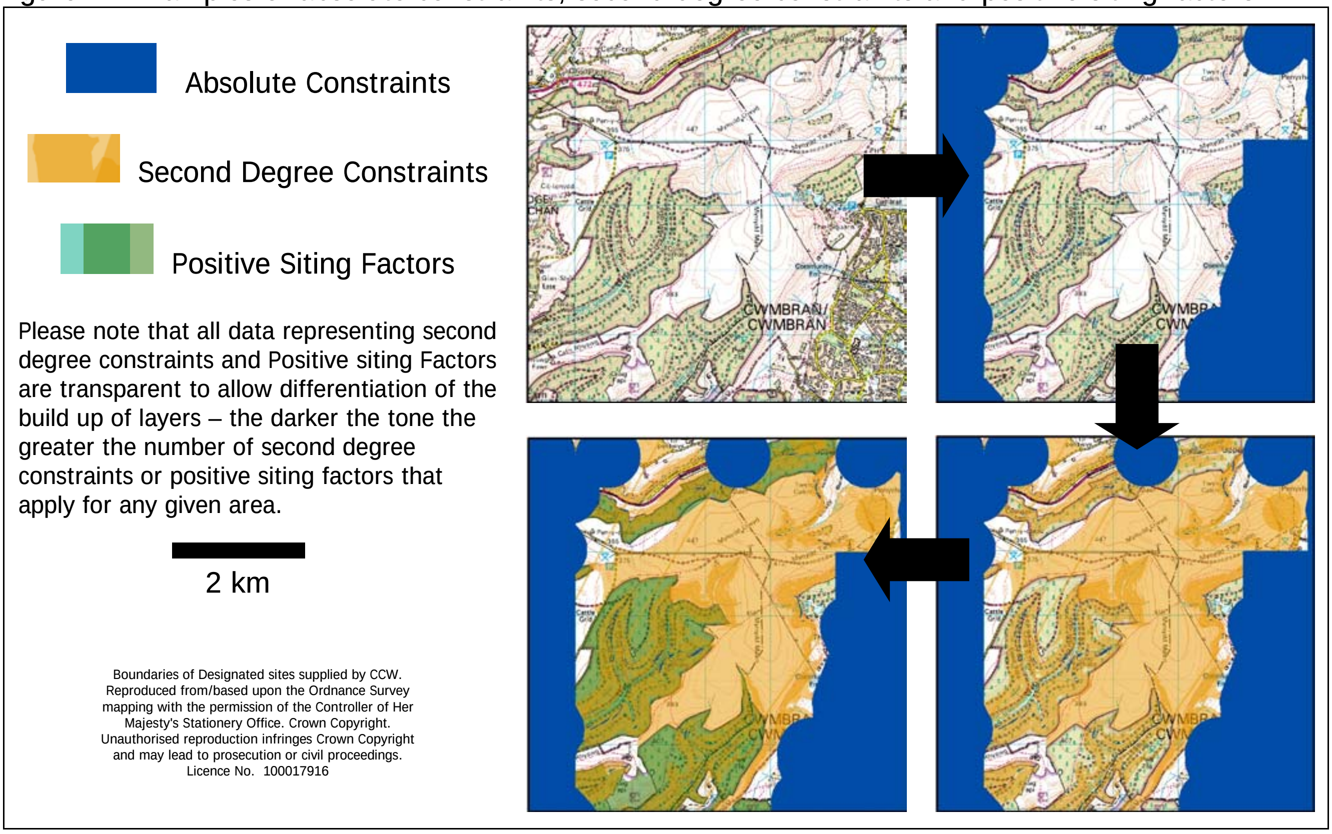
A steering group comprised of Arup in conjunction with the Welsh Assembly Government and the steering panel for the research developed the criteria that were used to aid in the development of strategic areas. The data have been compiled into separate layers and assigned into three distinct categories (Figure 2):

Absolute Constraints: are defined as those which, for all intent and purposes (at the all-Wales level), would be likely to prevent large-scale wind energy developments (Arup, 2004).

Second Degree Constraints: likely to inhibit the development of large wind energy developments but for which there is either a) some variability / uncertainty in their spatial exent or b) the possibility to develop within the area concerned but with appropriate mitigation (Arup, 2004).

Positive Development Siting Factors: are those which, in general, are likely to be viewed positively for large scale wind developments by the wind industry. Data sets have therefore been used which are generally indicative of single landownership, a reasonable degree of accessibility or relatively simple landcover (Arup, 2004).

Figure 2: Examples of absolute constraints, second degree constraints and positive siting factors

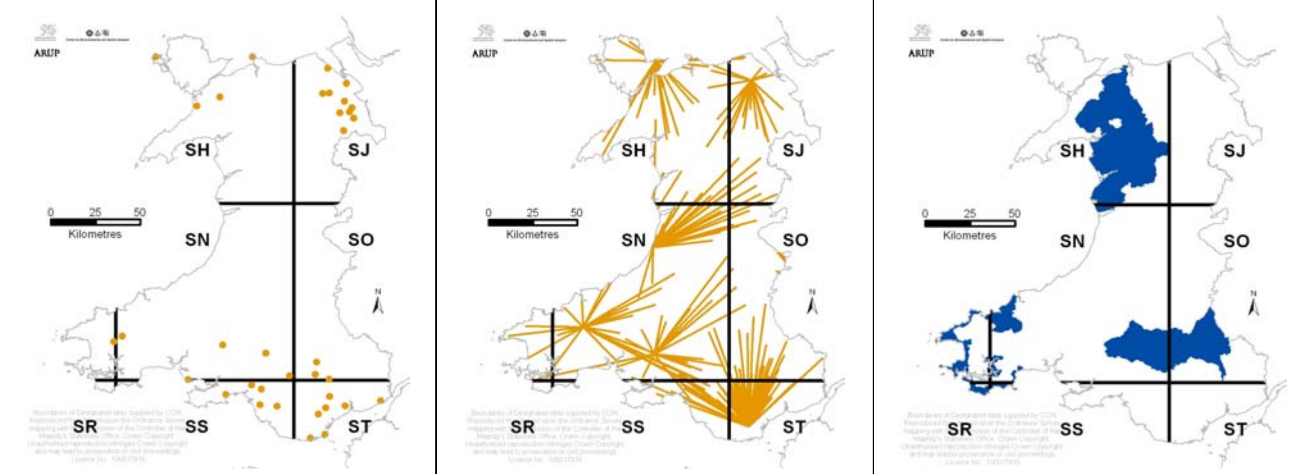


This assignment of data to the categories outlined above builds upon the Macaulay Land Use Research Institute Study for CCW and the Review of Strategic Study of Renewable Energy Resources in Wales undertaken by AEA Technology 5 Oct 2001, see main report.

4.2 Criteria and Parameters

Table 2 provides a summary of all data used in this study. Each criteria listed in the table exists as a layer of data in GIS either in point, line or polygon format. Some examples of each type are given in figure 3.

Figure 3: Examples of different types of GIS data formats: point, line and polygon.



Point: Country Parks | **Line:** Broadcast links between TV Masts | **Polygon**: National Parks

The data compiled for each format, point, line or polygon, has then been modified according to the parameters specified in table 2. There are three different types of parameters, footprints, buffers and Line of Sight (LOS).

Footprint is used to describe the actual location of designated sites/areas and other factors.

Buffers represent areas that lie within a specified distance or radius of the actual location of the feature be it a country park, a TV transmitter or civil aerodrome. Please note that for some of the data (as identified in table 2) a buffer with a defined radius has been applied as a cartographic tool to aid in the differentiation of features at the scale of cartographic representation or the data.

The third type of parameter represents the results of a viewshed calculation – ***Line of Sight (LOS)***. It is not possible to locate a wind turbine that is visible or within the line of sight of a radar installation (Figure 4).

Figure 4: Basic principles of a viewshed calculation.

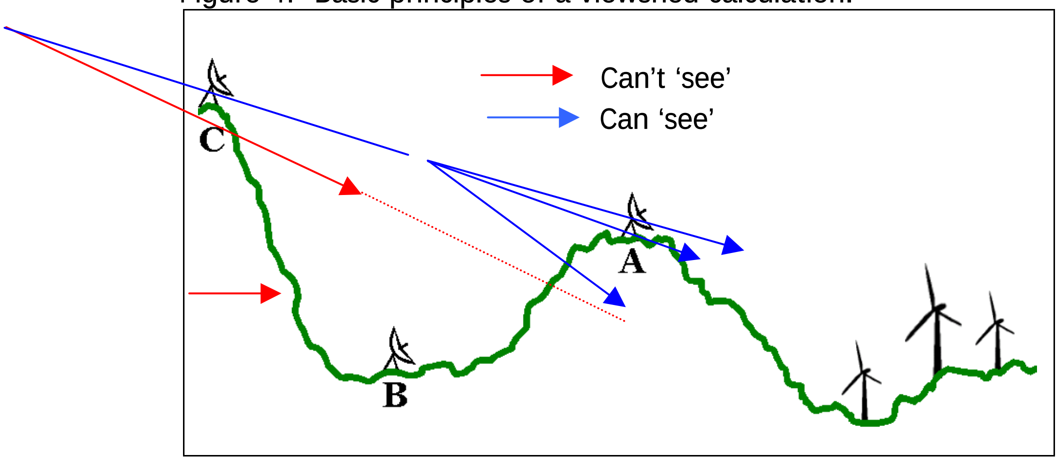


Table 2: List of data compiled for the GIS constraints model

Criteria	Format (Raw Data)	Source	Parameters
Absolute Constraints : Practical			
Windspeed at 45m Above Ground Level	Polygon	DTI	<=6m/s
MoD Low Flying Area 7T	Polygon	C-NAW	Footprint
MoD Surface Training Area Mynydd Eppynt	Polygon	C-NAW	Footprint
Lakes and Reservoirs	Polygon	C-NAW	Footprint
Major Urban areas	Polygon	C-NAW	Buffer - 500m Radius
OS Gazetteer Farms and Settlements	Polygon (Point)	C-NAW	Buffer - 500m Radius
Early warning Air Defence Radar on Anglesey	Polygon	C-NAW	LOS 74km Radius
Slope greater than 40 degrees	Polygon	C-NAW	Footprint
Greater than 10km from Grid Network	Polygon (Line)	NG	Footprint
Grid Areas: Very small and small capacity	Polygon	FES/Arup	Footprint
Absolute Constraints : Environmental			
National Parks	Polygon	CCW	Footprint
Areas of Outstanding Natural Beauty	Polygon	CCW	Footprint
SPAs	Polygon	CCW	Footprint
RAMSAR	Polygon	CCW	Footprint
pSAC	Polygon	CCW	Footprint
SAC	Polygon	CCW	Footprint
National Nature Reserves	Polygon	CCW	Footprint
Dyfi Valley Biosphere site	Polygon	CCW	Footprint
Blaenavon World Heritage Site	Polygon		Footprint
Second Degree Constraints : Practical			
Registered Common Land	Polygon	CCW	
Safeguarded Civil Aerodromes: Cardiff	Polygon (Point)	Website	LOS 30km Radius
Safeguarded Civil Aerodromes: Liverpool	Polygon (Point)	Website	
Non Official safeguarded Aerodromes: Caernarfon, Swansea, Hawarden, Haverfordwest & Welshpool	Polygon (Point)	Website	LOS 5km Radius
Military 'Technical Sites': RAF Valley, St Athan, Aberporth & Llandbedr	Polygon (Point)	Website	LOS - 5km Radius
Met Office Cloud scanning Radar: Crug y Gorllwyn	Polygon (Point)	Website	Buffer – 5km Radius
Major TV Transmitter Masts (10km radius)	Polygon (Point)	Website	Buffer – 10km Radius
Broadcast links between TV Masts	Line	Website	Footprint
Slope greater than 20 and less than 40 degrees	Polygon (Grid)	C-NAW	Footprint
Second Degree Constraints : Environmental			
Heritage Coasts	Polygon (Line)	CCW	Buffer – 2km Radius*
Scheduled Ancient Monuments	Polygon (Point)	CADW	Buffer – 300km Radius*
SSSIs	Polygon	CCW	Footprint
Local nature reserves	Polygon	CCW	Footprint
RSPB Reserves	Polygon	CCW	Footprint
Country Parks	Polygon (Point)	CCW	Buffer – 2km Radius*
Positive Siting Factors			
Areas of Forestry Commission Woodland	Polygon	CCW – WIFC	Footprint
Open Access	Polygon	CCW	Footprint

Key:
CCW: Countryside Council for Wales
C-NAW: CartoGrpahics – National Assembly for Wales
DTI: Department of Trade and Industry
FES: Future Energy Solutions
LOS: Line of Sight†
NG: National Grid
RAMSAR: Wetlands
RSPB: Royal Society for the Protection of Birds
pSAC: Proposed Special Areas of Conservation
SAC: Special Areas of Conservation
SPA: Special Protection Areas
SSSI: Sites of Special Scientific Interest
Website: see Appendix C for website addresses
WIFC: Woodland Inventory Forestry Commission

* Buffer is applied to aid in the differentiation of features at the scale of representation
† See page 6 for specifications and methods of calculation of Line of Sight

A viewshed calculation requires:

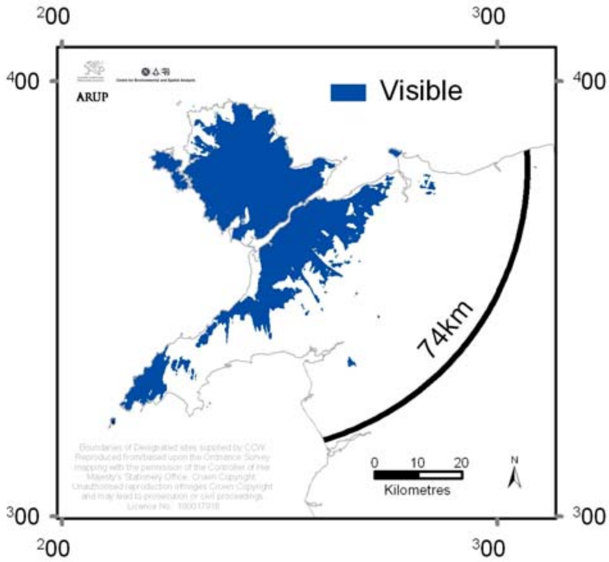
- A Digital Elevation Model (DEM): a digital map of elevation data made up of equally sized gridded cells each with a value of elevation in metres.[1]
- An observer point: a building, person or in this case radar installation.
- Calculation parameters: - Height offsets: the height of the observer point
  heights of feature that you are trying to 'see'.
- Radius: a limit beyond which visibility is no longer calculated - the effect of radar is no longer restrictive.

Line of Sight has been calculated for two radar installations in Wales, Ty Croes early warning defense radar on Anglesey and Cardiff Airport. The parameters used in the calculation of a viewshed for each of these are summarised below.

Observer point:
Cardiff Airport at 26.82m[2]
Ty Croes – Anglesey 15m[3]
Height offsets: wind turbines at 110m
Radius:
Cardiff Airport at 30km
Ty Croes – Anglesey at 74km

An example of an output of a viewshed calculation is given opposite (Figure 5).

Figure 5: The results of a viewshed calculation



[1] The DEM used in this calculation was supplied by OTCO Welsh Assembly – Landform Profile has a high grid resolution of 10m by 10m see http://www.ordnancesurvey.co.uk/oswebsite/products/landformprofile/
[2] Source: http://www.emairport.co.uk/aerocharts/aerochart.htm
[3] Source: http://www.emairport.co.uk/aerocharts/aerochart.htm

5 National Scenario Modelling

The GIS constraints model and the two categories of data used to identify strategic areas provide a valuable tool for assessing the capacity of Wales for the development of onshore wind in line with UK government targets. The ability to distinguish areas free of absolute constraints and to assess the cumulative impact of second degree constraints in association with positive siting factors has allowed the identification of strategic areas. Arup took the graphical outputs prepared by CESA outlined in table 3 and used these to identify strategic areas. The detailed methodology for this exercise is contained within the main Arup report.

Table 3: Cumulative consideration of criteria

Criteria: National GIS	Scenario 1 Spring 2004	Scenario 2 by 2010/15
• Existing National Grid • Regional Electricity Distribution Network	Map 1	
• Spatial distribution of Electricity Capacity for wind energy development	Map 2	Map 3
• Summary of grid constraints		Map 4
• Spatial Distribution of cumulative Practical and Environmental constraints	Map 5	
• Spatial Distribution of cumulative Practical and Environmental Constraints • Summary of Grid Constraints		Map 6
• Unconstrained areas “white land” that result from the combination of grid constraints and the Spatial Distribution of cumulative Practical and Environmental Constraints		Map 7
• Unconstrained areas “white land” • Positive Siting factors		Map 8

Using all data complied in the National GIS it is possible to:

- Switch off individual layers representing absolute and second degree constraints and positive siting factors in order to assess their impact upon the feasibility of windfarm development for any area within Wales.
- Change the parameters, of all of the layers used in the GIS constraints model and for the two visibility scenarios, in line with technological advances.

Map 9 in Appendix B presents the strategic areas identified by Arup.

6 Validating and testing the Strategic Areas

6.1 Introduction

A series of datasets have been complied in order to inform commentary by Arup throughout about the relative merits or otherwise of each of the strategic areas. These datasets are:

- Visibility and windfarm development:
  - Visibility from National parks and AONB
  - Visibility from National trails
  - Cumulative visual impact of windfarms
- Higher windspeeds
- Wildlands

The following sections present the data provided to Arup and outline any methods used to create data or to manipulate existing datasets. For information upon how the data were used please see main report.

6.2 Visibility Analysis

6.2.1 Introduction

The main aim of the visibility analysis has been to produce maps of relative visibility providing a map of:

- visibility of wind turbines from within National parks and AONB
- visibility of wind turbines from anywhere along the National trails within Wales
- cumulative impact of the visibility of existing windfarms

that can be used provide information about the nature of the strategic areas identified using the GIS constraints model - CESA has developed an application of visibility analysis, parameters set in consultation with Arup/White Landscape consultants, in order to produce maps that address the three key visibility scenarios identified above.

6.2.2 An Introduction to Visibility Analysis

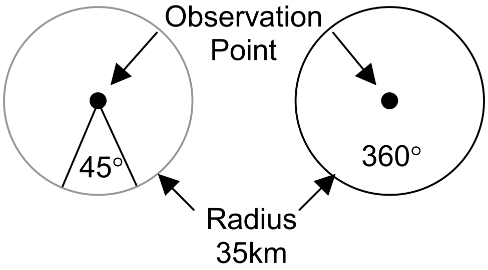
Visibility Analysis identifies those areas on a map that can see a single or many specified objects, for example, wind turbines. In this study the in-built viewshed function, part of the Spatial Analyst extension in ArcGIS v8.3, has been used to carry out the visibility analysis. Viewshed is one of many in-built functions within GIS software that are available for this type of analysis. There is no single description of visibility analysis, various software packages implement it differently. The type of datasets required in a visibility analysis and parameters that can be applied to them are summarised below:

- A Digital Elevation Model (DEM), that describes height over a topographic surface.

- A data set of predefined **observation points** can be used in the analysis. Observation points can take the form of any feature such as ferry routes or viewpoints or the whole land surface. For an area, a grid of observer points that covers the surface has to be created.

- For each observation point it is possible to set the field of view or **azimuth**, i.e. complete at 360º or at a defined azimuth of 45º.

Azimuth and Radius:



- In any visibility analysis, it is possible to set a distance limit beyond which visibility is no longer calculated. This **radius** can be set at any specified distance or is not set i.e. limitless. This brings in the issue of zones of theoretical limits of visibility (ZTV).

- Heights are then chosen above the height given by the DEM for the observation points being analysed. This is the **subject height** – the height of industrially available wind turbines. This is known as a height offset.

- An offset height for the observer is also essential, and is known as a **viewing height** – an individual standing within a National Park.

- The output or results of the analysis, a **visibility surface**, are usually recorded in Raster format.

Raster Format:

1
5
1

2
4
1

1
3
2

Uses a grid structure to store geographic information.

Calculating visibility identifies those cells in an input DEM that can be seen from one or more than one observation point subject to predefined parameters. Using one observation point as an example the output visibility map would contain cells that are classed as:

- A cell that can see the given observer point = 1
- A cell that cannot see the given observer point = 0

For each observation point the calculation is repeated individually. Each grid cell accumulates the cumulative score of visibility and it is equal to the number of observation points that that grid cell can 'see'. This number is controlled by the parameters set for the subject height, viewing height, location and number of observation points and resolution (grid size) of the output visibility surface.

The higher the number of observation points a grid cell can 'see', the more visible that given grid cell is.

To summarise there are five key parameters that can be defined:

- subject height: the object being observed
- viewing height: the observer
- radius: distance limit of visibility calculations
- azimuth: field of view
- output grid: resolution of the visibility surface

In terms of the resolution chosen for the output visibility surface created there are two variables to consider:

- The spacing of the observation points covering an area, for example, a point every 500m by 500m.
- The resolution of DEM, for all visibility calculations a DEM with a resolution of 10m by 10m was used.

The following sections describe how the requirements of the project are reflected in the specification of parameters given above. The method of data capture is also described along with an explanation of the results.

6.2.3 Visibility of wind turbines from within National parks and AONBs

Objective: to provide a relative indicator of the visibility of windfarm development from areas within National Parks and AONBs.

Areas designated as National Parks and AONBs were covered in a blanket grid of points that represent a potential 'observer'. These points were generated by first overlaying National Parks and AONBs with 500m grid squares. Each grid square is then converted to a central point – the centroid – which forms that cells observation point. Cumulative visibility is then calculated for the whole of the study area (Map A in Appendix B), limited to the outer radius limit of the ZTV at 30km (Benson, 2000). The output visibility surface also has a resolution of 500m and represents the relative visibility of windfarm development to areas within National Parks and AONBs.

- Subject Height: 110m to blade tip
- Viewing Height: 1.72m
- Radius: ZTV (30km)
- Azimuth: 360º
- Output Grid Size: 500m

Please note that as the number of observation points differs for each National Park and ANOB (dependent on area , see Table 4) this will weight larger areas, such as Snowdonia National Park over smaller areas, such as Ynys Mèn AONB on Anglesey. The visibility surface must therefore be interpreted with caution as it represents the relative visibility of windfarms from all designated AONB's and National Parks – it is not possible to distinguish for each individual cell which designated area it can or can't 'see' (Map A in Appendix B).

Table 4: Comparison of the Areas of National Parks and AONB

Designation	Name	Area (km^2)	No. of Observation Points
National Park	Snowdonia	1458	8547
National Park	Brecon Beacons	1154	5407
National Park	Pembrokeshire Coast	753	2453
AONB	Ynys Mon / Anglesey	469	876
AONB	Gower	431	740
AONB	Llyn	398	641
AONB	Clwydian Range	398	636
AONB	Wye Valley	571	478

6.2.4 Visibility of wind turbines from National Trails

Objective: to provide a relative indicator of the visibility of windfarm development when walking along National Trails.

An point has been generated every 500m along all national trails within Wales. Cumulative visibility is then calculated for the whole of the study area (Map B in Appendix B), limited to the outer radius limit of the ZTV at 30km (Benson, 2000). The output visibility surface also has a resolution of 500m and represents the relative visibility of windfarm development at any point along a national trail.

- Subject Height: 110m to blade tip
- Viewing Height: 1.72m
- Radius: ZTV (30km)
- Azimuth: 360º
- Output Grid Size: 500m

6.2.5 Cumulative impact of the visibility of individual wind turbines

Objective: to provide a relative indicator of the inter-visibility between existing windfarm developments in Wales to assess cumulative impact.

Each individual turbine location, for existing windfarms and for those with planning permission for site plans were obtained, has been converted into an observation point (Table 5). Cumulative visibility is then calculated for the whole of the study area (Map C in Appendix B), limited to the outer radius limit of the ZTV at 30km (Benson, 2000). To allow comparison between the two visibility studies the output resolution is also set at 500m. The visibility surface represents the relative visibility of the land surface in any given area in Wales of existing/proposed individual turbines. The higher the score the more turbines the area can 'see' and the greater the inter-visibility between windfarms.

- Subject Height: see Table 5.
- Viewing Height: 1.72m
- Radius: ZTV (30km)
- Azimuth: 360º
- Output Grid Size: 500m

Table 5: Windfarms in Wales 2004

Winfarms	Number of Turbines	Height (m)
	Existing	
Blaen Bowi	3	76
Bryn Titli	22	48
Carno	56	54
Cemaes II	18	66
Dyffryn Brodyn	11	53
Haffoty Ucha	1	61
Haffoty Ucha II	2	61
Llandinam P&L	103	45
Llangwyryfon	20	41
Llangwyryfon II	11	41
Llyn Alaw	34	53
Moel Maelogen	3	76
Mynydd Gorddu	19	55
Parc Cynog	5	67
Rheidol	8	46
Rhyd-y-Groes	24	46
Taff Ely	20	53
Trysglwyn	14	43
	Planning Permission	
Cefn Croes	100	99.7
Mynydd Clogau	17	68.5
Ffynnon Oer	16	91
Tir Mostyn	25	68.5

6.2.6 Points to consider

This approach is rigorous and well suited to the strategic nature of this study. However, there are a number of issues which a more detailed, local study would need to be aware of, and these points are relevant in any full appreciation of the results presented.

The key issues are as follows:

- Visibility analysis based on terrain models tend to ignore the screening effects of buildings / vegetation. At the strategic level this can be overlooked, but a local study, with a tactical focus on the location of specific turbines would need to factor such considerations in and the methodology presented here could be adapted to do this.

- Blade tip height used in this study will always give worst-case scenario, and there is no differentiation to show whether you could see all of the rotating blade or only the very tip. Again, this would be an issue for a more tactical study to factor in.

- The scale of investigation in this study is well suited to a strategic analysis. The resolution of the output visibility surface is 500m. However, grid cell resolution could be as high as 10m - equivalent to the resolution of the input DEM. The choice of grid resolution however is a trade-off between computing power/time and fitness of use.

6.3 Higher windspeeds

A map of windspeeds greater than 6m/s and displayed at defined intervals of 0.5m/s for 1km by 1km grid modelled at 45m above ground level is presented in association with the strategic areas (Map D in Appendix B).

6.4 Wildlands

Areas of wildland in association with strategic areas are examined (Map E in Appendix B). For a definition of the type of land that is designated as wildland and its relationship to the development of wind energy please see the main report.

6.5 Strategic areas at 1:50,000

Each strategic area identified by Arup was viewed with the Ordnance Survey 1:50,000 map as a backdrop. All maps are presented in Appendix B – for the methodology of their use please see main report.

References

Benson, John F, Jackson, Susan P and Scott, Karen E University of Newcastle (2000) *Visual Assessment of Windfarms: Best Practice*. Scottish Natural Heritage Commissioned Report F01AA303A, Edinburgh

Future Energy Solutions for the Welsh Assembly Government (2004) *Connection Areas for Wind Energy in Wales – Grid Considerations* – Contract 218/2001

APPENDIX A: Grid Capacity

The table presented here is a modified version of table 4 in - Connection Areas for Wind Energy in Wales – Grid Considerations – Contract 218/2001, Future Energy Solutions (2004) for the Welsh Assembly Government. Arup assigned each of the geographical regions and information concerning each regions ability to accommodate further distributed generation into categories representing the capacity of the given area for both scenarios of grid infrastructure – 2004 and 2010/15 (see section 3).

Table A1: The 23 Regions and their Ability to Accommodate Further Distributed Generation

Zone	Comment	Capacity	Arup Category	
			2004	2010/15
1	Sparely populated region with a 66 kV ring. Limited capacity with possible small connections near to Abergavenny of the 66 kV ring. Windfarms developed here would be within the acceptable range of the network but not necessarily the substations.	Small	**A**	**A**
2	Dependent on development of the southern section of MANWEB network. Windfarms developed here would be within the acceptable range of the network but not necessarily the substations.	50 MW	**C**	**C**
3	33 kV network aligned to the coast offers little connection opportunity coupled with limited local demand.	Small	**A**	**A**
4	Well developed 132 kV network with significant load centre. Windfarms developed here would be within the acceptable range of substations. In principle the Pembroke GSP offers the opportunity to connect significant capacity directly to the grid, provided it is fairly local. Grid line to Pembroke to be downsized.	50 MW – 100 MW to the Distribution network. More if the grid could be utilised	**F**	**F**

5	No major substation available but feed to the 132 kV line between Haverfordwest and Carmarthen possible provided within about 10 km.	50 MW	**C**	**C**
6	33 kV network mostly to the south east of this zone offers little connection opportunity unless within 10 km of the Ammanford 132 kV substation.	Small	**A**	**A**
7	Significant 132 kV network and Swansea as a large load centre. 132 kV connection probable anywhere within this region. Also has the Swansea North and Balgan Bay GSPs gives potential for high capacity connection.	50 MW – 100 MW on the 132 kV network. More if the GSPs could be utilised	**F**	**F**
8	Although strong network and load centre, proposed United Utilities Scarweather Sands off shore windfarm project will 'bag' available capacity in this zone.	small	**D***	**D***
9	132 kV network and load centre but recent 50 MW connection offer made to developer is likely to reduce any additional opportunities.	small	**A**	**A**
10	132 kV network and load centre available to take output, connection possible but fault level head room will need to be extended with further generation connections. Upper Boat GSP accessible for higher capacities.	50 MW – 100 MW More if the GSP could be utilised	**F**	**F**
11	Good 132 kV interconnected network and load centre, but fault level head room will need to be extended to enable further generator connections.	50 MW – 100 MW	**E**	**E**
12	132 kV network and load centre but presence of the AES Barry generator connected to the distribution network (132kV), already subject to constraint will limit further connection. Three possible GSPs could be used for larger developments.	Small unless GSP can be utilised	**B**	**B**
13	Sizeable amount of 132 kV network and load centre. Possible grid connections to Rassau and Upper Boat if development is close.	50 MW – 100 MW More if the GSP could be utilised	**F**	**F**
14	132 kV network and load centre but with limited fault level. Rassau GSP offers potential high capacity connection. Connections to the east of this zone will be restricted to lower voltage network.	50 MW More if the GSP could be utilised	**D**	**D**
15	132 kV interconnected network with load possibly including demand from across the English border. North of this region restricted by remoteness of the network. Uskmouth GSP available to support higher capacity.	50 MW More if the GSP could be utilised	**D**	**D**
16	Isolated 132 kV line and significant existing windfarm development on Anglesey will restrict further connections. The EATL study indicates a small number of substations with spare capacity but not large. Wylfa GSP may offer high capacity connection to the grid	Small unless the GSP could be utilised	**B**	**B**
17	Lleyn Peninsula with isolated 132 kV line and little load centre will restrict further connections. However the Pentir & Dinorwig GSPs may offer high capacity connection	Small unless the GSP could be utilised	**B**	**B**
18	Significant 132 kV line and 33 kV infrastructure with demand along the north Wales coast. Possible to accommodate limited further connections. The EATL study indicates about nine substations with spare capacity.	30 MW	**C**	**C**
19	Limited network restricted to 33 kV and little local load.	small	**A**	**G**†
20	33 kV and isolated 132 kV network with little local load but includes the Ffestiniog and Trawsfynydd GSPs which could offer sizeable connection opportunities if local. Windfarm linked to pump storage could provide interesting commercial approach.	Small unless the GSPs could be utilised	**B**	**B**

21	132 kV and 33 kV line through the urban areas of Wrexham and to the south offers some opportunity for local generation connection. The Legacy GSP could offer sizeable connection opportunities if local.	30 MW – 50 MW More if the GSP could be utilised	**D**	**G**†
22	Sizeable local generation causing export/import issues in this region although connected by 132 kV to the WPD network. Limited local demand.	Very small	**A**	**H**†
23	Limited network restricted to 33 kV and little local load	Very small	**A**	**A**

A - very small and small (represents and absolute constraint in the GIS constraints model)
B - Small but with National Grid possibility
C - 30MW -50MW without National Grid
D - 30MW -50MW with National Grid
E - >50MW without National Grid
F - > 50MW with National Grid
G - 50MW - 150MW (2010/15 only)
H - 250MW - 300MW (2010/15 only)

*assumes no Scarweather sands but grid † proposed new Manweb Grid passes through these areas

APPENDIX B: Maps

Maps used to identify strategic areas:

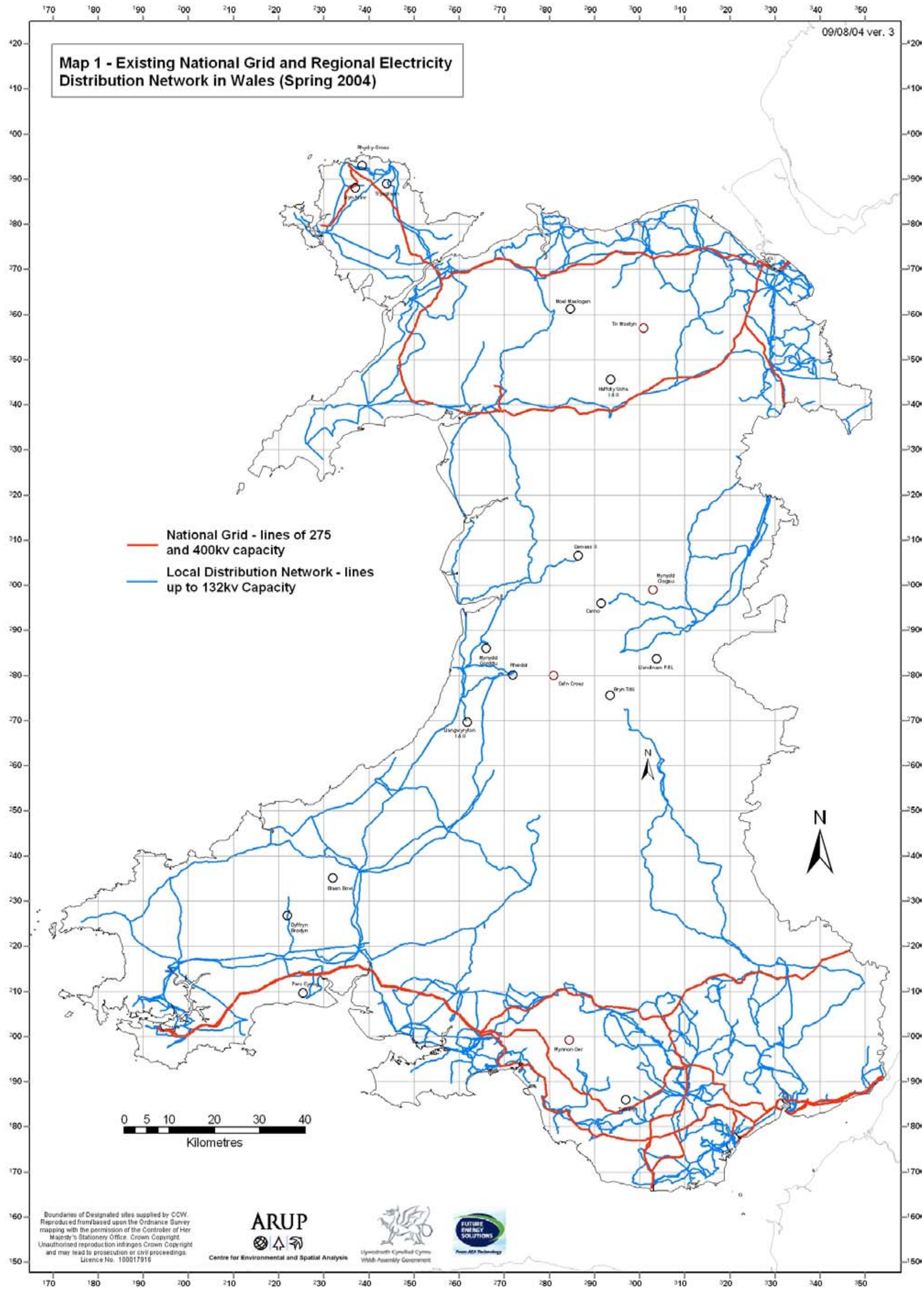
Map 1: Existing National Grid and Regional Electricity Distribution Network in Wales (Spring 2004)
Map 2: Spatial distribution of Electricity Capacity for wind energy development in Wales (Spring 2004)
Map 3: Spatial distribution of Electricity Capacity for wind energy development in Wales (by 2010/15)
Map 4: Summary of Grid Constraints
Map 5: Spatial distribution of cumulative Practical and Environmental constraints to wind energy development in Wales.
Map 6: Spatial distribution of cumulative Practical, Grid and Environmental constraints to wind energy development in Wales with positive siting factors applied (2010/1015)
Map 7: "Unconstrained areas" resulting from the combination of grid constraints and the spatial distribution of cumulative practical and environmental constraints (by 2010/2015)
Map 8: "Unconstrained areas" resulting from the combination of grid constraints and the spatial distribution of cumulative practical and environmental constraints shown with positive siting factors (by 2010/2015)
Map 9: Spatial distribution of strategic areas for major wind energy developments in Wales

Verification of strategic areas:

Map A: Visibility of wind turbines (110m) from within National Parks and AONB
Map B: Intervisibility of individual turbines
Map C: Visibility of wind turbines (110m) from National Trails
Map D: Spatial distribution of strategic areas and windspeed greater than 6m/s in Wales.
Map E: Spatial distribution of strategic areas and Wildland in Wales.

1:50,000 Backdrop of strategic areas:

Key to strategic areas map location
Key to constraints
Map A1: Strategic Area A – with OS 1:50,000 backdrop
Map B1 – B3: Strategic Area B – with OS 1:50,000 backdrop
Map C1: Strategic Area C – with OS 1:50,000 backdrop
Map D1: Strategic Area D – with OS 1:50,000 backdrop
Map E1 – E2: Strategic Area E – with OS 1:50,000 backdrop
Map F1 – F6: Strategic Area F – with OS 1:50,000 backdrop
Map G1: Strategic Area G – with OS 1:50,000 backdrop


09/08/04 ver. 3
Map 1 - Existing National Grid and Regional Electricity Distribution Network in Wales (Spring 2004)
National Grid - lines of 275 and 400kv capacity
Local Distribution Network - lines up to 132kv Capacity
0 5 10 20 30 40
Kilometres
N
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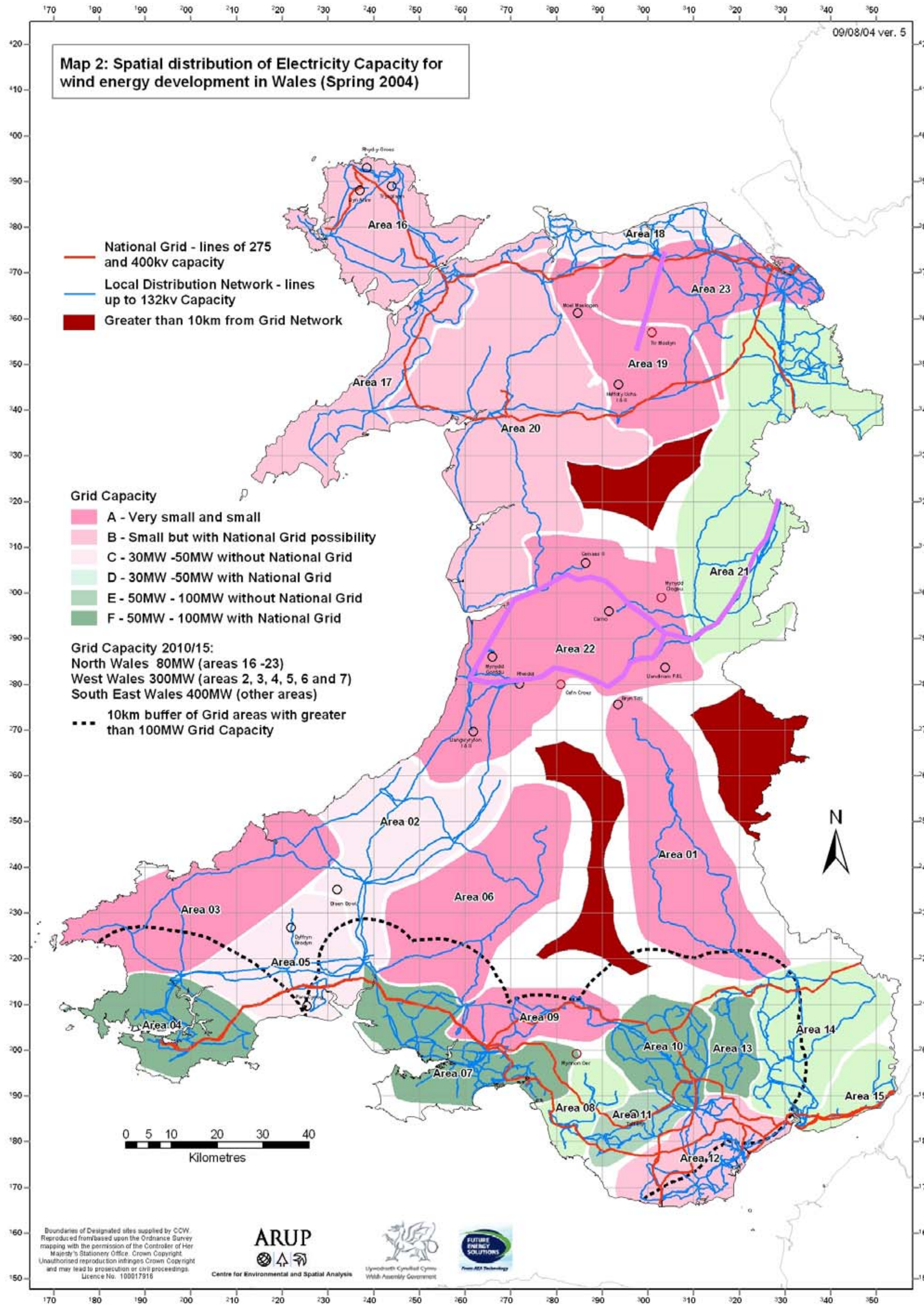
09/08/04 ver. 5
Map 2: Spatial distribution of Electricity Capacity for wind energy development in Wales (Spring 2004)
National Grid - lines of 275 and 400kv capacity
Local Distribution Network - lines up to 132kv Capacity
Greater than 10km from Grid Network
Grid Capacity
A - Very small and small
B - Small but with National Grid possibility
C - 30MW -50MW without National Grid
D - 30MW -50MW with National Grid
E - 50MW - 100MW without National Grid
F - 50MW - 100MW with National Grid
Grid Capacity 2010/15:
North Wales 80MW (areas 16 -23)
West Wales 300MW (areas 2, 3, 4, 5, 6 and 7)
South East Wales 400MW (other areas)
10km buffer of Grid areas with greater than 100MW Grid Capacity
Area 16
Area 18
Area 23
Area 19
Area 17
Area 20
Area 21
Area 22
Area 02
Area 01
Area 06
Area 03
Area 05
Area 04
Area 09
Area 07
Area 10
Area 13
Area 14
Area 15
Area 08
Area 11
Area 12
N
0 5 10 20 30 40
Kilometres
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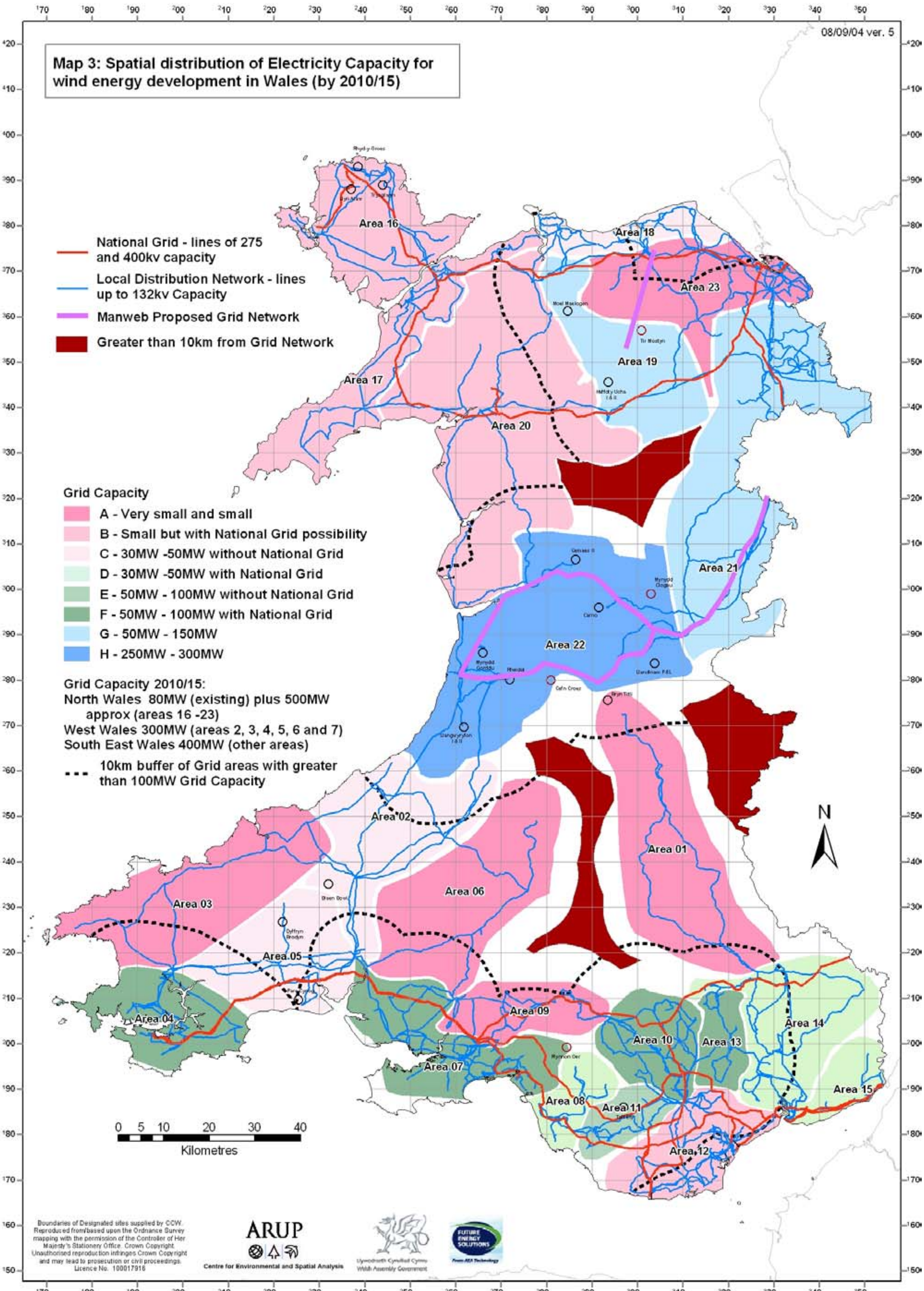

08/09/04 ver. 5
Map 3: Spatial distribution of Electricity Capacity for wind energy development in Wales (by 2010/15)
National Grid - lines of 275 and 400kv capacity
Local Distribution Network - lines up to 132kv Capacity
Manweb Proposed Grid Network
Greater than 10km from Grid Network
Grid Capacity
A - Very small and small
B - Small but with National Grid possibility
C - 30MW -50MW without National Grid
D - 30MW -50MW with National Grid
E - 50MW - 100MW without National Grid
F - 50MW - 100MW with National Grid
G - 50MW - 150MW
H - 250MW - 300MW
Grid Capacity 2010/15:
North Wales 80MW (existing) plus 500MW approx (areas 16 -23)
West Wales 300MW (areas 2, 3, 4, 5, 6 and 7)
South East Wales 400MW (other areas)
10km buffer of Grid areas with greater than 100MW Grid Capacity
Area 16
Area 17
Area 18
Area 19
Area 20
Area 21
Area 22
Area 23
Area 01
Area 02
Area 03
Area 04
Area 05
Area 06
Area 07
Area 08
Area 09
Area 10
Area 11
Area 12
Area 13
Area 14
Area 15
N
0 5 10 20 30 40
Kilometres
ARUP
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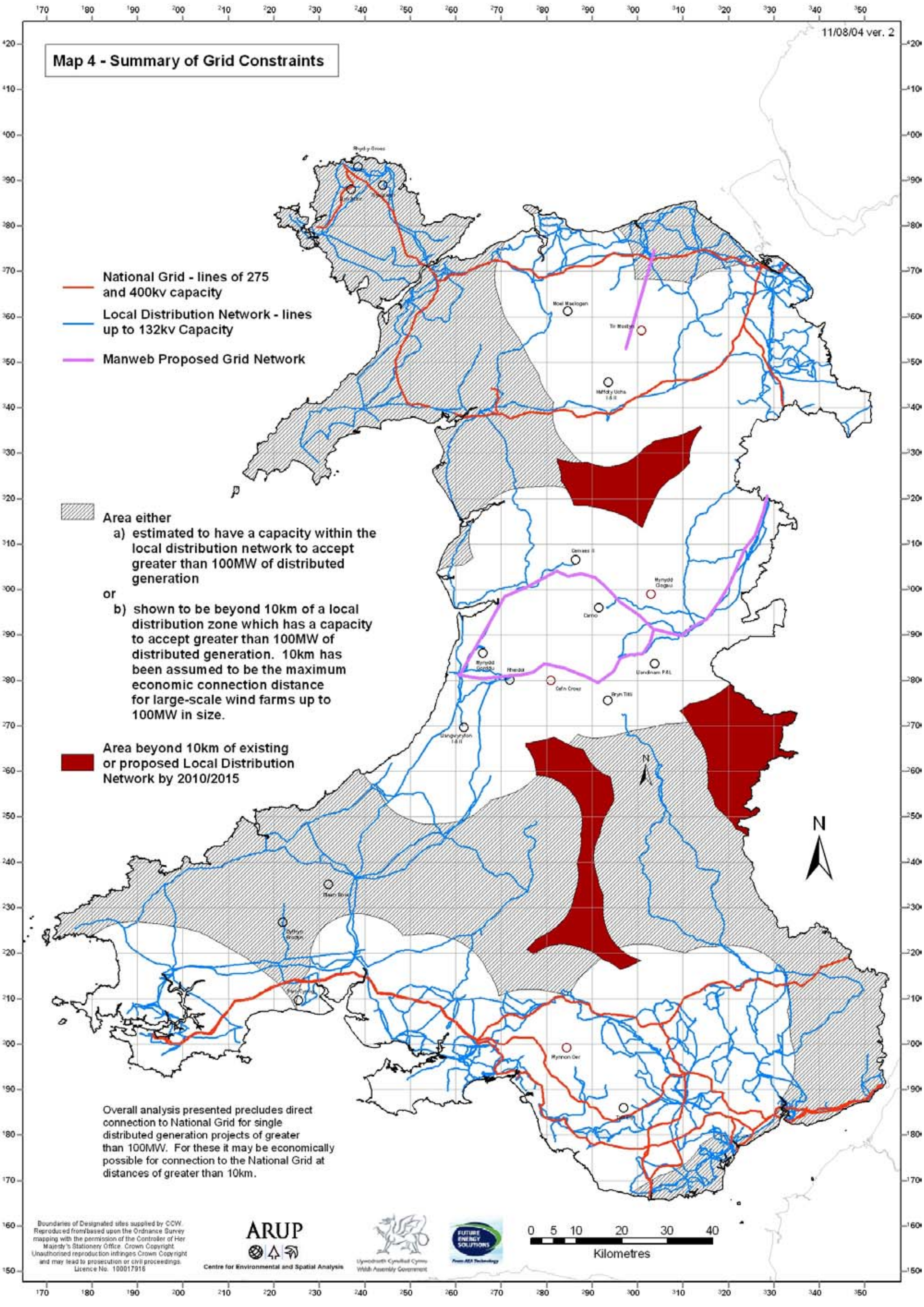
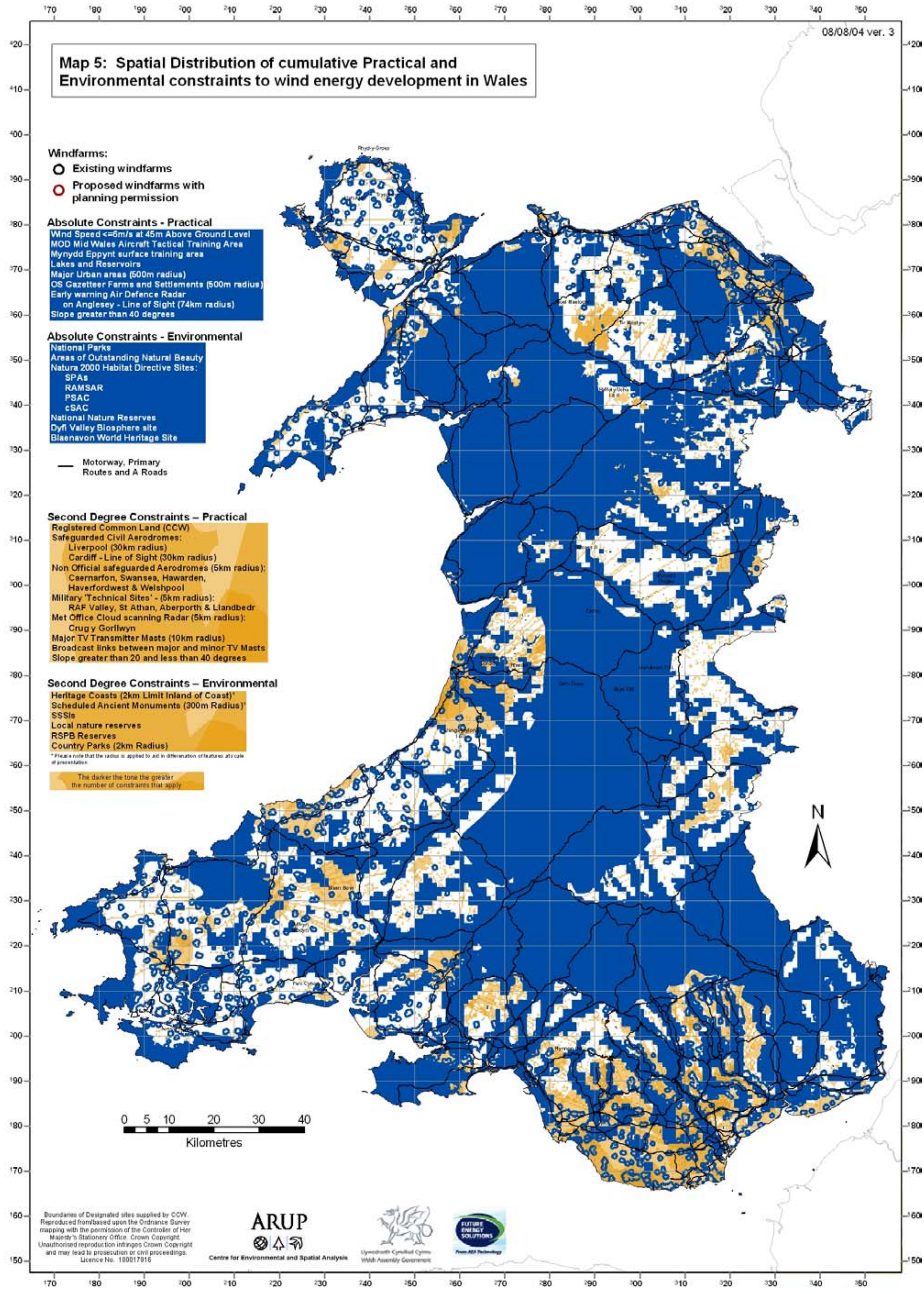

Map 4 - Summary of Grid Constraints
11/08/04 ver. 2
National Grid - lines of 275 and 400kv capacity
Local Distribution Network - lines up to 132kv Capacity
Manweb Proposed Grid Network
Area either
a) estimated to have a capacity within the local distribution network to accept greater than 100MW of distributed generation
or
b) shown to be beyond 10km of a local distribution zone which has a capacity to accept greater than 100MW of distributed generation. 10km has been assumed to be the maximum economic connection distance for large-scale wind farms up to 100MW in size.
Area beyond 10km of existing or proposed Local Distribution Network by 2010/2015
Overall analysis presented precludes direct connection to National Grid for single distributed generation projects of greater than 100MW. For these it may be economically possible for connection to the National Grid at distances of greater than 10km.
N
0 5 10 20 30 40
Kilometres
ARUP
Centre for Environmental and Spatial Analysis



08/08/04 ver. 3
Map 5: Spatial Distribution of cumulative Practical and Environmental constraints to wind energy development in Wales
Windfarms:
Existing windfarms
Proposed windfarms with planning permission
Absolute Constraints - Practical
Wind Speed <=6m/s at 45m Above Ground Level
MOD Mid Wales Aircraft Tactical Training Area
Mynydd Eppynt surface training area
Lakes and Reservoirs
Major Urban areas (500m radius)
OS Gazetteer Farms and Settlements (500m radius)
Early warning Air Defence Radar on Anglesey - Line of Sight (74km radius)
Slope greater than 40 degrees
Absolute Constraints - Environmental
National Parks
Areas of Outstanding Natural Beauty
Natura 2000 Habitat Directive Sites:
SPAs
RAMSAR
PSAC
cSAC
National Nature Reserves
Dyfi Valley Biosphere site
Blaenavon World Heritage Site
Motorway, Primary Routes and A Roads
Second Degree Constraints – Practical
Registered Common Land (CCW)
Safeguarded Civil Aerodromes:
Liverpool (30km radius)
Cardiff - Line of Sight (30km radius)
Non Official safeguarded Aerodromes (5km radius):
Caernarfon, Swansea, Hawarden, Haverfordwest & Welshpool
Military 'Technical Sites' - (5km radius):
RAF Valley, St Athan, Aberporth & Llandbedr
Met Office Cloud scanning Radar (5km radius):
Crug y Gorllwyn
Major TV Transmitter Masts (10km radius)
Broadcast links between major and minor TV Masts
Slope greater than 20 and less than 40 degrees
Second Degree Constraints – Environmental
Heritage Coasts (2km Limit Inland of Coast)*
Scheduled Ancient Monuments (300m Radius)*
SSSIs
Local nature reserves
RSPB Reserves
Country Parks (2km Radius)
The darker the tone the greater the number of constraints that apply
N
0 5 10 20 30 40
Kilometres
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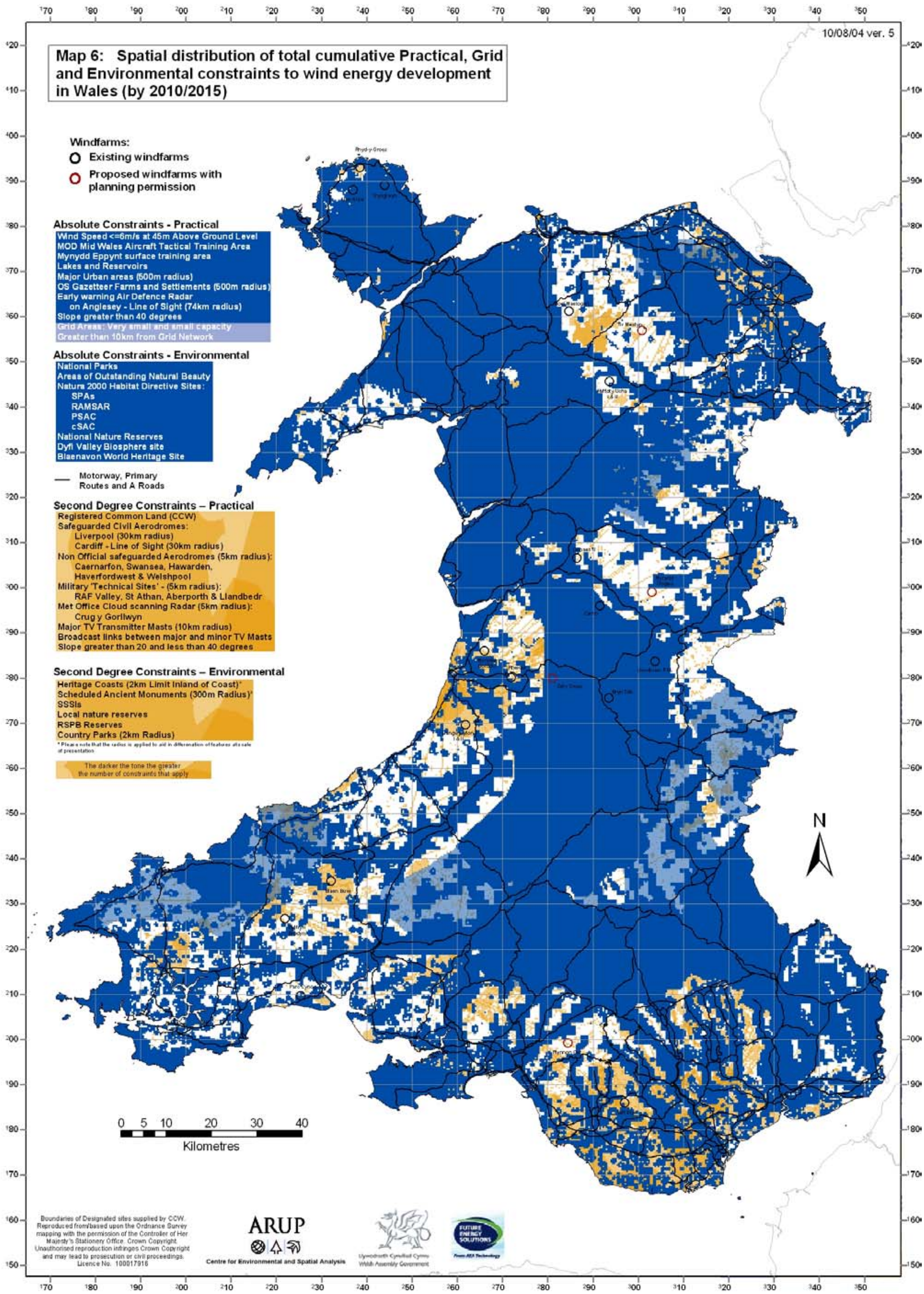
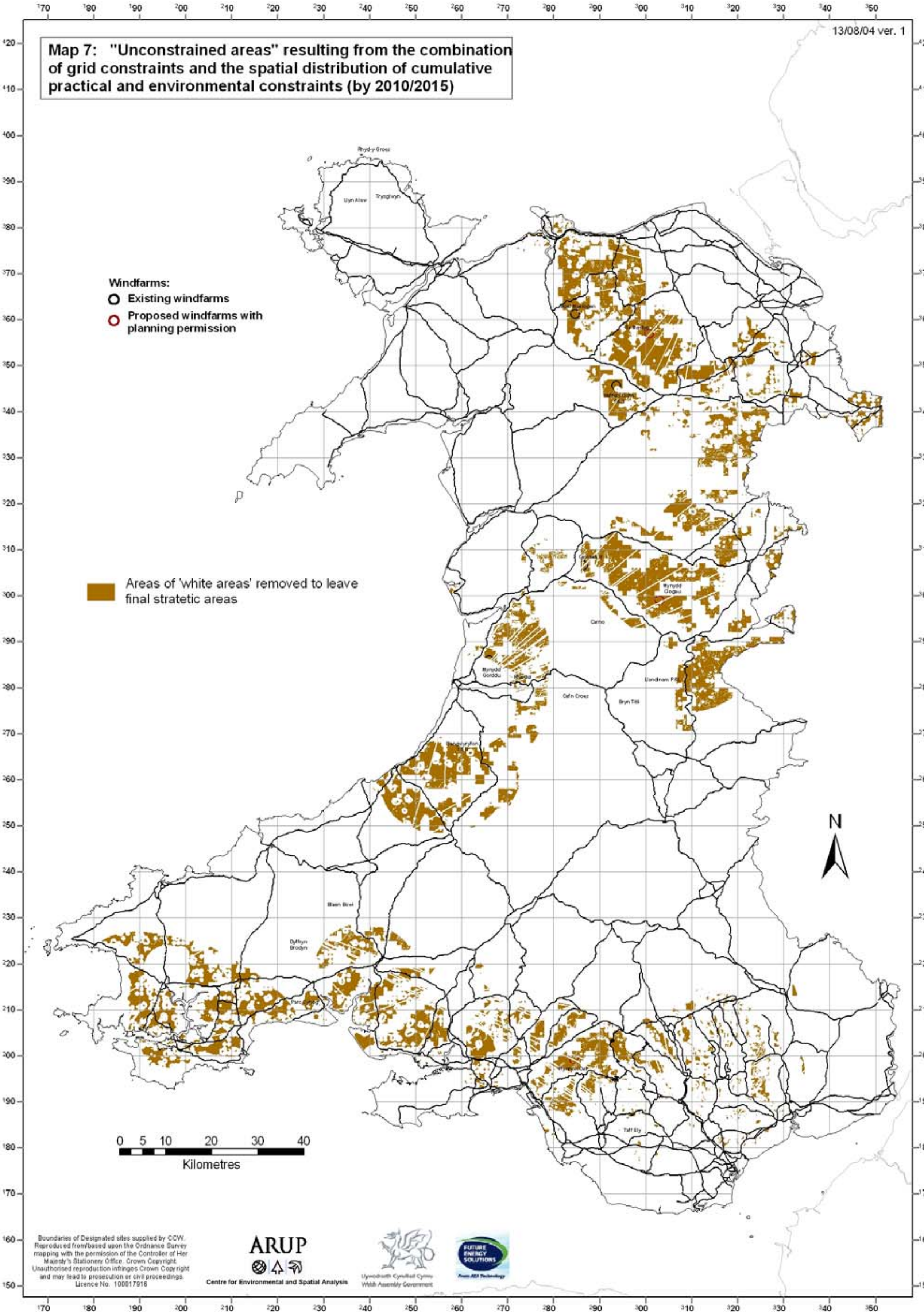
FUTURE ENERGY SOLUTIONS



Centre for Environmental and Spatial Analysis



Map 7: "Unconstrained areas" resulting from the combination of grid constraints and the spatial distribution of cumulative practical and environmental constraints (by 2010/2015)
13/08/04 ver. 1
Windfarms:
Existing windfarms
Proposed windfarms with planning permission
Areas of 'white areas' removed to leave final stratetic areas
N
0 5 10 20 30 40
Kilometres
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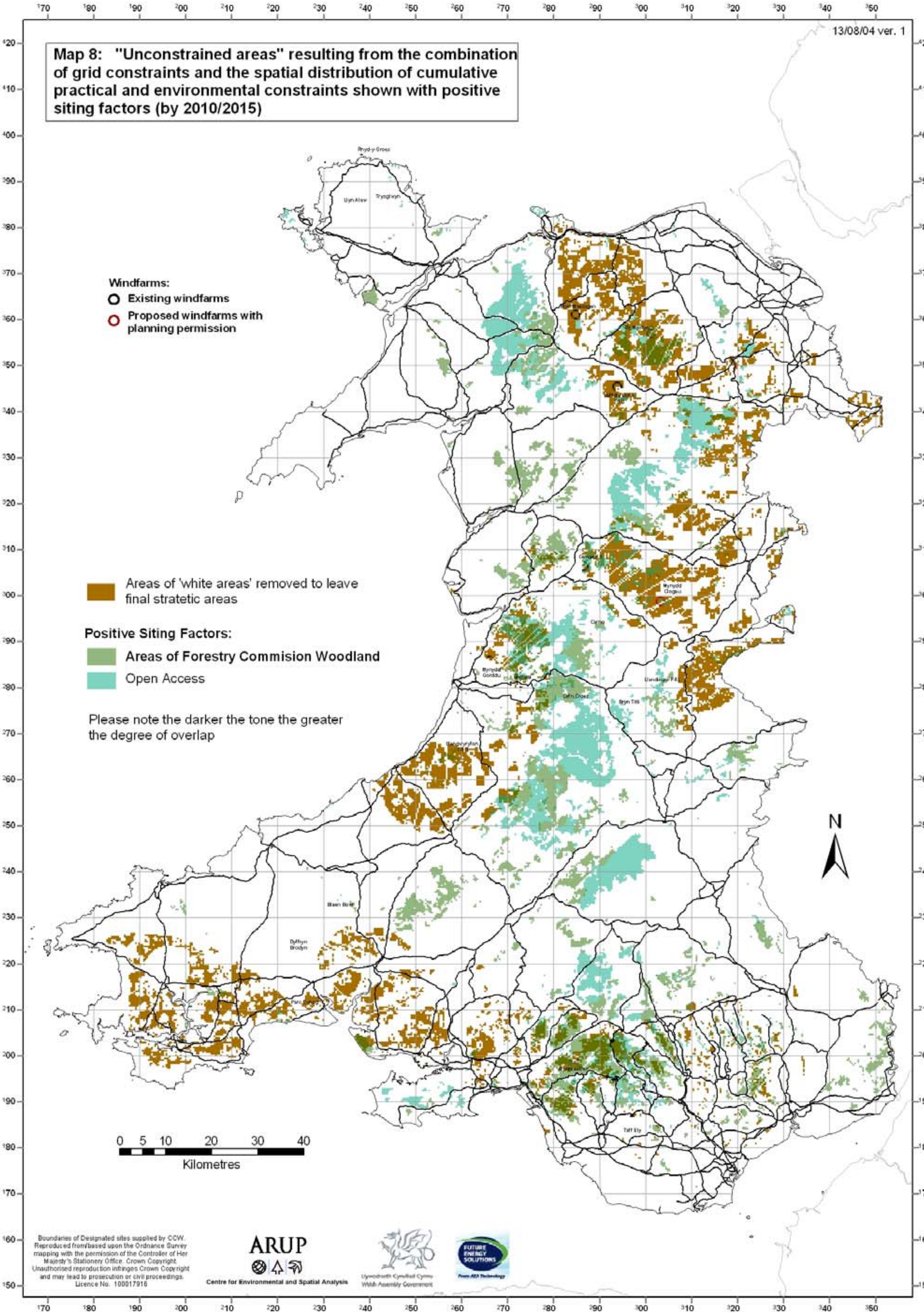
13/08/04 ver. 1
Map 8: "Unconstrained areas" resulting from the combination of grid constraints and the spatial distribution of cumulative practical and environmental constraints shown with positive siting factors (by 2010/2015)
Windfarms:
Existing windfarms
Proposed windfarms with planning permission
Areas of 'white areas' removed to leave final stratetic areas
Positive Siting Factors:
Areas of Forestry Commision Woodland
Open Access
Please note the darker the tone the greater the degree of overlap
N
0 5 10 20 30 40
Kilometres
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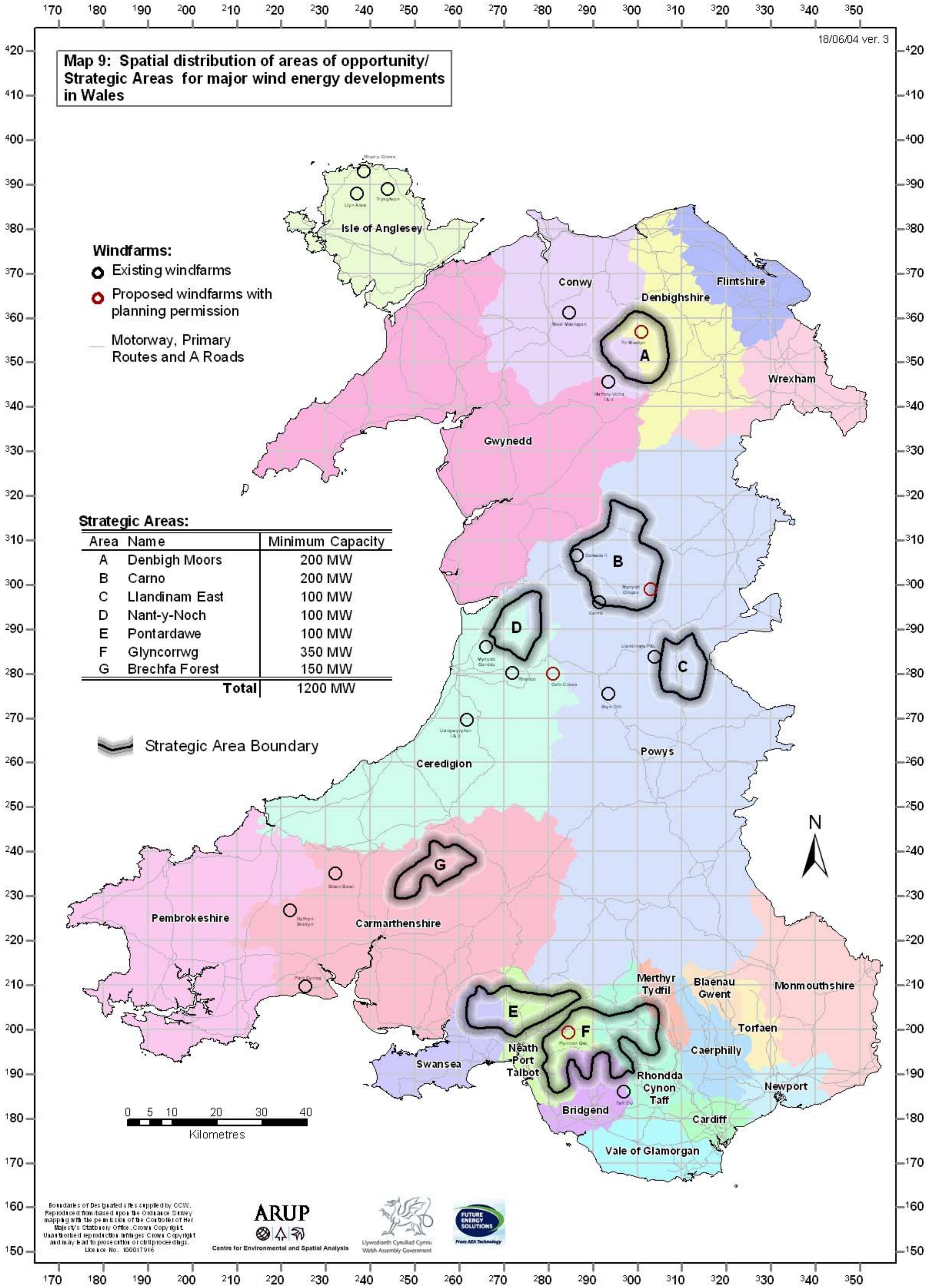
Map 9: Spatial distribution of areas of opportunity/
Strategic Areas for major wind energy developments
in Wales
18/06/04 ver. 3
Windfarms:
Existing windfarms
Proposed windfarms with planning permission
Motorway, Primary Routes and A Roads
Strategic Areas:
Area Name Minimum Capacity
A Denbigh Moors 200 MW
B Carno 200 MW
C Llandinam East 100 MW
D Nant-y-Noch 100 MW
E Pontardawe 100 MW
F Glyncorrwg 350 MW
G Brechfa Forest 150 MW
Total 1200 MW
Strategic Area Boundary
Isle of Anglesey
Conwy
Denbighshire
Flintshire
Wrexham
Gwynedd
Powys
Ceredigion
Pembrokeshire
Carmarthenshire
Swansea
Neath Port Talbot
Bridgend
Rhondda Cynon Taff
Merthyr Tydfil
Blaenau Gwent
Caerphilly
Torfaen
Monmouthshire
Newport
Cardiff
Vale of Glamorgan
N
0 5 10 20 30 40
Kilometres
ARUP
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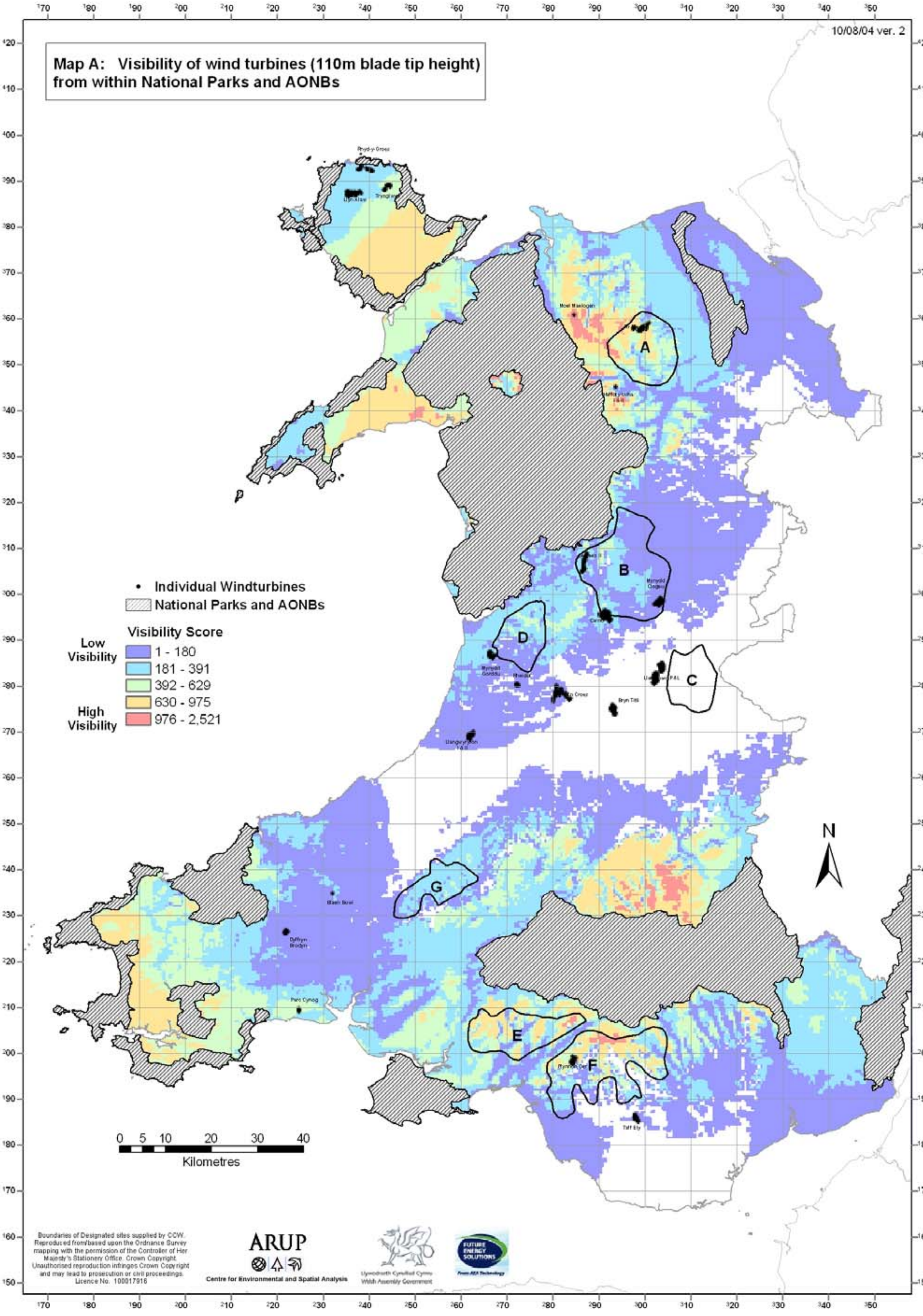
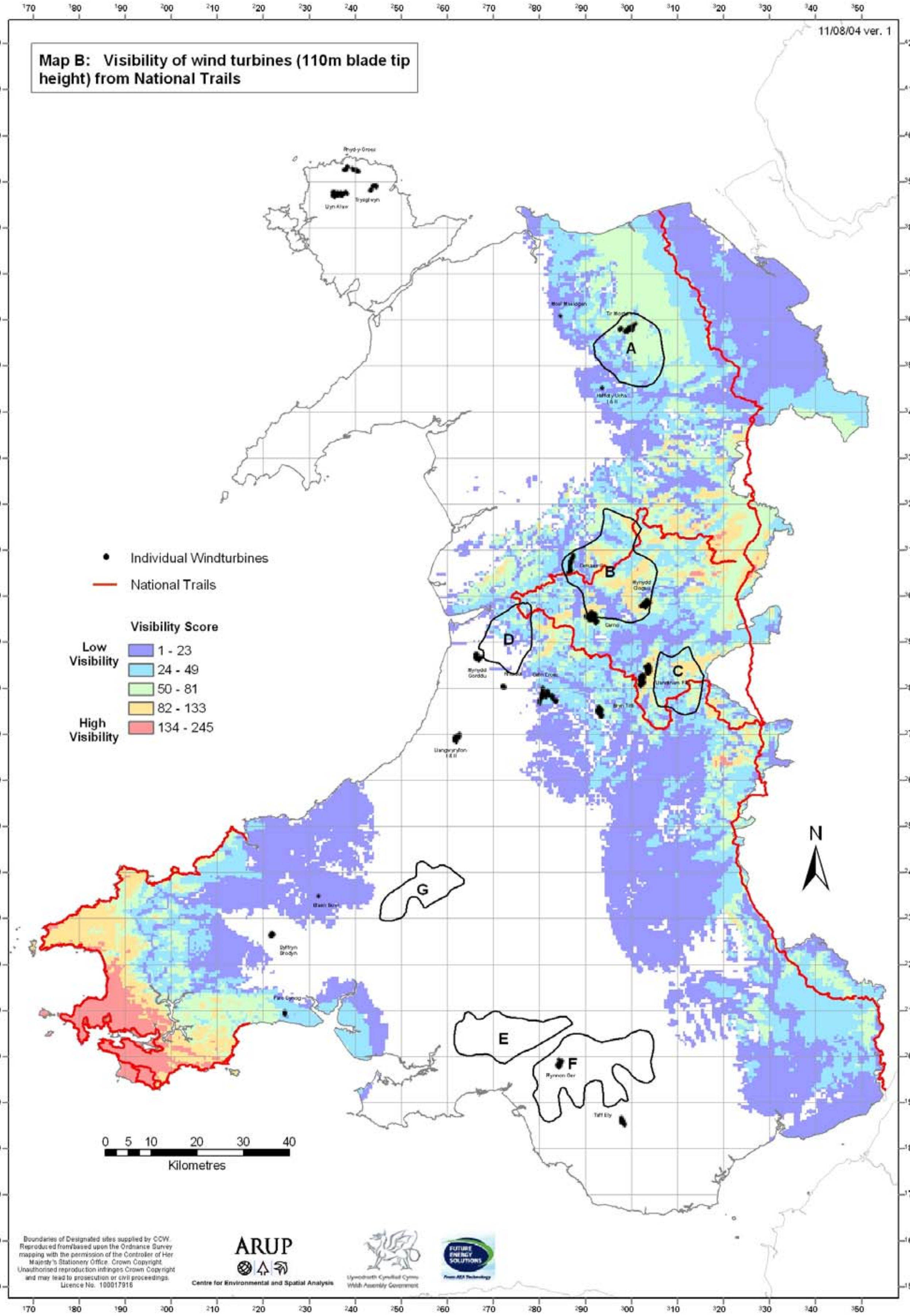
Welsh Assembly Government
FUTURE ENERGY SOLUTIONS
From AEA Technology


10/08/04 ver. 2
Map A: Visibility of wind turbines (110m blade tip height) from within National Parks and AONBs
Individual Windturbines
National Parks and AONBs
Visibility Score
Low Visibility
High Visibility
1 - 180
181 - 391
392 - 629
630 - 975
976 - 2,521
A
B
C
D
E
F
G
N
0 5 10 20 30 40
Kilometres
ARUP
Centre for Environmental and Spatial Analysis



11/08/04 ver. 1
Map B: Visibility of wind turbines (110m blade tip height) from National Trails
Individual Windturbines
National Trails
Visibility Score
Low Visibility
1 - 23
24 - 49
50 - 81
82 - 133
High Visibility
134 - 245
A
B
C
D
E
F
G
N
0 5 10 20 30 40
Kilometres
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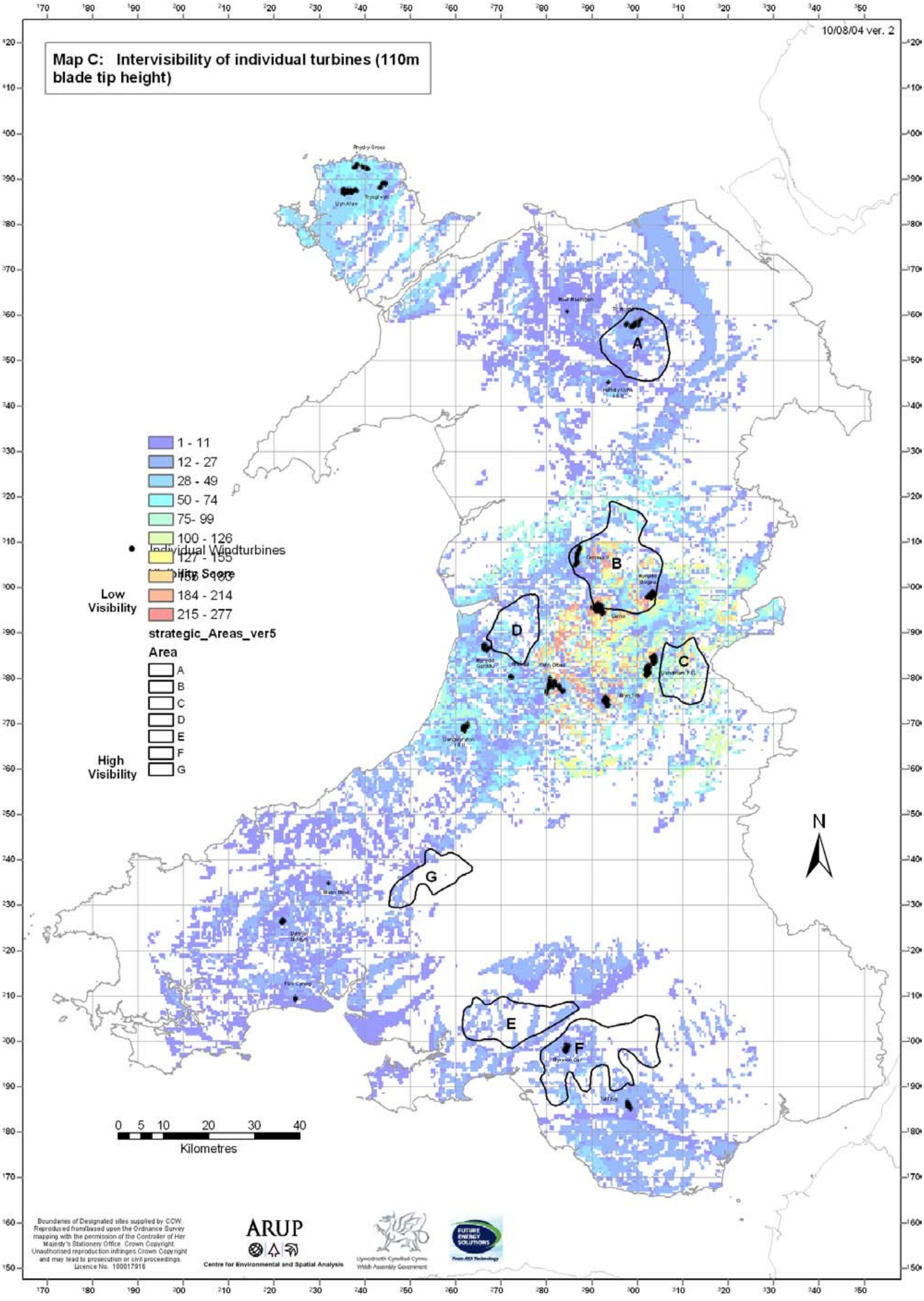
10/08/04 ver. 2
Map C: Intervisibility of individual turbines (110m blade tip height)
1 - 11
12 - 27
28 - 49
50 - 74
75- 99
100 - 126
127 - 155
184 - 214
215 - 277
Individual Windturbines
Low Visibility
High Visibility
strategic_Areas_ver5
Area
A
B
C
D
E
F
G
N
0 5 10 20 30 40
Kilometres
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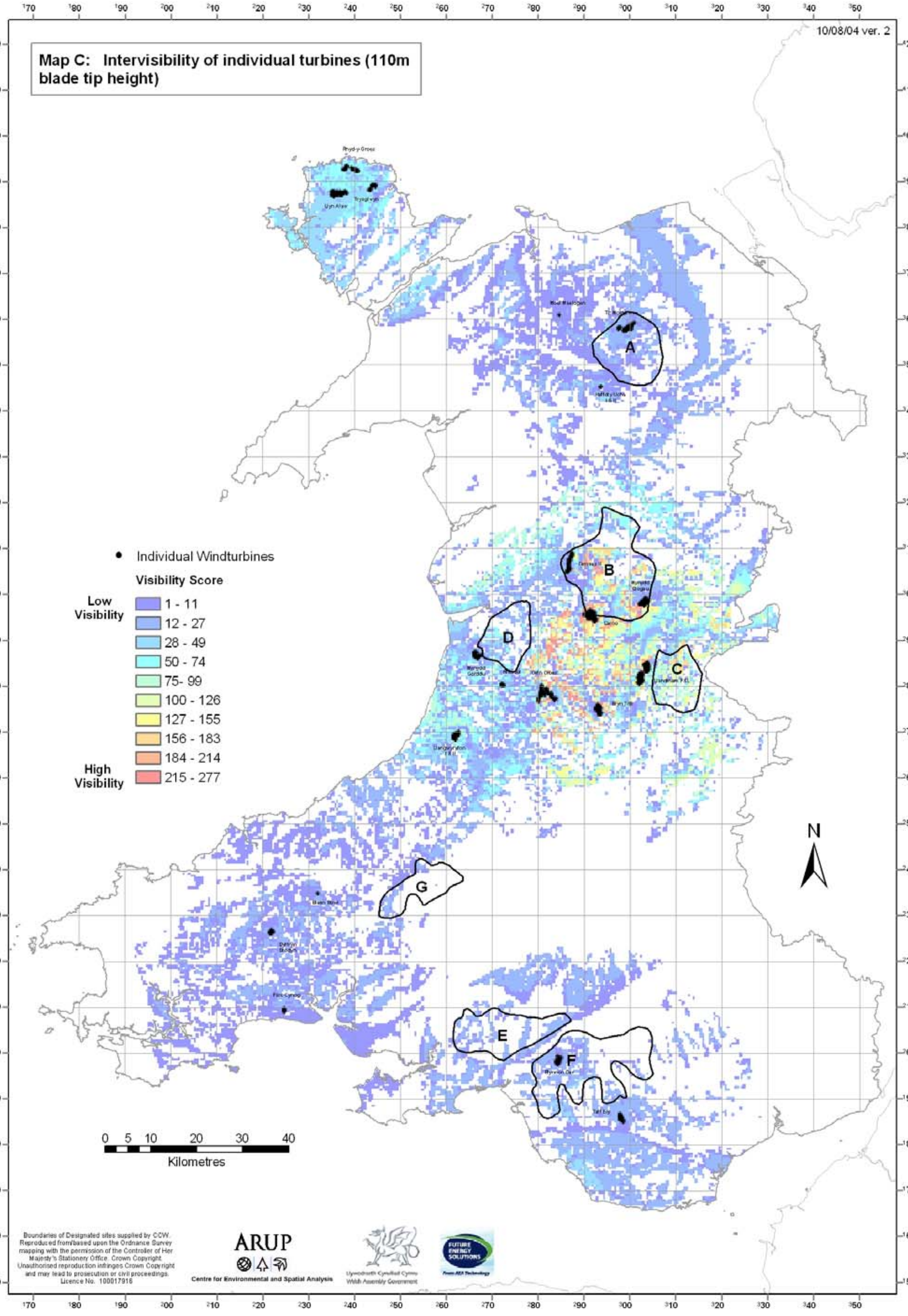

Map C: Intervisibility of individual turbines (110m blade tip height)
10/08/04 ver. 2
Individual Windturbines
Visibility Score
Low Visibility
1 - 11
12 - 27
28 - 49
50 - 74
75- 99
100 - 126
127 - 155
156 - 183
184 - 214
215 - 277
High Visibility
A
B
C
D
E
F
G
N
0 5 10 20 30 40
Kilometres
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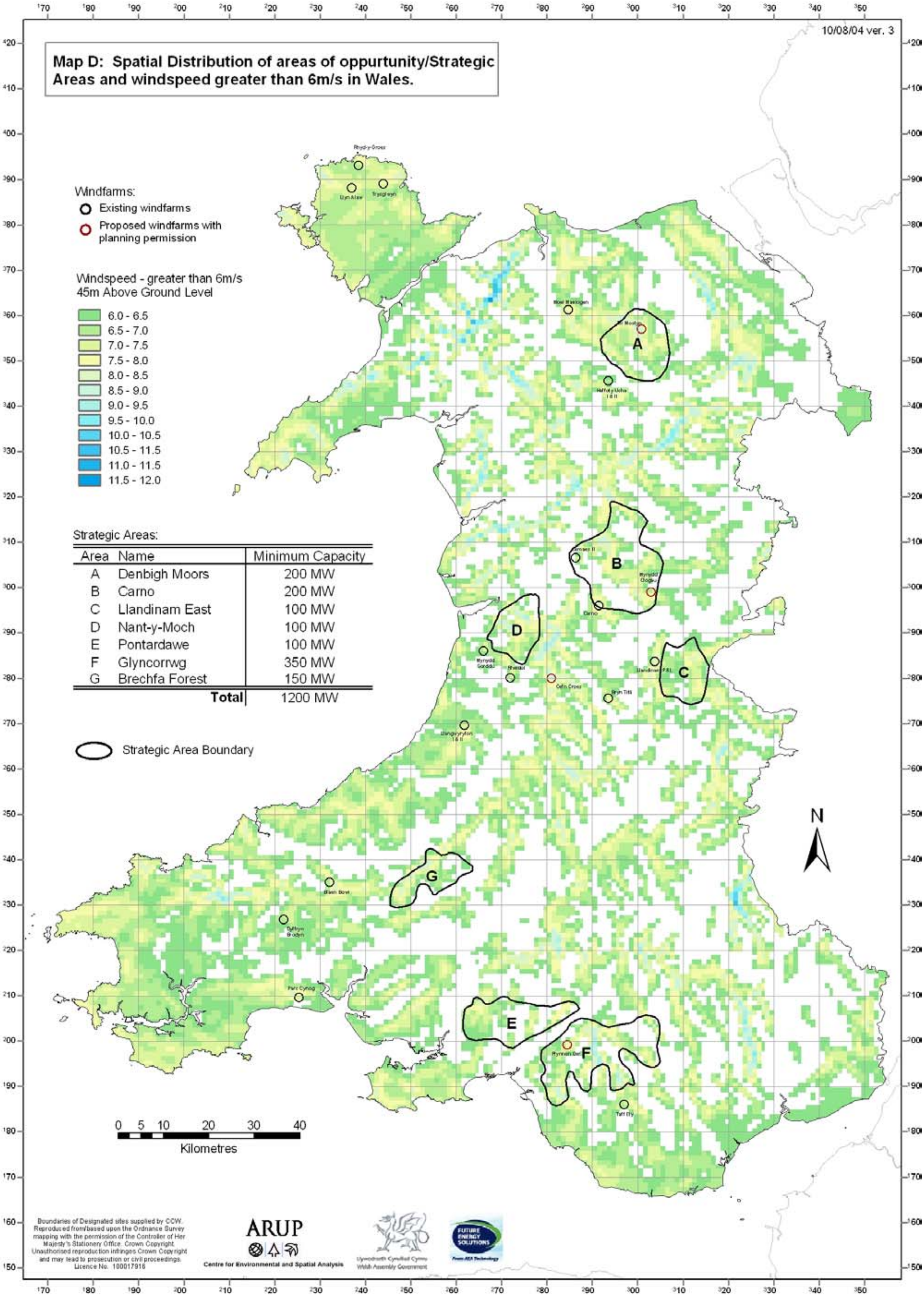
10/08/04 ver. 3
Map D: Spatial Distribution of areas of oppurtunity/Strategic Areas and windspeed greater than 6m/s in Wales.
Windfarms:
Existing windfarms
Proposed windfarms with planning permission
Windspeed - greater than 6m/s 45m Above Ground Level
6.0 - 6.5
6.5 - 7.0
7.0 - 7.5
7.5 - 8.0
8.0 - 8.5
8.5 - 9.0
9.0 - 9.5
9.5 - 10.0
10.0 - 10.5
10.5 - 11.5
11.0 - 11.5
11.5 - 12.0
Strategic Areas:
Area Name Minimum Capacity
A Denbigh Moors 200 MW
B Carno 200 MW
C Llandinam East 100 MW
D Nant-y-Moch 100 MW
E Pontardawe 100 MW
F Glyncorrwg 350 MW
G Brechfa Forest 150 MW
Total 1200 MW
Strategic Area Boundary
A
B
C
D
E
F
G
N
0 5 10 20 30 40
Kilometres
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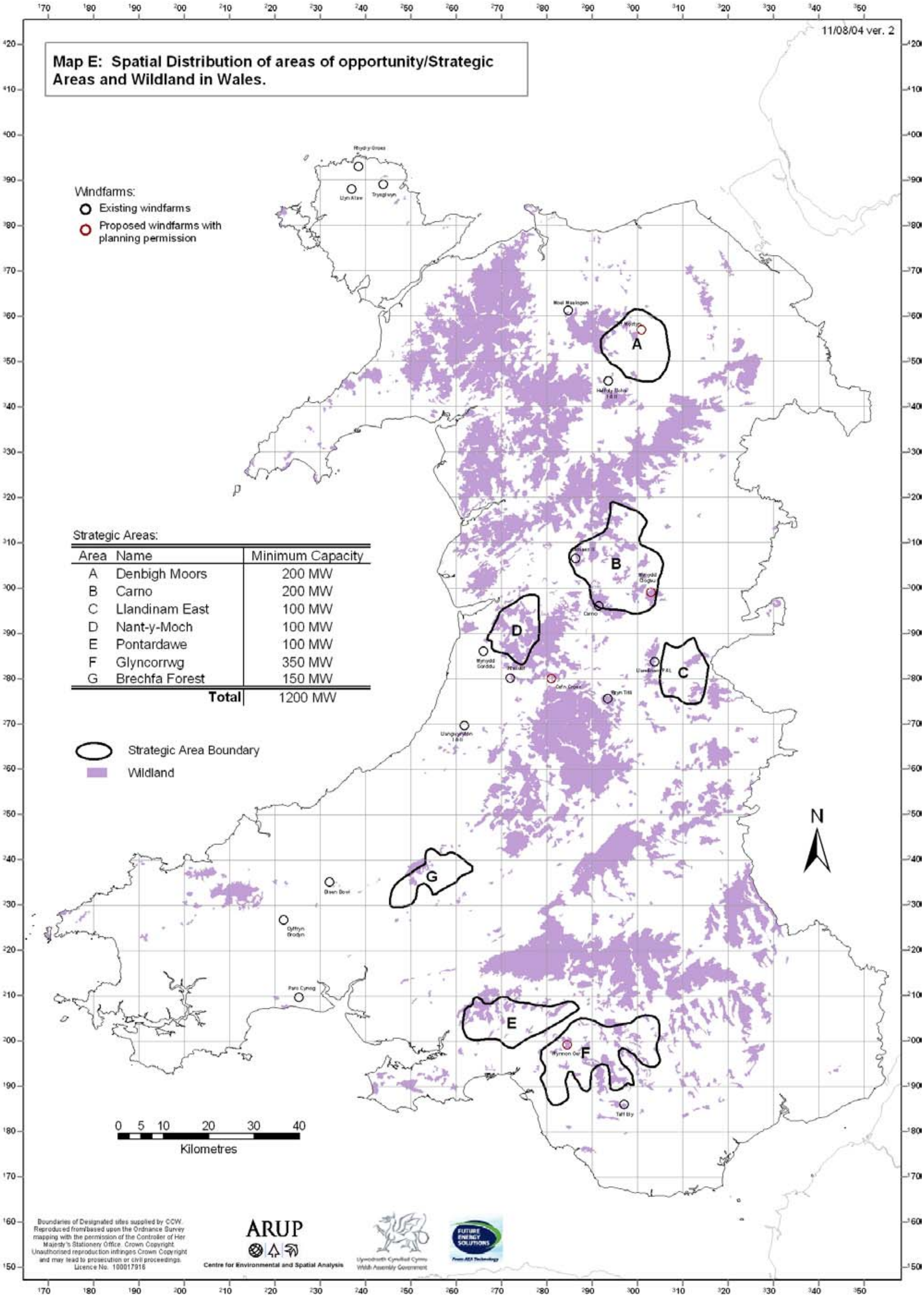
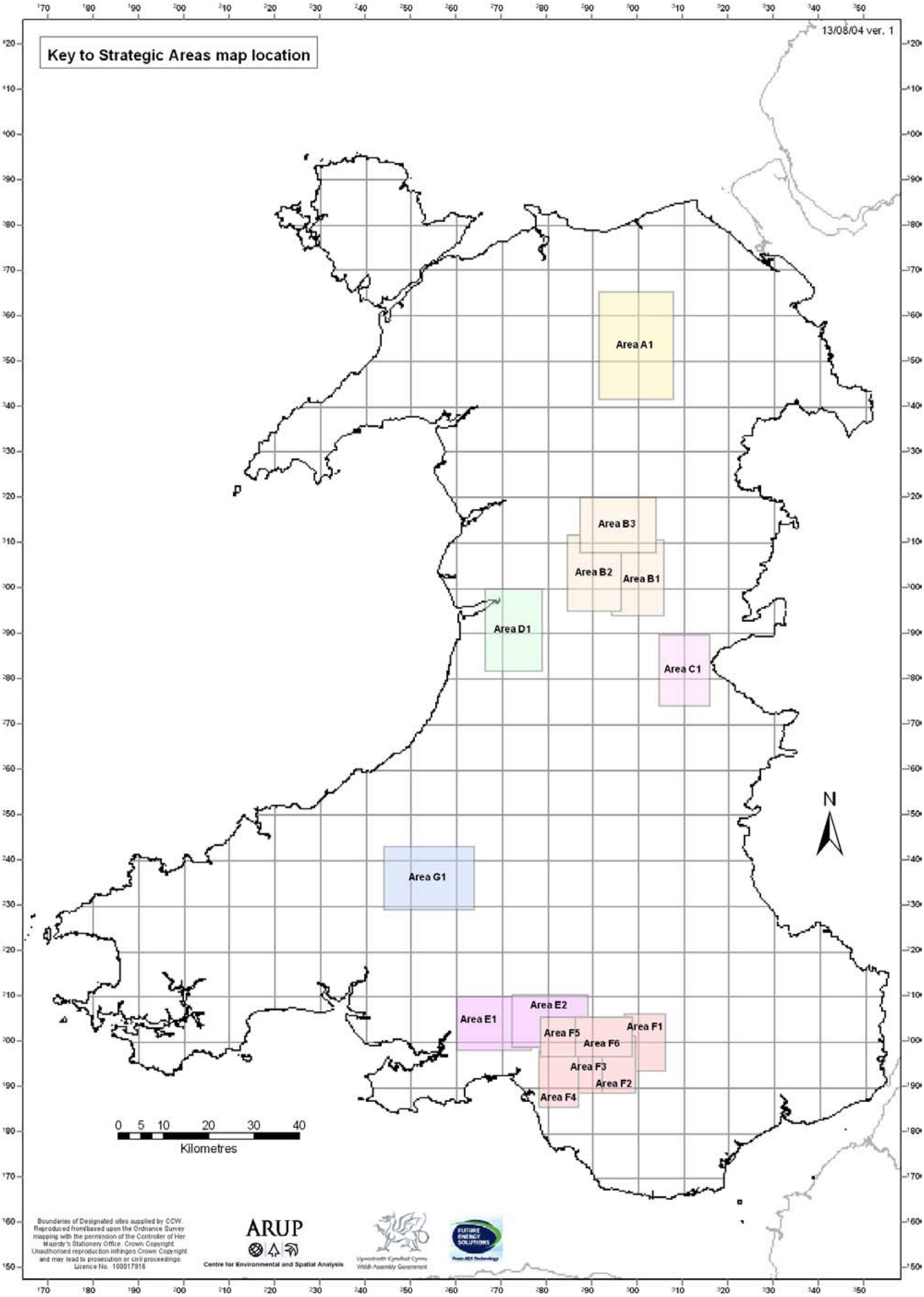

11/08/04 ver. 2
Map E: Spatial Distribution of areas of opportunity/Strategic Areas and Wildland in Wales.
Windfarms:
Existing windfarms
Proposed windfarms with planning permission
Strategic Areas:
Area Name Minimum Capacity
A Denbigh Moors 200 MW
B Carno 200 MW
C Llandinam East 100 MW
D Nant-y-Moch 100 MW
E Pontardawe 100 MW
F Glyncorrwg 350 MW
G Brechfa Forest 150 MW
Total 1200 MW
Strategic Area Boundary
Wildland
N
0 5 10 20 30 40
Kilometres
A
B
C
D
E
F
G
ARUP
Centre for Environmental and Spatial Analysis


Key to Strategic Areas map location
13/08/04 ver. 1
Area A1
Area B3
Area B2
Area B1
Area D1
Area C1
Area G1
Area E1
Area E2
Area F1
Area F5
Area F6
Area F3
Area F2
Area F4
N
0 5 10 20 30 40
Kilometres
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Key to Constraints:

Absolute Constraints - Practical

Wind Speed <=6m/s at 45m Above Ground Level
MOD Mid Wales Aircraft Tactical Training Area
Mynydd Eppynt surface training area
Lakes and Reservoirs
Major Urban areas (500m radius)
OS Gazetteer Farms and Settlements (500m radius)
Early warning Air Defence Radar
 on Anglesey - Line of Sight (74km radius)
Slope greater than 40 degrees
Grid Areas: Very small and small capacity
Greater than 10km from Grid Network

Absolute Constraints - Environmental

National Parks
Areas of Outstanding Natural Beauty
Natura 2000 Habitat Directive Sites:
 SPAs
 RAMSAR
 PSAC
 cSAC
National Nature Reserves
Dyfi Valley Biosphere site
Blaenavon World Heritage Site

Open Access

Second Degree Constraints – Practical

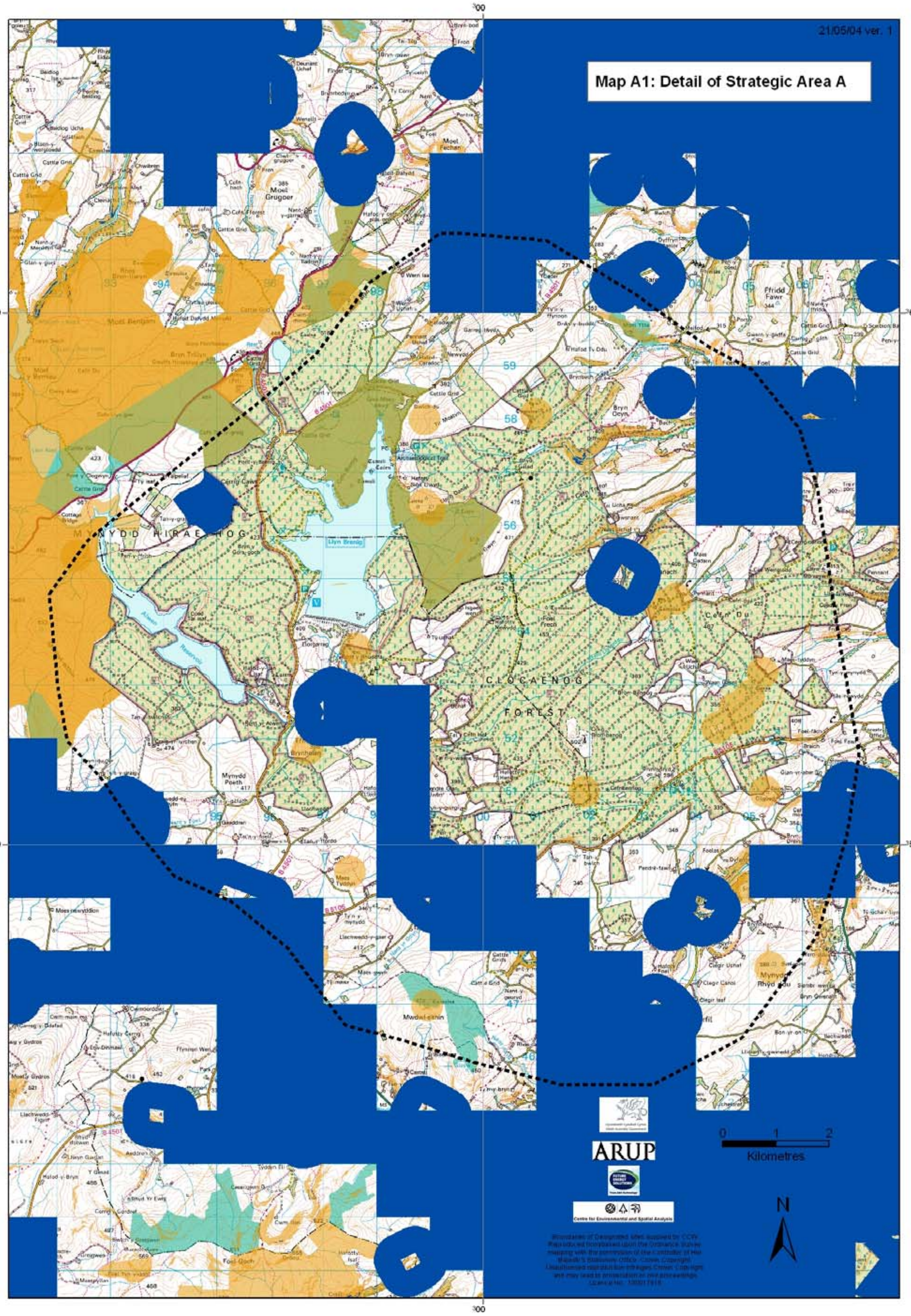
Registered Common Land (CCW)
Safeguarded Civil Aerodromes:
 Liverpool (30km radius)
 Cardiff - Line of Sight (30km radius)
Non Official safeguarded Aerodromes (5km radius):
 Caernarfon, Swansea, Hawarden,
 Haverfordwest & Welshpool
Military 'Technical Sites' - (5km radius):
 RAF Valley, St Athan, Aberporth & Llandbedr
Met Office Cloud scanning Radar (5km radius):
 Crug y Gorllwyn
Major TV Transmitter Masts (10km radius)
Broadcast links between major and minor TV Masts
Slope greater than 20 and less than 40 degrees

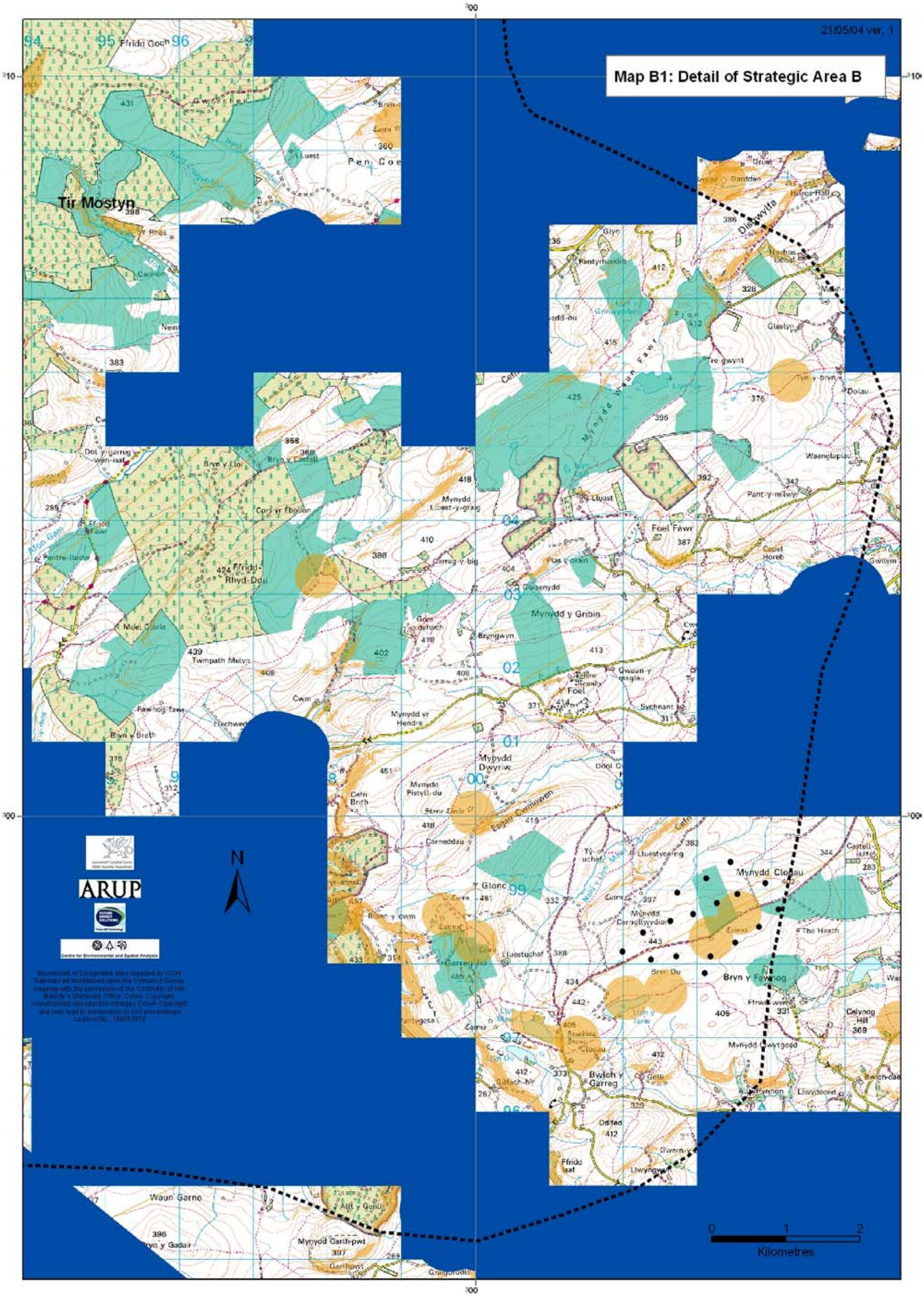
Second Degree Constraints – Environmental

Heritage Coasts (2km Limit Inland of Coast)*
Scheduled Ancient Monuments (300m Radius)*
SSSIs
Local nature reserves
RSPB Reserves
Country Parks (2km Radius)

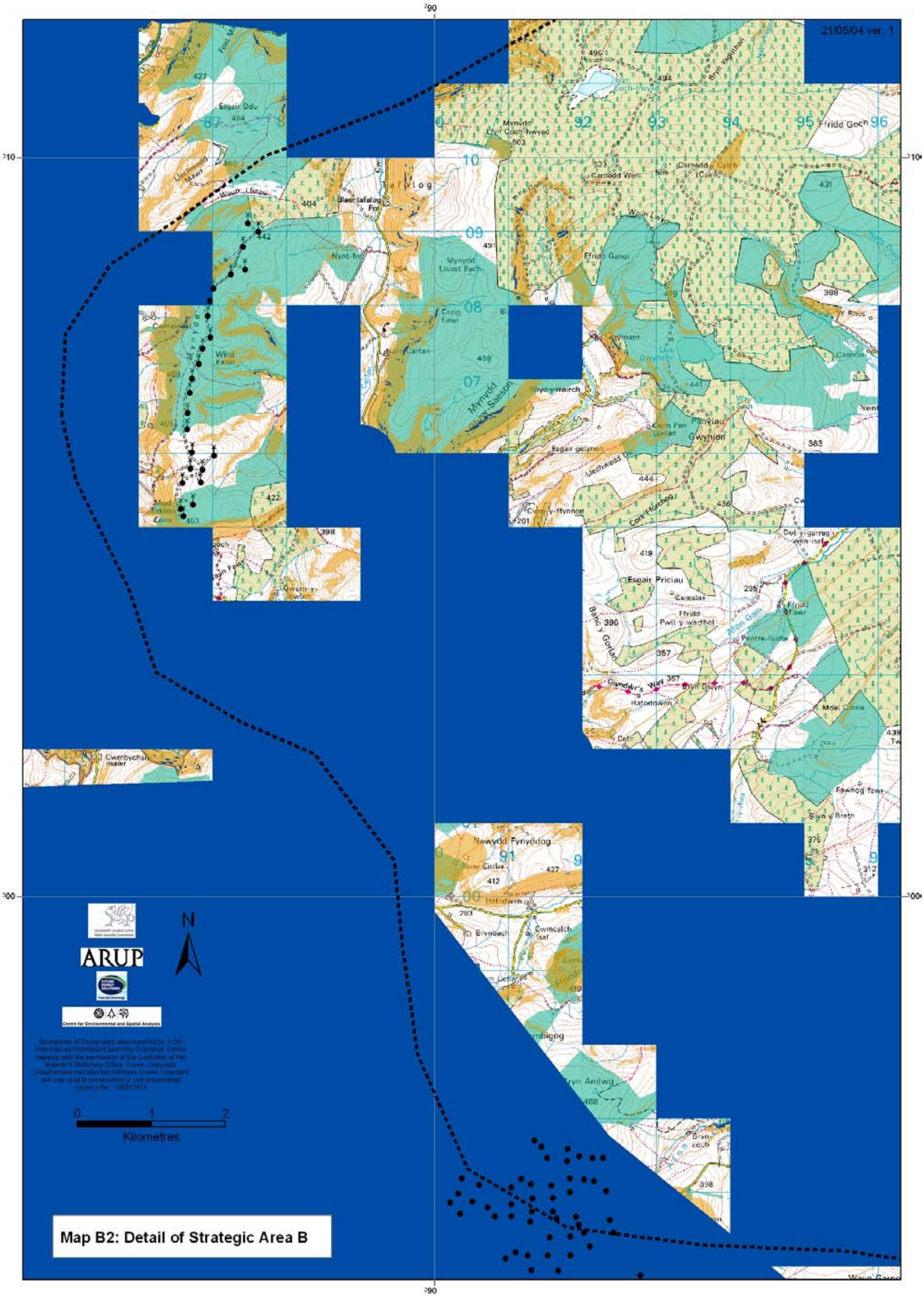
* Please note that the radius is applied to aid in differenation of features at scale of presentation

The darker the tone the greater the number of constraints that apply

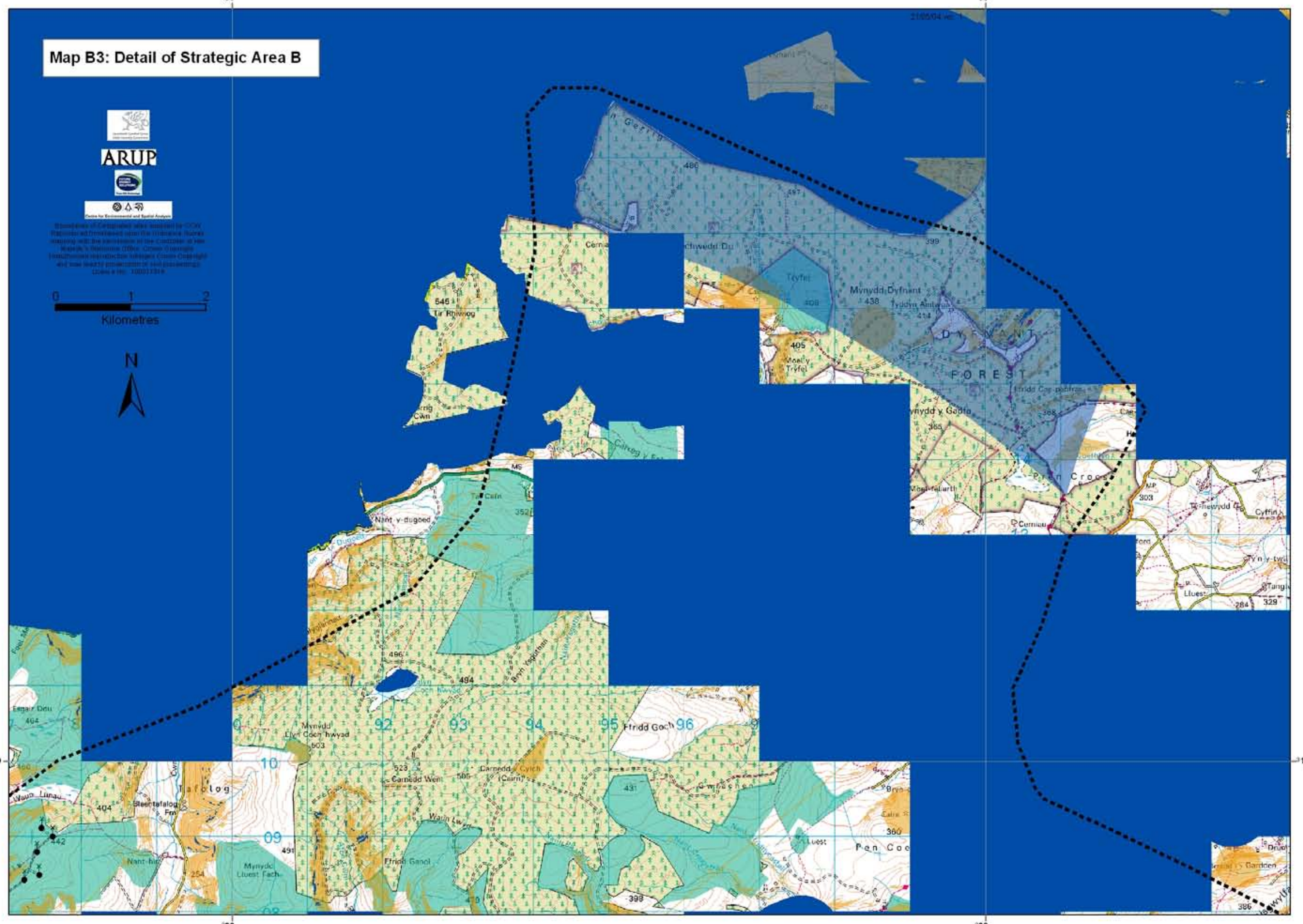

21/05/04 ver. 1
Map A1: Detail of Strategic Area A
MYNYDD HIRAETHOG
Llyn Brenig
CLOCAENOG
FOREST
Moel Grugoer
Ffridd Fawr
Mynydd Poeth
Mwdwl-eithin
ARUP
0 1 2
Kilometres
Centre for Environmental and Spatial Analysis
N

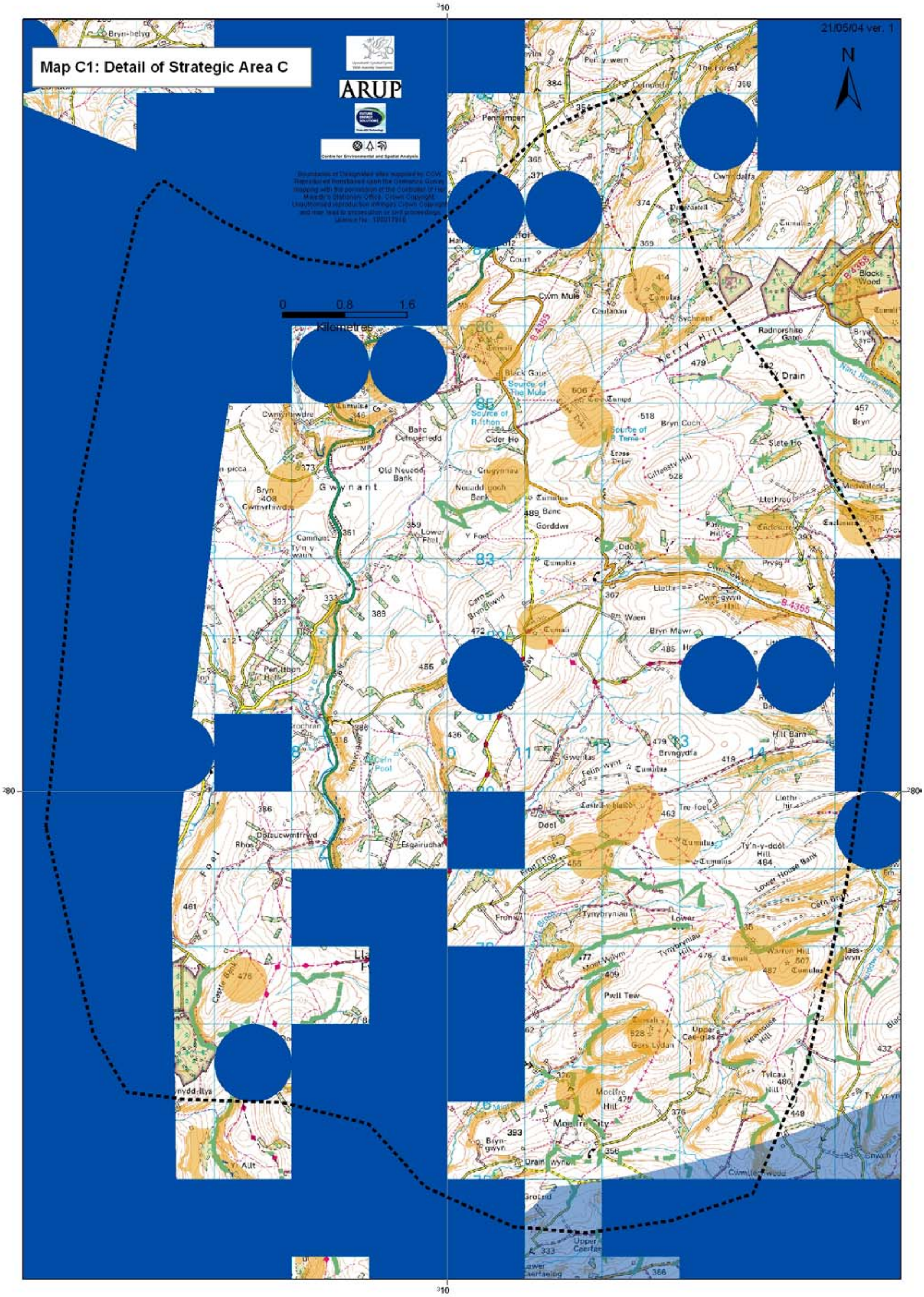


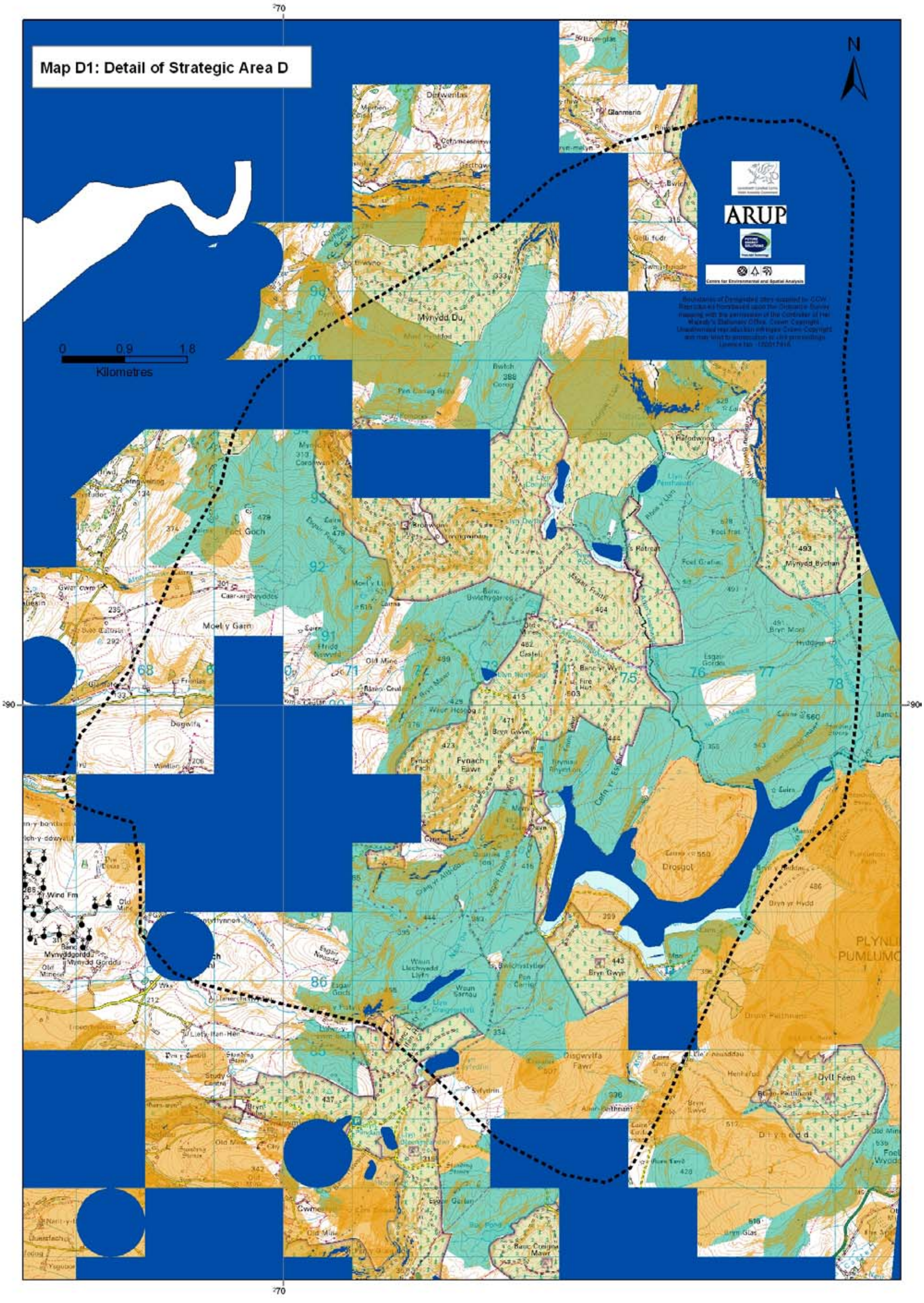
Map B1: Detail of Strategic Area B
21/05/04 ver. 1
Tir Mostyn
N
ARUP
Kilometres
0
1
2

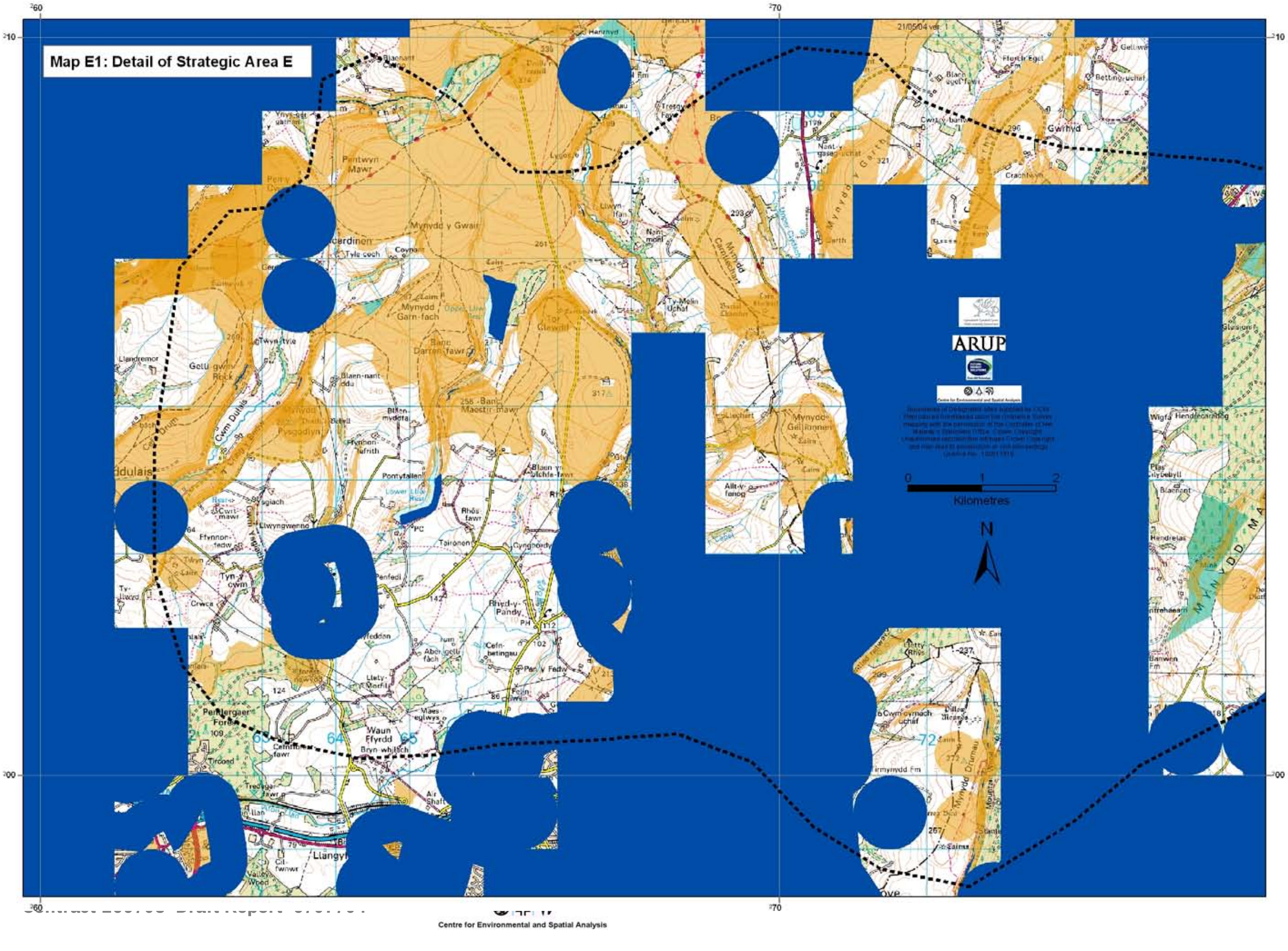


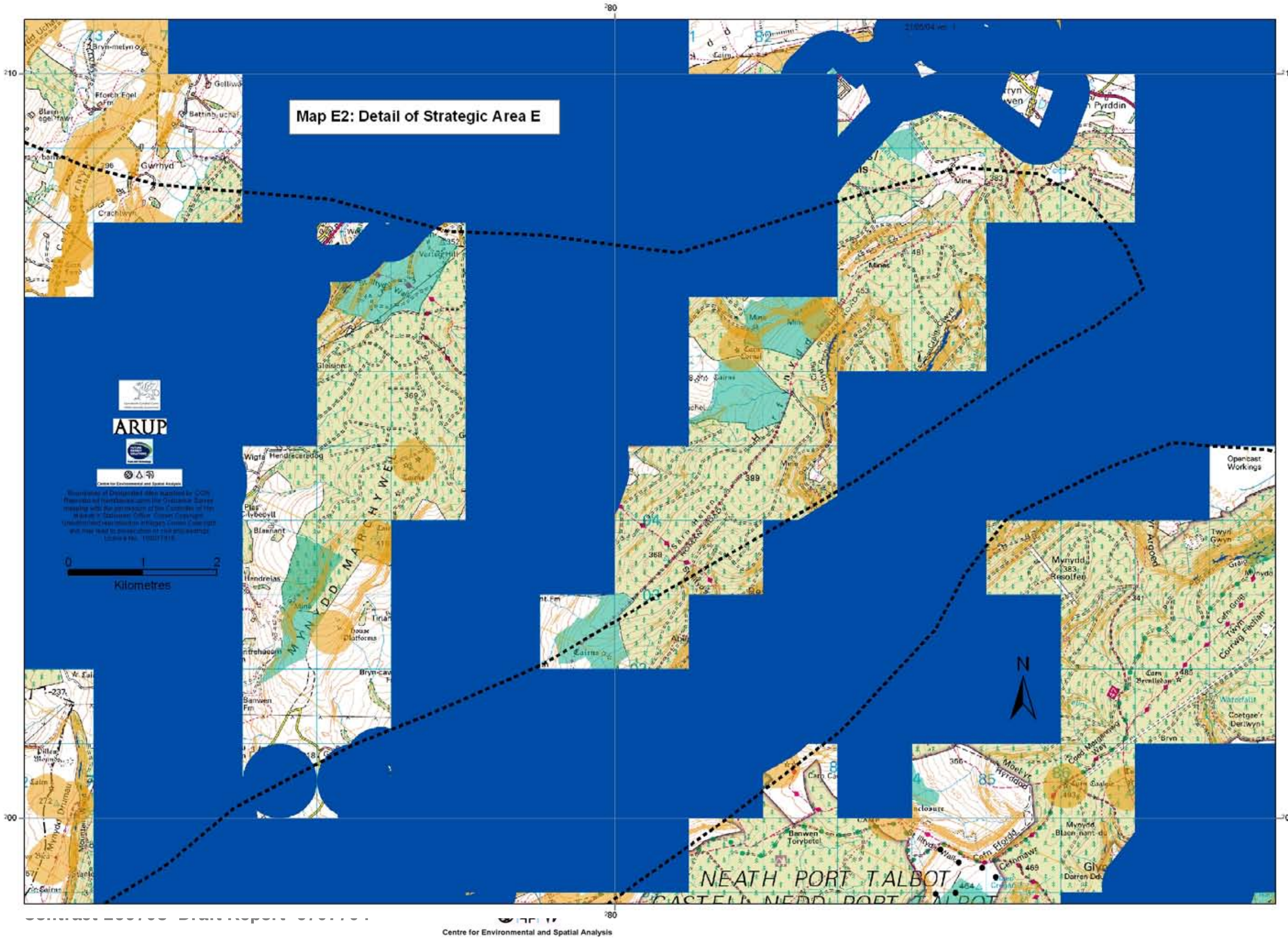
21/05/04 ver. 1
Map B2: Detail of Strategic Area B
Kilometres

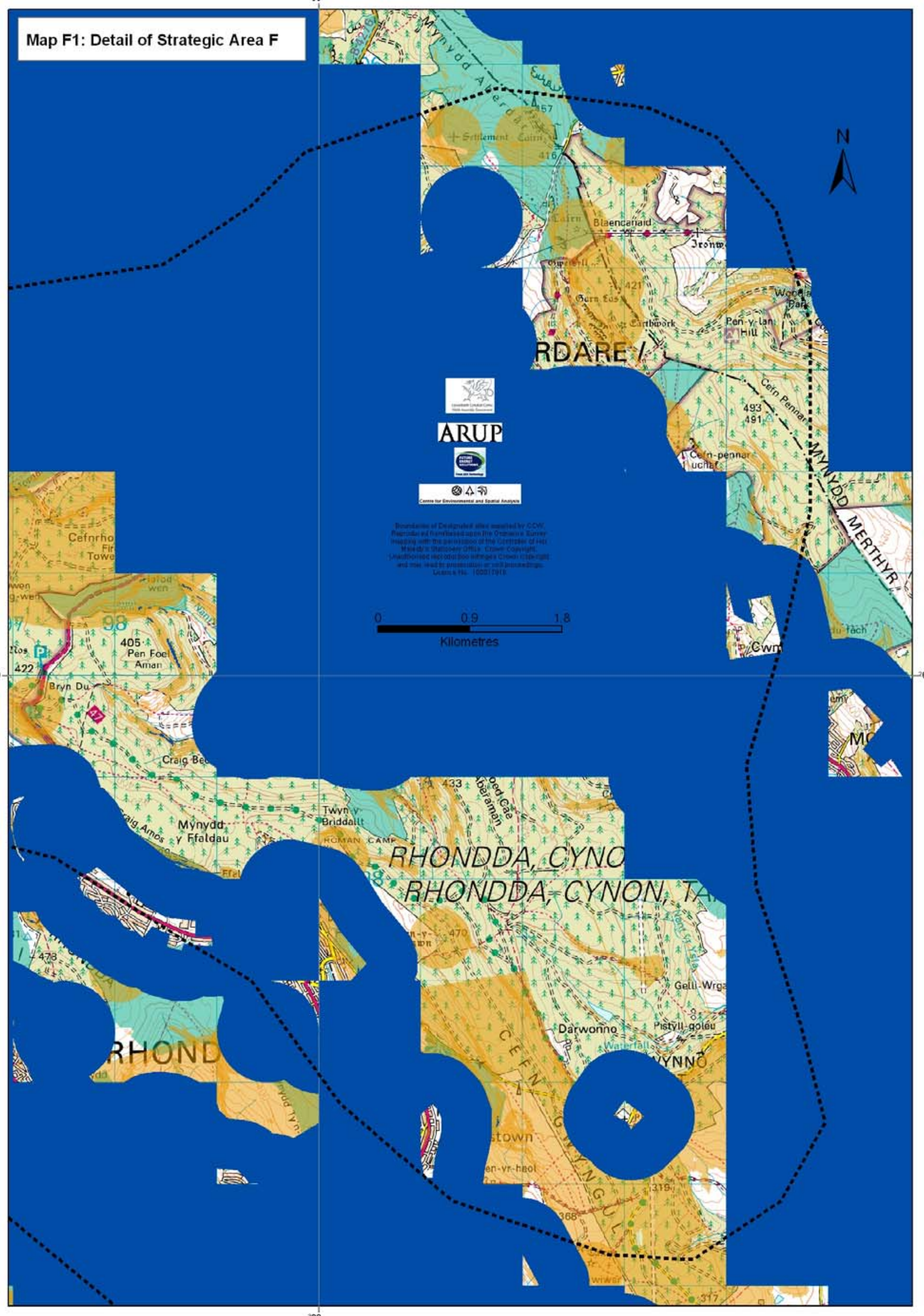

Map B3: Detail of Strategic Area B
ARUP
0
1
2
Kilometres
N
Mynydd Dyfnant
Tryfel
D Y F N A N T
F O R E S T
Fridd Goch
Tir Rhiwiog
Nant-y-dugoed
Carnedd Wen
Carnedd y Cylch (Cairn)
Waun Lwyd
Ffridd Ganol
Mynydd Llyn Coch-hwyad
Mynydd Lluest Fach
Pen Coe
Lluest
Cyffin
Steeltafalog Fm
Tafolog
290
300
310
Centre for Environmental and Spatial Analysis


Map C1: Detail of Strategic Area C
ARUP
Centre for Environmental and Spatial Analysis
21/05/04 ver. 1
N
0
0.8
1.6
Kilometres
310
280

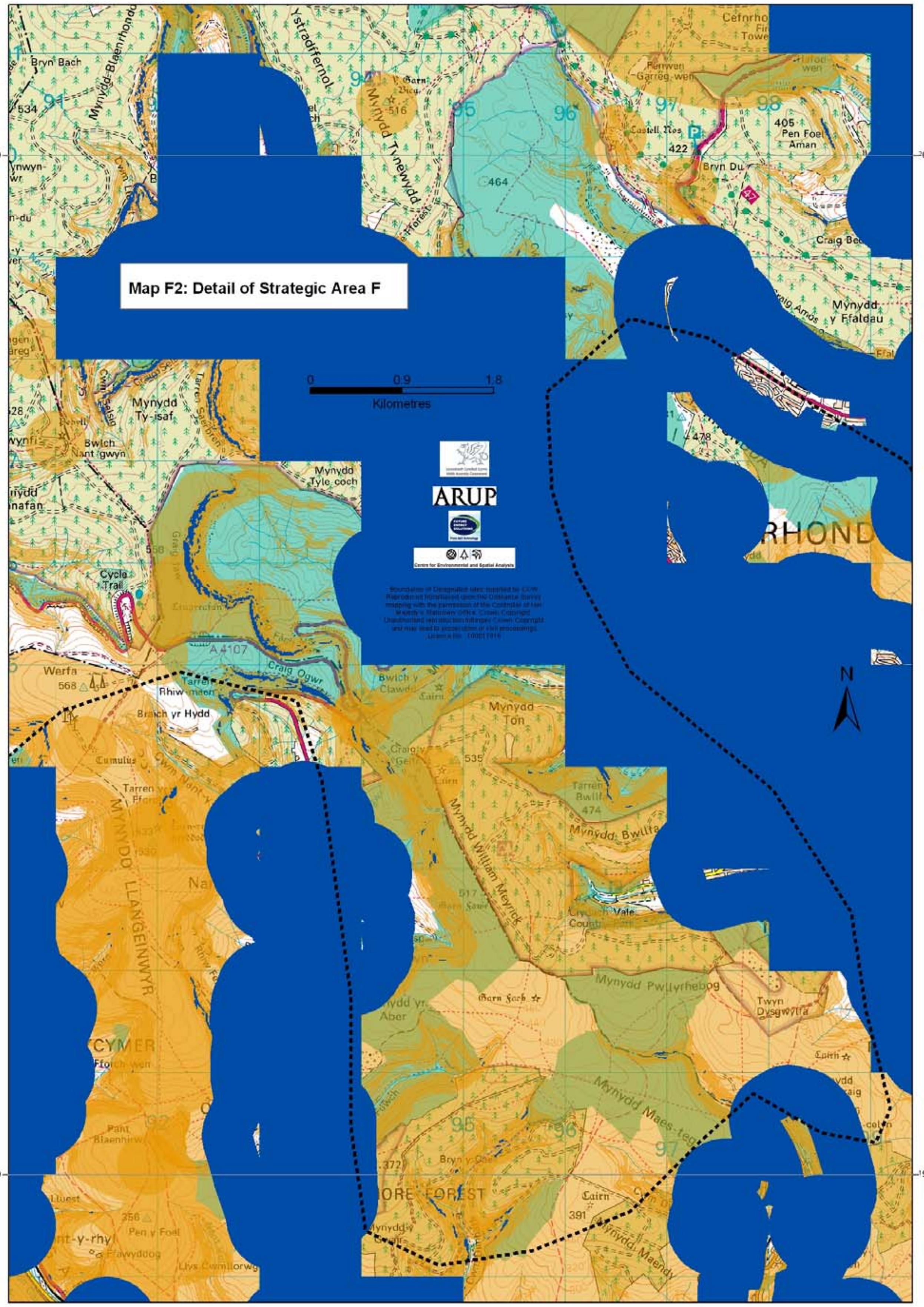

Map D1: Detail of Strategic Area D
0
0.9
1.8
Kilometres
N
ARUP
Mynydd Du
Moel y Garn
Foel Goch
Drosgol
Disgwylfa Fawr
Fynach Fawr
Bryn Gwyn
Wind Fm
Mynydd Gorddu

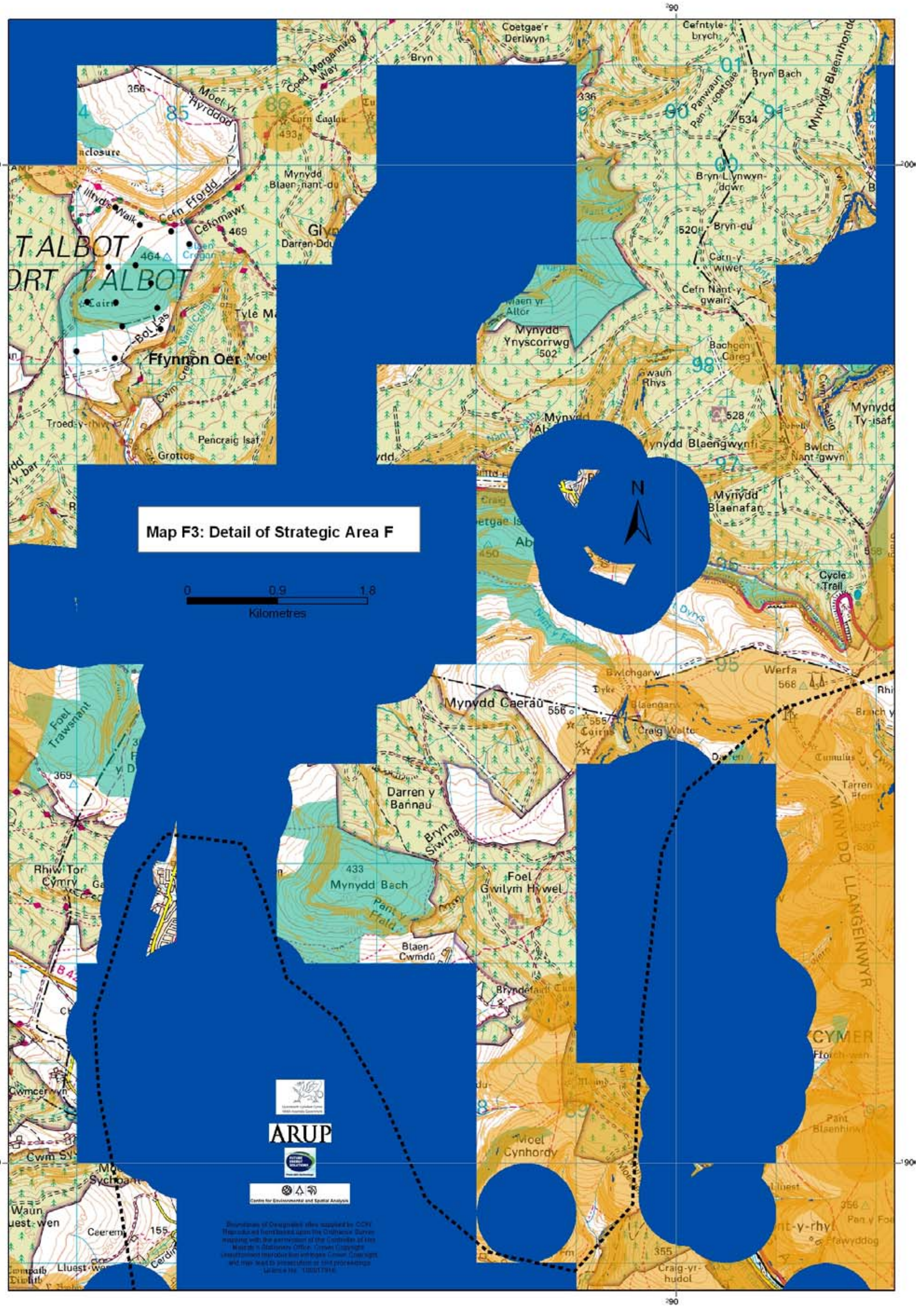

Map E1: Detail of Strategic Area E
ARUP
Kilometres
N
Mynydd y Gwair
Pentwyn Mawr
Gwrhyd
Centre for Environmental and Spatial Analysis

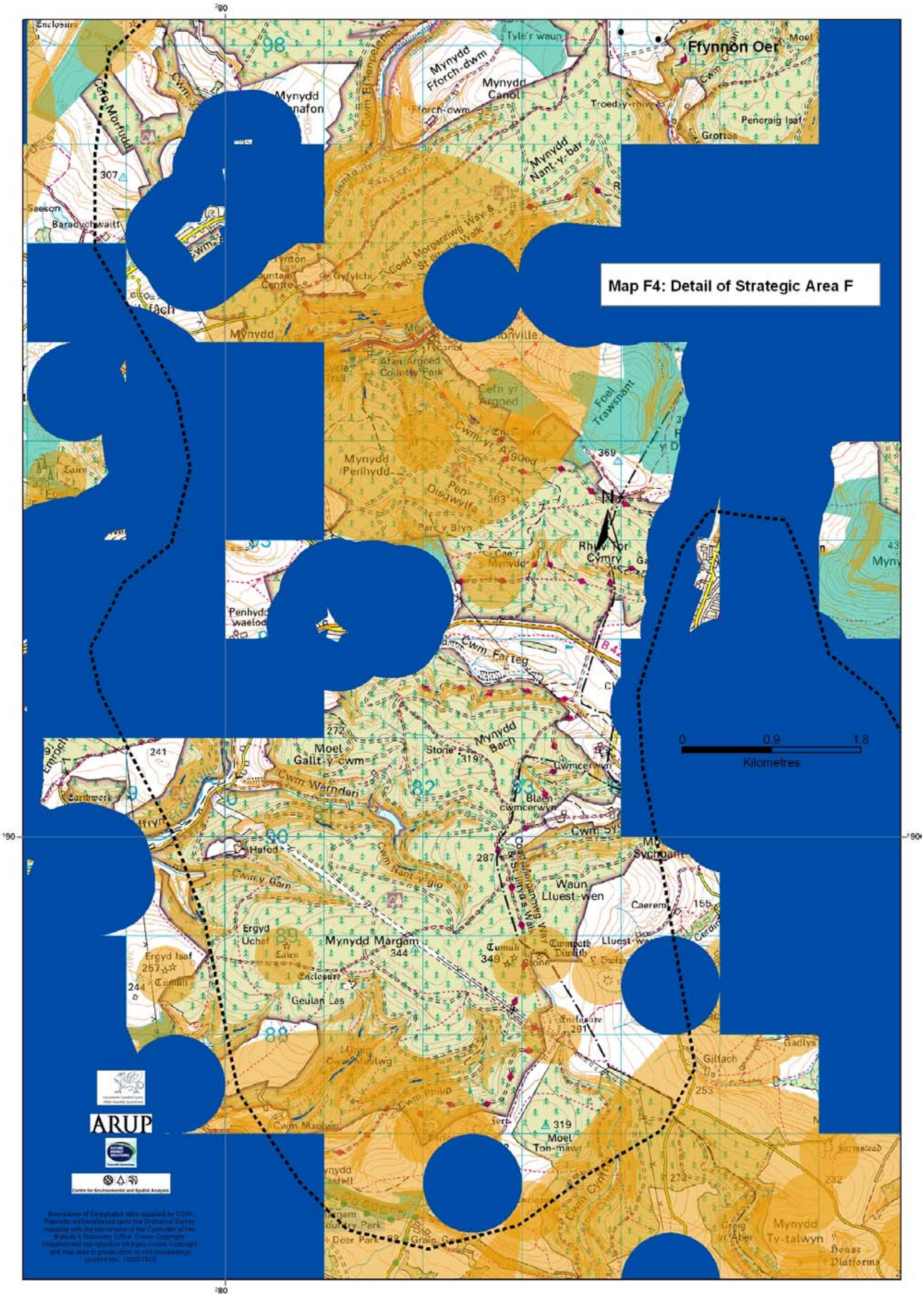

Map E2: Detail of Strategic Area E
ARUP
Kilometres
Opencast Workings
NEATH PORT TALBOT
Mynydd Resolfen
Centre for Environmental and Spatial Analysis



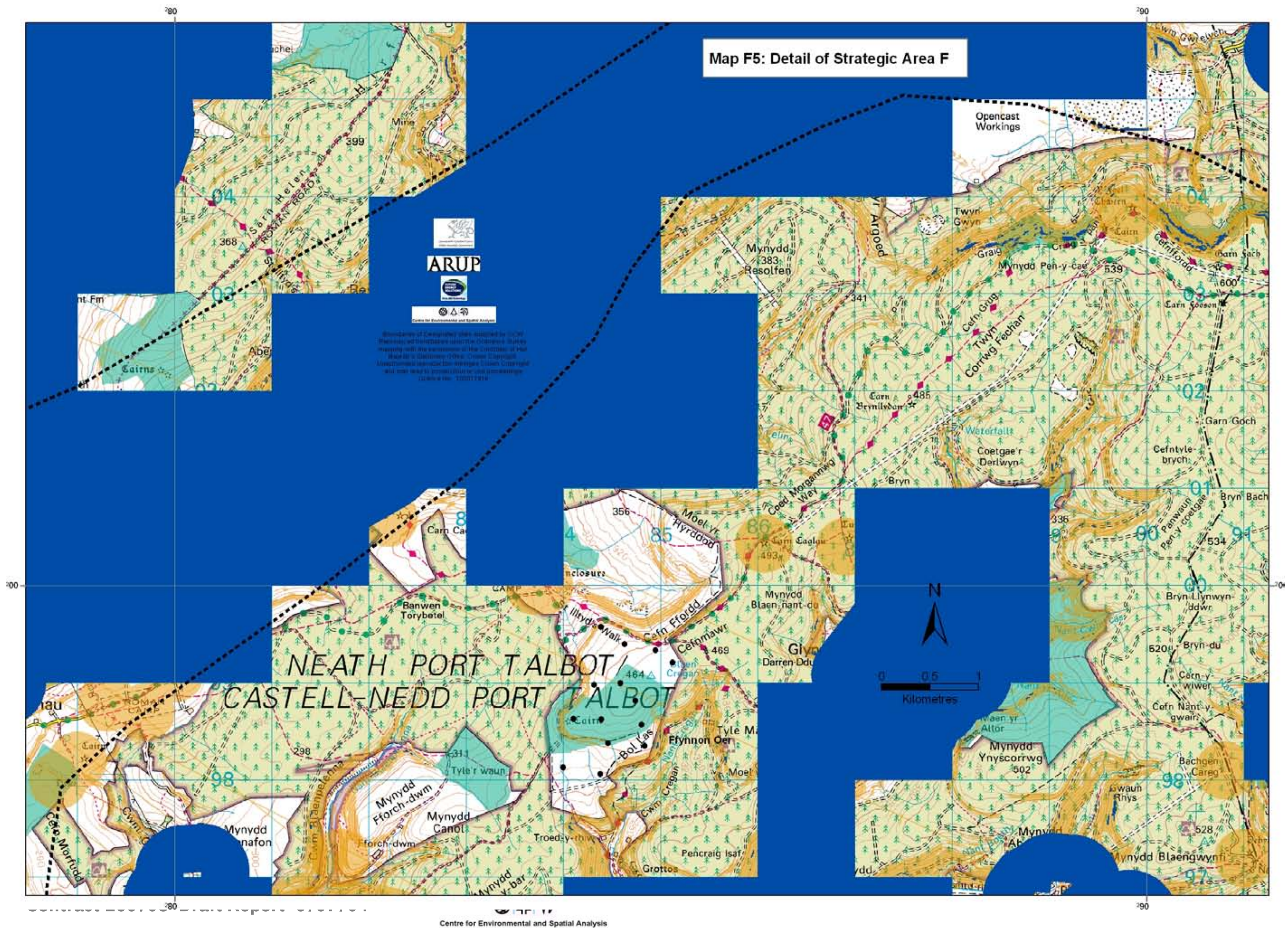
Map F1: Detail of Strategic Area F

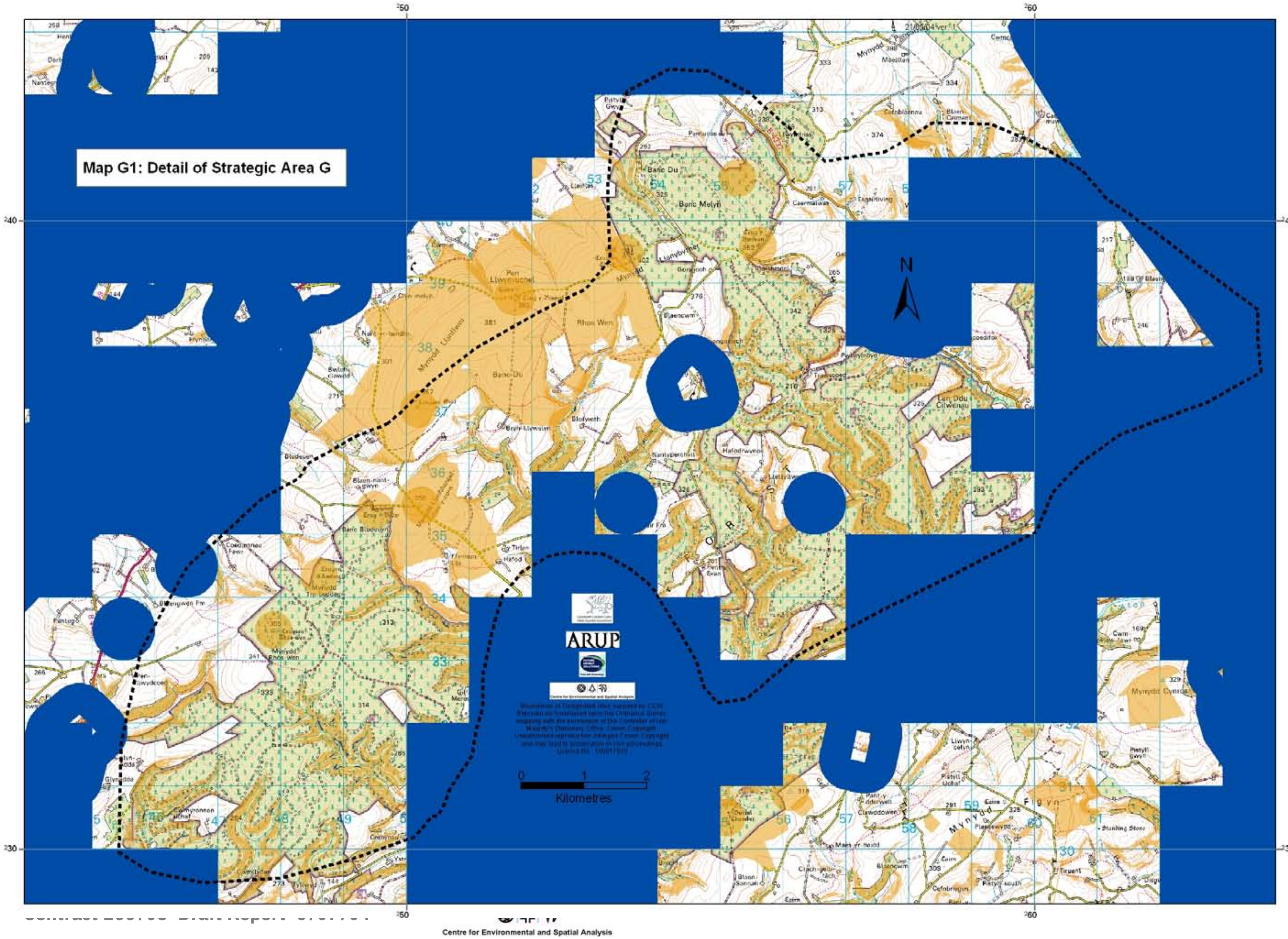

Map F2: Detail of Strategic Area F
0
0.9
1.8
Kilometres
ARUP
Centre for Environmental and Spatial Analysis
N
Bryn Bach
Mynydd-Blaenrhondda
Ystradffernol
Mynydd Tynewydd
Garn Wen
Castell Nos
Bryn Du
Pen Foel Aman
Craig Amos
Mynydd y Ffaldau
Mynydd Ty-isaf
Bwlch Nant-gwyn
Mynydd Tyle coch
Cycle Trail
A 4107
Craig Ogwr
Werfa
Rhiw-maen
Braich yr Hydd
Tarren y Fforch
Mynydd Ton
Tarren Bwllfa
Mynydd Bwllfa
Mynydd William Meyrick
MYNYDD LLANGEINWYR
Mynydd Pwllyrhebog
Twyn Dysgwylfa
Garn Fach
Mynydd Maes-teg
Pant Blaenhirw
Pen y Foel
Llys Cwmllorwg


Map F3: Detail of Strategic Area F
0
0.9
1.8
Kilometres
N
ARUP



Map F4: Detail of Strategic Area F
0
0.9
1.8
Kilometres
ARUP
Centre for Environmental and Spatial Analysis


Map F5: Detail of Strategic Area F
ARUP
Opencast Workings
NEATH PORT TALBOT
CASTELL-NEDD PORT TALBOT
N
0 0.5 1
Kilometres
Mynydd Resolfen
Coed Morgannwg Way
Corrwg Fechan
Garn Goch
Bryn Bach
Mynydd Ynyscorrwg
Mynydd Blaengwynfi
Mynydd Ffforch-dwm
Mynydd Canol
Tyle'r waun
Ffynnon Oer
Pencraig Isaf
Grottos
Banwen Torybetel
Sarn Helen
Roman Road
Cefn Ffordd
Mynydd Blaen-nant-du
Darren Ddu
Cefntyle-brych
Bryn-Llynwyn-ddwr
Bryn-du
Cefn Nant-y-gwair
Coetgae'r Derlwyn
Waterfall
Mynydd Pen-y-cae
Centre for Environmental and Spatial Analysis


Map G1: Detail of Strategic Area G
ARUP
Kilometres
Centre for Environmental and Spatial Analysis

APPENDIX C: GIS Absolute Constraints and Consultation Zones METADATA

Welsh National GIS/

Absolute_Constraints/	SecondDegree_Constraints/
prac_1a_wind45m_lesseq6ms.shp	prac_3a_registered_COMMON_LAND_ccw.shp
prac_1b_LowFly LFA7T_poly_region.shp	prac_3b_liv_30km_buffer.shp
prac_1c_Barts_mynydd_eppynt_danger_area.shp	prac_3c_cardiff_los_visible.shp
prac_1d_Strategi_inland_water_poly.shp	prac_3d_domestic_airport5_buffer_5km.shp
prac_1e_strategi_urban_poly_500m.shp	prac_3e_RAF_source_web_5km.shp
prac_1f_Wales_gazetter_T_FM_C_0.shp	prac_3f_CyG_5km.shp
prac_1g_air_defence_los_visible.shp	prac_3g_Aber_10km.shp
prac_1h_slope_greaterthanequalto_40.shp	prac_3h_Main_Transmitter_5km.shp
prac_1i_grid_capacity_verysmall_2004.shp	prac_3i_broadcastlinks_TVmasts.shp
prac_1j_grid_capacity_verysmall_2015.shp	prac_3j_slope_greaterthanequalto_20_40.shp
prac_1k_10km_grid_2004.shp	env_4a_heritage_coasts_2km.shp
prac_1l_10km_grid_2015.shp	env_4b_SAM_CADW_300m.shp
env_2a_npbound.shp	env_4c_sssi_ccw.shp
env_2b_aonb_ccw.shp	env_4d_lnr_ccw.shp
env_2c_Blaenavon_WHS.shp	env_4e_RSPB_wales.shp
env_2d_spa_ccw.shp	env_4f_c_park_point_2km.shp
env_2e_ramsar_ccw.shp	
env_2f_PSAC_ccw.shp	
env_2g_csac_ccw.shp	
env_2h_nnr_ccw.shp	
env_2i_Biosphere_ccw.shp	
Positive_factors/	
pos_5a_fc_estate_region.shp	
pos_5b_open.shp	

KEY:

Point Shapefile
Line Shapefile
Polygon Shapefile
Primary Data:
Secondary Data:

C1 Absolute Constraints

Practical: 1a) Windspeed <=6m/s at 45m Above Ground Level

Name	Welsh National GIS/ Absolute_Constraints/ prac_1a_wind45m_lesseq6ms.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1km square resolution
Source	ETSU NOABL data (http://www.bwea.com/noabl/download.htm)
Description	Secondary Data: File contains data with windspeed greater than 6m/s only *Primary Data: converted from ASCII format (downloaded – see above) into a 1km polygon grid for the whole of Wales.*
Notes	The Department of Trade and Industry wind speed database (ETSU NOABL) contains estimates of the annual mean wind speed throughout the UK. The data is the result of an air flow model that estimates the effect of topography on wind speed. There is no allowance for the effect of local thermally driven winds such as sea breezes or mountain/valley breezes. The model was applied with 1km square resolution and makes no allowance for topography on a small scale or local surface roughness (such as tall crops, stone walls, or trees), both of which may have a considerable effect on the wind speed. The data can only be used as a guide and should be followed by on-site measurements for a proper assessment. Each value is the estimated average for a 1km square at 45m above ground level (agl).
Constraint Type	Footprint
Copyright	ETSU for the DTI 1999

Practical: 1b) Ministry of Defence (MOD) Mid-Wales Aircraft Tactical Training Area LFA 7T

Name	Welsh National GIS/ Absolute_Constraints/ prac_1b_LowFly LFA7T_poly_region.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	Unknown
Supplied by	CartoGraphics: The National Assembly for Wales
Description	Primary Data
Notes	Summary of CartoGraphic Release of digital data - METADATA Description:- 18 co-ordinates used to plot low fly area, Owner of Data:- MOD HQ STC Ops Support, Original Source:- Ministry of Defence, Date Capture:- September 2003, Completeness:- 100%, Data Release: ISG. Steel & Energy. Simon Dupree/Rosemary Iles Comments: Data received 4/09/2003. SAC S T Rutherford. HQ Ops Support. Military Airspace Co-ord. LATCC MIL. Porters Way. West Drayton UB7 9AU. Tel: 01895 423937 Data captured by Philippa White, E/GIS/_DD/Topic Data/Transport/ Airfields.
Constraint Type	Footprint
Copyright	MoD

Practical: 1c) MOD Mynydd Eppynt surface training area

Name	Welsh National GIS/ Absolute_Constraints/ prac_1c_Barts_mynydd_eppynt_danger_area.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:250,000
Supplied by	Arup Contract 105/2002: - GeoData Institute
Description	Primary Data
Notes	Digitised by GeoData Institute Captured from Bartholemews data
Constraint Type	Footprint
Copyright	?unknown

Practical: 1d) Lakes and reservoirs

Name	Welsh National GIS/ Absolute_Constraints/ prac_1d_Strategi_inland_water_poly.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:250,000
Supplied by	OTCO
Description	Primary Data
Notes	Ordnance Survey Strategi dataset Data updated and maintained by Ordnance Survey. For more information on the accuracy of this dataset visit the following web address (page 45). http://www.ordnancesurvey.co.uk/oswebsite/products/strategi/pdf/StrategiUserGuide.pdf
Constraint Type	Footprint
Copyright	Reproduced from/based upon the Ordnance Survey mapping with the permission of the Controller of Her Majesty's Stationery Office. Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Licence No. 100017916

Practical: 1e) Major urban areas

Name	Welsh National GIS/ Absolute_Constraints/ prac_1e_strategi_urban_poly_500m.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:250,000
Supplied by	OTCO
Description	Secondary Data: buffer generated with a 500m radius *Primary Data: OS Strategi – original format: polygon.*
Notes	Ordnance Survey Strategi dataset Data updated and maintained by Ordnance Survey. For more information on the accuracy of this dataset visit the following web address (page 45). http://www.ordnancesurvey.co.uk/oswebsite/products/strategi/pdf/StrategiUserGuide.pdf
Constraint Type	Buffer – 500m Radius
Copyright	Reproduced from/based upon the Ordnance Survey mapping with the permission of the Controller of Her Majesty's Stationery Office. Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Licence No. 100017916

Practical: 1f) OS Place Name Gazetteer – Isolated properties and settlements

Name	Welsh National GIS/ Absolute_Constraints/ prac_1f_Wales_gazetter_T_FM_C_O.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:50,000
Supplied by	OTCO
Description	Secondary Data: buffer generated with a 500m radius *Primary Data: OS Place Name Gazzetteer – original format: points.*
Notes	Ordnance Survey place name national Gazetteer. Data updated and maintained by Ordnance Survey. Dataset includes the following only FM = Farm C = City T = Town O = Other settlement For more information on the accuracy of this dataset visit the following web address http://www.ordnancesurvey.co.uk/oswebsite/products/50kgazetteer/techinfo.html
Constraint Type	Buffer – 500m Radius
Copyright	Reproduced from/based upon the Ordnance Survey mapping with the permission of the Controller of Her Majesty's Stationery Office. Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Licence No. 100017916

Practical: 1g) Early warning air defence radar on Anglesey

Name	Welsh National GIS/ Absolute_Constraints/ prac_1g_air_defence_los_visible.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:10,000
Source	http://www.homepages.mcb.net/bones/06airfields/UK/uk.htm / CESA Website provided the point source location as a grid reference (accurate to 100m).
Description	Visibility Analysis – Line of Sight
Notes	Calculated using a 10m DEM (Ordnance Survey Profile http://www.ordnancesurvey.co.uk/oswebsite/products/landformprofile/) Observer Offset = 15m (height of radar) Target Offset = 110m (wind turbine) Calculation radius = 35km (Zone of theoretical visibility) For methodology see page ##
Constraint Type	Line of Sight 74km radius
Copyright	N/A

Practical: 1h) Steep slopes greater than 40°

Name	Welsh National GIS/ Absolute_Constraints/ prac_1h_slope_greaterthanequalto_40.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:10,000
Source	CESA
Description	Primary Data: Visibility Analysis – Line of Sight
Notes	Calculated using a 10m DEM (Ordnance Survey Profile http://www.ordnancesurvey.co.uk/oswebsite/products/landformprofile/) Raster data at 10 by 10 m resolution of all grid cells greater than 40 degrees was converted into a vector/polygon shapefile.
Constraint Type	Footprint
Copyright	N/A

Practical: 1i) Grid capacity very small 2004

Name	Welsh National GIS/ Absolute_Constraints/ prac_1i_grid_capacity_verysmall_2004.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	N/A
Source	FEA/Arup
Description	Areas digitised by CESA
Notes	A description of geographical zones of grid capacity is detailed in Connection Areas for Wind Energy in Wales – Grid Considerations – Contract 218/2001, Future Energy Solutions (2004) for the Welsh Assembly Government.
Constraint Type	Footprint
Copyright	N/A

Practical: 1j) Grid capacity very small 2010/2015

Name	Welsh National GIS/ Absolute_Constraints/ prac_1j_grid_capacity_verysmall_2015.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	N/A
Source	FEA/Arup
Description	Areas digitised by CESA
Notes	A description of geographical zones of grid capacity is detailed in Connection Areas for Wind Energy in Wales – Grid Considerations – Contract 218/2001, Future Energy Solutions (2004) for the Welsh Assembly Government.
Constraint Type	Footprint
Copyright	N/A

Practical: 1k) Greater than 10km away from the grid network 2004

Name	Welsh National GIS/ Absolute_Constraints/ prac_1k_10km_grid_2004.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	N/A
Source	OCTO
Description	Secondary Data: buffer of existing grid infrastructure with a radius of 10km *Primary Data: existing grid network – original format: line*
Notes	None available
Constraint Type	Buffer
Copyright	N/A

Practical: 1l) Greater than 10km away from the grid network 2010/20015

Name	Welsh National GIS/ Absolute_Constraints/ prac_1l_10km_grid_2015.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	N/A
Source	OCTO
Description	Secondary Data: buffer of existing grid with a radius of 10km *Primary Data: existing grid network – original format: line*
Notes	None available
Constraint Type	Buffer
Copyright	N/A

Environmental/Planning with National/International Status: 2a) National Parks

Name	Welsh National GIS/ Absolute_Constraints/ env_1a_npbound.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	Unknown
Source	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	None Available
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Environmental/Planning with National/International Status: 2b) Areas of Outstanding Natural Beauty (AONB)

Name	Welsh National GIS/ Absolute_Constraints/ env_2a_npbound.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:50,000
Supplied by	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	AONB are established under the same legislation as National Parks, but the key difference between the two is that creating opportunities for recreation is not a specific purpose of AONB. However, recreation within AONB is acceptable if it is consistent with the conservation of natural beauty and the needs of agriculture, forestry and other uses. AONB are designated by CCW and the proposals are confirmed by the First Minister for the National Assembly for Wales. Each AONB is managed by a Joint Advisory Committee which represents local authorities, land owning and community interests. Last updated: 13/08/00, Digitised from O.S. 1:50,000 raster
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Environmental/Planning with National/International Status: 2c) Blaenavon World Heritage Site

Name	Welsh National GIS/ Absolute_Constraints/ env_2c_Blaenavon_WHS.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	Unknown
Source	CESA
Description	Primary Data: Outline boundary digitised using Ordnance Survey 1:25,000 as a backdrop using the image of the site boundary available at the following web address: http//www.torfaen-objectiveone.org.uk/bil/site/site.htm
Notes	The accuracy of the digitised boundary is limited by the quality of the image and therefore is inaccurate in places.
Constraint Type	Footprint

Environmental/Planning with National/International Status: 2d) Natura 2000 Habitat Directive site – SPA

Name	Welsh National GIS/ Absolute_Constraints/ env_2d_spa_ccw.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:10,000
Supplied by	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	The EC Birds Directive of 1979 requires member states to establish Special Protection Areas to conserve the habitats of two categories of birds:- i) Species which are rare or vulnerable, of which there are forty-eight in the UK. ii) Some migratory species which visit our shores regularly. SPAs in Wales are identified by CCW, in conjunction with the UK Joint Nature Conservation Committee, and designated by the First Minister for the National Assembly for Wales. They are also protected through being SSSI. The 1994 Conservation Regulations also provide a means of protecting such areas at sea. SPA together with SAC will contribute to a European Union network of protected sites to be known as 'Natura 2000'. Last updated: 29/05/2001, Digitised from O.S. 1:10,000 raster
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Environmental/Planning with National/International Status: 2e) Natura 2000 Habitat Directive site – RAMSAR

Name	Welsh National GIS/ Absolute_Constraints/ env_2e_ramsar_ccw.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:10,000
Supplied by	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	Wetlands of International Importance (Ramsar Sites) In ratifying the Convention in 1976, the UK government accepted a commitment to promote the conservation of internationally important wetland sites within its territories. Wetlands are vital for many types of birds particularly waterfowl and Wales have some prime sites that are essential to the survival of many wetland plants and animals. Wetland sites can be areas of marsh, fen, peatland or open water; natural or artificial; permanent or temporary; with water that is fresh, brackish or salty. They can also include shallow areas of sea. All Ramsar sites are also SSSI. Wetlands of International Importance are identified by CCW, in collaboration with the UK Joint Nature Conservation Committee, and designated by the First Minister for the National Assembly for Wales. Last updated: 01/06/01, Digitised from O.S. 1:10,000 raster
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Environmental/Planning with National/International Status: 2f) Natura 2000 Habitat Directive site – PSAC

Name	Welsh National GIS/ Absolute_Constraints/ env_2f_PSAC_ccw.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	Unknown
Source	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	None Available
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Environmental/Planning with National/International Status: 2g) Natura 2000 Habitat Directive site – CSAC

Name	Welsh National GIS/ Absolute_Constraints/ env_2g_csac_ccw.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:1,250 or 1:2,500 or 1:10,000
Supplied by	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	Special Areas of Conservation: The EC Habitats and Species Directive came into effect in 1992 and its aim is to maintain a rich variety of wildlife by protecting vulnerable habitats, and the plants and animals they support. The Habitat Directive together with the 1979 Birds Directive will lead to the establishment of a series of sites throughout Europe that will be known as ' Natura 2000'. This represents the cream of European sites and will ensure their survival for future generations. The sites listed here are all Candidate status, that means, they have been to public consultation and the UK government are currently presenting them to the EC for recommendation. Last updated: 18/09/2001 Digitised from a combination of O.S. Landline and O.S Raster products
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Environmental/Planning with National/International Status: 2h) Natura 2000 Habitat Directive site – Natural Nature Reserves (NNR)

Name	Welsh National GIS/ Absolute_Constraints/ env_2h_nnr_ccw.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:2,500 or 1:10,000
Supplied by	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	National Nature Reserves represent the very best examples of our wildlife habitats and geological features and can range in size between five hectares to well over 2,000. NNR are declared by CCW under the National Parks and Access to the Countryside Act of 1949, or under the Wildlife and Countryside Act of 1981. They are owned or leased by CCW, or the land is held by an approved body, such as a County Wildlife Trust. Each reserve has a programme of work to manage the site's special features. All of them are also SSSI and may provide places for educational projects, research and management trials. Some reserves require permits to gain access to them. Last updated: 13/06/2001 Digitised from a combination of O.S. Landline and O.S Raster products
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Environmental/Planning with National/International Status: 2i) Dyfi Valley biosphere site

Name	Welsh National GIS/ Absolute_Constraints/ env_2i_Biosphere_ccw.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:10,000
Supplied by	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	The Biosphere Reserve is an international designation made by UNESCO based on nominations made by more than 110 countries. Each reserve is therefore part of a world-wide chain of permanently protected areas dedicated to the study and understanding of the changes affecting land and water. The biosphere is rapidly changing under the influence of human activity, so understanding it's effect is of paramount importance. Last updated: 23/09/1999 Digitised from O.S 1: 10,00 Raster product.
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

C2 Second Degree Constraints

Practical: 3a) Registered common land

Name	Welsh National GIS/ SecondDegree_Constraints / prac_3a_registered_COMMON_LAND_ccw.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:2500 and 1:10000
Supplied by	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	Registered common land element of Maps for (Area Name) as required by Countryside and Rights of Way Act 2000. This dataset is a faithful copy of the original common land registers and was digitised by Landmark/RMSI from July 2000 - July 2001. Any line shown as not matching the original boundary has been copied from what is shown on the original registers and is not a digitising error. Last updated: 01/03/04. Digitised from a combination of O.S. Landline and O.S Raster products. Contact: Christine Jones MSc GIS, Recreation and Access GIS Officer, Countryside Council for Wales, CCW HQ Bangor, Tel. (0) 1248 385618, Email cr.jones@ccw.gov.uk. Draft map valid only until the provisional map is issued. Provisional map only valid until conclusive map is issued.
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Practical: 3b) Safeguarded civil aerodrome – Liverpool

Name	Welsh National GIS/ SecondDegree_Constraints / prac_3b_liv_30km_buffer.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:50,000
Source	http://www.homepages.mcb.net/bones/06airfields/UK/uk.htm / CESA. Website provided the point source location as a grid reference (accurate to 100m)
Description	Secondary Data: buffer generated with a 30km radius *Primary Data: point location of Liverpool Airport – grid reference obtained from website given above.*
Notes	N/A
Constraint Type	Buffer at 30km
Copyright	N/A

Practical: 3c) Safeguarded civil aerodrome – Cardiff

Name	Welsh National GIS/ SecondDegree_Constraints / prac_3c_cardiff_los_visible.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:10,000

Source	http://www.homepages.mcb.net/bones/06airfields/UK/uk.htm / CESA Website provided the point source location as a grid reference (accurate to 100m).
Description	Visibility Analysis – Line of Sight
Notes	Calculated using a 10m DEM (Ordnance Survey Profile http://www.ordnancesurvey.co.uk/oswebsite/products/landformprofile/) Observer Offset = 26.82m (height of radar) Target Offset = 110m (wind turbine) Calculation radius = 30km For methodology see ###
Constraint Type	Line of Sight 30km radius
Copyright	N/A

Practical: 3d) Non official Safeguarded civil aerodromes – Caernarfon, Swansea, Hawarden, Haverfordwest and Welshpool

Name	Welsh National GIS/ SecondDegree_Constraints / prac_3d_domestic_airport5_buffer_5km.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:50,000
Source	http://www.homepages.mcb.net/bones/06airfields/UK/uk.htm / CESA Website provided the point source location as a grid reference (accurate to 100m).
Description	Secondary Data: buffer generated with a 5km radius *Primary Data: point location of Caernarfon, Swansea, Hawarden, Haverfordwest and Welshpool airports– grid reference obtained from website given above.*
Notes	N/A
Constraint Type	Buffer at 5km
Copyright	N/A

Practical: 3e) Military 'Technical Sites' - RAF Valley, St Athan, Aberporth & Llandbedr

Name	Welsh National GIS/ SecondDegree_Constraints / prac_3e_RAF_source_web_5km.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:50,000
Source	http://www.homepages.mcb.net/bones/06airfields/UK/uk.htm / CESA Website provided the point source location as a grid reference (accurate to 100m).
Description	Secondary Data: buffer generated with a 5km radius *Primary Data: point location of RAF Valley, St Athan, Aberporth & Llandbedr – grid reference obtained from website given above.*
Notes	N/A
Constraint Type	Buffer at 5km
Copyright	N/A

Practical: 3f) Met Office cloud scanning radar at Crug-y-Gorllwyn

Name	Welsh National GIS/ SecondDegree_Constraints / prac_3f_CyG_5km.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:50,000
Source	CESA
Description	Secondary Data: buffer generated with a 5km radius *Primary Data: point location of Crug-y-Gorllwyn digitised using OS Raster 1:50,000*
Notes	N/A
Constraint Type	Buffer at 5km
Copyright	N/A

Practical: 3g) Wind profiling radar at Aberystwyth

Name	Welsh National GIS/ SecondDegree_Constraints / prac_3g_Aber_10km.shp
File Type	ESRI Shapefile - Polygon

Nominal Scale	1:50,000
Source	CESA
Description	Secondary Data: buffer generated with a 10km radius *Primary Data: point location of Aberystwyth cloud radar digitised using OS Raster 1:50,000.*
Notes	N/A
Constraint Type	Buffer at 10km
Copyright	N/A

Practical: 3h) Major TV Transmitter Masts (5km radius)

Name	Welsh National GIS / SecondDegree_Constraints / prac_3h_Main_Transmitter_5km.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:50,000
Source	http://www.bbc.co.uk/reception/tv_transmitters/region_wales.shtml / CESA Website provided the point source location as a grid reference (accurate to 100m).
Description	Secondary Data: buffer generated with a 10km radius *Primary Data: point location of major TV Transmitter Masts radar digitised using OS Raster 1:50,000 using grid references supplied by the website given above.*
Notes	N/A
Constraint Type	Buffer at 10km
Copyright	N/A

Practical: 3i) Broadcast links between major and minor TV Masts

Name	Welsh National GIS / SecondDegree_Constraints / prac_3i_broadcastlinks_TVmasts.shp
File Type	ESRI Shapefile - Polyline
Nominal Scale	1:50,000
Source	http://www.bbc.co.uk/reception/tv_transmitters/region_wales.shtml / CESA Website provided the point source location as a grid reference (accurate to 100m).
Description	Secondary Data: lines generated between major and minor television masts *Primary Data: point location of major TV Transmitter Masts radar digitised using OS Raster 1:50,000 using grid references supplied by the website given above.*
Notes	N/A
Constraint Type	Footprint
Copyright	N/A

Practical: 3j) Slope greater than 20 and less than 40 degrees

Name	Welsh National GIS / SecondDegree_Constraints / prac_3j_slope_greaterthanequalto_20_40.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:10,000
Source	CESA
Description	Secondary Data - Derivation of slope from a DEM *Primary Data: generated from OS Survey Profile DEM (http://www.ordnancesurvey.co.uk/oswebsite/products/landformprofile)*
Notes	Calculated using a 10m DEM - (Ordnance Survey Profile http://www.ordnancesurvey.co.uk/oswebsite/products/landformprofile/) Raster data at 10 by 10 m resolution of all grid cells between 20 and 40 degrees was converted into a vector/polygon shapefile.
Constraint Type	Footprint
Copyright	N/A

Environmental – some existing planning status: 4a) Heritage Coasts

Name	Welsh National GIS / SecondDegree_Constraints / env_4a_heritage_coasts_2km.shp

File Type	ESRI Shapefile - Polygon
Nominal Scale	1:200,000
Source	Countryside Council for Wales (CCW)
Description	Secondary Data: buffer generated with a 2km radius *Primary Data: Heritage Coasts supplied by CCW – original format: line representing the coastline*
Notes	Heritage coasts occupy about a third of the Welsh coastline, that is 500kms (300miles), and they were set up more than 20 years ago to protect our coastlines from insensitive developments. Most are defined simply by the coastline between two named points, however some to have clearly defined inland boundaries. Their status carries no legal protection, but planning authorities must take the designation into account when making decisions on development. Management of Heritage Coasts is the remit of the local authority and is generally carried out by Heritage Coast Officers with some practical tasks been done by volunteers. Last updated: 3/10/99 Digitised from: unknown. Please note that the radius has been applied to aid in differentiation of features at the scale of presentation
Constraint Type	Buffer at 2km
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply.

Environmental – some existing planning status: 4b) Scheduled Ancient Monuments

Name	Welsh National GIS/ SecondDegree_Constraints / env_4b_SAM_CADW_300m.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	Unknown
Source	CADW: Welsh Historic Monuments
Description	Secondary Data: buffer generated with a 300m radius *Primary Data: Scheduled Ancient Monuments supplied by CADW – original format: point*
Notes	Please note that the radius has been applied to aid in differentiation of features at the scale of presentation
Constraint Type	Buffer at 300m
Copyright	"This report is based on Scheduled Ancient Monument Data. © Crown copyright. CADW: Welsh Historic Monuments".

Environmental – some existing planning status: 4c) Natura 2000 Habitat Directive site – SSSI

Name	Welsh National GIS/ SecondDegree_Constraints / env_4c_sssi_ccw.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:1,250 or 1:2,500 or 1:10,000
Source	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	SSSI cover a wide range of habitats from small fens, bogs and riverside meadows to sand dunes, woodlands and vast tracks of uplands. Most are in private ownership, although some are owned and managed by local wildlife trusts, or other voluntary conservation bodies. Notification of an SSSI under the Wildlife and Countryside Act 1981 has since been amended by the Countryside and Rights of Way Act 2001, which brought about numerous changes in the way SSSI are notified managed and protected. In order to ensure consistent, favourable long-term management of these sites, CCW is working with landowners to prepare management plans for all SSSI in Wales. Local planning authorities are required to consult CCW before allowing any development to proceed that may affect an SSSI. Water, gas and electricity companies must also do the same. Last updated: 12/08/02, Digitised from O.S. Landline and O.S. 1:10,000 raster
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Environmental – some existing planning status: 4d) Natura 2000 Habitat Directive site – Local Nature Reserves

Name	Welsh National GIS / SecondDegree_Constraints / env_4d_lnr_ccw.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:2,500 or 1:10,000
Source	Countryside Council for Wales (CCW)
Description	Primary Data
Notes	Local Nature Reserves are established and managed by local authorities, following consultation with CCW under the National Parks and Access to the Countryside Act 1949. For a site to become an LNR it must have natural features of special interest to the local area, and the authority must either have a legal interest in the land or have an agreement with the owner to manage the land as a reserve. LNR prove to be useful not only to protect habitats and wildlife but increase people's awareness of their environment. They are places where children can learn about nature, and they are often situated in or near urban areas. Last updated: 09/06/2002 Digitised from O.S. 1:10,000 raster
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Environmental – some existing planning status: 4e) RSPB reserves

Name	Welsh National GIS / SecondDegree_Constraints / env_4e_RSPB_wales.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:10,000 or 1:50,000
Source	Data downloaded from the following website: http://www.rspb.org.uk/reserves/
Description	Primary Data
Notes	The RSPB endeavours to maintain accurate information. However, the RSPB can accept no responsibility for the consequences of errors or omissions in the data. For further information, please contact the Conservation Data Management Unit (01767 680551).
Constraint Type	Footprint
Copyright	The RSPB reserve the right to comment on the accuracy of representation of the data in material produced by the recipient.

Environmental – some existing planning status: 4f) Country Parks

Name	Welsh National GIS / SecondDegree_Constraints / env_4f_c_park_point_2km.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:25,000
Source	Countryside Council for Wales (CCW)
	Secondary Data: buffer generated with a 300m radius *Primary Data: Country Parks supplied by CCW – original format: point*
Notes	Please note that the radius has been applied to aid in differentiation of features at the scale of presentation Point data only Last updated: 23/08/1999
Constraint Type	Buffer at 2km
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply.

C3 Positive Development Siting Factors

Positive development siting factor: 5a) Forestry Commission woodland

Name	Welsh National GIS / Positive_factors / pos_5a_fc_estate_region.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:25,000
Source	Countryside Council for Wales (CCW)
Notes	Based on interpretation of O.S. 1:25,000 (some fill in 1:10,000) aerial photography (flown 1991-1999) and plotted against O.S. mapping for the Forestry Commission. Miscellaneous adjustments to original aerial photography interpretation 9API) as detected by survey foresters. Woodland grant schemes approximately 1992 – 1999 digitised from paper maps held by FC. 1995 – 2001 – WGS digital data supplied by FC (date varies per 100k tile). FC new planting, 1992 – 1999 digitised from FC paper maps. 1995 – 2001 digital data supplied by FC date varies per 100k tile). Interpreted forest type woodland greater than 2ha updated by woodland surveys for the national inventory of woodland and trees to include FC new planting and new grant schemes as at 31st March 2001. Woodland consists of areas of a tree cover with a crown density of, or likely to achieve, at least 20%, a minimum width of 5o metres and a minimum of 2ha. Woodland also includes areas that may be temporarily without tree cover following forest operations such as felling. Within woodlands, internal polygons may be identified with a minimum area of 1ha. Fo Last updated: 31/03/01 Contact Steve Smith – Head of Woodland Surveys, Forest Research, Forestry Commission HQ. Tel 0131 314 6357
Constraint Type	Footprint
Copyright	Forestry Commission

Positive development siiting factor: 5b) Open access land dataset

Name	Welsh National GIS / Positive_factors / pos_5b_open.shp
File Type	ESRI Shapefile - Polygon
Nominal Scale	1:2500 / 1:10000
Source	Countryside Council for Wales (CCW)
Notes	Open Country element of Maps for (Area Name) as required by Countryside and Rights of Way Act 2000. Open Country boundary derived from Habitats data digitised for CCW by Landmark (subcontracted to RMSI) between 2000-2001. Draft map valid only until the provisional map is issued. Provisional map only valid until conclusive map is issued. Last updated: 01/03/04 Digitised from O.S. landline
Constraint Type	Footprint
Copyright	Copyright is held by the Countryside Council for Wales. Normal restrictions apply. See legal maps for definitive boundaries.

Appendix I

Wildlands

Please note that the contents of the this appendix do not represent the Planning Policy of the Welsh Assembly Government

Wildlands

Wildlands are a relatively recent concept to describe remote areas which combine particular physical and perceptual characteristics which are becoming rarer in the UK and Europe. They are relevant to this study as these areas tend to be upland, have the highest wind speeds and are technically desirable for wind farms. Scotland has some of the most extensive 'remote' areas in Europe and has carried out some work on how to define both the term and the extent of wildlands.

Scottish National Planning Policy Guidance (NPPG) 14 on Natural Heritage[1] states that ' Scotland's remoter mountain and coastal areas possess an elemental quality from which many people derive psychological and spiritual benefits. Such areas are very sensitive to any form of development or intrusive human activity and planning authorities should take great care to safeguard their wildland character. This care should extend to the assessment of proposals for development outwith these areas which might adversely affect their wildland character' (para16).

Scottish Natural Heritage (SNH) has published a policy statement on 'Wildness in Scotland's Countryside'[2]. It makes a distinction between 'wildness' which is a quality which can be enjoyed (even in locations close to urban areas) and 'wildlands' which are places where that quality is best expressed. It goes on to say that wildness can offer benefits including engagement with the physical world, solitude and sanctuary, closeness to nature and as a quality in its own right. The value of wildlands is said to be through their scarcity as a resource in Europe, intrinsic quality (although this is not a prerequisite), potential for nature, economic value for tourism and active outdoor pursuits and accessibility. SNH's policy statement on onshore wind farms in relation to natural heritage[3] defines wildland as 'uninhabited and often relatively inaccessible countryside where the influence of human activity on the character and quality of the environment has been minimal' (2.1 p16).

Planning Policy Wales[4] states that 'the natural heritage of Wales… embraces the relationships between landform and landscape, habitat and wildlife, and their capacity to sustain economic activity and to provide **enjoyment and inspiration'** (para 5.1.1 p48) (emphasis added). A significant part of the Welsh landscape could be defined as wildlands. In Wales, the scale of these wildlands and their distance from settled areas are less than in Scotland. The sense of wildness may, in many cases, also be less extreme (see photographs below). However, this relative accessibility makes these areas valuable as many people can enjoy them. This makes wildlands an important landscape asset for Wales. The resource is finite and is under pressure from various forms of development and agricultural practices. Forestry also reduces the feeling of wildness of an area although it can still remain remote.

[1] Scottish Executive (revised 2000) National Planning Policy Guidelines 14 – Natural Heritage
[2] Scottish Natural Heritage (2002) Policy Statement No. 02/03 – Wildness in Scotland's Countryside
[3] Scottish Natural Heritage (2002) Policy Statement No. 02/02 – Strategic Locational Guidance for onshore wind farms in respect of the Natural Heritage
[4] Welsh Assembly Government (2002), Planning Policy Wales

In order to determine the extent of wildlands for use as part of the research, the following criteria set out in Table I.1 were developed:

Table I.1 Criteria for defining Wildlands in Wales

Qualities	Wildlands should be:
Physical qualities	
Remoteness and inaccessibility	• 5km from major roads above 10,000 vehicles/day • 2km from A roads [say around 5,000-10,000 vehicles/day] • 1km from B roads [say around 2,000-5,000 vehicles/day • Very lightly travelled minor roads- no buffer • 2km from mainline railway • 1km from local railway
Lack of evidence of human use of the land	Grade 5 or similar, unenclosed open land, no intensive agricultural practices eg moorland, heathland. Forestry reduces wildness of an area but it can still feel remote.
Lack of modern artefacts or structures	No modern structures such as fences, buildings or masts- wildland is unlikely to run up to the mountain fence as at this point more settled areas will be visible and the area will not be perceived as wild.
Perceived naturalness	Evidence of natural processes, natural vegetation cover and wildlife. Forestry will reduce sense of wildness because of its planted nature.
Perceptual qualities	
Solitude	Evidence of human activity should not be visible and few people should be seen over a prolonged period of time which give a feeling of remoteness.
Tranquillity	No noise of human related activity
Inspiration/Awe	Natural beauty or scale of the area may lead to feelings of inspiration, awe or spiritual awareness.
Threat	Perceived danger posed by terrain and or weather

Appendix J

Initial Guidance to Local Planning Authorities on the treatment of the strategic areas

Please note that the contents of the this appendix do not represent the Planning Policy of the Welsh Assembly Government

General planning advice/guidance at the development control level

With respect to the general technical and environmental issues associated with the planning for onshore wind energy developments at the planning application stage, there are a wide range of documents already available. These comprise (but not exclusively) the following:-

Environment Agency – Scoping the environmental impacts of wind farms[5]
The existing Welsh Assembly Technical Advice Note[6]
The technical advice note published by the Scottish Executive[7]
DTI/ETSU – Wind information needs for Planners[8]

The research does not attempt to summarise these or the issues therein as this is in part the role of the Technical Advice Group in updating the Welsh Technical Advice Note on Renewable Energy. Instead further work is presented below with respect to siting, landscape and visual issues, as these are likely to be the most important issues during the next stages of 'master-planning' the draft strategic areas

Guidance to minimise landscape and visual impacts

In order to help guide where wind energy developments are most acceptable within the strategic areas, the research has developed a series of criteria and resulting rules of thumb (which have emerged through research and observation) and these are presented below as guidelines in Table J. Some criteria can be expressed spatially while others remain as criteria against which individual proposals can be judged. Each wind farm proposal has to be judged on its own merits and broad geographic guidance can only give an indication of suitability.

[5] EA (2002) Scoping Guidelines on the Environmental Impact Assessment of Projects -Wind farms on and offshore
[6] Welsh Assembly Government (1996) Technical Advice Note 8: Renewable Energy
[7] Scottish Executive (2002), Planning Advice Note 45- Renewable Energy Developments
[8] DTI/ETSU and Land use Consultants (2001) Wind information needs for planners, ETSU Report W/14/00564/REP.

Table J: Initial Guidelines to minimise the landscape and visual impacts of wind farms within the strategic areas

Aim	Guideline	Comment
Optimise location of wind farm	Site large wind farms on large-scale and simple landscapes with simple, smooth skylines	Avoid *complex* ridgelines and areas of *complex land cover*.
	Where views are possible towards wind farms site them back from the edge of plateaux, valley sides, hill fringes.	Site turbine a distance of around 5 times its height to blade tip from top of break of slope where possible
	Avoid breaking skylines when viewed from *sensitive landscapes* and viewpoints	
Optimise layout of wind farm	Lay out wind turbines in apparently random pattern. Avoid straight lines unless in highly rectilinear field pattern or industrial landscape.	
	Where possible break small wind farms into small groups in *finer grain* field landscapes.	Break up into small visually separate groups of around 5 turbines where possible.
	Avoid a cluttered appearance without spreading out	
Optimise wind turbine design and size	All turbines in one wind farm must be of the same appearance and size. It is commonly accepted that the three bladed wind turbines with a solid evenly tapering tower is the most elegant design.	Colour turbines off-white or light grey with a matt finish
	Respect scale of landscape where there is pronounced topography by using wind turbines sizes and numbers that do not dwarf hills / ridges[9]. Consider where possible not using wind turbines that are higher than a third of the height of the landform they are placed on, (or likely to be viewed against), where breaks of slope and heights are well defined. (Note: in gently undulating or flat landscapes this is irrelevant).	
Optimise design and layout of ancillary equipment	Site ancillary equipment below the skyline including buildings, sub-stations and transmission lines.	Locate transmission lines underground in exposed parts of the site. Use timber poles to support higher voltage overground lines on lower slopes, where voltage allows.
	House all clutter within wind turbine structure.	
	Design access roads so they are not widely visible using local quarried crushed stone where possible.	

[9] Most of the wind farms assessed in the field during this research have wind turbines ranging from 46m to 55m blade tip (Llandinam to Cemmaes). Of the sites visited, only Blaen Bowi in Carmarthenshire has larger turbines at 76m tall (these are also installed at other locations, including Moel Maelogan in North Wales). During the visits, the range of 45-55m appeared to be generally acceptable in respecting the scale of this part of the Welsh landscape. Larger wind turbines could potentially have the effect of being out of scale with the topography particularly where landform is pronounced and smaller in scale (say up to 200m change in level). The 76m turbines at Blaen Bowi make the hill on which they are standing appear relatively small. However, the low number of turbines (3) reduces its potential visual and landscape impact.