FOE/JC3

Town and Country Planning Act 1990 (as amended)

Application by West Cumbria Mining Limited

Proposal: Development of a new underground metallurgical coal mine and associated development

Site: Former Marchon Site, Pow Beck Valley and area from Marchon Site to St Bees Coast, Whitehaven, Cumbria

Planning Inspectorate reference: APP/H0900/V/21/3271069

Cumbria County Council reference: 4/17/9007

REBUTTAL PROOF OF EVIDENCE

OF

DR JONATHAN M CULLEN

Date: 31 August 2021

Contents

Appendices

1. Introduction and summary of conclusions

1.1. In this rebuttal proof of evidence I respond to parts of the proof of evidence of Mr Jim Truman [**WCM/JT/1**]. This is further to my proof of evidence of 10 August 2021 [**FOE/JC/1**]. The fact that I have not responded to other parts of Mr Truman's evidence does not mean that I necessarily agree with him on those matters.

1.2. The evidence which I have prepared and provide for in this rebuttal proof is true and I confirm that the opinions expressed are my true and professional opinions.

1.3. The conclusions I have reached in this rebuttal proof are:

1.3.1. <u>Demand for metallurgical coal</u>: Mr Truman's estimates of the need for metallurgical coal beyond 2035 are significantly overstated. The 'Base Case' scenario relied upon by Mr Truman is inconsistent with UK and EU ambitions to reach net-zero emissions and mitigate the impacts of climate change. Put simply, if the UK and EU are to achieve the reductions to which they have committed, they need to introduce measures to ensure Mr Truman's Base Case scenario does not happen. Even the more 'ambitious' 'AET2.0', scenario - found in the appended Wood Mckenzie report [**WCM/JT/2**] but not Mr Truman's proof itself - is inconsistent with the UK's climate obligations, which will require reductions in metallurgical coal demand well above those set out in the AET2.0 scenario.

1.3.2. <u>Increased steel making from scrap</u>: (a) There is plenty of headroom (up to at least the 72% achieved in the US) for the UK and the EU to move away from iron ore based steelmaking and to increase steelmaking from scrap steel. This directly contradicts Mr Truman's evidence that "*there is limited scope for scrap availability to grow*"; (b) The USA has been able to overcome the challenges of using scrap steel for high quality sheet applications for half of their sheet metal production There is no reason why the UK and Europe could not achieve similar scrap fractions, while continuing to produce high quality steels from iron ore with the remaining 28% feedstock input.

1.3.3. <u>Reduction in steel demand not considered</u>: Mr Truman's failure to include any provision for reduction in steel demand in his scenarios is surprising, and risks overestimating the demand for metallurgical coal in the future.

2. Demand for metallurgical coal

2.1. Mr Truman's estimates of future metallurgical coal demand in his proof at paragraph 4.8 are based on the Wood Mckenzie 'Base Case scenario' presented in the appendix at paragraph 1.34-5 **[WCM/JT/2**], with:

2.1.1. global demand for metallurgical coal falling 5% from 1,201 million tonnes per annum ('**Mtpa**') in 2022 to 1,129 Mtpa in 2049;

2.1.2. European demand between 50-55 Mtpa over the 2021-2049 period;

2.1.3. UK demand holding at about 1.5 Mtpa from 2021-2049.

2.2. A more ambitious Wood Mckenzie scenario, the 'Accelerated Energy Transition 2.0' ('**AET2.0**'), is described in the appendix to Mr Truman's proof at paragraph 1.77-8 as an "*extreme*" scenario which "*diverges a long way from our base case*". In this scenario, metallurgical coal demand falls, with:

2.2.1. global demand 245 Mtpa lower in 2040 compared with the base case (~855 Mtpa);

2.2.2. European demand falling from 85 Mtpa in 2021 to 60 Mpta in 2040, with most of the decline occurring between 2030 and 2040 (note the higher 2021 value);

2.2.3. UK demand not stated (appendix to Mr Truman's proof, paragraph 1.76).

2.3. The appendix at paragraph 1.76 states "*The steel industry achieving a two-degree warming pathway has would have* [sic] *significant implications for metallurgical coal demand*."

2.4. Mr Truman, in his proof, uses only the metallurgical coal demand estimates from the Base Case scenario, where the likely climate change impacts are not described. However, the AET2.0 scenario, which includes reductions in metallurgical coal demand of 22% global and 30% in Europe, is described as being consistent with the "*the steel industry successfully follow*[ing] *a two-degree warming pathway case*" (appendix paragraph 1.72).

2.5. In my view, it is clear from this that even Mr Truman's AET2.0 scenario is inconsistent with the UK's obligations under the Paris Agreement, under which the parties are committed to limiting global warming to well below two degrees. Further, the UK and the EU have committed to deploying actions earlier to allow the world to keep warming below 1.5 degrees, a significantly more ambitious target than 2 degrees. The Climate Change Committee has advised the government to target near-zero emissions from steelmaking in the UK by 2035 (Climate Change Committee, 2020 [**CD8.11, p.1495**]). Achieving these targets will require reductions in metallurgical coal demand which are well above the 30% stated for Europe in the AET2.0 scenario.

2.6. Mr Truman's Base Case, which is the focus of his main proof of evidence, is even further adrift and is a scenario for future metallurgical coal demand which is not consistent with the UK or EU ambitions to reach net-zero carbon emissions and mitigate the impacts of climate change. Demand for metallurgical coal in the world, Europe and the UK will need to be significantly lower than that predicted by Mr Truman, if these targets are to be met. Put simply, if they are to achieve the reductions to which they have committed themselves, both the EU and the UK will need to introduce measures (whether by way of increasing the incentives for other, greener technologies or by making conventional BF-BOF production less attractive) which ensure that Mr Truman's Base Case scenario does not happen.

2.7. On this basis, I consider Mr Truman's estimates of the need for metallurgical coal beyond 2035 to be significantly overstated. Any reduction in demand for metallurgical coal undermines the case for opening a new mine in West Cumbria which would increase carbon emissions.

3. Increased steel making from scrap

3.1. Mr Truman states that: "*EAF share of crude steel production in Europe will rise from 47% in 2020 to 60% in 2049*" and "*BF-BOF steel production is forecast to decline only marginally in the long term, from 99 Mt in 2021 to 88 Mt in 2049*" (proof, paragraph 4.5); "*there is limited scope for scrap availability to grow*" (appendix, paragraph 1.38); "*there are technical limits to the use of scrap in the production of high-quality steel products, which cannot tolerate feedstock impurities (e.g. for use in the automotive sector)*" (appendix, paragraph 1.68).

3.2. Metallurgical coal use in steel making is not directly related to the steel-making route, either BF-BOF or EAF, but instead the input ratios of iron ore and scrap to each process (see section 4 in my proof of evidence). The use of scrap steel in the BF-BOF route, up to 30% scrap by weight, can prevent the closure of BF-BOF plants, but still results in the same reduction in metallurgical coal demand, as if the scrap had been input to new EAF plants.

3.3. The fraction of scrap used in the production of crude steel is directly related to metallurgical coal demand, irrespective of the steel-making route. In Table 2 of my proof of evidence **[FOE/JC/1]**, I calculate scrap as a fraction of crude steel production in the UK, EU-28 and USA at 34%, 54% and 72% respectively. Each country/region is assessed to have reached saturation of per capita steel stocks in use. Therefore, there is plenty of headroom (up to at least 72%) for the UK and the EU to move away from iron ore based steelmaking and to increase steelmaking from scrap steel. This directly contradicts Mr Truman's evidence that "*there is limited scope for scrap availability to grow*".

3.4. For example, the UK generates 10 Mtpa of scrap steel, but only uses about 2.6 Mtpa of scrap in steel production. About 75% of UK's scrap is exported overseas (ranging from 6 to 9.4 Mt between 2008-17). In 2017, the EU-28 exported 48 million tonnes (Mt) of scrap and imported 32 Mt of scrap, a net difference of 16 Mt, roughly 10% of crude steel production (worldsteel, 2018, tables 53 and 54, appended to this proof [**FOE/JC3/1**]). The UK and the EU-28 both still have headroom to increase their steel-making from scrap.

3.5. In paragraph 6.3 of my proof of evidence, I describe how the USA has been able to overcome the challenges of using scrap steel for high quality sheet applications for half of their sheet metal production. The USA has increased its scrap fraction up to 72% while avoiding complications from scrap feedstock impurities. There is no reason why the UK and Europe could not achieve similar scrap fractions, while continuing to produce high quality steels from iron ore with the remaining 28% feedstock input.

4. Reduction in steel demand not considered

4.1. Mr Truman bases his metallurgical coal demand estimates on the Wood Mckenzie scenarios which assume that demand for steel in the future continues to rise: "*Global finished steel demand is forecast to continue to rise over the next 20-30 years, albeit at a slower rate than historical levels*" for the Base Case scenario (appendix, paragraph 1.21) and "*steel demand remains unchanged from the base case view*" for the AET2.0 scenario (appendix, paragraph 1.74).

4.2. These scenarios both overlook material efficiency and the circular economy as strategies to reduce future steel demand through strategies such as: using less metal by design; reducing yield losses; diverting scrap; re-use with no melting; longer life products; reducing final demand. Delivering the services that steel provides, while at the same time reducing steel demand, is increasingly seen as critical for meeting net-zero climate change targets. In section 7 of my proof of evidence I provide examples from a number of studies which suggest reductions in steel demand of between 28% and 75% are required to meet climate change targets, under different low energy and material demand scenarios.

4.3. Mr Truman and Wood Mckenzie's failure to include any provision for reduction in steel demand in their scenarios is surprising, and risks overestimating the demand for metallurgical coal in the future.

5. References

Climate Change Committee. (2020). '*The Sixth Carbon Budget Manufacturing and construction*'. www.theccc.org.uk [**CD8.11**]

worldsteel. (2018). '*Steel Statistical Yearbook 2018*' [**FOE/JC3/1**]. https://www.worldsteel.org/en/dam/jcr:e5a8eda5-4b46-4892-856b-00908b5ab492/SSY_2018.pdf

worldsteel
ASSOCIATION

STEEL STATISTICAL YEARBOOK 2018

Preface

This yearbook presents a cross-section of steel industry statistics that are exchanged or published by the World Steel Association. The co-operation of both members and non-members in supplying the information included in this publication is gratefully acknowledged. Further details of the statistical sources used are given in the Annex (p. 121). These contents were finalised in November 2018.

Data are expressed in thousand metric tons unless stated otherwise.

Zero indicates that the quantity concerned is less than 500 tonnes.

'e' indicates a figure that has been estimated by the World Steel Association.

Totals comprise listed countries only. Trade data totals include intra-regional exports and imports.

Three dots (...) indicate that an item of information was not available.

World Steel Association
Economics Committee

Contents

(continued overleaf)

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Table 53 **Exports of Scrap**

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Austria	1 397	1 700	969	952	978	999	1 077	1 051	1 114	1 231
Belgium	3 161	3 245	3 701	3 544	3 476	3 212	3 931	3 152	3 540	3 756
Bulgaria	740	511	949	851	731	611	399	240	240	399
Croatia	324	304	357	463	517	364	352	306	362	408
Cyprus	72	80	97	139	135	104	79	64	58	67
Czech Republic	1 793	1 441	1 775	1 993	1 901	1 880	2 045	1 751	1 774	2 101
Denmark	1 118	1 180	1 626	1 915	1 537	1 270	1 703	1 277	1 572	1 568
Estonia	635	384	507	537	593	489	415	291	369	561
Germany	8 269	7 275	9 176	9 034	8 924	8 378	8 433	7 492	8 675	8 174
Finland	308	273	224	337	363	326	398	353	318	336
France	5 796	5 145	6 683	6 167	6 118	5 985	6 177	5 380	5 428	6 176
Greece	36	35	67	87	57	71	62	24	17	38
Hungary	692	534	1 118	1 216	1 108	1 048	1 019	843	906	911
Ireland	478	392	469	588	491	404	440	349	350	447
Italy	388	325	422	318	325	254	269	309	353	426
Latvia	339	214	342	523	489	469	517	457	341	404
Lithuania	652	415	579	656	535	473	540	508	526	820
Luxembourg	347	115	121	91	83	75	90	100	117	111
Malta	25	28	29	38	34	28	49	29	38	45
Netherlands	3 931	4 340	5 080	4 482	4 798	4 195	3 994	4 055	5 037	5 572
Poland	1 369	911	1 283	1 660	1 833	1 909	2 005	1 431	1 340	1 397
Portugal	172	173	237	141	167	245	230	215	216	434
Romania	1 960	2 565	2 517	2 340	1 894	1 946	1 422	710	702	816
Slovak Republic	489	313	504	633	414	353	489	486	570	556
Slovenia	199	285	343	408	414	394	415	396	370	445
Spain	215	286	277	425	663	510	600	345	331	398
Sweden	1 449	1 415	1 313	1 422	1 525	1 298	1 441	1 246	1 389	1 402
United Kingdom	6 640	6 008	7 519	7 814	7 299	6 948	6 987	7 270	8 130	9 396
European Union (28)	**42 997**	**39 894**	**48 285**	**48 774**	**47 403**	**44 238**	**45 577**	**40 129**	**44 183**	**48 396**
Albania	94	102	194	97	100	24	23	17	32	23
Bosnia-Herzegovina	169	90	136	227	218	184	156	121	117	206
Macedonia	184	72	154	73	53	30	29	35	46	40
Montenegro	49	15	51	39	43	29	17	4	2	28
Norway	269	228	338	290	346	363	423	420	459	483
Serbia	346	67	417	358	373	330	267	168	161	300
Switzerland	636	565	624	628	627	712	632	620	681	757
Turkey	78	67	94	106	95	102	168	145	156	172
Other Europe	82	68	55	54	44	114	69	52	61	60
Other Europe	**1 908**	**1 275**	**2 063**	**1 872**	**1 898**	**1 889**	**1 784**	**1 582**	**1 715**	**2 068**
Byelorussia	37	5	4	28	19	10	13	11	12	9
Georgia	421	383	427	402	199	52	23	15	4	13
Kazakhstan	1 797	856	816	866	781	726	14	7	194	11
Kyrgyzstan	28	25	28	54	17	2	1	0	0	3
Moldova	334	2	189	89	28	127	4	1	1	4
Russia	5 128	1 202	2 390	4 042	4 349	3 714	5 765	5 910	5 524	5 247
Ukraine	636	891	665	802	367	255	928	1 208	273	487
Other CIS	9	0	5	4	4	2	2	2	27	14
C.I.S.	**8 390**	**3 363**	**4 526**	**6 286**	**5 763**	**4 888**	**6 751**	**7 155**	**6 035**	**5 787**

Table 53 **Exports of Scrap**
(continued)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Canada	4 048	4 793	5 191	4 846	4 248	4 521	4 510	3 415	3 632	4 409
Costa Rica	106	87	114	144	131	143	147	120	83	103
Dominican Republic	229	86	143	225	198	176	229	124	120	161
El Salvador	46	16	55	64	42	31	31	20	11	19
Guatemala	34	7	19	30	22	30	33	10	18	22
Haiti	76	21	35	43	50	24	37	27	26	32
Honduras	84	41	70	76	60	60	65	59	51	72
Jamaica	68	40	66	90	5	19	40	17	21	30
Mexico	...	702	1 014	1 053	858	779	701	459	416	626
Nicaragua	51	37	58	77	63	54	53	46	39	40
Panama	193	87	135	169	134	67	153	119	215	268
Trinidad and Tobago	136	16	50	49	58	62	82	52	48	53
United States	21 712	22 439	20 557	24 373	21 397	18 495	15 340	12 976	12 819	15 016
Other North America	91	50	98	106	137	125	89	40	28	57
North America	**26 872**	**28 420**	**27 606**	**31 344**	**27 403**	**24 585**	**21 511**	**17 482**	**17 527**	**20 908**
Bolivia	28	16	36	46	44	40	52	49	30	41
Brazil	119	115	80	259	444	453	648	679	611	589
Chile	69	61	131	267	221	204	337	253	221	262
Colombia	28	36	92	107	63	76	64	34	27	56
Ecuador	75	40	17	3	3	3	4	3	4	3
Paraguay	56	36	58	53	58	54	57	77	51	82
Other South America	55	33	26	56	78	76	27	30	16	15
South America	**431**	**337**	**441**	**791**	**912**	**907**	**1 189**	**1 125**	**960**	**1 049**
Algeria	667	668	379	1	0	...	0	0	0	...
Egypt	941	30	786	32	46	30	23	13	32	26
Ghana	66	48	53	74	57	23	32	12	10	10
Morocco	206	36	133	31	35	72	64	47	48	20
South Africa	1 270	1 144	1 224	1 436	1 632	1 485	1 486	1 266	644	467
Zimbabwe	70	42	51	28	8	8	37	21	8	4
Other Africa	950	467	747	1 024	821	685	623	627	526	854
Africa	**4 170**	**2 435**	**3 374**	**2 626**	**2 598**	**2 302**	**2 265**	**1 985**	**1 268**	**1 382**
Bahrain	59	68	81	112	106	96	107	61	66	162
Iran	99	7	69	12	21	2	0	0	2	1
Israel	276	278	414	378	338	209	265	141	201	285
Kuwait	233	124	201	221	221	123	130	55	36	67
Lebanon	283	323	512	553	365	408	265	173	248	383
United Arab Emirates	1 114	731	1 231	1 271	1 004	920	1 162	964	901	786
Other Middle East	332	87	126	146	139	111	92	70	45	270
Middle East	**2 396**	**1 617**	**2 635**	**2 693**	**2 195**	**1 869**	**2 022**	**1 464**	**1 498**	**1 954**
China	204	9	373	25	1	0	1	1	1	2 230
Hong Kong	1 318	823	873	806	729	622	635	508	537	1 380
Indonesia	75	39	40	40	41	42	42	52	59	70
Japan	5 344	9 398	6 472	5 453	8 594	8 150	7 351	7 847	8 706	8 208
South Korea	369	485	459	397	236	205	298	418	559	621
Malaysia	38	78	101	70	80	53	52	47	151	273
Philippines	713	391	547	543	253	170	403	188	512	486
Singapore	624	556	585	606	852	978	911	844	1 048	790
Taiwan, China	145	154	93	104	96	74	67	62	77	104
Thailand	361	342	547	567	481	437	384	397	431	388
Other Asia	1 849	2 089	2 233	454	347	277	308	219	254	420
Asia	**11 040**	**14 363**	**12 323**	**9 066**	**11 709**	**11 007**	**10 453**	**10 583**	**12 335**	**14 971**
Australia	1 708	1 925	1 636	1 745	2 245	2 200	2 362	1 898	1 583	1 979
New Zealand	274	318	359	358	363	352	367	413	609	572
Other Oceania	53	43	72	86	81	62	53	30	20	63
Oceania	**2 034**	**2 285**	**2 067**	**2 189**	**2 688**	**2 614**	**2 781**	**2 341**	**2 212**	**2 615**
World	**100 238**	**93 990**	**103 320**	**105 642**	**102 568**	**94 299**	**94 332**	**83 848**	**87 732**	**99 129**

Table 54

Imports of Scrap

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Austria	1 797	1 702	967	998	1 060	1 141	1 188	1 098	1 018	1 040
Belgium	4 830	3 679	5 294	4 633	4 054	4 213	4 760	4 167	4 084	4 643
Bulgaria	246	202	697	230	114	93	115	105	92	101
Czech Republic	502	372	393	463	456	546	565	493	475	442
Denmark	392	236	242	342	229	236	253	113	101	135
Estonia	532	9	277	10	7	20	36	55	84	126
Germany	5 675	3 865	5 305	6 180	5 484	5 340	5 045	4 236	4 348	4 463
Finland	569	466	745	700	203	49	81	65	10	15
France	3 219	2 423	2 416	2 658	2 705	2 363	2 473	2 247	1 806	1 909
Greece	1 485	1 159	995	935	498	301	455	438	764	889
Hungary	146	31	54	44	47	47	70	97	90	94
Italy	5 705	3 321	4 591	5 747	5 264	4 957	5 145	4 643	4 434	5 209
Latvia	681	214	612	365	883	318	201	124	110	140
Lithuania	491	30	320	72	56	30	35	24	30	84
Luxembourg	3 391	1 830	1 722	2 449	1 682	805	1 403	903	2 258	2 197
Netherlands	1 563	1 851	1 803	1 612	1 872	1 742	1 885	1 641	1 940	2 238
Poland	466	597	372	403	385	507	481	745	779	806
Portugal	1 128	481	323	460	587	1 279	1 352	1 490	1 396	1 616
Slovak Republic	169	155	331	149	339	380	234	165	162	253
Slovenia	367	282	515	558	550	538	576	514	531	571
Spain	6 657	4 642	5 712	4 597	4 289	4 705	4 827	5 030	3 965	4 101
Sweden	193	174	225	238	236	256	295	261	275	293
United Kingdom	237	220	277	425	286	303	351	302	266	345
Other E.U.	107	16	1 644	51	53	62	99	101	130	184
European Union (28)	**40 550**	**27 957**	**35 833**	**34 318**	**31 338**	**30 233**	**31 926**	**29 058**	**29 150**	**31 894**
Albania	36	84	236	160	99	39	105	49	2	81
Macedonia	243	201	275	287	135	47	129	71	81	168
Montenegro	117	33	51	34	8	7	2	13	4	6
Norway	97	91	109	139	211	203	156	184	266	278
Serbia	251	10	270	35	90	169	148	105	24	18
Switzerland	506	313	453	456	344	417	426	474	459	521
Turkey	17 415	15 666	19 200	21 453	22 415	19 725	19 068	16 251	17 716	20 980
Other Europe	203	33	47	34	23	22	24	13	24	21
Other Europe	**18 868**	**16 430**	**20 640**	**22 598**	**23 325**	**20 631**	**20 058**	**17 159**	**18 576**	**22 074**
Byelorussia	1 437	1 294	1 595	1 561	1 356	1 239	1 253	1 382	1 235	1 353
Moldova	716	304	143	121	27	73	101	256	5	309
Russia	95	9	27	0	4	5	264	235	444	755
Ukraine	164	11	10	127	116	239	28	3	22	25
Uzbekistan	142	227	276	249	250	297	0	0	153	5
Other CIS	1 799	857	821	868	871	734	18	1	14	10
C.I.S.	**4 353**	**2 702**	**2 872**	**2 924**	**2 624**	**2 587**	**1 665**	**1 876**	**1 874**	**2 458**
Canada	1 691	1 424	3 049	1 925	2 343	1 746	1 520	1 516	1 839	2 115
Mexico	851	850	934	733	946	864	915	1 483	1 893	1 782
United States	3 570	2 986	3 773	4 003	3 711	3 882	4 215	3 513	3 864	4 636
Other North America	39	39	21	116	69	25	12	19	12	61
North America	**6 152**	**5 299**	**7 777**	**6 777**	**7 070**	**6 517**	**6 661**	**6 530**	**7 607**	**8 594**
Brazil	44	28	134	79	51	55	23	25	33	20
Peru	171	174	308	192	265	340	372	430	415	500
Other South America	76	14	199	105	140	186	204	141	163	281
South America	**291**	**217**	**641**	**375**	**456**	**581**	**598**	**597**	**611**	**801**

Table 54 **Imports of Scrap**
(continued)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Egypt	2 398	1 299	2 736	2 644	2 021	2 891	2 971	928	1 028	2 035
Morocco	158	220	182	448	474	292	360	563	312	350
South Africa	85	41	54	32	11	28	101	74	66	67
Other Africa	15	80	13	18	18	40	19	23	10	25
Africa	**2 657**	**1 639**	**2 985**	**3 141**	**2 524**	**3 251**	**3 451**	**1 587**	**1 416**	**2 477**
Iran	85	6	3	6	5	24	2	1	15	13
United Arab Emirates	54	57	41	90	45	41	184	62	52	125
Other Middle East	9	52	49	133	183	76	975	584	656	956
Middle East	**147**	**116**	**93**	**228**	**232**	**140**	**1 161**	**647**	**723**	**1 094**
Bangladesh	337	545	238	325	205	279	459	946	2 011	2 142
China	3 590	13 692	5 848	6 767	4 974	4 465	2 564	2 328	2 162	2 326
Hong Kong	323	317	258	269	155	151	108	135	87	309
India	4 579	4 727	4 643	6 175	8 156	5 632	5 699	6 710	6 380	5 365
Indonesia	1 907	1 500	1 644	2 157	1 944	2 399	2 137	1 020	1 020	1 857
Japan	699	194	491	580	225	234	370	149	176	232
South Korea	7 319	7 800	8 091	8 628	10 126	9 260	8 002	5 758	5 845	6 175
Malaysia	2 303	1 741	2 308	2 050	1 816	1 921	961	446	316	844
Pakistan	764	1 806	793	955	922	874	1 340	2 119	2 388	2 830
Singapore	439	347	345	299	295	130	114	46	52	225
Taiwan, China	5 539	3 912	5 364	5 328	4 954	4 446	4 272	3 373	3 155	2 919
Thailand	2 752	1 490	1 483	1 877	1 701	961	1 383	945	953	1 741
Viet Nam	853	1 830	1 889	1 451	2 169	2 131	2 277	2 466	3 286	4 550
Other Asia	242	452	102	54	179	80	39	73	58	68
Asia	**31 646**	**40 351**	**33 497**	**36 917**	**37 821**	**32 963**	**29 724**	**26 514**	**27 888**	**31 581**
Australia	5	2	3	3	5	2	23	22	81	52
New Zealand	2	0	228	18	16	14	15	9	7	8
Other Oceania	4	13	38	36	1	32	0	0	0	49
Oceania	**10**	**15**	**269**	**57**	**22**	**48**	**37**	**31**	**88**	**108**
World	**104 675**	**94 727**	**104 606**	**107 335**	**105 411**	**96 951**	**95 283**	**83 999**	**87 933**	**101 081**

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FOE/MC3

Town and Country Planning Act 1990

Application West Cumbria Mining Ltd

REBUTTAL

Michael Spence BA(Hons), MLD, CMLI, REIA, FRGS

Photography and Visualisations

Land at Former Marchon Site, Kells, Whitehaven

Cumbria Local Planning Authority reference 4/17/9007

PINS reference APP/H0900/V/21/3271069

1 September 2021

Contents

Appendices

Appendix 1 [**FOE/MC3/1**]	Landscape Institute, Advice Note 01/11, '*Photography and photomontage in landscape and visual impact assessment*', March 2011
Appendix 2 [**FOE/MC3/2**]	Scottish Natural Heritage, '*Visual Representation of Wind Farms, Guidance*', Version 2.2, February 2017
Appendix 3 [**FOE/MC3/3**]	Landscape Institute, Technical Guidance Note 06/19, '*Visual Representation of Development Proposals*', 17 September 2019
Appendix 4 [**FOE/MC3/4**]	MS Environmental '*6. Stephenson Halliday Viewpoint 12, High House Road*' sequence

1.0 Introduction

1.1 My name is Michael Spence. I hold a Bachelor of Arts Degree in Geography from Nottingham University. I hold a Master of Landscape Design Degree from Manchester University. I have been a Chartered Member of the Landscape Institute since 1995. I have been a Registered EIA Practitioner since 2003. I have been a Fellow of the Royal Geographical Society since 2017.

1.2 Since 2013 I have provided technical support to the Landscape Institute in both photography and visualisation knowledge and digital technology. I was a key technical input behind the Landscape Institute's TGN 06/19 Visualisation of Development Proposals, I have also worked for Scottish Natural Heritage (now NatureScot) on technical improvements to their 2014 windfarm visualisation guidance, and I am currently on IEMA's EIA Technical Steering Group and have fed into the Institute of Lighting Professionals Lighting Impact Assessment guidance. I have given lectures and workshops on photography and visualisation techniques, both across the UK and internationally.

1.3 I have undertaken photography and prepared visualisations for EIA projects since 1992.

1.4 This rebuttal on behalf of Friends of the Earth is in regard to the photography and visualisation material supplied by West Cumbria Mining Ltd ('WCM') [**WCM/JF/2**] and accompanying the proof by John Flannery [**WCM/JF/1**] with regard to his evidence on landscape and visual matters in relation to the proposed metallurgical coal project in Whitehaven.

1.5 The approach of this rebuttal is to seek to identify the key aspects of difference between my own photography and visualisation work and Mr Flannery's evidence and in doing so assist the Inspector to identify the main issues in dispute. To assist with this, I have considered it necessary to undertake a brief preamble covering four documents of particular relevance:

- Guidelines for Landscape and Visual Impact Assessment (GLVIA3)
- Landscape Institute Technical Advice Note 01/11
- Visual Representation of Windfarms Guidance 2017
- Landscape Institute Technical Guidance Note TGN 06/19

2.0 Background

2.1 By way of background there has been great development in knowledge and techniques used for photography and visualisation work since 2006, largely due to the concern over visual representation of windfarms in Scotland. This concern led both Scottish Natural Heritage and the Highland Council to work on two differing approaches to presentation of photographic and visualisation imagery. Fundamentally the main difference was the use of cylindrical projection photography and visualisations on large format sheets by SNH and planar projection photography and visualisations on A3 sheets by the Highland Council. The 2017 document prepared by SNH saw an alignment of the two approaches, with both planar and cylindrical photography and A3 imagery presented.

2.2 Since 2016 I had been working for the Landscape Institute's Technical Committee on updating LI Advice Note 01/11, which culminated in the publication of TGN 06/19. This broadened the scope of visualisation projects to encompass all development, beyond windfarms.

2.3 The original WCM application was undertaken by Stephenson Halliday in 2017, during a period of unclear direction by the Landscape Institute on presentation of development proposals. It was therefore interesting to consider and understand the approach followed for this major project.

3.0 Guidelines for Landscape and Visual Impact Assessment

3.1 The process of assessing landscape and visual effects in the planning process is well established and will be covered by Mr Radmall and Mr Flannery in their main proofs of evidence. An important part of this process is the identification of viewpoints and presentation of photographs and visualisation material to accompany their work.

3.2 GLVIA3 covers the use of viewpoints in chapter 6, Assessment of Visual Effects. Para 6.23 references LI Advice Note 01/11, Photography and Photomontage in LVIA. This has now been replaced by TGN 06/19 Visualisation Representation of Development Proposals.

4.0 Landscape Institute Advice Note 01/11

4.1 At the time Stephenson Halliday undertook their photography and visualisation work the Landscape Institute still had Advice Note 01/11 in place (Appendix 1 [**FOE/MC3/1**]). This document was, however, already out of date because of the work SNH and the Highland Council had been carrying out in Scotland. It is therefore pleasing to see that Stephenson Halliday, in their work for WCM, followed the SNH visualisation approach.

4.2 Therefore, none of the original work followed the Landscape Institute Advice Note 01/11.

5.0 Visual Representation of Windfarms Guidance 2017

5.1 This guidance document published by Scottish Natural Heritage was the culmination of a number of years of research and alignment with the Highland Council visualisation standards (Appendix 2 [**FOE/MC3/2**]).

5.2 The approach included a standardised set of figures to be produced for all viewpoints, consisting of both cylindrical and planar projection images.

5.3 This list comprises the following:

- 90 degree baseline cylindrical photograph and matching cylindrical wireline (A1 wide x A4 high sheet)
- 53.5 degree planar wireline (A1 wide x A4 high sheet)
- 53.5 degree planar photomontage (A1 wide x A4 high sheet)
- 27 degree planar montage (A3 sheet)

5.4 This standardised set of images should be produced for each viewpoint, except the 27 degree planar montage, which is an optional extra for the Viewpoint Pack.

6.0 Landscape Institute Technical Guidance Note 06/19 Visual Representation of Development Proposals

6.1 This technical guidance published by the Landscape Institute in 2019 was the culmination of three years of research and alignment with the SNH Visualisation of Windfarm guidance (Appendix 3 [**FOE/MC3/3**]).

6.2 The TGN replaced the previous Advice Note 01/11

6.3 The guidance introduced the concept of 'proportionality' to visualisations, which effectively meant that more significant (EIA) projects, such as this one, should be undertaken to greater levels of technical accuracy, whilst less important projects could be undertaken with simpler techniques.

6.4 Similar presentation techniques were introduced to those specified by SNH, with wider application of townscape visualisations specified in the the London Views Management Framework (2012).

6.5 One of the main requirements as a result of the guidance was the requirement for a technical methodology to explain how the photography and visualisation work has been carried out, so that any technical examination of the approach could be understood and checks made on accuracy.

7.0 Visualisations by Stephenson Halliday

7.1 The photography and visualisation work was undertaken by Stephenson Halliday in combination with a 3D modelling company, called 'Tangible Visual'.

7.2 No Technical Methodology appears to have been included in the original ES or its appendices.

7.3 Interestingly, the visualisations appear to partly follow the SNH windfarm visualisation guidance (2017). Each viewpoint figure specifies a 53.5 degree field of view in planar projection, to accord with SNH.

7.4 However, the majority of the visualisations required by SNH for each viewpoint have not been prepared. Specifically:

- 90 degree baseline cylindrical photograph and matching cylindrical wireline (A1 wide x A4 high sheet)
- 53.5 degree planar wireline (A1 wide x A4 high sheet)

7.5 Stephenson Halliday include just a 53.5 degree existing planar view and a 53.5 degree planar photomontage. The reason for these important omissions is not clear.

7.6 The photography appears to have been taken in good, clear conditions and is on the face of it an example of how to undertake this kind of work.

7.7 However, a more detailed review of some of the images and visualisations reveal a few errors appearing in the work. These are covered in my technical methodology (Appendix 2 to Mr Radmall's proof of evidence[**CD10.9**]).

7.8 One of the important parts of any visualisation is that the view presented shows the full extent of development in the view. Following the SNH approach properly would have resulted in either a single 90 degree view or multiple 90 degree views, with accompanying wireline images, for all viewpoints.

7.9 None of the SH viewpoints is presented beyond a 53.5 degree field of view.

7.10 Therefore, the first two important sheets of the SNH sequence of visualisations have been missed out. This means that the full extent of this major development has not been presented in the visualisations.

7.11 Closer inspection of the 53.5 degree planar views by Stephenson Halliday reveals that the photography is actually cylindrical, not planar, as specified in the visualisation sheet information. This raises a question about the projection system used by the 3D modelling company, Tangible Visual. Have the 3D model views been rendered cylindrically, or are they planar? When matching the render views between a render and a photograph it is essential that both use the same projection system.

7.12 Normally the cylindrical projection photograph and photomontage are then re-projected to a 53.5 degree planar image as part of the windfarm visualisation sequence process.

7.13 Consequently, whilst it is encouraging to see the visualisation work undertaken by Stephenson Halliday, the actual approach and delivery falls short of what would normally be produced for windfarm visualisations, to a point where the results would actually be dismissed at Planning Application stage as not complying with the SNH guidance. For a Public Inquiry, there is no doubt that the full extent of images should have been supplied by Stephenson Halliday to correspond with the required sequence.

7.14 A detailed check on the photography used by Stephenson Halliday Viewpoints 12 and 4 was undertaken. These are shown and explained in my technical methodology [**CD10.9**].

7.15 Essentially, the photography as presented by Stephenson Halliday/WCM remains cylindrical. It is unclear if the 3D modelling renders are cylindrical or planar.

7.16 The location of the Rail Loading Facility in Stephenson Halliday's Viewpoint 12 is incorrect. In fact, the original co-ordinates and location plan given for Viewpoint 12 were completely different to the actual co-ordinates.

7.17 The failure to show the full extent of the development in views should have been addressed by SH/WCM. Detailed checks on their 3D modelling for Viewpoint 12 would have revealed similar errors.

7.18 The photography and visualisation work undertaken by Stephenson Halliday therefore fails to follow any guidance, either in 2017 or in 2021.

8.0 Photography by John Flannery

8.1 Updated photography was undertaken by John Flannery in June and July 2021 [**WCM/JF/2**]. The work appears to be reasonably thorough and captures wider views from each of the viewpoints, effectively ensuring greater coverage of the view towards the development, which had not been achieved in the original Stephenson Halliday work.

8.2 In Mr Flannery's evidence, Document No 4 is helpful in giving photographic detail of the proposed site.

8.3 These images provide wider views capturing greater detail. However, the images require careful labelling to ensure that the areas affected by the development are clearly identified. The presentation photographs should have been improved by having a 90 degree wide view on a single A1 wide sheet with clear labels. The presentation included over 180 degrees of view on an A1 wide sheet. Closer views should have used a wider angle lens to capture more vertical detail than the 50mm lens. Ideally a tripod and panoramic tripod head should have been used.

8.4 The resultant images are poor on detail and miss foreground elements which may prove important in discussions.

8.5 The site photographs don’t fully capture the whole of the development site. Additional photography should have been undertaken east of Abbey Wood, near the proposed RLF and a view from Skiddaw Road.

8.6 The viewpoint photographs correspond with the original Stephenson Halliday viewpoint numbering, although Mr Flannery appears to have changed the location of some of the viewpoints, which creates some confusion. The original Stephenson Halliday viewpoint photographs are generally very good. Whilst I have been unable to individually check each viewpoint I share a few observations.

8.7 Mr Flannery’s images appear to have been limited to an A3 sheet size. Neither the original Stephenson Halliday viewpoint photography, SNH visualisation guidance nor the LI TGN 06/19 specifies this sheet size for this size of image. Both SNH and the LI TGN require a 90 degree view on an A1 wide sheet. Or a 27 degree image on an A3 sheet can be produced (for the photomontage), according to SNH, but the 72.9 degrees shown on Mr Flannery’s evidence is almost 3 times smaller than this. As a result, there will be little detail in the resultant images.

8.8 The reference on each sheet ‘to be viewed at comfortable arm’s length’ is incorrect. For this to be correct, a 53.5 degree horizontal field of view on an A1 wide sheet would be required. The A3 images are far too small to be comfortably viewed at arm’s length. They will need to be held close to the eyes to gain a similar view.

8.9 Some of the viewpoint photography was undertaken with poor levels of visibility. In Mr Flannery’s Viewpoint 3, the western Lakeland Fells should be clearer in order to illustrate the wider context of the development in the backdrop of the UNESCO World Heritage Site.

8.10 Viewpoint 4 should have been a wider view to capture the whole of the development site, which is around 270 degrees of the view.

8.11 Viewpoint 6, A & B all appear to be within the development site and should have captured the full 360 degree view.

8.12 Viewpoint 7 appears to have been taken in extremely poor weather conditions and should be re-taken.

8.13 Viewpoint 10 appears to have an overhead electric transmission pylon in direct line of sight of the Rail Loading Facility. Moving 10 metres further north would have corresponded better with Stephenson Halliday’s original Viewpoint 10 and given a much clearer view of the site. Why Mr Flannery moved this viewpoint location is not clear, but the original location was better and more useful.

8.14 Despite Mr Flannery using the correct camera and lens, the majority of the photography is poor, and it is likely that a tripod and panoramic tripod head has not been used and that manual settings have not been used.

8.15 As Mr Flannery's photography was undertaken very recently, the presentation of his viewpoint photography should have followed LI TGN 06/19 and SNH with a 90 degree view on an A1 wide sheet. The viewpoint locations should not have been altered by Mr Flannery, as the changed location in, for example, Viewpoint 10 introduces intervening visual clutter that was not present in views towards the site in the original photography.

8.16 Many of these points have been shared with WCM, providing an opportunity for the developer to improve the quality of the information being shared in advance of the Public Inquiry.

8.17 The limited work I have done for the Rail Loading Facility viewpoints, together with a technical check on Stephenson Halliday Viewpoint 12 (Appendix 4 [**FOE/MC3/4**]), shows how the visualisation and viewpoint photography work could and should have been undertaken and presented.

9.0 Summary

9.1 In 2017 the guidance available from the Landscape Institute for undertaking and presenting photography and visualisations was poor.

9.2 Stephenson Halliday correctly identified that the approach used in SNH's Windfarm Visualisation Guidance was the appropriate technique to follow.

9.3 Unfortunately, they failed to follow the detailed requirements contained in this guidance. The resultant 53.5 degree cylindrical images on an A1 sheet produced to accompany their LVIA are not specified or required by any guidance, either in 2017 or in 2021.

9.4 WCM should have asked Stephenson Halliday to update their visualisations to correctly comply with SNH's visualisation guidance, or to update the approach to follow LI TGN 06/19.

9.5 Mr Flannery's updated photography was reasonably thorough.

9.6 However, Mr Flannery failed to take photographs in good weather conditions to give clear views of the development site.

9.7 Mr Flannery did not use a levelled tripod or panoramic tripod head, which means that the imagery will have geometric distortion.

9.8 The majority of his photography is poor and should be re-taken and presented at a reasonable size on an A1 sheet. This size is 90 degrees on an A1 sheet, which would conform with both SNH and the LI requirements.

9.9 We have presented 5 views for the Rail Loading facility in support of Mr Radmall's evidence and to check the accuracy of Stephenson Halliday's Viewpoint 12 [**CD10.8**].

9.10 The resultant images I have prepared are fair and reasonable. They conform with both SNH and the Landscape Institute TGN 06/19. We have used highly accurate survey equipment to capture the camera location to 1 cm accuracy.

9.11 As one of the technical authors behind the Landscape Institute Technical Guidance Note, and acting in an independent roll, in my opinion these images should give the Inspector, Mr Flannery, Mr Radmall and the public confidence in what is being presented to them. That is not currently the case.

9.12 I would suggest that the images for the main mine site are likely to be incorrect, based on the checks I have made, and have offered to work with Mr Flannery and Stephenson Halliday to ensure that a full set of images are produced that can be used by the Inspector and both sides and give the public confidence in what is being presented.

Photography and photomontage in landscape and visual impact assessment

Landscape Institute
Advice Note 01/11

Contents

1.0 Purpose and background

The purpose of this Advice Note is to provide advice to the landscape professional on photography and photomontage methods in landscape and visual impact assessment. It does not consider the use of photography or photomontage for other purposes, such as promoting or exhibiting a scheme.

Photographs and photomontages often form an important part of planning applications and Environmental Statements, in which the preparation and presentation of reliable visual information is integral to the assessment of landscape and visual impacts. Photographs and photomontages are technical documents in this context, and should be produced and used in a technically appropriate manner.

It is essential to recognise that:

— Two-dimensional photographic images and photomontages alone cannot capture or reflect the complexity underlying the visual experience, and should therefore be considered an approximation of the three-dimensional visual experiences that an observer would receive in the field;

— As part of a technical process, impact assessment and considered judgements using photographs and/or photomontages can only be reached by way of a visit to the location from which the photographs were taken.

This Advice Note was prepared by members of the Landscape Institute (LI) Technical Committee, in consultation with LI members and technical experts experienced in photography, photomontage and landscape and visual impact assessment. It will be reviewed and updated as necessary to reflect the rapid pace of change in digital photography and related technologies.

2.0 Current guidance

— This Advice Note supersedes LI Advice Note 01/09. The LI's guidance on photography and photomontage in landscape and visual impact assessment in Appendix 9 of *Guidelines for Landscape and Visual Impact Assessment* 2nd ed (2002) remains relevant.

— Scottish Natural Heritage's *Visual representation of windfarms: good practice guidance* states that the guidance may also be applicable to other forms of development or within other locations (SNH 2006, para 15). **The LI endorses this guidance and strongly advises members to follow this where applicable in preference to any other guidance or methodology.**

— When regulatory authorities specify their own photographic and photomontage requirements, the landscape professional should carefully consider whether they are justified, or whether they would under- or over-represent likely effects, in the professional's opinion. Consideration may then be given to adding images to the impact assessment, or omitting them, and explaining the reasons for doing so.

3.0 Principles of photography and photomontage

3.1 Objectives
The overall aim of photography and photomontage is to represent the landscape context under consideration and the proposed development, both as accurately as is practical.

The objective of photography for visual and landscape impact assessment is to produce printed images of a size and resolution sufficient to match the perspective and, as far as possible, the detail in the same view in the field (SNH 2006, para C12-21) and which can also serve as an accurate aide-memoire once the observer has left the field.

The objective of a photomontage is to simulate the likely visual changes that would result from a proposed development, and to produce printed images of a size and resolution sufficient to match the perspective in the same view in the field.

3.2 Criteria for photomontages
Photomontages use photographs of an actual scene modified by the insertion of an accurate representation of the visible changes brought about by the proposed development. They are subject to the same inherent limitations as photographs, for example only showing the scene as it would appear under the same conditions that prevailed when the original photograph was captured. A properly constructed photomontage can serve as a useful means of indicating the potential visual effect of a future development, however.

The LI recommends that for landscape and visual impact assessment purposes a photomontage should:

— be reproduced at a size and level of geometric accuracy to permit impact assessment, which must include inspection at the location where the photograph was taken;
— be based on a replicable, transparent and structured process, so that the accuracy of the representation can be verified, and trust established;
— use techniques, with appropriate explanation, that in the opinion of the landscape professional best represent the scheme under consideration and its proposed environment accurately as possible;
— be easily understood, and usable by members of the public and those with a non-technical background;
— be based on a good quality photographic image taken in representative weather conditions

3.3 Viewpoint selection
The landscape professional should select a set of photographic viewpoints which are considered representative of the range of likely effects, viewing experiences and viewers, ensuring that none are under- or over-represented. Viewpoints should be agreed with the regulatory authority or authorities where possible, and with other parties as considered necessary.

3.4 Field of view
The most appropriate combination of lens, camera format and final presentation of image should be deployed to represent the relevant landscape. This is likely to include both the site of the proposed scheme and its context, so that a scheme's appearance and its place within its environment can be recognised and understood. The proposal under consideration and its relevant landscape context will determine the horizontal field of view required for photography and photomontage from any given viewpoint. This will in turn determine whether a single-frame image will suffice or whether a panorama will be required.

While a standard lens giving a horizontal field of view of about 40 degrees may be suitable for some purposes, a single-frame photograph based on this field of view is unlikely to convey the breadth of visual information required to represent a proposed development and relevant context. If the required field of view is only slightly greater than 40 degrees, a wide-angle lens or wide-angle setting on a zoom lens may be appropriate. Where it is much greater than 40 degrees, a panoramic image produced by the careful 'stitching' together of single-frame images, or the use of a suitable true panoramic camera, can provide a more informative representation of the effect of a development in the landscape (SNH 2006, Technical Appendix B).

The horizontal field of view is usually more relevant to representations of rural and peri-urban landscapes. The vertical field of view may be more important in urban landscapes, however, in which case it may be necessary to use a wide-angle lens or wide-angle setting on a zoom lens. The camera may be used in portrait orientation for panoramic as well as single-frame images.

4.0 Photography

4.1 Cameras

A good quality camera and lens are essential to the production of photographs and photomontages for landscape and visual impact assessment work. Many good quality digital cameras are suitable, but it is essential to consider the whole process from field procedure to post-processing to printing in order to choose equipment which will give results of the accuracy required.

A camera with a fairly high resolution will be required to produce sufficiently good-quality images to be reproduced at the size required: a 12 megapixel sensor is usually sufficient. This resolution outperforms 35mm colour print film in terms of both image resolution and graininess. The lens used must be of a sufficiently high optical quality to take advantage of the sensor's resolution.

Change in all aspects of photography and photomontage have taken place over the last ten years. 35mm colour film and the associated cameras and lenses have been almost completely supplanted by digital cameras; digital image processing is now a fundamental element of photography, both within the firmware of the camera and as a subsequent operation on a computer, and printing has become wholly digital, using a wide variety of devices offering different qualities of output. Future changes will undoubtedly further change the parameters for landscape photography.

4.2 Lenses

The use of 35mm film and a 50mm focal length standard lens as a reference standard, while still valid, is now somewhat outdated. That combination of lens and film gives a horizontal field of view of a little under 40 degrees.

Use of a fixed focal length lens ensures that the image parameters of every photograph are the same, simplifies the construction of panoramas, and ensures compatibility of photography for all viewpoints. Fixed focal length lenses are often either unavailable or prohibitively expensive for many digital cameras however.

It is usually impossible to set a zoom lens to a specific focal length, apart from the longest and shortest ends of its focal length range. The zoom setting and focal length are recorded in the image metadata (EXIF data) stored with each image, however. The horizontal field of view for a given zoom lens setting can be calculated from the focal length and the camera's sensor size (see Technical Appendix for details). Theoretically zoom lenses are always of inferior optical quality to fixed focal length lenses, but the difference is not significant in modern lens design.

When a wide-angle lens or zoom lens at a wide-angle setting is used, a higher camera resolution may be required in order to obtain the same resolution in the finished image than would be needed for a 'standard' setting and an approximately 40 degree field of view (see Technical Appendix for details).

Use of a telephoto lens, or enlargement of part of a larger image, either single-frame or panoramic, may be necessary to show detail that is too small to be displayed at the correct viewing distance for the image as a whole. The purpose of the additional image should be explained when this is done.

4.3 Setting up and recording data

Wherever possible, cameras should be tripod mounted and levelled in horizontal and vertical axes. Where it has been necessary to raise or lower the horizon line by cropping, this should be stated.

It is recommended that the following data is recorded:

— Camera, lens focal length and horizontal field of view
— Date, time, weather, lighting conditions and direction of view
— The viewpoint's height above ground level and OS grid coordinates

5.0
Preparing and viewing images

5.1 Producing photomontages

A digital photomontage consists of a base photograph composited digitally with a computer-rendered image of the proposal under consideration. This compositing process will typically include digitally manipulating the masking of the proposed development by foreground features and may also involve digitally removing existing features such as trees. The compositing necessarily demands a level of digital manipulation and visual skill and judgement on the part of the person carrying it out.

It is critical that the scale of the proposal and its location within the scene depicted in the photograph are accurately represented. In order to achieve this, it is necessary to match the perspective parameters of the photograph accurately, to record viewpoint location and camera settings, and to use rendering software correctly (SNH 2006, para 209ff).

Explanatory text should be provided to describe the procedure used to fit the rendered image to the underlying photographic view. The accuracy of a photomontage may usefully be illustrated by means of a wireline image incorporating sufficient topographic or other features to allow a comparison to be made between the wireline and the photograph.

It should be borne in mind when preparing images that inkjet printing, laser printing and digital press technologies all have different colour rendition and resolution issues. A minimum resolution of 300 pixels per inch will generally be required for high-quality printing (see Technical Appendix). The image size and resolution together determine the number of pixels required to be captured by the camera.

5.2 Viewing distance

Given that the objectives of photography and photomontage are to produce printed images of a size and resolution sufficient for use in assessment work in the field, the exact dimensions of these images will depend on the characteristics of the view under consideration.

All photographs, whether printed or digitally displayed, have a unique, correct viewing distance - that is, the distance at which the perspective in the photograph correctly reconstructs the perspective seen from the point at which the photograph was taken (SNH 2006, para A18-25). The correct viewing distance should be stated for all printed or digitally displayed photographs and photomontages, together with the size at which they should be printed. All photographs and photomontages used in a document should have the same viewing distance whenever possible.

The viewing distance for hand-held photographs and photomontages should be between 300mm and 500mm (SNH 2006, para 126). The viewing distance and the horizontal field of view together determine the overall printed image size.

Photographs and photomontages should be printed or published digitally at an appropriate scale for comfortable viewing at the correct distance, noting the limitations of the printing process particularly with regards to colour and resolution. Guidance should be provided on viewing the image in order to best represent how the proposal would appear if constructed, such as the required viewing distance between the eye and the printed image, and an indication of whether the image is a single-frame or panorama. Panoramic images should be curved so that peripheral parts of the image are viewed at the same intended viewing distance, or viewed by panning across a flat image with the eye remaining at the recommended viewing distance (SNH 2006, para B20). It is important to indicate the correct viewing distance for single-frame or panoramic images to allow consistent comparison between different image formats provided from the same viewpoint. The ‘before’ photograph and the ‘after’ photomontage should be presented on the same page and/or at the same scale to allow comparison if practicable.

6.0 Summary

The selection of an appropriate combination of camera, lens and printing technology requires informed technical decision-making. Other aspects of photography and photomontage such as choice of view, post-processing, and presentation of the final images are a matter of professional judgement.

A suitable digital camera for environmental impact assessment work will need to have a fairly high resolution sensor, good quality lenses, and manual focus and exposure settings. Most digital SLRs and some non-SLRs are likely to be suitable. The quality of the printing process is critical in producing finished images which successfully reproduce the digital data captured by the camera. As much care and consideration should be applied to the selection of a print process as to the selection of a camera.

Landscape Institute Technical Committee
February 2011

References

Landscape Institute and IEMA (2002) Guidelines for landscape and visual impact assessment (2nd ed). London: Spon.

Scottish Natural Heritage (2006) Visual representation of windfarms: good practice guidance. Inverness: Scottish Natural Heritage. SNH report no. FO3 AA 308/2

Technical appendix: Digital photography

This appendix provides technical background information on digital photography relevant to landscape and visual impact assessment work, as little detailed advice is available on this subject. This appendix should be read in conjunction with the Technical Appendices in the SNH guidance *Visual representation of windfarms: good practice guidance*, referenced below by the relevant paragraph number in brackets.

Focal length and field of view

As with any camera, a digital camera's horizontal field of view is determined by the focal length of the lens and the size of the sensor (A26-28). The formula given in (A27) provides a method of calculating the field of view.

The sensor size will usually be stated in the documentation supplied with a digital camera, but may not be specified in millimetres. For example, the commonly used 23.7 x 15.7mm size may be expressed as 1.8" or as APS-C. It may require some online research to discover the actual dimensions.

For a fixed focal length lens, the focal length will usually be marked somewhere on the lens barrel. A zoom lens will generally have the range of focal lengths marked on it. To determine the focal length used for an image taken using a zoom lens, it is necessary to refer to the EXIF metadata stored with the image. Lens focal length is one of the fields of information usually stored in the EXIF data. This value needs to be known to at least one and preferably two decimal places in order to calculate the field of view accurately. Different cameras store this information to different degrees of numerical precision. Software also varies in the number of decimal places it shows for the focal length value.

Some models of digital camera have been found to store inaccurate information in the EXIF data. It is prudent to take advice on this before purchasing a camera.

35mm equivalent focal length

The focal length of lenses on digital cameras is sometimes expressed in terms of the '35mm equivalent focal length'. This value is what the focal length of a lens on a 35mm film camera would be with the same horizontal field of view as the camera and lens combination under discussion. For example a lens with a focal length of 32.9mm on camera with a sensor 23.7mm wide would have a horizontal field of view of about 39.6 degrees, the same as a 50mm lens on a 35mm film camera. A 32.9mm focal length lens in this context might therefore be described as a 50mm equivalent lens.

The 35mm equivalent focal length is one of the fields of information stored in the EXIF data of a digital image but unfortunately not all cameras store this information and those that do round it to the nearest millimetre of focal length, which is not sufficiently precise for field of view calculations.

Print resolution

Given that the objective is to produce a printed image, the required print resolution is the starting point for calculating the required camera resolution. This appendix therefore addresses these issues in the order that they should be considered.

The limit of acuity ability to resolve detail of the human eye is about 1 minute of arc (C1). At a viewing distance of 300mm, this equates to a spatial dimension of 1/291 inch. A good target resolution for printing is therefore 300 pixels per inch PPI giving a pixel size of 1/300 inch for images to be viewed at 300mm viewing distance.

At greater viewing distances, larger pixels may be used and still be too small for the eye to resolve individually. For 400mm viewing distance, the minimum resolution is 225 PPI and for 500mm viewing distance, it is 180 PPI.

Note that pixels per inch, PPI, is not the same as the dots per inch, DPI, usually used to describe printer resolution. Each pixel in a photographic image consists of 256 levels of brightness in each of red, green and blue, giving 16,777,216 possible different colours and this is what is displayed on a monitor. Most printers can only lay down dots of pure primary colours of ink or toner, depending on technology. Many printers can deliver variable ink drop sizes and many have more than the minimum of four primary colours of ink available, but each printed dot is still limited to far fewer colours than the number required to reproduce the contents of a pixel. The technical solution to this is to lay down many very small dots to represent each image pixel. For this reason, the printer resolution required to deliver a 300 PPI image may be as high as 2400 DPI depending on the printer technology used.

It may in practice be difficult to achieve 300 PPI printing, which may lead to a decision either to accept a lower print quality or to use a viewing distance greater than 300mm.

It is important to understand the limitations of the print process chosen, whether the printing is being done in-house or by an external print bureau. It will probably be necessary to print some test images to check the print quality.

Calculating the required camera resolution

Having decided the image resolution required to print images at the sizes recommended in the 2006 SNH Good Practice Guidance, it is possible to to arrive at the minimum camera resolution needed to achieve that.

Printed image size is defined by horizontal field of view and correct viewing distance (D2). It therefore follows that the horizontal scale of an image, which may be expressed in millimetres per degree of field of view, is determined solely by the correct viewing distance. For example, a 360 degree panorama with a correct viewing distance of 300mm is 1885mm wide; see (B22-29) for formulae. The image scale will therefore be 5.24mm per degree. For a panorama with a viewing distance of 500mm, the scale is 8.73mm per degree.

A panoramic image has a constant horizontal scale, so the millimetres per degree calculated above, will be correct across the whole width of the image. A single-frame image, however, has a scale increasing radially from the centre. The values calculated above will therefore only be correct at the centre of a single-frame image and will increase towards the sides of the frame; see (A11-13) and (B17-18).

At 300 PPI print resolution, these calculated scales correspond to 61.8 pixels per degree for 300mm viewing distance and 103.1 pixels per degree for 500mm viewing distance.

These resolutions are therefore the minimum angular resolution that it is desirable to capture in the original digital image in the camera for eventual use at 300mm and 500mm viewing distances.

It is not mathematically correct simply to multiply the pixels per degree resolution by the field of view of the lens to obtain the required number of pixels across the image. The true value will always be less than a simple multiplication. However, as this calculation is simply a way of checking that enough image detail is being captured, a simple multiplication is a good enough estimate, especially as it is guaranteed to be an overestimate.

If the lens used has a horizontal field of view of 39.6 degrees equivalent to a 50mm lens on a 35mm camera (Table A1), then for 300mm viewing distance printing, the required image width in the camera is 61.8 x 39.6 = 2448 pixels rounding up to the nearest pixel, which is about equivalent to a 4.5 megapixel image. For 500mm viewing distance, the required image width is 103.1 x 39.6 = 4083 pixels, equivalent to about 12.5 megapixels.

If it is necessary to use a wide-angle lens or wide-angle zoom setting, rather higher numbers will result. If the lens has a field of view of 65.5 degrees equivalent to a 28mm lens on a 50mm camera (Table A1), then for 300mm viewing distance, the required image width will be 61.8 x 65.5 = 4048 pixels, equivalent to about 12.3 megapixels. For 500mm viewing distance, this becomes 103.1 x 65.5 = 6754 pixels, equivalent to about 34.2 megapixels.

For most purposes, a 12 megapixel camera will produce images with detail at the limit of the print technology used to reproduce them. If however, it is necessary to print material for 500mm viewing distance based on original photographs taken with a very wide-angle lens, then either a very high specification camera will be needed or a slightly lower image quality may have to be accepted.

For comparison, it should be borne in mind that 35mm film has a resolving power about equivalent to a 9 megapixel digital sensor; a 12 megapixel camera will potentially capture far more detail than was ever possible with film. Also note that while 300 PPI print resolution is essential at 300mm viewing distance, 225 PPI will produce the same effect at 400mm viewing distance and 180 PPI at 500mm, although it will look a little 'blocky' on the page until held at the correct distance.

Choice of lenses

As noted in the SNH guidance, the main issue in the choice of lens focal length is the balance between detail captured and field of view (D7); there is no single best focal length that works best under all circumstances.

Irrespective of the focal length of a lens, its optical quality is of paramount importance. Many digital cameras offer very high resolutions in terms of megapixels. However, it is the case with some cameras, particularly cheaper ones, that the resolving power of the supplied lens does not justify the installed sensor resolution. The fact is that digital sensors and memory chips are quite cheap components whereas good lenses are relatively expensive.

There is no simple way of judging the quality of a camera lens; however, an informed choice can often be made based on in-depth independent technical reviews many are available on-line and a study of sample images.

Technical appendix: Digital photography

Camera settings
Most digital cameras come with a plethora of automatic settings designed to make the photographer's task easier. Some of these should be disabled or treated with caution while undertaking photography for landscape and visual impact assessment.

Autofocus: Many passive autofocus systems are sensitive to the presence of foreground objects and can result in the focus being at less than infinity. More seriously, the focus can be slightly different in successive frames of a panoramas, potentially precluding a clean splice. Autofocus should be switched off and the lens manually focussed on infinity (E8-9). Note also, that as focussing involves physically shifting the lens back and forth along its axis, focussing other than on infinity will change the principal distance of that image (A21-22).

Digital zoom: Many inexpensive digital cameras offer both 'optical zoom' and 'digital zoom'. 'Optical zoom', as the name implies, uses the optics of a zoom lens to enlarge the image projected onto the sensor. 'Digital zoom' is a simple enlargement of the digital image and adds no information. 'Digital zoom' should never be used in photography for landscape and visual impact assessment.

Automatic exposure: Automatic exposure greatly speeds opportunistic photography, but rarely results in optimum results for landscape and visual impact assessment work. Manually setting an aperture of about f/5.6 or f/8 will usually yield the sharpest possible photographs (E11). The ISO setting for the sensor should generally be set to 400 or less to limit image noise. Some cameras have a special panoramic setting which enables the shutter speed, aperture and ISO setting of the first frame to be maintained for successive frames. If that facility is available, then it may be possible to use an aperture-priority automatic mode, otherwise it is safer to meter a typical frame in the panorama and then set the exposure manually (E10).

Automatic white balance: Many digital cameras have a facility to automatically compensate for ambient colour temperature, so that, for example, photographs taken under indoor lighting do not appear yellow compared with those taken in daylight. This facility can have unforeseen consequences when taking panoramas. For example, the presence of a red telephone box in the foreground of one frame may result in a cyan cast on the colour in that frame only. White balance should be set manually to daylight.

Image sharpening: Many digital cameras have a facility to sharpen the photographic image in the camera. This option should be switched off. Compositing a photomontage is much more difficult to do satisfactorily if the base image has already been sharpened, particularly if it is over-sharpened. Any image sharpening required for printing can be done in a more controlled manner in image processing software.

Image format: All digital cameras offer a range of formats in which the image will be stored on the camera's memory card. Typically these will be JPEG at a variety of quality settings, camera 'raw' and on some cameras, but increasingly supported Adobe DNG digital negative format. Raw and DNG both serve the same function of storing the contents of the sensor unaltered hence 'raw' together with a series of parameters recording the camera's current settings. Thus post processing stages, such as white balance and sharpening are recorded as parameters but not actually applied to the image. Raw and DNG provide the user with the maximum possible opportunity to get the best quality out of the image. Their disadvantage is that the image sizes will be 2-6 times as large as JPEG equivalents, requiring more storage space on memory cards and computers and also requiring more time and effort to post-process. Unless there is a compelling reason to use raw or DNG, the highest-quality JPEG format usually provides sufficient image quality. Some cameras provide the option of automatically storing both raw and JPEG, which allows the choice of format to be made on an image by image basis but of course requires even more storage space than raw alone.

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Scottish Natural Heritage

Visual Representation of Wind Farms

Guidance

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CONTENTS

1 Introduction

1 ‘Pictures speak louder than words’. Images are a powerful way of conveying information, illustrating options and capturing our imagination. They also form an important part of planning applications and Environmental Statements. The landscape and visual assessment of wind farms, however, involves much more than just looking at visualisations.

2 This guidance is aimed at landscape practitioners, those involved in producing visual representations of wind farms and at planning officers or decision makers involved in the planning process. A condensed version aimed at members of the public is also available on our website. The visualisations described are designed for use by **all** stakeholders within the planning process.

3 Visualisations are very useful in communicating information, but they can never tell the whole story. They cannot replicate the experience of seeing a wind farm in the landscape, whether they are photographs, maps, sketches or computer-generated visualisations, prepared using the highest specification and skill possible. They are an aid to decision making which must be considered alongside further information.

4 Experience gained since this guidance was first published in 2006 has led to a better understanding of how to represent proposed wind farm developments in a more accessible and realistic way. The revised methodology provides visualisations which are easier for both the public and decision makers to use. New sections on offshore wind farms and repowering have also been included, and there are additional points on turbine lighting.

5 Nonetheless, anyone using visualisations should be aware of their limitations, and these are explained throughout the text and in **Annex A. It is recommended that the standard text in Annex A should be inserted into the Environmental Statement and made available at public exhibitions.**

6 **All wind farm applications requiring a Landscape and Visual Impact Assessment as part of an Environmental Impact Assessment should conform with the requirements set out within this document**. Applications which do not require an EIA should follow a proportionate approach agreed with the determining authority. Different landscapes, types of wind farms and conditions in other countries may require different approaches. SNH cannot offer advice on applications outside Scotland.

7 Smaller scale wind farm proposals (up to 3 turbines) and single turbine applications do not usually require the same level of visual representation. A tailored, proportionate approach is required which is likely to include fewer viewpoints (2-3 will generally be sufficient) and fewer visualisations per viewpoint. This should be determined on a case-by-case basis. Wirelines may be relatively unhelpful in flat landscapes for example, other than during the design stage or in conjunction with other, photographic, visualisations. However, we recommend that the same methodology (camera, lens, image presentation) is used for small scale applications for consistency and ease of understanding by decision makers and members of the public. Viewpoints immediately adjacent to small scale proposals tend to less useful than those a few

kilometres away which show more context. Our guidance on assessing small scale wind farms should be referred to.

8 Some aspects of this guidance are **prescriptive and must be complied with**. A summary of these requirements is provided in **Annex B**. Other aspects include options, and it is for the landscape assessor to choose the most appropriate approach for the site in question, agree it with relevant consultees, and justify these choices in the ES.

9 Some planning authorities have also produced specific guidance for wind farms and single turbines. Early engagement with authorities is encouraged to establish their information requirements. SNH will require visualisations which meet the requirements of this guidance for all applications we are consulted on.

Landscape and Visual impact assessment

10 Landscape and visual impact assessment (LVIA) is the method used to identify and assess the effects of, and the significance of, change resulting from development on both the landscape and on people's views and visual amenity (see Guidelines for Landscape and Visual Impact Assessment, 3rd edition, 2013 (GLVIA)). Visual analysis forms just one part of a Visual Impact Assessment (VIA), the process by which the potential significant effects of a proposed development on the visual resource are methodically assessed. In turn, VIA forms just one part of a Landscape and Visual Impact Assessment (LVIA) and the wider process of Environmental Impact Assessment (EIA).

11 It is essential that a wind farm proposal is assessed within its wider landscape and visual context. For those who visit the viewpoints described, the context will be visible in the field. However, many people, including members of planning committees and other decision makers, may not be able to visit all of the viewpoints for themselves. It is therefore essential that visualisations which demonstrate the wider landscape and visual context are provided to all audiences throughout the development process. The combination of images in this guidance seeks to achieve this.

Stages in the planning process

12 Different types of visualisations (plans, maps, wirelines, photographs, photomontages) will be used at different stages in the process. Flexibility is required to provide the right information to the right audiences at each stage in the process. An indication of likely requirements is provided below.

Pre application

13 Prior to the application being submitted, draft wirelines and Zone of Theoretical Visibility (ZTV) maps will be most useful for the designer, assessor, planning authority and consultees such as SNH. Draft photomontages, which comply with the standards set out in section 4, may also be useful for public exhibition. It is important that draft images are clearly labelled as such so that it is clear to everyone that the design of the wind farm is likely to change prior to the submission of the application.

Submission of the planning application

14 A combination of images will be required to support the planning application, and these are described in more detail in section 4. All images submitted alongside the application should conform with this guidance and be as accurate as possible in terms of turbine height and turbine locations, noting that these may alter through the decision-making process.

Decision making

15 Whether the application is determined by the planning authority, or by an appeal or inquiry, or by Scottish Ministers, it is for the decision-maker to determine which images to use to inform their decision. In some cases a detailed examination of all the images may be required, including visits to viewpoints. In others it may be possible to reach a determination on the basis of a selection of images. Either way, the purpose of this guidance is to generate a suite of images that all decision makers, consultees and members of the public can use to inform their judgement. Each individual image serves a different purpose and it is important decision makers use the correct image for the correct purpose. **Annex C** provides a summary of when each of the images should be used.

16 In all cases **it is important that decision makers consider the proposal within the wider landscape and visual context**, ideally by visiting the viewpoint or by viewing suitable panoramas. Zone of Theoretical Visibility maps should also be referred to.

Visiting viewpoints

17 It is important that key viewpoints are visited in order to assess likely effects. **To facilitate this, we now recommend that all visualisations are folded to A3 and provided in a ring binder for ease of use**.

Cumulative Landscape and Visual Impact Assessment (CLVIA)

18 As the number of proposed wind farms increases, cumulative impacts become more prevalent. Separate guidance from SNH describes how to assess cumulative impacts. The methodology in this guidance takes account of the need to illustrate cumulative effects and recommends the use of additional tools to do so.

Scope of this guidance

19 This guidance is focussed on the production of visualisation-related materials to be included within an Environmental Statement (ES) LVIA, made available to the public and to inform decision making. Other methods of visualisation using computer animation and video montage are not covered in this guidance. These methods may be helpful to illustrate the effects of the proposal, in some situations adding value to the decision making process, although the outputs are difficult to verify. These methods are not currently considered appropriate as a replacement for hard copy visualisations in the ES, although advances in technology may facilitate this in the future. This guidance applies to both **onshore and offshore** wind farms. Slight differences in the methodology apply to offshore wind farms and these are described in Section 5.

Glossary of key terms

Cylindrical projection A method used to map a panorama onto a curved surface using software. The arc of curvature in degrees is equal to the overall horizontal field of view.

DTM Digital Terrain Model. A 3D model of the topography within the study area.

Environmental Impact Assessment (EIA) The evaluation of likely significant effects on the environment of development proposals.

Focal Length Refers to the focal length of the lens used to take the photograph(s).

Landscape and Visual Impact Assessment (LVIA) This is the professional and methodical process by which assessment of the effects of a proposed development on the landscape and visual resource is undertaken. It comprises two separate but related parts - Landscape Impact Assessment and Visual Impact Assessment.

Landscape Impact Assessment This is the process by which assessment is undertaken of the effects of a proposed development on the landscape as a resource, including its character and quality; and the significance of the likely effects.

Panorama An image covering a horizontal field of view wider than a single 50mm frame. Wirelines and photomontages may also be produced as panoramas.

Photomontage A visualisation which superimposes an image of a proposed development upon a photograph or series of photographs.

Planar projection A method used to map a panorama onto a flat surface using computer software. The result is the same as the way in which a camera lens creates an image on the flat film or sensor.

Principal distance The perpendicular distance from a printed image at which the exact perspective 'as seen by the camera' is reconstructed.

Scoping The process of identifying the likely significant effects of a development on the environment which are to be the subject of assessment.

Visual impact assessment The professional and methodological process used to identify and asses the visual effects, and their likely significance, of a proposed development. Visual effects are effects on specific views and on the general visual amenity experienced by people.

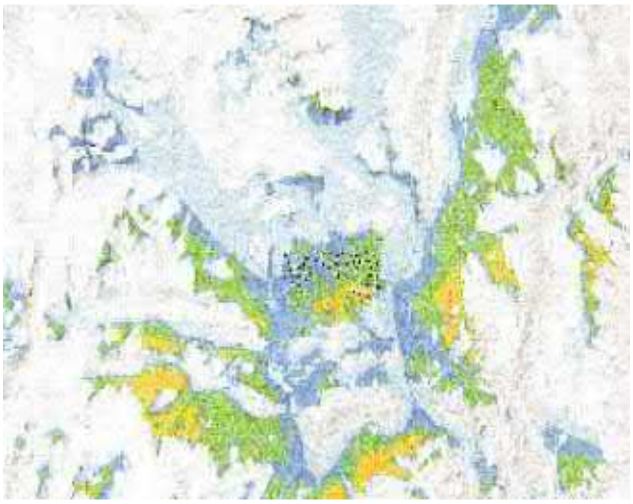
Visualisation A computer simulation, photomontage or other technique to illustrate the predicted appearance of a development. This includes photographs, wirelines and photomontages, but not Zone of Theoretical Visibility (ZTV) maps.

Wirelines These are also known as **wireframes** and **computer generated line drawings**. These are line diagrams that are based on DTM data and illustrate the three-dimensional shape of the landscape in combination with additional elements such as the components of a proposed wind farm.

Zone of Theoretical Visibility (ZTV) Previously known as **Zone of Visual Influence (ZVI).** This represents the area over which a development could theoretically be seen, based on a DTM. The ZTV usually presents a 'bare ground' scenario – i.e. a landscape without screening structures or vegetation.

2 Zone of Theoretical Visibility Maps

20 The term 'Zone of Theoretical Visibility' (ZTV) is used to describe the area over which a development can theoretically be seen, based on a Digital Terrain Model (DTM) and overlaid on a map base. This was previously known as a Zone of Visual Influence (ZVI), however the term ZTV is preferred for its emphasis of two key factors:



- the maps indicate **theoretical** visibility only - that is, the areas within which there may be a line of sight, but the proposal may not actually be visible in reality due to localised screening which is not represented by the DTM; and

- they do not convey the **nature or magnitude** of visual effects, for example whether visibility will result in positive or negative effects, and whether these are likely to be significant or not.

21 Production of ZTVs is usually one of the first steps in LVIA, helping to inform the selection of the study area in which impacts will be considered in more detail. ZTVs provide the following information:

- from where wind turbines are most likely to be visible;
- how many of the wind turbines are likely to be visible;
- how much of the wind turbines is theoretically visible (if separate ZTVs are produced showing theoretical visibility to blade tip height, and also theoretical visibility of the hub or nacelle); and
- a means of identifying the extent and pattern of theoretical visibility.

ZTV maps are a powerful tool, but require careful interpretation. The number of ZTV maps should be kept to the minimum required to enable proper assessment of the proposal.

22 In combination with a site visit, possibly with initial wireline diagrams, this information enables the landscape architect or experienced specialist assessor to identify a provisional list of viewpoints (see Section 3). It also allows the determining authority and consultees to judge how representative these are of the range of likely landscape and visual receptors and whether they include particularly sensitive vantage points. Information such as designated landscapes and popular walking / scenic routes can also be included.

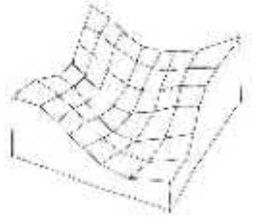
23 Importantly, **ZTVs indicate areas from where a wind farm is theoretically visible within the study area, but they cannot show what it would look like, nor indicate the nature or magnitude of landscape or visual impacts**.

USES OF ZTVs	LIMITATIONS
• A ZTV gives a good indication of the **broad areas** from where wind turbines might be seen and can help identify the LVIA study area • The ZTV can be used to help **identify viewpoints** from where turbines may be visible, enabling an assessment of these with the aid of visualisations • A ZTV is a useful tool for comparing the relative theoretical visibility patterns of different wind farms or different wind turbine layouts and heights	• A ZTV is only as accurate as the data on which it is based and the algorithm used in its calculation • A ZTV alone **cannot indicate the potential visual impacts** of a development, **nor show the likely significance of impacts**. It shows theoretical visibility only • It is not easy to test the accuracy of a ZTV in the field, although some verification will occur during the assessment from viewpoints

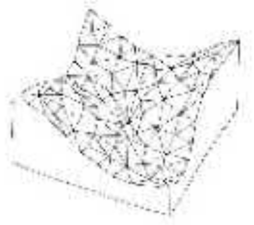
ZTV preparation

ZTV height and/or terrain data

24 A ZTV is produced using a specialised software package. Several of these are commercially available and most wind farm design packages, and many Geographical Information System (GIS) packages, have this facility. However, operation of even the most user-friendly package requires a high level of expertise and understanding of all the specific features and assumptions applied by the software. The name and details of software used should be noted in the ES and on the ZTV itself, including the version and the date of the data used.



Square grid DTM



TIN

25 ZTV production begins with a DTM that represents the ground surface as a mesh of points. This may form a regular grid of squares when seen on plan, known as a Square Grid DTM; or an irregular network of triangles, known as a TIN (Triangulated Irregular Network).

26 A Square Grid DTM cannot represent terrain features smaller than the cell size, for example a small knoll or outcrop. Such features are either lost between grid points or represented by one point only. A TIN can, in principle, illustrate finer detail than a Square Grid DTM, as it can represent all the detail shown by contours. However, in practice, a Square Grid DTM with a suitably chosen cell size will represent almost as much detail, and it may also interpolate better between contours on less steeply sloped land.

27 Both formats are acceptable. The choice between them is most likely to depend on the software being used, and the source of the data. It is common practice for a Square Grid DTM to be chosen if OS data is to be used, while a TIN is used when based on independent and/or detailed survey data, enabling high and low points to be better represented.

28 The Ordnance Survey (OS) supplies data in two formats - gridded, which has already been interpolated into a Square Grid DTM, and as contours, which is the usual starting point for constructing a TIN. The OS Square Grid DTM product, ‘Terrain 5’, uses a 5m cell size and is interpolated from a TIN maintained by Ordnance Survey. ‘Terrain 50’ (which is part of the OpenData initiative and therefore free) uses a 50m cell size and is derived from the same TIN.

29 The Terrain 5 DTM provides a more precise representation of topography than its Terrain 50 counterpart. Although they are interpolated from the same TIN, the smaller cell size of Terrain 5 allows smaller features of landform to be represented.

30 The recommended preference is for OS Terrain 5 data especially on ridge crests or in "rough" terrain where small-scale undulations have a significant effect on visibility. However, OS Terrain 50 is considered acceptable, especially if the terrain comprises hills or mountains with well-defined slopes. Legacy datasets, such as Landform Profile or Landform Panorama, may also be appropriate depending on the characteristics of the site and the availability of data.

31 Although considered adequate for the purposes of LVIA (given that ZTVs are just one part of the process), the accuracy of most DTMs is limited and they do not include accurate representation of minor topographic features and may not represent areas of recent topographic change, such as opencast coal mines, spoil heaps and road cuttings. Known significant discrepancies between the DTM and the actual landform should be noted in the ES text. If survey information on recent topographic change is available, together with the necessary software to amend the DTM, it may be useful to include it. Any changes to the DTM should also be noted in the text.

32 The OS provides accuracy figures for each of its data products (expressed statistically as root-mean-square error in metres). Where the DTM is obtained from another source, the accuracy can also usually be obtained from the data supplier. These accuracy figures should be stated within the ES.

33 ZTV production also requires accurate data on the locations and heights of the proposed wind turbines. For the purposes of ZTV calculation, it is sufficient to represent each proposed turbine as a single point in space, located directly above the centre of the proposed base of the turbine. The height specified is usually that at either hub or nacelle height, or at a blade tip pointing straight up, but can be at any other point on the turbine depending on the ZTV analysis required.

34 It is recommended that separate ZTV calculations are run for the overall height (to blade tip) and for the height of the turbine to its hub (representing the nacelle that houses the generator on top of the tower). This is a useful comparison that helps to identify areas where turbine blades may be visible, but not the tower. These separate ZTVs will also be helpful for proposals involving turbine lighting, as lights are usually sited on the nacelle.

35 In some cases it may be useful to provide alternative ZTVs showing different turbine heights to enable comparison of the effects on wind farm design. Creating a draft ZTV for different

portions of the wind farm can also aid wind farm design, particularly for large applications on complex terrain.

ZTV calculation

36 Some software packages offer both a standard and 'fast' option for ZTV calculation. 'Fast' implies the use of mathematically approximate methods in order to speed up the computation, which tends to result in a more generalised pattern of visibility. It is recommended that this is only used to obtain a provisional result which will be later superseded by a more comprehensive calculation for presentation in the ES. It is also important that users of ZTV software are clear about the technical limitations inherent in their chosen package.

37 Visibility is affected by earth curvature and the refraction (bending) of light through the atmosphere, particularly at greater distances. The effect of earth curvature should be included in the ZTV calculation as its absence will tend to overestimate visibility. **Annex D** describes this issue in more detail and includes a table of the vertical difference introduced by earth curvature and refraction with distance. At 10km, the vertical difference is enough to hide a single storey house and it increases thereafter.

38 These limitations, inherent in the data and in the method of calculation, should always be acknowledged and, if possible, quantified. Note that these limitations may either over or under-represent visibility. As a general rule, **ZTVs should be generated to err on the side of caution, over-representing visibility**.

39 A ZTV usually represents visibility as if the ground surface were bare. It takes no account of the screening effects of intervening elements such as trees, hedgerows or buildings, or small scale landform or ground surface features. In this way, the ZTV can be said to represent a 'worst case scenario'; that is, where the wind farm could potentially be seen given no intervening obstructions, and in favourable weather conditions (while accepting that the DTM data can sometimes understate visibility at the very local level). To assess how this might be affected by typical visibility conditions within a particular area, Meteorological Office data on visibility conditions can be obtained.

Taking account of surface screening

40 Some software allows the use of more sophisticated datasets, enabling some screening effects to be taken into account. One example is the application of different "thicknesses" to various land uses such as forestry and urban areas. When doing this the results will be closely tied to the specifications used, for example the height of trees; as a consequence, these should be noted within the ES. Another example is the use of digital surface data obtained from laser-based aerial surveys which represent the tops of vegetation and buildings.

41 For most projects these datasets do not make a significant difference to the pattern of visibility and they tend to be quite expensive (though some datasets such as VectorMap are free); therefore, their use should be limited to specific projects and viewpoints where the benefits will be notable. For example, it may be used to examine visibility in detail within a property listed in

the Inventory of Gardens and Designed Landscapes, or other key natural or cultural heritage assets.

42 Care needs to be taken when assessing ZTVs which take screening into account, as their accuracy is limited by data availability and the constant change in landscape conditions. Particular care is required when representing forestry, which will be felled and replanted on varying timescales, and should not be considered a permanent screening feature. If these techniques are used too simplistically they can lead to turbines being indicated as visible from the roofs of buildings, and the top of woodland canopy, which may be correct but is unrealistic for the person on the ground.

43 In some situations, it might be useful to map other characteristics such as the number of wind turbines seen against the skyline, or what proportion of the horizontal field of view is likely to be occupied by the visible part of a wind farm - known as the 'horizontal array angle' or 'horizontal subtended angle'. This information is particularly useful for considering the impact of a very large wind farm, or several wind farms where they would be seen together within panoramic views. However, for most wind farms the width of view can usually be more simply judged by considering the distance to the development in combination with wireline diagrams from specific viewpoints.

44 Any analyses that calculate characteristics other than simple visibility over bare ground should be produced **in addition to bare ground visibility**, not as an alternative to it. Although these currently have various limitations, improvement and development of these kinds of datasets is likely to occur in the future.

Viewer height

45 Viewer height in a ZTV map is generally set at 2m above ground level. This is higher than the camera height recommended for photographic visualisations (1.5m) to compensate for potential inaccuracies in digital terrain data and to ensure that the 'worst case' is represented. There may, however, be specific circumstances when an alternative viewer height is more appropriate (such as a very extensive flat landscape). Where this is the case it should be explained in the ES.

Extent of ZTV

46 A ZTV map illustrates locations within a study area from where a development would potentially be visible. However, just because a development can be seen, it does not automatically follow that this will result in likely significant landscape and visual impacts. This creates a circular process of decision-making. The final distance of a ZTV should extend far enough to include all those areas within which significant visual impacts of a wind farm are likely to occur (LVIA "study area"); yet the significance of these landscape and visual impacts will not be established until the VIA has been completed; and the LVIA process needs to be informed by the ZTV. As part of this cycle of assessment, the distance recommendations given within the table below act as a starting point.

47 The extent of ZTV required may need to be adjusted inwards or outwards according to the specific characteristics of a landscape and/or proposed development. The extent of the final ZTV should be discussed and agreed with the determining authority and consultees. In some situations where cumulative effects are being assessed the ZTV may not be circular in shape, but may be extended to include a specific transport route, for example.

48 The table below recommends the initial ZTV distance for defining the study area based on turbine height. Greater distances may need to be considered for the larger turbines used offshore.

Height of turbines including rotors (m)	Recommended initial ZTV distance from nearest turbine or outer circle of wind farm (km)
up to 50[1]	15
51-70	20
71-85	25
86-100	30
101-130	35
131-150	40
150+	45

49 If a wind farm is very small and concentrated in layout, typically 5 wind turbines or fewer, it may be reasonable to measure the extent of the ZTV from the centre of the site. However this should always be agreed with the determining authority and consultees.

50 The purpose of the ZTV is to illustrate theoretical visibility (within reasonable limits), not significant effects. Wind turbines can be visible at considerably greater distances than 30km and, regardless of likely significance, potential visibility should be illustrated on the ZTV to an agreed radius. The reasons for establishing the eventual radius of a wind farm ZTV for use in an ES should be clearly documented.

Cumulative ZTVs

51 Representing cumulative ZTVs can be difficult when there are large numbers of wind farms involved. A sensible and pragmatic approach is required to focus on the **wind farms with which significant cumulative effects are likely to occur and which are likely to affect decision making**. Reproducing very large numbers of overlapping cumulative ZTVs does little to assist decision making. The selection of ZTVs should therefore be discussed and agreed with the planning authority and consultees at an early stage.

52 Presenting cumulative ZTVs in a sequence of pairs or trios can help avoid confusion. A maximum of three sites per ZTV is recommended. Where there are large numbers of combinations of ZTV it may be helpful to present the various iterations in digital format, enabling users to switch on and switch off the various layers of visibility on screen. It may also be helpful in some locations to treat multiple wind farms which are closely clustered together

[1] See Assessing the impact of small scale wind farms on the natural heritage (2016)

as a single wind farm to reduce the number iterations. If this approach is taken only the main ZTVs need to be provided in hard copy within the ES.

Presentation of ZTV information

Base map

53 A ZTV should be presented on a single piece of A1 paper folded within the ES, using OS 1:50,000 as the base map. For a ZTV to be clear and legible when overlain with colour shading the base map needs to be in greyscale. This is to prevent confusion of overlays: for example a yellow overlay upon blue coloured lochs will appear green, and this could be confused with woodland. To maximise legibility it is also important that the base map is of a high quality resolution and not too light or dark.

54 Feedback suggests that some users find it useful to see the ZTV data beyond the agreed maximum radius shown on the ZTV. We therefore recommend that the ZTV layer is shown on the full A1 page and is not clipped to the agreed radius shown on the map.

55 Each individual wind turbine should be clearly marked upon the ZTV, usually shown as a small circle or dot, depending on the base map against which it has to be distinguished. It is recommended that the ES includes a map that shows individual turbine numbers and their grid coordinates, and that the ZTV should include reference to this map. However, it is better not to include this information on the ZTV itself to keep this map as clear as possible.

56 Numbered viewpoint locations should also be shown on the main ZTV and it is important to label these carefully to avoid obscuring vital ZTV information.

57 For ease of legibility it is recommended that the ZTV shows concentric rings to indicate different distances from the proposed development, for example 10, 20 and 30 km. The areas encircled by these rings should not be shaded or coloured as this may imply a direct relationship between distance and relative visibility or visual impact that would be misleading. To maintain legibility, the number of rings should also be limited.

58 Comparing two ZTVs that separately show visibility at blade tip and hub height will indicate where only the turbine blades, or part-blades, may be visible from. Where this is required, the ZTVs should be clearly labelled:

- Blade tip ZTV; and
- Hub height (or nacelle) ZTV.

Colour Overlays

59 Areas of potential visibility should be illustrated by a colour overlay. This should be transparent so that the detail of the underlying map can be seen clearly. The level of overlay transparency chosen should ensure that the detail of the base map remains clearly discernible and no single colour appears more prominent than another.

60 If a range of colours is to be used, the shades and tones should be chosen carefully. Darker colours tend to read as portraying greater visibility than lighter colours, whilst several colours of similar tone tend to convey information of equal importance. Using different shades of only one colour should generally be avoided, as the distinctions between bandings usually appear merged and this can also imply a gradation of impacts represented by the decreasing shades that is misleading. Legibility of a ZTV map tends to decrease with greater numbers of colours. Seven colours should typically be the maximum used on any one map, and it is recommended that these are bright and strongly contrasting.

61 When choosing a colour palette, it is also important to consider colour blindness. It is estimated that around 7-8% of males and 0.4-1% of females in Britain have some form of colour blindness. To them, legibility of maps depends on the type of colour blindness they have, the shade and brightness of the colour, and on the contrast and combinations of colours used. This requires careful consideration and is not just about avoiding the juxtaposition of red and green.

62 While it would be useful to specify a standard range of colours consistently legible to colour blind people, it is impossible to develop this without also standardising computer screens and colour printer reproduction. It is recommended that individual maps shown within each ES are checked for colour blind legibility using a quick clarification tool such as Vischeck.

63 One of the most important considerations is how the same colour will be represented differently according to the specification of different computer screens and/or printers. It is recommended that practitioners always print out draft copies to check that any discrepancy between these still produces a clearly legible map, and then print out all the final copies on the same printer.

Visibility bands

64 The theoretical visibility of different numbers of wind turbines (within a single development, or between different wind farms within a cumulative ZTV) is usually distinguished upon a ZTV as different coloured bands. These bands only differentiate between the visibility of different numbers of wind turbines. They are not intended to imply that greater numbers of turbines will necessarily result in higher levels of visual impact. These bands are particularly useful for identifying potential viewpoints where the visibility of the wind farm varies considerably within an area.

65 The number of visibility bands should be high enough for each band to represent just a small range of turbine numbers, but low enough to avoid the need for too many colours which can appear confusing. For example, with 30 turbines, it is better to have 6 bands each covering 5 turbines (1-5, 6-10, etc) rather than 3 bands of 10 turbines which would provide limited resolution, or 10 bands of 3 turbines which would appear confusing. It is recommended that no more than 7 colour bands should be used upon a ZTV.

66 Where equal banding is impossible (for example 11 turbines), then the widest band size chosen should apply to the lower end of the scale – for example 1-3, 4-5, 6-7, 8-9, 10-11, as greatest resolution is then retained where proximity is greatest. In cumulative assessments a single set of bands should be applied consistently to all maps to allow comparison if this is possible.

Recording ZTV information

67 It is vital to include information on all the key assumptions made in ZTV production, and to summarise these within the LVIA. This should include the following information:

1	The DTM data from which the ZTV has been calculated, including date, original cell size and whether this has been "down sampled" (note down sampling is not acceptable for 50m resolution data)
2	Confirmation that it is based on a bare-ground survey; where additional non-bare-ground ZTV(s) are included, provide information on the specifications of further land-use data if this has been incorporated
3	The viewer height used for the ZTV (generally 2m)
4	Confirmation that earth curvature and light refraction has been included
5	The extent of the ZTV overlay as a minimum distance from the development, in addition to the frequency of any distance rings shown
6	The numbers of wind turbines represented for each colour band
7	The height used for the turbine and whether this is to hub or blade tip
8	Confirmation that the ZTV software does not use mathematically approximate methods

3 Viewpoints

68 The term ‘viewpoint’ is used within VIA to define a place from where a view is gained, and that represents specific conditions or viewers (visual receptors). A number of representative viewpoints are chosen in order to assess:

- the existing visual resource
- the sensitivity of this resource and visual receptors to wind farm development
- the proposed design (incorporating mitigation measures to minimise any adverse impacts); and
- the predicted appearance of the proposed development

This section addresses the selection of viewpoints and the information that should be provided for them.

69 It is important to stress that **viewpoint assessment forms just one part of LVIA**. Because of the powerful nature of viewpoint images and the widespread recognition of some of the locations from where these are taken, there is often over-emphasis of their role. However, LVIA also includes assessment of the following:

- the extent and pattern of visibility throughout the study area (considering those areas from where a wind farm would not be seen, as well as those areas from where it may);
- views of the proposed wind farm from areas of potential visibility other than the selected viewpoints; and
- sequential views.

70 Separate assessment of impacts on residential properties is increasingly common. The production of visual materials for individual properties may be appropriate to assist this, but they will not normally form part of the LVIA.

USES OF VIEWPOINTS	LIMITATIONS
• Carefully chosen viewpoints enable representation of a range of views within a study area • Carefully chosen viewpoints enable representation of a range of viewers who experience the landscape in different ways • Viewpoints enable consultees to assess specific views from important viewpoints, for example settlements, tourist attractions and mountain tops • By considering a range of views at different viewpoints, the designer can consider how the wind farm would vary in appearance, informing design development	• Whilst the choice of viewpoints is very important, the LVIA should also be based on other aspects. Over-emphasis on viewpoint assessment may create the erroneous assumption that this is the only aspect of LVIA • There may be a tendency to focus on the particular characteristics of specific viewpoints, rather than considering these as being broadly representative of a wider area. It is inappropriate to make design modifications to change the visual effects of the proposed wind farm from a single viewpoint because this may have negative 'knock-on' effects from other viewpoints. A more holistic approach considers the wind farm from a range of viewpoints in relation to the design objectives.

• Views from several viewpoints can be assessed to determine sequential effects that occur as one moves through the landscape • By assessing viewpoints in combination with ZTV maps, it is possible to consider the potential pattern of visibility for a wind farm in 3 dimensions • Viewpoints which show no actual visibility of the proposal should not be shown in the ES (unless there is good reason to do so) – the rationale for this should be given in the supporting text of the ES	• A viewpoint is by its very nature static whilst views tend to be experienced on the move as well as when stationary • Some viewpoints are difficult to access and some people might not be able to assess the viewpoint on site. They will therefore rely on the landscape architect or experienced specialist assessor's assessment and visualisations to indicate predicted visual effects. It is therefore essential that sufficient landscape and visual context is provided on visualisations • Due to the limitations of DTM data several provisional viewpoints may need to be visited to find a suitable location • The exact location and conditions of individual viewpoints are required to be able to create accurate visualisations • Some requested viewpoints might be judged inappropriate for formal visualisations due to unacceptable health and safety risks

Selection of viewpoints

71 Viewpoint selection is informed by the ZTV and other maps, fieldwork observations, and information on relevant issues such as access, landscape character, designations and popular views (see GLVIA 3 for more detail). These datasets enable a provisional list of viewpoints that can be later refined through further assessment, consideration of provisional wireline diagrams and discussions with the determining authority and consultees. Interested members of the public, and in particular Community Councils, can also advise on sensitive local vantage points at public meetings and/or exhibitions held by the applicant.

72 Feedback suggests that members of the public do not feel sufficiently engaged in the viewpoint selection process. Applicants should increase their efforts to engage the public, bearing in mind the need to limit the list of viewpoints to a reasonable number. Alternative methods of illustrating the effects at individual properties (where these are required) should be considered to ensure that all local residents feel informed about the impact from their property. These would be for illustrative purposes only and they would not be assessed within the LVIA.

73 A ZTV is very useful in focussing upon those areas with potential visibility of a proposed development, but the ZTV is only one source of information used to inform the selection of viewpoints. Over-reliance on a ZTV to identify viewpoints can result in concentration on open locations with the greatest visibility of a site, which may be far from the proposed development. This may be at the expense of potential viewpoints where visibility is less extensive, but from where views of the site are more typical.

74 During early consultations regarding the provisional list of viewpoints it is essential that the determining authority and consultees are provided with a copy of the draft ZTV at the

appropriate scale and A1 size. A selection of provisional wireline diagrams may also be helpful to give an impression of possible effects from viewpoints.

75 Wirelines are used to inform the design development of the proposed wind farm during the initial stages of the LVIA. Some of the viewpoints will be described and assessed within the main ES report; however, others may ultimately be omitted, for example because they show very similar results to another viewpoint. Details regarding these original viewpoints should be included within the ES appendices if they have informed the design process. Likewise, during the LVIA process, it may be found that some of the original viewpoints will not have a view of the wind farm due to local screening or changes to the wind farm design. These should also be documented within the ES.

76 The range of issues that influence the selection of viewpoints is listed in the table below. The aim is to **choose a range of viewpoints from where there are likely to be significant effects and those which are representative of views within the study area**. Local knowledge will greatly assist this process. It is desirable to choose viewpoints which represent several of the issues described below from the same location as this will reduce the overall number of viewpoints. These issues are discussed in more detail in the GLVIA 3 paragraphs 6.16-23. It is preferable not to include too many viewpoints as this can distract attention from the key significant effects.

View type	• **Settlements and visual amenity**
	• **Various landscape character types and areas** (separate and in combination)
	• **Areas of high landscape, scenic or recreational value** – for example views to and from designated areas; wild land; long distance routes; view points; tourist routes, local amenity spaces
	• **Various distances** from the proposed development
	• **Various directions and aspects** (viewpoints from all around the development should be considered; views to the north will result in a different effect to those facing south; for design in particular)
	• **Various elevations**
	• **Various extents of wind farm being visible**, including places where all the wind turbines will be visible as well as places where partial views of turbines occur
	• **Sequential** along specific routes
	• **Cultural heritage** including the wider setting of the heritage asset
Viewer type	• **Various activities,** for example those at home, work, travelling in various modes or involved in recreation
	• **Various modes of transport,** for example those moving through the landscape by road, train, ferry, bicycle or on foot (note, in some cases it may be desirable to choose an alternative camera height to represent typical views. If so, this should be noted in the ES)

77 The assessment of viewpoints should not involve unacceptable risks to health and safety. Examples of these situations include viewpoints from motorways, railway lines, scree slopes or cliffs.

78 Viewpoints within the local area surrounding the wind farm are particularly useful in understanding and developing the wind farm layout and design. They also represent the likely effects on residents living, travelling and working within the nearest area. Local residents will experience the wind farm on a regular basis (often daily) in different weather, lighting and seasonal conditions. It is important that these effects are considered and that the assessment recognises the varying conditions in which residents will experience the wind farm.

79 When identifying viewpoints it is important to consider whether a CLVIA is also required as part of the ES. If it is, the choice of all viewpoints should be informed by the cumulative ZTV as well as the individual ZTV. In most parts of Scotland many of the viewpoints chosen will be used to represent cumulative effects. Although it is possible to add supplementary viewpoints as part of a cumulative LVIA, it is preferable to use the same viewpoints for both the individual and cumulative LVIA to enable direct comparisons to be made.

80 Likewise, it is also useful to choose viewpoints already used for other wind farm LVIAs in the surrounding area. This allows direct comparison and also assists the determining authority, consultees and the general public who are already familiar with these viewpoints. Some planning authorities have standard viewpoint lists and these should be referred to at an early stage.

81 The reasons for selection or omission of viewpoints recommended by consultees should be clearly justified and documented within the ES. **It is essential that a final list is agreed with the determining authority.** Not all viewpoints will require a photomontage. Distant viewpoints and those where there are no significant effects may be better illustrated by wirelines only.

Number of viewpoints

82 The number of viewpoints for different projects will vary depending on the scale of the proposal, the sensitivity of the receiving landscape and / or visual receptors, and how many are required to represent likely significant effects from the range of views and viewers of a development. The initial list of provisional viewpoints will probably be high. This is necessary to enable identification of the required viewpoints during the early stages of the LVIA, and to ensure that no key viewpoints have been omitted.

83 This process will involve the production of wirelines, as one will need to be produced for each layout and design option, including alternative turbine heights where these are being considered. However, these iterations are only likely to be helpful from several 'design viewpoints' and it is not necessary to provide these from all of the viewpoints agreed, or to include them in the ES.

84 After reducing the number of viewpoints to those that are required to illustrate the ES, it is common for there to be around 10-25 viewpoints within a LVIA in Scotland. However, this number will vary depending on the specific circumstances of a proposal. Over-provision of viewpoints can be as unhelpful as under-provision. This is because an excessive number of

viewpoints may distract attention from the smaller number of viewpoints where impacts may be significant. **An appropriate balance must be struck through the LVIA consultation process to agree a proportionate number of viewpoints**.

85 Feedback gathered by our research project and steering group suggests that there are still too many viewpoints being represented in applications. **We therefore encourage all applicants and consultees to further scrutinise the list of viewpoints selected and reduce these where possible.** A final list of agreed viewpoints to be illustrated in the ES should be agreed pre submission with the planning authority. Some viewpoints may be dropped during the assessment process if the effects are assessed as not significant, or if two viewpoints illustrate similar effects, with the agreement of the planning authority.

86 Statutory consultees should provide a brief rationale for each viewpoint requested. A summary of the viewpoints considered throughout the process, with the reasoning behind the final viewpoint list, should be included within the ES.

Viewpoint siting

87 Following agreement on the general location of viewpoints through consultation, the selection of the precise viewpoint site should be considered carefully. If, on visiting a potential viewpoint, it is apparent that there will be no view of the proposed development, for example due to localised screening, this location should be amended or withdrawn and the reason recorded in the ES.

88 The siting of viewpoints needs to balance two key factors:

- the likely significance of impacts; and
- how typical or representative the view is.

For example, in choosing a viewpoint along a stretch of main road it may be difficult to choose one location to represent the range of views experienced. It may also be difficult to find a safe location for the viewpoint. Laybys and junctions are often used but may not always represent the ‘worst case’ views, or the first sight gained of the wind farm. Where this is the case it should be noted in the ES. In all cases, judgement needs to balance these factors, and the decision-making process must be documented.

89 Most importantly, **the location chosen must avoid the view of the wind farm being misrepresented by the inclusion of atypical local features, such as a single tree in the foreground**. Where this has mistakenly occurred, the viewpoint location should be revised and the photographs retaken. Conversely, it is also unacceptable to move too far from the most prominent viewpoint in order to avoid typical foreground objects, for example moving into a neighbouring field when the view is intended to be from a road, in order to avoid typical foreground objects, unless these would obscure views to the wind farm. An alternative location may be required.

90 Viewpoints should be free from any avoidable foreground objects and other obstructions such as fences, walls, gates, roadways, road furniture, summit cairns and unnecessary foreground, trees, shrubs or foliage unless these are typical of the view. It is also important that viewpoints are publicly accessible, for example not within private property.

Recording viewpoint information

91 It is important to record the field conditions in which a viewpoint is photographed, as well as the camera details including the information listed in the table below.

Viewpoint	**Specification required**
Precise location	12 figure OS grid reference, measured in the field, ideally using GPS or a large-scale map and a photograph of the tripod location.
Viewpoint altitude	Viewpoint altitude in metres Above Ordnance Datum (m AOD) (usually better interpolated from map or DTM than relying on GPS height).
Field of view	Horizontal field of view (in degrees).
Distance to wind farm	Approximate distance (in km) to the nearest turbine
	Compass bearings to distinctive elements in the view that will assist with the placement of the turbines in some circumstances (plus optional sketch of the view with these elements marked if appropriate).
Conditions:	Date
	Time
	Weather conditions and visual range
Camera:	Camera type, Lens focal length and make
	Spacing between the frames

92 This information is essential to allow others to visit precisely the same viewpoint and make on-site checks or assessment. It also helps others to understand the conditions under which professional judgements have been made.

93 All viewpoints should be numbered and their location shown upon separate maps as follows:

- detailed ZTV map(s) based upon a greyscale 1:50,000 OS base and printed at A1. Viewpoints should be marked using symbols and numbering that avoid obscuring or confusing the ZTV information.
- Each visualisation should include a short description to make it easy for members of the public to find the exact viewpoint location.

94 It is recommended that the original viewpoint numbers are retained until all the viewpoints are finalised and agreed and the LVIA has been completed, to keep track of which viewpoints have been added or withdrawn during the LVIA process. At this point they can be re-numbered in a continuous and logical manner. Where material developed during the early stages of the LVIA process information is included this should show both the original and new numbering so these can be easily cross-referenced. If an extension is proposed, using the same numbering of viewpoints as in the original application will allow consultees to compare the impacts of the new proposal more easily. The same applies if different wind farms are proposed concurrently within a district. **Viewpoint numbering needs to be clear**.

4 Visualisations

95 Visualisations are illustrations that aim to represent the appearance of a proposed development. Visualisations of wind farms most commonly comprise photographs, wireline diagrams, photomontages, sketches and diagrams. However, it is important to stress that visualisations represent just one source of information that informs a LVIA.

96 Considerable debate on visualisations in the past has revolved around making them 'true to life'. **Visualisations, whether they are hand drawn sketches, photographs or photomontages can never exactly match what is experienced in reality.** They should, however, provide a representation of the proposal that is accurate enough for the potential impacts to be fully understood.

97 The assessor, consultees, decision-makers and any interested parties or members of the public **should ideally visit the viewpoint(s)** where visualisations can be compared to the 'real life' view. It is acknowledged this is not always possible – time, weather and accessibility will restrict the number of viewpoints which can be visited.

98 Interpretation of visualisations must take account of additional information specific to the proposal, viewpoint and landscape which cannot be shown on a single 2-dimensional image. Factors include variable lighting, movement of turbine blades, seasonal differences and movement of the viewer through the landscape. **Visualisations in themselves can never provide the full picture in terms of potential impacts; they only inform the assessment process by which judgements are made**.

Key issues affecting visualisations

99 In order to see sufficient detail the photograph must have high resolution. Contrast also has a great influence on how well detail can be seen. Against a white background a black line is easier to see than a grey one. A key limitation of photographs in replicating the visual experience is that it is generally impossible to reproduce the full contrast range visible to the human eye.

100 On a bright day outdoors we may experience a brightness ratio of 1000:1 between the brightest and darkest shades, whereas a good quality computer monitor is only likely to achieve a ratio of about 100:1, and a printed image is only likely to manage 10:1. This is one reason why holiday snaps of mountain ranges often look disappointing when viewed on screen or as printed photographs – neither the screen nor the printed image can capture the contrast or depth you see in real life.

101 This has an effect on the representation of both the detail in the scene and the way in which contrast usually decreases with distance ('aerial perspective'). This has been a challenge since the beginning of photography. The methodology set out below seeks to ameliorate the lack of contrast and depth in printed images to ensure that they provide the best representation of the wind farm proposal – but it can never replicate the real life view.

Viewing distance

102 In the previous (2006) version of this guidance it was recommended that images should be viewed at a correct "viewing distance" to recreate the correct perspective geometry of the view. However, viewing printed images at a 'correct viewing distance' is not easy, especially when provided as a cylindrical projection (which should be viewed curved). More importantly, experience has shown that geometrically correct printed images, viewed at a theoretical viewing distance, do not necessarily portray the view as experienced by people in reality[2] .

103 The method described below results in significantly larger images, for which an accurate viewing distance is less important. The images are enlarged and this provides a better representation of the real view, at a comfortable viewing distance.

104 **As a result, it is recommended that photomontages are simply viewed at a comfortable arm's length**. This will vary depending on the length of the viewer's arms and their eyesight. However, the difference in viewing distance which results will have little impact on the impression of scale / depth in the image due to the increased size of the images. An instruction to view images at a 'comfortable arm's length' should be included on all visualisations produced. They should also **be viewed flat** as they are in planar projection.

105 Planar projection has been chosen for the photomontages as it is easier to use both in print and on screen (a computer screen cannot be curved to view a cylindrical image). Both planar and cylindrical projections have limitations. The main limitation of planar projection is that, if viewed incorrectly, it can slightly increase the scale of turbines at the edge of the image[3]. **Ideally the viewer should view the image with their eyes in the centre** – however, in practice the difference in scale in most images will be difficult to perceive.

106 Some technical users of the visualisations may still wish to know the principal distance of the image. This should be included on all images to allow technical comparison if required. It is not necessary, however, for members of the public or decision makers to view the images at this distance and it should **not** be referred to as the viewing distance.

Making visualisations more accessible to the public

107 It is essential that decision-makers and consultees are provided with, and that members of the public have access to, a colour paper copy of the visualisations, printed at the correct size.

Using all the tools available

108 Visualisations are complementary to ZTVs and vice versa, and neither can be interpreted satisfactorily without the other. A visualisation simulates a photograph of the wind farm from a particular location, but gives no indication of whether this is characteristic of views over a

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[2] For a detailed discussion of this issue see 'Windfarm visualisation: Perspective or Perception ?' by Alan Macdonald (2012), Whittles Publishing.

[3] Conversely, if a cylindrical projection image is viewed incorrectly the turbines at the edges will appear too small

wider area or is peculiar to a specific location. Used carefully together, a ZTV and a set of visualisations can provide information on all of these aspects.

USES OF VISUALISATIONS	LIMITATIONS
• Visualisations give an impression of a proposed wind farm • Used carefully in the field, a visualisation can be used to inform assessment • Visualisations can aid development and appraisal of the wind farm layout and design • Visualisations can help illustrate the location and nature of a proposed wind farm	• Visualisations provide a tool for assessment that can be compared with an actual view in the field; they should never be considered as a substitute to visiting a viewpoint in the field • Neither photographs nor visualisations can replicate a view as seen in reality by the human eye. • Visualisations are only as accurate as the data used to construct them • Visualisations can only represent the view from a single location at a particular time and in particular weather conditions • Static visualisations cannot convey the effect of turbine blade movement

Photography

Objectives

109 Undertaking photography for visualisations requires high quality specification and skill. This is because the perspective geometry of the resulting photographic image must be known in order to use software to generate an image with exactly matching perspective. This requires considerable care in the selection and use of appropriate photographic equipment.

110 Representing landscape conditions through photography (and thus photomontages) has limitations and, while some of these effects can be ameliorated and/or compensated for by using presentation techniques discussed in the following section, other effects are less easy to counteract. One of the most significant difficulties of photographing wind farms, in contrast to other types of development, is that they often appear on the skyline where there can be little contrast between the light-coloured turbines and a light-coloured sky. **It is therefore essential that all baseline photographs are taken in good visibility**.

111 This will generally mean clear skies, in suitably clear air to allow sufficient contrast between the different elements within the landscape. This is particularly important for long-range views where poor light and atmospheric conditions such as haze or cloud can reduce the clarity of the view, or for views where the turbines are predominantly viewed against the sky. In most circumstances, clear skies are preferred. However, in some locations, especially where the turbines will be predominantly backclothed, photographs taken in cloudy conditions can also be used to illustrate the effects. The key requirement is that the turbines are rendered with sufficient contrast against the backdrop (whether this is the sky or the landform).

Field of view

112 The term ‘field of view’ is used to describe the width and height of a view as represented by an image. These constitute the horizontal field of view and vertical field of view and are expressed as angles in degrees (the terms 'angle of view', 'included angle' and 'view cone angle' are all equivalent, but they can be ambiguous in some contexts).

113 The photomontages to be included in the ES (described further below) have a horizontal field of view of 53.5 degrees and a vertical field of view of 18.2 degrees[4]. In most situations this will capture the whole wind farm and provide sufficient landscape and visual context. In some situations, however, it may be necessary to provide a wider horizontal field of view. These include:

- Viewpoints which are very close to the wind farm;
- Very large wind farms
- Locations where cumulative effects require detailed representation (e.g. two wind farms on the same ridge).

Where these necessitate the use of a wider horizontal field of view which will not fit on an A1 width page, it may be necessary to print on slightly longer paper (folded in the ES), or to print several panoramas on separate sheets (with the wind farm shown on the central sheet) if the paper length becomes unwieldy, or distortion affects the edges of the image. Where separate sheets of paper are required to cover an exceptionally large angle of view, each section should be re-stiched from the baseline photography to avoid distortion effects as the horizontal field of view increases.

114 To ensure that the photographs (which may be taken by someone other than the landscape architect or experienced specialist assessor) can accommodate the required horizontal field of view to assess cumulative effects, a series of photographs should be taken from each viewpoint to include the entire width of view. It is recommended to take 360° at each viewpoint to ensure this can be achieved.

115 Photographs should generally be taken in landscape format. However, in some circumstances, such as a steep sided valley or viewpoints which are very close to the proposal, it may be necessary to use portrait format to capture the full vertical extent of the wind turbines and/or landscape. Where this is necessary an alternative format of image will be required and this should be agreed with consultees.

116 There may be circumstances where it is necessary to illustrate the full 360° view on the baseline panorama. If an obstruction (such as a summit cairn) makes it difficult to capture the full 360° view, it is acceptable to move the camera tripod to an alternative location to capture

[4] NB – this applies to the photomontage, not the baseline panorama which will have a horizontal field of view of 90º, 180º, 270º or 360º as required

the obscured view. This will make the production process more complex, but will result in clear, unobstructed views. Ideally, the alternative tripod location should only be used for one of the 90° segments of the view, with this noted on the visualisations.

Verification

117 In some cases the determining authority may wish to verify the accuracy of the image produced. This is possible using the original image data recorded by the camera (to check camera format and lens used) and a simple template (to check that the image dimensions have been correctly adjusted (by cropping and then enlarging)). This process is described in **annex E**. Camera metadata should be provided by the applicant on request.

Choice of camera and camera height

118 A high quality **digital camera** with a **full frame sensor** is required to produce satisfactory results for ES purposes. Note that full frame sensors can also vary slightly in size – this is discussed in more detail in **Annexes E and F**.

119 A **50mm fixed focal length** camera lens is required.   Note – even fixed focal length lenses can vary slightly in their geometry; this and various other technical considerations are discussed in more detail in **Annex F**. Lenses need to be of high quality both in terms of resolving power (the ability to capture detail) and in freedom from excessive distortion.

120 The use of a fixed focal length reduces the scope for error in establishing the perspective geometry of the photographic image and reduces variables in the method used. Such lenses have less distortion than alternatives and are currently used as standard by most practitioners. It also facilitates the verification process set out in **Annex E.**

121 In some circumstances it may be necessary, or beneficial to use an alternative lens or camera. **Where this is the case it should be agreed with the determining authority and a clear justification should be included in the ES**.

122 The camera should be **1.5m** above ground level, unless there are good reasons to adjust this (such as a hedge, tree, summit cairn or similar obstruction). If an alternative camera height is used this should be marked on the visualisation and explained in the ES.

Post-photographic processing

Turbine image

123 The turbines shown on a visualisation should represent reasonably faithfully the shape of the intended turbines for a project. They should, at least, have the correct hub height and rotor diameter. This will allow the proportions of the turbines to be appreciated from the visualisation.

124 Some practitioners prefer to depict all turbines with the rotors set with one blade pointing straight up; whereas others prefer these set at random angles, helping to simulate more realistically the fact that the turbine blades will be moving. The disadvantage of setting blades at random angles is the risk of 'losing' turbines behind the landform because the blade angle happens not to place a tip high enough in its arc to be seen. On the other hand, having all the blades at the same angle can produce a very 'regimented' effect that appears less realistic.

125 It is recommended that, for all wireline diagrams (especially those used by the assessor), turbines are always shown with one blade positioned straight upwards, while photomontages, as illustrations, can show turbines at random positions. All the wind turbines that could potentially be seen from a viewpoint must be shown within the photomontage, even if their highest blades are on the diagonal. The rotors of every turbine in the proposed development should face the same direction, forwards towards the viewpoint (note this may not be necessary on photomontages, see paragraph 162).

Image enhancement

126 Enhancement of images is an inherent part of photographic production. Photographic processing involves judgements - there is no process by which a 'pure' photograph can be produced without the application of human decision-making, from exposure timing to the specification of the camera, and whether this is applied manually or automatically.

127 Although enhancement, for example to maximise clarity, has traditionally occurred within the photographic darkroom, this practice has often raised concern with regards to producing photomontages. This may be because it is difficult to quantify the level of enhancement in a way that is easy to understand, raising the suspicion that an image has been 'enhanced', and is consequently misleading. In reality there is no way to avoid a photograph being enhanced as this is an integral part of photography and photomontage production.

128 Enhancement must be done to acceptable standards and this requires extreme care by a suitably experienced professional. The extent of enhancement must be limited to that which would conventionally occur in a darkroom to improve the clarity of an image, not change its essential character. For example, it is important that any enhancement, such as sharpening elements within a view, is carefully balanced throughout an image, not just the wind turbines, otherwise other features may seem less prominent in comparison.

129 Sharpening an image slightly can also help to make fine details, visible in the field, also be visible on printing. This operation works by identifying areas of high contrast in the image, which correspond to the detail we see, and locally further increasing the contrast so that the detail becomes more apparent. However, this operation must be applied carefully as over-sharpened images can result in a hard dark line that appears at the skyline, with a corresponding light edge to the sky above it, while miniscule details can appear unrealistically prominent. **Overall, there should be a minimum of post-processing image enhancement.**

Other considerations

Information to provide on the visualisations

130 Information provided on the visualisation should be sufficient for the user to understand the basis of the visualisation, but not so much as to be overwhelming. Each image should also include a small thumbnail location map, either located beneath the image or on a fold out at the right hand side of the page. The information provided on the visualisation should include:

Viewing instructions, including standard text in **Annex A**
Figure number and viewpoint number
Information on viewpoint location, altitude and both vertical and horizontal fields of view
Direction to centre of photograph as a bearing
Distance to nearest visible turbine in kilometres
Principal distance (mm), Camera make, Lens, Camera height
Date and time of photograph

Paper and printing

131 There is an extremely wide variety of printers and paper types available. To obtain the best results in relation to the size and type of visualisation, it is recommended that advice is sought from specialist providers.

132 The quality of a printed visualisation will depend significantly on the printing process and set-up. Colour inkjet printers tend to show more detail than other machines because of their higher colour range and resolution. However, it is generally difficult to produce large numbers of pages in this way so colour laser printing may be necessary. Whichever method is used a good quality, photo equivalent finish is essential. A matt finish is preferable and good quality paper should be used.

Constructing the visualisations required in the ES

133 Three visualisations are required as standard within the ES and these are described in turn below:

1) Baseline panorama and matching wireline

Construction of baseline panorama

134 The first image required from each viewpoint is a baseline panorama. This shows the **existing view** and captures the overall landscape and visual context. This information is essential to underpin the LVIA and to provide those who cannot visit the viewpoint with an understanding of the wider context within which the wind farm would sit.

135 In most cases 180° should be sufficient. In some cases (such as a popular Munro summit or viewpoint, or to illustrate cumulative effects) it may be necessary to provide a 360° baseline

panorama. In a few cases (such as a narrow view down a glen) a reduced field of view of 90° may be adequate.

136 To construct the panorama a series of frames should be taken which cover the full 360° from each viewpoint. The decision whether to present 90°, 180°, 270° or 360° can be taken later by the assessor.

137 The images should be stitched together by a competent professional using suitable software. Each 90° image should be presented on a single A1 width page as shown in **figure 1** below. The size of the image will be 820mm by 130mm. To accommodate 90° horizontal field of view the vertical field of view will be 14.2°. Additional images (up to 4 for 360°) should be provided on separate A1 sheets as required.

138 To present images with this wide field of view **cylindrical projection** is required – however, it is not important to view this image in a curve, as they are provided to illustrate the wider landscape and visual context only. **The wind farm proposal should not be represented on this image,** in order to avoid confusion.

139 To facilitate the verification process described in **annex E,** the horizontal extent of the central 50mm frame should be indicated on the image, along with the extent of the 53.5° panorama. An example of these markings is provided in the pdf version of the image available on our website. The following text should be included: "**This image provides landscape and visual context only.**" More detailed guidance on wireline production is provided below.

140 In some locations it may be useful to annotate key features (such as hilltops, key routes and popular destinations) on the baseline panorama where these are not easily identifiable.

Construction of matching wireline

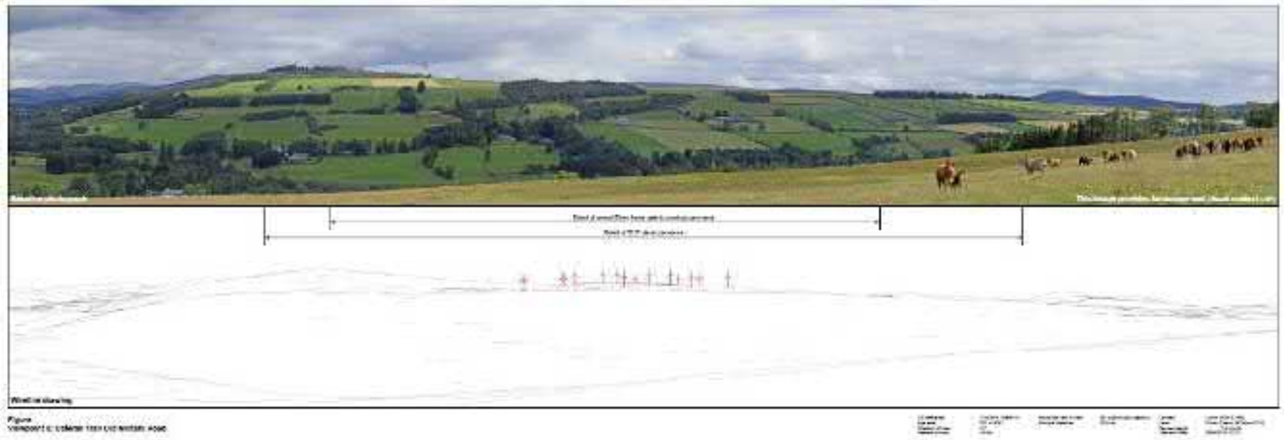
141 A wireline with matching dimensions and geometry should be constructed for either 90°, 180°, 270° or 360° horizontal field of view as required. The resulting vertical field of view will be 14.2°. The image will be 820mm by 130mm. The wireline will be particularly helpful to show cumulative effects, which cannot be captured in the illustration described below. It should also be provided in cylindrical projection, to match the baseline panorama. **The wind farm proposal and all other wind farms included in the cumulative assessment (including existing wind farms) should be illustrated on the wireline** – but not the baseline panorama which is an illustration of the current landscape.

142 Turbines at different stages in the planning process (i.e. existing, consented, proposed) should be shown in different colours to make it clear what the baseline is and what is proposed. Potential scenarios of development, depending on which applications receive approval and are constructed, can therefore be assessed.

143 It can also be helpful to show the horizontal extent of each wind farm with a small bar at the top of the image, particularly when there are multiple wind farms in the same angle of view. In

some cases it will be difficult to annotate the wind farm(s) on the wireline, especially if the viewpoint is close to the proposal and the turbines fill the vertical field of view. In these circumstances, labelling should be included on a separate wireline image or the individual wind farms (or turbines) identified on a key.

Figure 1 90º Baseline panorama and matching wireline



2) Wirelines

Use of wirelines

144 Wirelines are computer generated line drawings, based on a Digital Terrain Model, that indicate the three-dimensional shape of the landscape in combination with additional elements. They are a valuable tool in the wind farm LVIA process as they allow the assessor to compare the position and scale of the turbines to the existing view of a landscape.

145 Wirelines are particularly useful to the landscape architect or experienced specialist assessor as they portray objective data. This means that, by comparing wirelines with the views on site, the assessor can make judgements on the likely visual impacts in a variety of environmental conditions, safe in the knowledge that the wirelines have not been subject to manipulation that cannot be quantified. They can also reveal what would be visible if an existing screening element, for example vegetation or a building, were removed.

Data

146 The accuracy of a wireline depends on the accuracy of the data used to create it. In general, this data will be the same as that used for calculation of the ZTVs, commonly the OS Terrain 50 or Terrain 5 DTM products, or the older 'Landform' products.

147 It is important that sufficient DTM data is used to enable the full landform background to the turbines to be appreciated and thus easily matched to a view on site or photographs of the

existing landscape. For some views, DTM data may need to extend further than the LVIA study area because the distant horizon extends beyond this.

148 In some locations, such as very flat landscapes with few features, achieving a good fit with the digital terrain model will be difficult. The use of artificial features such as a meteorological mast or other infrastructure may be required to position the image.

Geometrical properties

149 To allow direct comparison (and reduce confusion) wirelines should be provided using the same perspective geometry and image height as the photomontage. They should also be presented in **planar projection** to provide a consistent representation of the wind farm.

Drawing style

150 Wirelines consist of little more than simple line-drawings of the DTM and the wind farm. However, there are a range of graphic styles used to depict these which can affect the clarity and legibility of the finished image. A number of options are acceptable; however it is important that the same format is used throughout a single ES.

151 The DTM is most commonly drawn as a mesh seen in perspective. While this is a faithful depiction of the landform as represented by the DTM, it can often result in the more distant parts of the scene becoming unreadable as the grid lines get closer together, eventually merging into solid colour. This is not helpful and in these circumstances **grid lines should, if possible[5], be removed to maintain a simple image**. Only the outline of the topographic features in the scene, approximating to the lines one might draw as a sketch of the scene, should be shown.

152 Colour is useful to highlight the wind turbines in contrast to the landform lines, especially in distant views where the effect of merging lines noted above often occurs, and where some turbines may only just be visible against the landform. There are a number of options, such as those listed below:

- Green turbines on a black DTM
- Red turbines on a black DTM
- Black turbines on a grey DTM
- Blue turbines on a grey DTM
- Grey turbines on a green DTM

The use of pale colours, such as yellow, is not recommended as these have insufficient contrast with the white paper background and cannot be seen clearly.

153 Using the same colour and/or shade for the turbines and DTM is not recommended due to the lack of distinction between them. All the other options listed above are acceptable with the

[5] It is noted that some wind farm visualisation software does not have this function at present, hopefully this will rectified in due course. In the meantime it is accepted that some practitioners may not have the ability to easily remove all grid lines.

caveat that care must be taken to ensure that the type of colouring does not produce an illusion that the turbines are closer (or further away) than the landform on which they are sited.

154 Varying colours of turbines should be used to distinguish different wind farms within a view or existing turbines from proposed turbines planned as an extension.

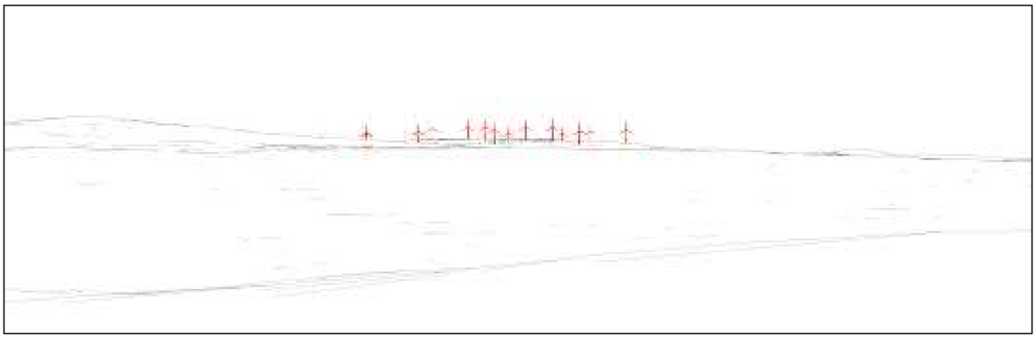
155 Turbines should be numbered so that the individual turbines can be directly referred to a layout plan also showing the turbines numbered[6]. Unless the wind farm comprises a small number of turbines, however, this information will usually take up a large amount of space upon the wireline image and, similar to any other labelling, may distract from the wireline image itself. It is preferable to label duplicate wirelines within an appendix (a selection of key viewpoints may suffice, if agreed during consultation). For cumulative wirelines, only the turbines relating to the proposal need to be numbered.

156 Features other than wind turbines can also be modelled into the wireline, depending on the software being used. Existing landscape features can be shown, such as pylons or distinctive buildings, which will help direct comparison with the photograph of the existing view (as long as these do not obscure the wind turbines). This can be particularly helpful for offshore sites where platforms and other existing infrastructure can be useful. Other elements of the wind farm development can also be shown, such as access tracks and other permanent ancillary infrastructure.

Construction of wireline

157 The production of wireline images is well understood, using standard software, so detailed guidance is not provided here. The key objective is to provide a wireline of the same geometry and image height as described for the photomontage below. **Planar projection** is required. The wireline should be 260mm by 820mm wide. The horizontal field of view should be 53.5° and the vertical field of view should be 18.2°.

Figure 2: Example wireline



[6] NB, not for offshore wind farms as this is likely to be impractical

3) Photomontages

The use of photomontages

158 The basic concept of photomontage is simple: it combines a photograph of an existing view with a computer-rendered image of a proposed development. In this way, **photomontages are used to illustrate the likely view of a proposed development as it would be seen in a photograph (not as it would appear to the human eye in the field)**.

159 **Although photomontages are based on a photograph of the existing landscape, it is important to stress that they are not a substitute to visiting a viewpoint in the field**. They are only one tool to aid assessment. They provide a two-dimensional image that can be compared with an actual view of the landscape to provide information, such as the scale and potential appearance of a proposed development; but they cannot show other qualities of the landscape experience that can only be appreciated in the field.

160 Given the limitations of depicting turbines in photomontages, their production will usually be of most value for views within 20km of a wind farm site, for turbines up to 150 metres high to blade tip[7]. At distances greater than this it can be difficult to represent the turbines well on a photomontage. However, this will depend on issues such as the specific wind farm design and environmental conditions**, so this parameter, and which viewpoints require photomontage, should be discussed and agreed with the determining authority and consultees.**

Rendering of photomontages

161 In order to address the difficulty of representing wind farms clearly within photos, it is common practice to exaggerate the prominence of the turbines to ensure that they stand out in the finished photomontage. When done poorly, this results in a level of predicted visibility unwarranted by the conditions seen in the photograph. However, where done sensitively, this can improve the clarity of an illustration, comparable to the conventional processing of photographs within a darkroom. It is recommended that the rendering of photomontages is carried out extremely carefully by a suitably experienced professional. The nature of any enhancement should also be noted within the ES.

162 Where a project involves an extension to an existing wind farm it is important that the existing wind farm appears clearly in the photographs. If this is not achievable the existing turbines have sometimes been ‘painted out’ in the baseline photograph and re-montaged back in, so that the images of both existing and proposed turbines match. An accurate representation of the baseline conditions is important and we therefore prefer good photographs of the existing development. However, in some conditions it may be necessary to enhance the depiction of existing turbines if they are not clear in the photographs taken (for example due to weather conditions, or because the rotors are oriented perpendicular to the viewpoint).

[7] For turbines larger than 150m the distances should be discussed with SNH

163 **Enhancement and rendering cannot compensate for photographs that have been taken in poor light or weather conditions**. In these circumstances, the photographs should be retaken.

164 It is important to use turbine locations, dimensions and heights which are as accurate as possible. The location and height of turbines in visualisations can be verified using the process set out in **Annex E.** The production process should be documented within the ES to enable this.

Accuracy of match to photography

165 In order to create a photomontage, the geometry of the overlain rendered image of the wind farm must match as exactly as possible that of the base photography. The viewpoint location, height and direction of the view must be **identical**, as must the horizontal field of view. Both the resulting panoramic photograph and the rendered image must be **planar projections**. In some cases, to achieve an accurate match, the images will need to be produced in cylindrical projection, thus allowing a much wider horizontal field of view and providing more features to achieve a match. Once a good match is achieved, the image should then be converted to planar projection for presentation in the ES.

166 The most reliable method of obtaining an accurate match is to generate a wireline image that matches the photograph. If the wireline can be accurately overlaid onto the photograph, then the fit is good. However, where there are few landform features, this process may require the matching of specific structures identified and mapped on site. A transparency copy of the image can also be used to check this on site.

167 An accurate GPS position, taken when the photography was carried out, is almost always sufficient for wind farm applications. Viewpoint location errors usually manifest as a mismatch in the horizontal position of elements in the photograph and wireline and are always more apparent in closer objects or landscape elements. If it is impossible to obtain a simultaneous match on both near and distant landform features, then the viewpoint position is incorrect and will need to be either re-measured on site or identified through iteration.

168 In certain landscapes, where there are few distinctive topographic features, it is necessary to use man-made features such as masts, pylons or buildings. Even when these types of features are clearly visible in photographs, it is often difficult to identify them accurately on the map. Where there is no view of a distant skyline a hand-level or, better, a surveyor's level, can assist in setting the correct vertical alignment of panorama and wireframe. Without this one may be reliant solely on the leveling of the camera.

169 Adjustments should be made until a satisfactory match between topographic features in the wireline and the photograph are achieved across the whole width of the panorama, to ensure that there are no errors of scale. If this cannot be achieved, then the fields of view do not exactly match and the parameters must be adjusted further. It is often the case that a small rotation needs to be applied to the panorama to compensate for residual errors in levelling the camera.

170 Once a satisfactory match has been achieved, it is possible to use the parameters for the wireline as perspective parameters for rendering the turbines for photomontage. Many packages combine wireline and rendering and some also include the facility to overlay the wireline on the photograph while adjusting parameters. However, the best quality is usually obtained using a separate computer program designed for high-quality rendering. Most rendering programs do not include the effect of the earth's curvature, so it may be necessary to make vertical adjustments to the turbine positions before rendering. The rendered wind farm should be overlaid on the photograph using a matched wireline for reference, to ensure that the position is correct.

Accuracy of lighting

171 The lighting model used to render wind farm images for photomontages should be a reasonably faithful match to the lighting visible in the base photograph. Consequently, the date and time that the photographs were taken should be recorded by the photographer or assessor to enable an exact sun direction to be calculated. In practice, however, as long as the direction of light is correct to within about 10 degrees, a convincing match can be obtained. The effect of light and shade on wind turbines is an important aspect of their visual character and should be represented well.

Associated infrastructure and land use change

172 Wind farm proposals include elements other than wind turbines, such as access tracks; borrow pits, crane pads, site compounds, cabling, and a substation. A wind farm development may also be both directly and indirectly responsible for vegetation and land use change. If these elements are likely to result in permanent significant impacts (for the duration of the consent), either individually and/or collectively, they should be included in photomontages where this is practical.

173 Some of these components may be difficult to model well, particularly changes in vegetation. In these circumstances it may be necessary to "paint" them directly onto the photomontage, guided by a wireline or other computer generated image to ensure that the positioning, perspective and scale of these elements is represented as accurately as possible.

Turbine lighting

174 In some circumstances it may be necessary to provide lighting on turbines if this is required to address military and/or civil aviation requirements. We recommend that where turbines are proposed in excess of 150m SNH are consulted on the requirement for night time visualisations. It is difficult to illustrate turbine lighting well in visualisations, although some recent examples which use photographs taken in low light conditions (just before or after sunrise / sunset) have been more useful. We encourage applicants to explore new techniques to do this, and emphasise the importance of early dialogue.

175 Where an illustration of lighting is required, a basic visualisation showing the existing view alongside an approximation of how the wind farm might look at night with aviation lighting may be useful. This is only likely to be required in particular situations where the wind farm is likely to be regularly viewed at night (eg from a settlement, transport route) or where there is a

particular sensitivity to lighting (eg in or near a Dark Sky Park or Wild Land Area). **Not all viewpoints will need to be illustrated in this way**. The visualisation should use photographs taken in low light conditions[8], preferably when other artificial lighting (such as street lights and lights on buildings) are on, to show how the wind farm lighting will look compared to the existing baseline at night. It is only necessary to illustrate visible lighting, not infrared or other alternative lighting requirements.

176 We have found that approximately 30 minutes after sunset provides a reasonable balance between visibility of the landform and the apparent brightness of artificial lights, as both should be visible in the image. It is important that the photographs represent the levels of darkness as seen by the naked eye at the time and the camera exposure does not make the image appear artificially brighter than it is in reality. It can also be helpful to note the intensity of other lights in the area to enable comparison (e.g. television transmitters) as this can aid the assessment process. SNH may prepare further guidance on assessment of lighting in due course.

177 The developer should attempt to formally agree the lighting requirements with the aviation authorities in advance of the application. Where this is not possible the visualisations should illustrate the lighting as described in the current legislation.

Image requirements

178 Production of the photomontage requires care to ensure that an accurate image is created. **The section on constructing visualisations is prescriptive and images must comply with these requirements. This will avoid concerns over the 'accuracy' of images or the method by which they have been produced.**

Construction of photomontages

179 The photomontage should be formed from several 50mm photographs stitched together by a competent professional using suitable software. The information that should be included on the photomontage is described in paragraph 130.

180 The panorama should be printed on A1 width paper[9] [10] in **planar projection**. The image size should be 260mm high by 820mm wide. The horizontal field of view should be 53.5° and the vertical field of view should be 18.2° in the centre of the image. The image will have a principle distance of 812.5mm.

181 A clear viewing instruction should be included on the photomontage as follows: "**View flat at a comfortable arm's length**. If viewing this image on a screen, enlarge to full screen height". To address concerns about the viewing instruction not being clear enough, this should be printed in larger font than the example below.

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[8] The health and safety considerations of low light photography should be taken in to account but should not, in themselves, be used as a reason to avoid the production of night time visualisations.
[9] Unless a wider Horizontal Field of View is required
[10] Folded to A3, see paragraph 184

Figure 3: Panoramic photomontage

Presentation of visualisations

182 It will usually be appropriate to present the photograph, wireline and photomontage such that the proposed wind turbines are centred in the horizontal field of view. However, at certain viewpoints it may be appropriate to centre the view on an alternative feature, or part way between two or more foci. These additional foci may or may not be wind farms. In these circumstances, it is important that the proposed wind farm does not appear at the far edge of the image. This is because sufficient context or horizontal field of view needs to be provided for each of the foci.

183 Paper and electronic copies of all ES materials will be required by the Planning Authority and SNH. Where possible, images from each viewpoint should be saved in to one pdf for ease of use, and be clearly named. The number of copies should be agreed for each application. Additional loan copies for members of the public will also need to be provided, and these should be made available at accessible locations throughout the study area. Typical locations include local libraries, Council offices and village halls. The number of loan copies should be agreed with the Planning Authority.

184 The A1 length visualisations **should be folded to A3 size** in the ES. This is to allow ease of use and transport. The visualisations should be provided in a ring binder so that users can remove individual sheets easily and we recommend these are limited to 10 viewpoints per binder to make this easier to transport.

Public Exhibition display

185 Stakeholder engagement is extremely important and exhibitions provide an important opportunity to present visualisations to the public. It is recommended that **the same visualisations**, printed at the same size, should be used for public exhibitions. The limitations of visualisations should be clearly marked on all of the material, and the information in **Annex A** clearly displayed at the exhibition.

Presentation to council planning committee

186 It is for the Planning Authority to determine which images are presented to the committee – but it is important that those who are unable to visit viewpoints are provided with a suitable panorama to provide landscape and visual context. All hard copy images should be printed in colour at the correct size.

187 Projection of a selection of the visualisations on PowerPoint slides, or similar, may be helpful to the planning officer and committee members. However, **it is essential that members are also provided with hard copies of the images, printed at the right size** to aid their decision-making and that they read the supporting text assessment in the ES. Visualisations on their own cannot substitute for the assessment of likely effects.

188 Committee members should ideally **visit a representative selection of viewpoints** as part of the decision-making process, especially where there are differing opinions on the likely effects.

Optional visualisation techniques

Viewpoint pack

189 In some cases the planning authority may find the provision of a viewpoint pack helpful. These should be provided on thicker A3 paper for durability and ease of use in the field. Images contained within the pack should be loose leaf and should have a detailed location map printed on the reverse side to make it easier for users to find the exact viewpoint location. A brief description of how to find the viewpoint should also be included.

190 The pack should contain images from a set of key viewpoints, to be agreed with the determining authority. It may not be necessary to provide them for every ES viewpoint. SNH do not require viewpoint pack images.

191 Each image should be clearly labelled: "**This image is intended only for use at the viewpoint. Further information in the ES should also be referred to**."

Construction of A3 single frame photomontages in the viewpoint pack

192 The images should be prepared from the same baseline photography and using the same process for rendering turbines[11]. The image height should be 260mm by 390mm wide. The horizontal field of view should be 27° and the vertical field of view should be 18.2°. The image will have a Principal Distance of 812.5mm.

Figure 4: A3 single frame for use in viewpoint pack

Using the viewpoint pack

193 The pack holder or title page should be clearly labelled "Images for assessment only at the identified viewpoints" along with the name of the wind farm and supplementary information. It should include a map showing the location of each viewpoint and detailed grid references to help users find the viewpoint location in the field.

194 It is important to get as close to the precise viewpoint location as possible. The viewpoint map, grid reference and photograph of the tripod location can all be used to achieve this. The

viewpoint map should be easy to find and use, showing recognised landmarks, roads or buildings, for example, for the user to identify the viewpoint. A short description of the viewpoint may also be helpful.

195 In poor weather the use of an A3 Perspex holder, or document wallet, can help keep the images dry and reduce the effect of wind. Planning officers and other users who visit viewpoints regularly should consider purchasing a holder for this purpose and in particular for presenting images to the planning committee in the field (when it is often not possible to choose optimal weather conditions). These are widely available at low cost and can also be used to hold folded A1 length images.

196 The Viewpoint Pack should only be used at the viewpoint location, or by those who have previously visited the viewpoint (such as on a Committee site visit). At viewpoints which are very close to the wind farm it may be necessary to take the larger panoramas or wireframes as it is unlikely that the whole wind farm will be captured on the single frame. It is not necessary to produce multiple single frames to cater for this situation – though if turbines are missing this should be clearly noted on the single frame image.

Hand-drawn illustrations

197 Drawings and paintings have been used for centuries to illustrate proposed landscape or architectural changes. However, digital photography has resulted in radical changes to the way images are conventionally presented, with an associated demand for these to be based on technical data for which accuracy can be measured.

198 There are instances when hand-drawn illustrations remain an invaluable tool in the process of visual analysis and the illustration of impacts within an ES. This is because they can offer:

- clarity of image, by omitting some of the distracting details that might be prominent within a photograph but which are overlooked on site;
- an element of interpretation by highlighting prominent focal features; and,
- their limitations are obvious – they are clearly not trying to replicate an exact view as it would be seen.

199 However, for these same reasons, hand-drawn illustrations also have disadvantages, chiefly that their quality is closely linked to the abilities of the illustrator and they may be distrusted for incorporating 'artistic licence'.

Diagrammatic sketches and annotated visualisations

200 Diagrammatic sketches allow the key elements of the composition to be drawn out and highlighted. This may be in relation to the landscape or the wind farm development, highlighting the main characteristics and principles of design. The advantage of using this medium is that important points can be stressed without them being clouded by insignificant details.

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[11] The single frame can be extracted from the panoramic photomontage, as long as it is cropped from the centre of the panorama.

Animation

201 Wind turbines are intrinsically dynamic objects, with large moving parts and variable orientation, so static images are in many ways a poor illustration. Computer animation, videomontage and virtual-reality techniques are being used to some extent to address this issue.

202 To date, most animation and videomontage has been used principally as a means of conveying a general impression of a development to the determining authority and the public, rather than as a tool for carrying out VIA or as part of an ES. However, considerable scope exists for their use in the future as various techniques are developed and presented, and then tested against wind farms once these have been built (similar to the scrutiny applied in the past to wirelines and photomontages). At present, the application of these techniques requires specialist contractors.

203 The provision of animation may assist in the decision making process. However, it cannot replace the need for professionally produced photomontages and wirelines from selected viewpoints. SNH will conduct further research on the use of digital visualisations in 2017-18.

Additional techniques for cumulative assessment

204 Additional guidance on further techniques to illustrate cumulative effects is provided in our guidance on Assessing the Cumulative Impacts of Wind Farms. The presentation of sequential effects as bar charts or on coloured maps is increasingly common. Video and virtual reality simulations of journeys have also been used with varying success. All such approaches should be carefully considered and discussed with the determining authority. Care is required not to use technology for technology's sake, nor to overburden the ES and decision-makers with additional information.

5 Offshore wind farms

205 Offshore wind farm visualisation presents different challenges to onshore situations. As well as having different environmental factors to consider, developments may be significantly larger in turbine size and number.

206 In general terms, given good meteorological conditions, visibility is higher on the coast than inland; periods of exceptional visibility occur in north and west Scotland. However, in the coastal and marine environment, light quality and weather conditions change more rapidly and are more variable than onshore, so it is difficult to represent these varying conditions in a single image. Practitioners should aim to prepare visualisations representing the specific time of day and season when there is optimum visibility and clarity. The reasoning and background to choosing this seasonal or diurnal 'window' should be explained, for example by supporting Meteorological Office data. Note that there may be some additional requirements for visualisations to illustrate other light conditions such as sunrise or sunset.

Specific photographic requirements

207 It is difficult to judge the distance of an object when it is out at sea. It can also be difficult to judge the scale of a single turbine, or of a wind farm, where there is no scale indicator giving a familiar, comparative size. Thus, it is essential to include local landmarks or familiar features within a photograph where at all possible[12]. Where existing offshore features, such as oil platforms, existing turbines or lighthouses are present, they may aid in estimating the scale of the turbines, as well as the overall size and extent of the wind farm.

208 Most requirements will be for visualisations from onshore viewpoints looking out to sea but in some instances there may be a need for photography at sea to illustrate views back to shore, for example from ferry routes. Such photography can be difficult to undertake because of wave action, so in some instances relaxation of photographic standards to reflect this may be appropriate, provided they are supported by wirelines. In some locations, especially those which are difficult to access, wirelines may be the only feasible approach.

209 Scotland's east and west coasts differ in terms of their light, aspect, weather and coastal character. This needs to be considered when planning photography and visualisations. The direction of sunset and sunrise are also a key consideration from sensitive viewpoints and should be illustrated in some circumstances.

210 There is limited evidence to support an alternative 'focal length' for offshore wind farms. A report by the DTI[13] recommended using a 70 or 80mm 'focal length'. **To maintain consistency with the approach used onshore, the same methodology and image specification is recommended for offshore wind visualisations.** Note – as for the images described in section 4 above, this should be cropped and enlarged from a photograph taken

[12] Longer than A1 paper lengths may be required
[13] Guidance on the assessment of the impact of offshore wind farms: Seascape and Visual Impact Report, DTI, (2005)

with a **50mm fixed focal length lens**. This will be kept under review and determining authorities may chose an alternative focal length if circumstances support this.

Use of design envelopes

211 To date, most offshore wind farm applications have been submitted on the basis of a design (or “Rochdale”) envelope, with assessment carried out on the basis of a realistic “worst case” scenario, with the final design not confirmed until after consent. SNH has provided guidance on the landscape and visual aspects of this process[14].

Viewpoint choice for offshore wind farms

212 Viewpoint selection will depend on factors including the size and scale of the wind farm, its distance from shore, proximity to other development or projects, and the extent of visibility (particularly on land). Viewpoints will be agreed between Marine Scotland, the relevant planning authority and SNH. If a design envelope is used, key “design viewpoints” will also be identified, from which a range of design options will need to be illustrated.

213 Factors affecting viewpoint choice include, but are not limited to:

- Choosing key viewpoints to illustrate design options and evolution adequately
- Use of inland viewpoints to see offshore proposals in the context of onshore foreground
- Inclusion of appropriate features or foreground to help the location and scale of the wind farm to be appreciated
- Choosing viewpoints that represent recognised circulation routes, such as ferry routes (reflecting the type of boat and therefore viewing height from which the view will be seen), beaches, onshore roads and footpaths, cruising routes, popular sailing competition areas and other sea users, even if these may not be the most easily accessible points
- Including a range of elevations of viewpoints, where relevant
- Importance of representing land to sea, sea to land, and sea to sea views, including the coastal, sea and land interfaces
- Representing a variety of lighting conditions, e.g. side-lit, back-lit and front-lit
- There may also be a need to choose viewpoints to show tidal differences if inshore locations are proposed for development.

In all cases it remains essential that the number of viewpoints remains proportionate to the assessment.

Elevation of viewpoint

214 The horizon is the most distant point seen on the sea surface – this distance increases with the elevation of the viewpoint, and decreases the lower your position (because of the curvature of the earth). Under special weather conditions, on many days of the year from high

[14] Offshore Renewables – guidance on assessing the impact on coastal landscape and seascape; please refer to Annexe 2

points, it is possible to see the horizon up to 80+km distance[15]. On a clear day, viewed from a beach, the horizon is of the order of three nautical miles (approximately six km) distant. This means that the nature of views of offshore wind farms will vary significantly according to the elevation of the viewer, and any visual assessment should examine a range of viewpoints from different elevations.

Photomontage for offshore wind farms

215 In the production of offshore wind farm photomontages:

- It is important to recognise that the greater distances involved are a technical challenge. There may be a need to 'zoom in' for detailed design assessment.
- It is often difficult to represent turbines on the horizon in photomontages as this zone is generally hazy. The horizon may need to be rendered back in to the image in such situations, and wireframes will be particularly helpful.
- A key factor is achieving sufficient contrast between the sky and the sea so that the horizon is clear.
- It may be necessary to prepare images wider than 180^{o} to capture landscape and visual context.
- It will be necessary to show the visual impacts of any ancillary infrastructure (including offsite implications), such as offshore substation platforms, on-shore grid connections, converter stations, associated tracks, access routes or buildings, fencing, car parks, lighting, borrow pits and service platforms. Additional colouring on the turbines (such as coloured foundation jackets) should be represented on the photomontage where possible.

Wirelines for offshore wind farms

216 The use of wirelines is especially useful in offshore visualisation where producing photomontages may be very difficult, and these will replace photomontages in some instances.

Turbine lighting

217 All offshore and inshore wind energy development will require lights for marine navigation and aviation safety. It is often one of the major visual issues relating to this type of development. Generally, the turbines are proposed in areas currently characterised by their darkness. Reflection of lights on the water surface can also increase the effects of lighting in some conditions.

218 Precise lighting requirements are not known at pre-application stage and are only agreed post-consent via a "Lighting and Marking Plan". This is due to the wide spectrum of different design variations (the use of the 'Rochdale Envelope' in planning schemes) which make it difficult to finalise CAA, MoD and Northern Lighthouse Board requirements. Nevertheless, it is important to assess and illustrate likely lighting effects. Paragraphs 174-177 provide further guidance on this.

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[15] *An assessment of the sensitivity and capacity of the Scottish seascape in relation to wind farms.* SNH Commissioned Report 103 (2005), p 12

6 Repowering

219 Repowering involves the replacement of the old turbines with new ones and a new planning application. In most cases this will require a new LVIA and new visualisations.

220 Our guidance on assessing repowering applications is in preparation and we will consult on this later in 2017. In the meantime, we are scoping the assessment of repowering applications on a case by case basis. As a starting point we advise that visualisations for repowering schemes are prepared as follows:

- The baseline panorama should show the baseline landscape with the existing wind turbines removed
- An additional visualisation which compares the existing wind farm with the proposed new one should be provided. This should follow the same format as recommended for the baseline panorama, with the existing wind farm at the top of the image and the new proposal below.

Annex A Information on limitations of visualisations.

Visualisations of wind farms have a number of limitations which you should be aware of when using them to form a judgement on a wind farm proposal. These include:

- A visualisation can **never show exactly** what the wind farm will look like in reality due to factors such as: different lighting, weather and seasonal conditions which vary through time and the resolution of the image;

- The images provided give a reasonable impression of the scale of the turbines and the distance to the turbines, but **can never be 100% accurate**;

- A static image cannot convey turbine movement, or flicker or reflection from the sun on the turbine blades as they move;

- The viewpoints illustrated are representative of views in the area, but cannot represent visibility at all locations;

- To form the best impression of the impacts of the wind farm proposal these images **are best viewed at the viewpoint location shown**;

- The images **must** be printed at the right size to be viewed properly (260mm by 820mm);

- You should hold the images **flat at a comfortable arm's length**. If viewing these images on a wall or board at an exhibition, you should stand at arm's length from the image presented to gain the best impression.

- It is preferable to view printed images rather than view images on screen. If you do view images on screen you should do so using a normal PC screen with the image enlarged to the full screen height to give a realistic impression. Do not use a tablet or other device with a smaller screen to view the visualisations described in this guidance.

Viewing instruction to be provided on every image

To minimise the risk of images being viewed incorrectly on screen, every photomontage should contain the following instruction: "**View flat at a comfortable arm's length. If viewing this image on a screen, enlarge to full screen height**". The correct paper size and image size should also be provided.

Annex B Standard requirements which all visualisations should comply with

Checklist

Photography	**Camera**	Full Frame Sensor Size	
	Lens	50mm fixed focal length	
	Camera height	1.5m (unless alternative height can be justified, in agreement with planning authority)	
	Location	Grid reference, relevant location map, and photograph of tripod location provided	
Photomontage	**Image**	Clear of foreground objects	
	Conditions	Visibility sufficiently good	
	Baseline panorama and wireline	Cylindrical projection 90, 180, 270 or 360 degrees printed on A1 length sheet(s). Image size for both the baseline panorama and wireline should be 820mm by 130mm	
	Wireline	Planar projection, image size 260 by 820mm on A1 sheet. HFOV 53.5° and VFOV 18.2°	
	Panorama	Planar projection, image size 260 by 820mm on A1 sheet. HFOV 53.5° and VFOV 18.2°	
	Principal Distance	Printed on visualisations	
Maps	**Viewpoint map**	To include overall viewpoint location map (combined with ZTV). Thumbnail location map provided on each panorama	
Methodology		Statement of methodologies used to produce visualisations including ZTVs and software used	

HFOV = Horizontal field of view
VFOV = Vertical field of view

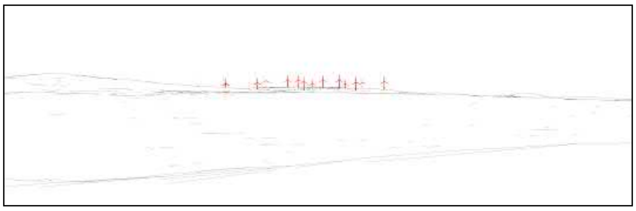
Annex C Summary of visualisation requirements[16].

Baseline panorama and wireline

The purpose of the baseline panorama and wireline is to provide wider landscape and visual context to help the viewer understand where development sits within the wider landscape. The wireline also illustrates cumulative effects and provides the viewer with the full cumulative context. The baseline panorama is not intended to represent how large or small the turbines will appear in reality or how close they will appear to the viewer.

Wireline

Wirelines are very useful in the design stages and can used to illustrated changes to the proposal quickly and effectively. They illustrate 'bare ground' visibility and a provide a clear view of the wind farm to inform the assessment.



A1 Panorama

The A1 panorama is intended to provide the best impression of the apparent size of the turbines and the distance to the development from the viewpoint location. Only images at this scale[17], held at a comfortable arms length, should be used when trying to understand the size of the development and its distance from the viewpoint.

[16] Note – it is not always necessary to produce all 3 images. In some cases a wireline may suffice, for example, if agreed by the determining authority and consultees

[17] The horizontal and vertical fields of view define the scale of this image which is equivalent to the image which would be captured with camera lens of a focal length of 75mm on a full frame camera. Images produced which have an equivalent focal length of less than 75mm will make the development appear smaller and further away than it would in reality, regardless of viewing distance.

Annex D Earth Curvature and Refraction of Light

Ordnance Survey co-ordinates are not fully 3-dimensional. The northing and easting define a point on a plane corresponding to the OS transverse Mercator map projection, and the altitude above OS datum is measured above an equipotential surface passing through the OS datum point at Newlyn. In reality, the earth is curved so a correction has to be made in order to position geographical features correctly in three dimensions for ZTV calculation and for visualisations.

If it were not for the presence of the Earth's atmosphere, a simple allowance for curvature would be sufficient. The formula for this can be worked out quite easily from Pythagoras' theorem:

$$
\begin{aligned}
c^2 + r^2 &= (r+h)^2 \\
c^2 + r^2 &= r^2 + 2rh + h^2 \\
c^2 &= 2rh + h^2 \\
&= 2(r+h)h \\
c &= \sqrt{2(r+h)h}
\end{aligned}
$$

h is very small in comparison with ***r***, so the formula can be approximated with:

$$c = \sqrt{2rh}$$

Rearranging for ***h***, we get:

$$
\begin{aligned}
\sqrt{2rh} &= c \\
2rh &= c^2 \\
h &= \frac{c^2}{2r}
\end{aligned}
$$

In practice, rays of light representing sightlines over long distances are also curved downwards as a result of refraction of light through the atmosphere, allowing one to see slightly beyond the expected horizon. (The atmosphere reduces the vertical correction due to curvature alone by about 15%.) The standard formula used in surveying work is modified from the one derived above as follows:

$$h = \frac{c^2(1-2k)}{2r}$$

Where:

h is the height correction in metres
c is the distance to the object in metres
k is the refraction coefficient
r is the radius of the Earth in metres

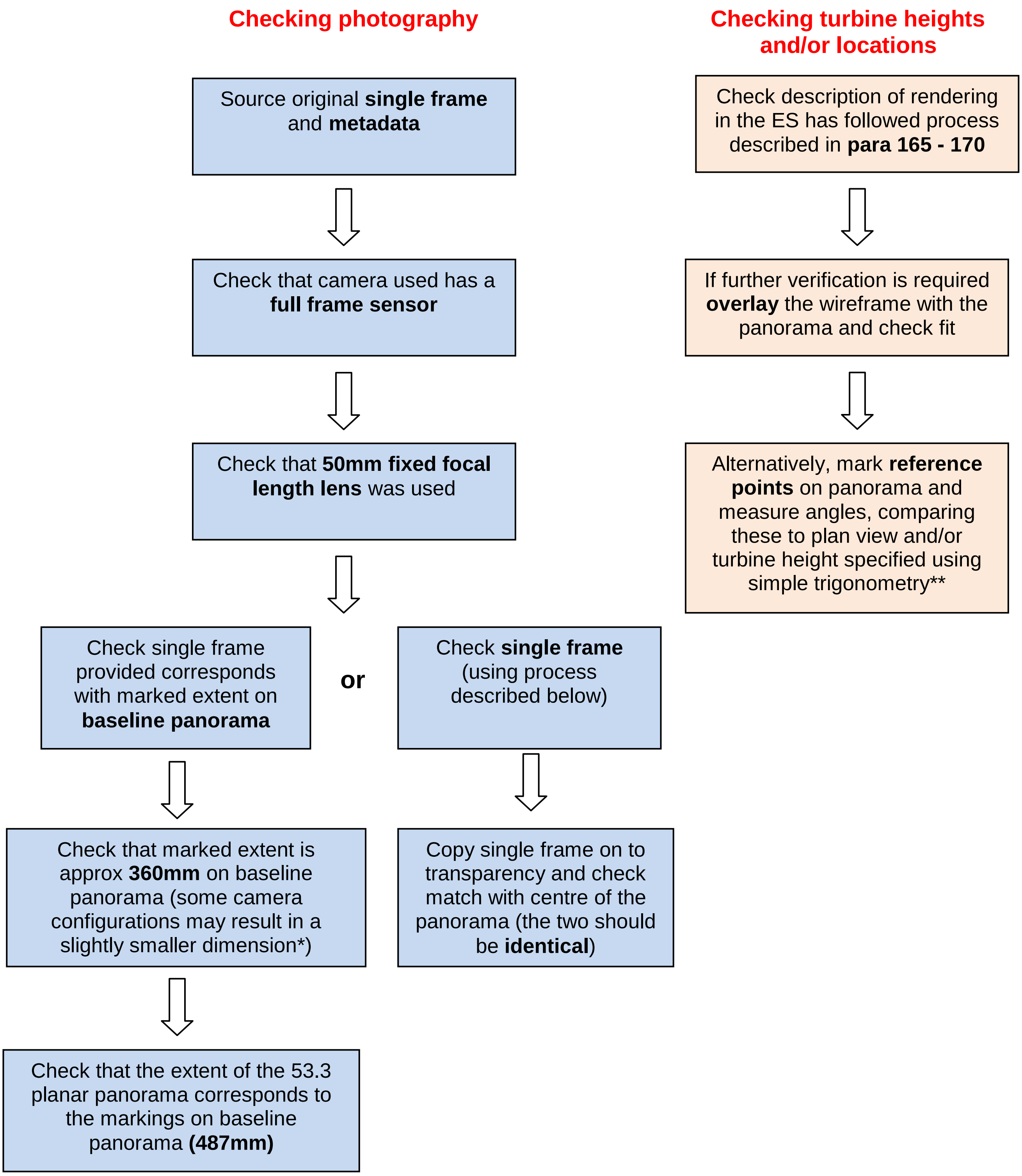
The parameter ***k*** is not constant but varies with temperature and barometric pressure (and therefore also with altitude). For precise geodetic surveying work both these quantities would have to be measured at both ends of a line of sight. Visualisation and visibility analysis do not require such precision; therefore a representative value may be used. 0.075 is a reasonable average for inland upland observations, but very slightly different values may be found quoted in surveying or navigation textbooks. (***k*** is a numerical coefficient and therefore has no units.) Taking ***k*** = 0.075 and ***r*** = 6,367,000m (a representative radius for the UK), the following example values are obtained:

Distance c	Vertical correction for Earth curvature and atmospheric refraction h
5 km	1.7m
10 km	6.7m
15 km	15.0m
20 km	26.7m
25 km	41.7m
30 km	60.1m

Annex E Verification of images

Some users of visualisations may wish to ‘verify’ the images provided. The following methods can be used. The first is provided to check that the photographs have been taken on the correct camera and lens and then enlarged appropriately. The second is to test that the turbines have been placed in the correct locations and at the correct size.

There are two ways to check the A1 panorama, both are described below. The verification of single frame images (for the optional viewpoint pack) is described separately on page 51.



Single frame images

The single frame image provided in the viewpoint pack (if this is requested by the Planning Authority) can be verified using a similar process. A simple template can be used to check that the correct portion of the 50mm image has been cropped and then enlarged*. To check this:

- Obtain original 50mm photograph with **metadata**. Check full frame sensor camera and 50mm fixed focal length lens used

- print the original **50mm** photograph on A3 at **390mm** wide by **260mm** in height

- overlay a **template** to check that the correct proportion of the image has been cropped (an example is available on our website). The template should include two rectangles, one at 390mm by 260mm, and one at 260mm by 174mm as shown on the example.

- the cropped area should then be printed at **390mm** wide by **260mm** in height and this can be measured on the image submitted.

*** Note** – not all full frame sensors are exactly the same size. Very slight variations in sensor size and lens focal length may affect this measurement / comparison by a few mm. However, the difference is small enough that the horizontal field of view can be verified with sufficient confidence.

** **Note –** if measuring turbines on the image, make sure that you measure the full height of the turbine – i.e. check that the base of the turbine is not obscured either by vegetation, screening or topography.

Annex F Taking Good Photographs

This appendix is not intended to be a general manual of photography, there are plenty of good books available on that subject. It sets out briefly the main issues relating to photography aimed at constructing panoramas suitable for photomontages and ES work.

Camera and lens

A good quality camera is essential. A digital camera with **full frame sensor** is required to capture sufficient information and produce a verifiable image. A **fixed focal length 50mm** lens should be used to produce photomontages. A fixed focal length a) reduces the risk of inaccuracies and b) enables easy verification of the image should this be required. A full frame sensor also provides a verifiable reference point and a higher resolution than most alternative sensor sizes (depending on the camera).

Note, however, that sensor size varies slightly on most ‘full frame sensor’ cameras and that even high quality fixed focal length lenses can vary in their geometry. The precise sensor size and geometry of the lens should be recorded, where available. Any significant variation from 36x24mm sensor size or 50mm focal length should be recorded and, if significant, corrected for.

Tripod

A stable tripod is essential. As a minimum, a head with independent tilt adjustments for both pitch and roll should be used (ball-head tripods are more difficult to level satisfactorily). A panoramic head should be used, allowing a single adjustment to be made for an entire panorama. Camera height should be 1.5m (unless an alternative height is required). A photograph of the tripod in situ should be taken.

Levelling

In order to obtain photographs which will splice together satisfactorily to form the baseline panorama, it is essential that the camera is levelled accurately. A simple, cheap spirit level will do this quite satisfactorily and, with care, can produce images levelled to an accuracy of about 0.2°. A tripod head with a built-in sprit level and adjusting screws is better.

Focus

The camera lens should always be focussed on infinity. On auto-focus lenses, the focussing should be set to manual or locked on infinity.

Aperture and Exposure

If at all possible, the exposure should be metered once for a complete panorama and then used for all frames either by using a manual setting or by locking the exposure.

For greatest depth of field in the images, the aperture should be set to the minimum available on the lens (typically f/16 or f/22). If it is necessary to obtain slightly more resolution, it may help to use a slightly wider aperture: f/5.6 or f/8 are often the optimum settings. However, the photographer should use professional judgement to achieve the best results.

Shutter speed should be selected to obtain the correct exposure consistent with the aperture selected. If there are existing wind turbines in the view, the shutter speed will affect the degree of blurring seen in the photograph due to the movement of the blades.

Landscape Institute Technical Guidance Note

Visual Representation of Development Proposals

Technical Guidance Note 06/19

17 September 2019

This guidance aims to help landscape professionals, planning officers and other stakeholders to select types of visualisations which are appropriate to the circumstances in which they will be used. It provides guidance as to appropriate techniques to capture site photography and produce appropriate visualisations.

Contents

1 Introduction

1.1 Purpose of this Guidance

1.1.1 This document aims to help landscape professionals, planning officers and other stakeholders in the selection, production and presentation of types of visualisation appropriate to the circumstances in which they will be used. In doing so, it follows and amplifies the broad principles set out in The Guidelines for Landscape and Visual Impact Assessment 3rd edition (GLVIA3). Consistent with the Environmental Impact Assessment Regulations (EIA Regs), GLVIA3 advocates proportionate and reasonable approaches to the scope of assessments.

1.1.2 In all instances, the principles of clear, open and transparent communication and fitness for purpose should apply. Visualisations produced in accordance with this guidance should assist in informed decision-making.

1.2 Why Visualisations are Required

1.2.1 The world we live in constantly changes and this affects our visual experience. New development is one of the causes of this change. When people are asked to consider the merits of new development proposals or major changes in the landscape, the information available normally includes images illustrating the likely appearance of the proposals. Developers will often illustrate their proposals in brochures using drawings, photographs and artists impressions. Many other kinds of images are used in the formal planning process.

1.2.2 This guidance focuses on the production of **technical visualisations**, described as Visualisation Types, which are intended to form part of a professional Landscape and Visual Impact assessment (LVIA), Townscape and Visual Impact Assessment (TVIA) or Landscape and Visual Appraisal (LVA) that typically accompany planning applications. It is critical that these visualisations are accurate, objective and unbiased. They should allow competent authorities to understand the likely effects of the proposals on the character of an area and on views from specific points.

1.2.3 In contrast, **illustrative visualisations** may be intended for marketing or to support planning applications by conveying the essence of what a proposal would look like in context. These do not have to be based on specific viewpoints and could, for example, include a colour perspective illustration or an artists impression based on a bird's eye view.

1.2.4 Similarly, context photographs and sketches may be effective ways to communicate to stakeholders, in advance of, or association with, more sophisticated Visualisation Types. Generally speaking, they will not be used to explain design proposals *within the planning process*. They may indicate the appearance or context of a landscape or site, show specific points of detail, or be used for internal design iteration. Such illustrations, sketches and photographs are not, therefore, the subject of this guidance.

1.2.5 Technical visualisations can take a variety of generally 'static' forms, including: annotated photographs, wirelines, photomontages and 3D simulations. Plans and sections are potentially effective ways to communicate to stakeholders, in association with visualisations.

1.2.6 Augmented Reality (AR) and Virtual Reality (VR) are 'dynamic' visualisation techniques which are considered separately in this guidance.

1.2.7 Photographs show the baseline conditions; visualisations show the proposed situation; and both combine to simulate the change, for example as photomontages. Visualisations help to show how a proposed development could give rise to change in the character of a place, or affect the quality and nature of views, for example through introduction of new built elements or structures, changes in ground level, and loss of trees, vegetation or landscape features. Visualisations may also be used to illustrate other forms of landscape change, such as changes arising from landscape management or from influences such as climate change.

1.2.8 Depending upon the nature / type of the development or change, visualisations may need to show the development: during construction (if the construction period is of long duration and a notable element of the proposal's visual impact); at specific points in time during operation to illustrate the effectiveness of landscape mitigation; or possibly at decommissioning and restoration (e.g. as with a quarry or landfill site).

1.2.9 Visualisations should provide the viewer with a fair representation of what would be likely to be seen if the proposed development is implemented and should portray the proposal in scale with its surroundings. In the context of landscape / townscape and visual impact assessment, it is crucial that visualisations are objective and sufficiently accurate for the task in hand. In short, visualisation should be fit for purpose.

1.2.10 Visualisations may be used to illustrate other forms of landscape change, such as changes arising from landscape management or from influences such as climate change.

1.2.11 Some types of visualisation are more readily or quickly produced, but all visualisations share a role as a form of graphic communication, intended to represent the anticipated change in the visual environment, to illustrate key components of the proposed change or to give an indication of how much would or would not be visible from a given location.

1.2.12 As a general principle, any visualisation should reasonably represent the proposal in such a way that people can understand the likely landscape and visual change. The degree of detail shown will typically be relative to the design and / or planning stage that has been reached. Visualisations should assist interested parties in understanding the nature of a proposed development within its context, and its likely effects. Their use as part of an iterative process of assessment and design can help inform sensitive siting, design and primary mitigation, all of which are important considerations in the planning process. Showing the development within its context should help to secure better design at an early stage.

1.2.13 Two-dimensional visualisations, however detailed and sophisticated, can never fully substitute what people would see in reality. They should, therefore, be considered an approximation of the three-dimensional visual experiences that an observer might receive in the field.

1.2.14 Note that this guidance cannot provide a complete manual of techniques. Landscape professionals may need to draw upon the expertise of visualisation specialists, particularly for the most sophisticated forms of photography and visualisation.

1.3 A Proportionate Approach

1.3.1 To maintain a proportionate approach, different types of visualisation may be required, depending on:

- the type and scale of project;
- the aim (Purpose) and likely audience (Users) of the visualisation in the decision-making process; and
- the Sensitivity of the receptors and Magnitude of potential landscape and visual change.

1.3.2 The time, effort, technical expertise and cost involved in producing visualisations should be proportionate to these factors.

1.3.3 Other considerations which influence the scope of required visualisations, which should be reasonable and proportionate in relation to Purpose, are:

- The number of viewpoints to be illustrated photographically, and how many of these require visualisations;
- The Visualisation Type (1-4 in the following guidance); and
- The level of detail illustrated within the visualisation, for example as described in the London View Management Framework (see Appendix 6.4)

1.3.4 This guidance represents current best practice, provides a starting point to identify what types of visualisation may be appropriate and sets out approaches to potential visualisation techniques.

1.4 Relationship to previous LI Guidance

1.4.1 This guidance note replaces Landscape Institute (LI) Advice Note 01/11 (Photography and Photomontage for LVIA) and LI Technical Guidance Note 02/17 (Visual Representation of Development Proposals).

1.4.2 Advice Note (AN) 01/11 has been replaced in order to:-

- reflect other sources of guidance and additional research on the topic (see Section 5 - Further Reading);
- accord with the principles of GLVIA3 (2013) - (especially GLVIA3 paras 8.15-8.34);
- encourage best practice in the presentation of visualisations accompanying LVIAs, LVAs and planning applications; and
- ensure that visualisation techniques are properly explained and easily understood by all Users.

1.4.3 TGN 02/17 has been integrated in this guidance in order to provide a single source of guidance from the LI in respect of visualisations. LI AN 01/11 and TGN 02/17 are now withdrawn.

1.4.4 Further information on related landscape and visual assessment, and visualisation advice, may be found on the LI website: https://www.landscapeinstitute.org

1.4.5 These include:

- Glossary and Abbreviations;
- Earth Curvature;
- Camera Auto Settings and Limitations of Zoom Lenses; and
- Examples of Visualisation Types 1-4.

1.5 Visualisation Guidance by Others

1.5.1 This guidance applies to visual representation of all forms of development. The LI recommends its use to its members and to all parties using visualisations as part of the development process. The LI recognises that, for some types of development, targeted or authority-specific guidance may be appropriate.

1.5.2 The Highland Council (THC) Visualisation Standards for Wind Energy Developments 2016, the SNH Visual Representation of Wind Farms 2017 and the London View Management Framework 2012 (LVMF) are examples of 'authority-specific' guidance.

1.5.3 The LI supports Scottish Natural Heritage Guidance: Visual Representation of Wind Farms v2.2 February 2017 (SNH 2017). This Technical Guidance Note is broadly consistent with SNH 2017, particularly in respect of Type 4 Visualisation (see Sections 3 and 4).

1.5.4 The London View Management Framework provides useful guidance for large-scale urban development, and is particularly useful in identifying what it refers to as 'AVR Types' (0 - 3). See 'Further Reading' and Appendices 6.4 and 11.3.

1.5.5 When regulatory authorities specify their own photographic and photomontage requirements, the landscape professional should follow them unless there is a good reason not to do so. Failure to follow such guidance may risk requests for further information during the planning consultation process. Failure to satisfy stated validation requirements could lead to delays in validating planning applications. Seeking early engagement with the competent authority is recommended.

2 Guiding Principles

2.1 This guidance follows the broad principles set out in GLVIA3. Readers should note should note the comments in the Introduction (para 1.2.13) regarding the limitations of two-dimensional images.

2.2 Baseline photography should:

- be sufficiently up-to-date to reflect the current baseline situation;
- include the extent of the site and sufficient context;
- be presented at a size and relative position, on a corresponding sheet, to allow like-for-like comparison with the visualisation;
- be based on good quality imagery, secured in good, clear weather conditions wherever reasonably possible *(see Appendix 4 and GLVIA3 para 8.22)*;
- avoid foreground clutter; and
- in LVA / LVIA baseline photography, if relying on only existing views with no visualisations, clearly identify the extent of the application site in the view *(see Type 1 Visualisations)*.

2.3 Visualisations should:

- provide a fair representation of what would be likely to be seen if the proposed development is implemented;
- be based on replicable, transparent and structured processes *(Section 4)* and use a reasonable choice of agreed viewpoint locations, view directions, view angles and times of day *(Appendix 4)*;
- be reproduced at a suitable size and level of geometric accuracy relative to the baseline photographs *(Sections 3/4 and Appendices 7/8)*;
- be accompanied by appropriate information, including a Technical Methodology and required data within page title blocks *(Appendix 7.2 and 10)*; and
- where necessary, the photography and visualisation should be capable of being verified *(see Visualisation Type 4, Section 4 and Appendix 11)*.

2.4 The producers of visualisations should:

- refer to GLVIA3 paras 8.15-8.31
- use Visualisation Types 1-4, described further below, selected by reference to Purpose of use and anticipated Users, combined with the indicative overall Degree or Level of Effect (a product of Magnitude and Sensitivity) *(see Section 3)*;
- use techniques and media, with appropriate explanation, that represent the proposed scheme and its setting as accurately as reasonably practicable, proportionate to its potential effect;
- where reasonable within project timescales, include maximum effect scenario *(e.g. winter views - see GLVIA3 paras 6.28, 8.15)*; and
- use appropriate equipment and settings *(Sections 3/4 and Appendices 1-5)*.

3 Taking a Proportionate Approach

3.1 Understanding the Proportionate Approach

3.1.1 This section concerns how to determine which type of visualisation is proportionate to the task in hand. When identifying the need for some form of visual representation, landscape professionals, competent authorities and other stakeholders should use this guidance as the basis for reaching agreement on the appropriate Visualisation Type for the project in question. That does not preclude subsequent preparation of other visualisations, but working this way should help to ensure that public interests are secured in a way that is recognised as proportionate and fit for purpose by all those involved.

3.1.2 The factors which determine the appropriate Visualisation Type are:

- the intended Purpose of the visualisation;
- the anticipated Users;
- the stage in the planning application process;
- the Sensitivity of the context / host environment, having regard to the landscape and visual receptors [1]; and
- the likely overall Magnitude of effect of the development in terms of its 'size and scale', 'geographic extent' and 'duration and reversibility' [2].

[1] GLVIA3, paras 6.31- 6.37
[2] GLVIA3, paras 6.38- 6.41

3.1.3 Selecting the appropriate Visualisation Type requires a staged approach, described in more detail below in this section, and summarised as follows:

- identifying the Purpose and Users of the visualisation;
- identifying the type and nature of the proposed development and early indications of the likely overall Magnitude of effect it would generate;
- examining the context / host environment in which the development would be placed and assessing its overall Sensitivity;
- using the above to arrive at an indicative overall 'Degree or Level of Effect'; and
- selecting the most appropriate Visualisation Type based on the above criteria; and
- explaining the reason for its selection.

3.1.4 The process of selecting Visualisation Types can be considered in terms of a need for increasing levels of scrutiny of information or evidence required, with Purpose and Users considered alongside the likely overall effect of the proposed development on the host environment.

3.1.5 This guidance proposes four Visualisation Types (1-4), from least to most sophisticated, which are described in more detail in Section 4 and summarised in Tables 1 and 2 below.

3.2 Working with the Competent Authority

3.2.1 EIA development may be subject to Scoping, which can be used to help determine the appropriate scope and level of detail for the visual components of the LVIA. For non-EIA development, developers are encouraged to request pre-application ('pre-app') advice. If landscape / townscape and visual issues will be a key issue, submission of the proposed visualisation approach, suggested viewpoints and a Zone of Theoretical Visibility (ZTV), will assist in reaching agreement with the competent authority. Draft visualisations which are not fully worked up can be used for pre-app discussions or scoping requests. This should help reduce risk of requests for further information during the planning consultation period, and consequential further costs and delays.

3.2.2 The landscape professional is likely to need to determine an approach to visualisation before having completed (or possibly started) the LVA / LVIA itself. Therefore, a preliminary judgement on the likely overall 'Degree or Level of Effect' will be required. Whilst this should not prejudice the detailed process or outcome of the LVA / LVIA, the context and likely extent of the proposal will be known at an early stage and should be sufficient to inform the initial assessment.

3.2.3 It may be possible at this stage to anticipate a transition from one Purpose and set of Users to another during the course of the project and, therefore, to determine an approach appropriate to the spectrum of Users involved. A typical example is the transition from Planning Application to Planning Appeal.

3.2.4 Although this guidance is particularly aimed at visualisations prepared for use in the decision making process with competent authorities as the intended main Users, visualisations may also be used iteratively during the design process where the Users will be design / planning professionals and their clients.

3.3 Purpose and Users

Purpose

3.3.1 A principal consideration is the of the visualisation, i.e. the Purpose for which it will be used. For example, does it:

- provide basic contextual information in support of a planning application?
- purport to demonstrate the visual change that will be brought about if the development proceeds? or
- aim to prove or disprove if the development is visible, or demonstrate the effectiveness of a mitigation strategy?

3.3.2 Examples of the potential range of Purposes are:

- the illustration of a project prepared for the client as the project develops;
- the illustration of a development proposal prepared to accompany a planning application; and / or
- to illustrate the likely change in a view that may occur as a result of the development being introduced into that view; to inform an LVA or LVIA, e.g. as part of an EIA.

Users

3.3.3 In addition to being clear about the Purpose of the visualisation, it is important to understand and identify the likely Users. Are they:

- people potentially affected by the development who are being asked to give an early opinion as part of a consultation process?
- clients?
- other consultants communicating with the landscape professional?
- those formally commenting on the planning application?
- planning officers considering the merits of an application?
- participants at public inquiry (including members of the public, expert witnesses, legal advisers, Inspectors and Reporters)? and / or
- decision-makers (Councillors, Reporters / Inspectors, Ministers)?

3.4 Combining Purpose / User and Degree or Level of Effect

3.4.1 Having established the Purpose and Users of the visualisations, it is necessary to consider these in relation to the type of development proposed and the likely overall effect it would have on the host environment, having regard to landscape and visual receptors, in line with GLVIA3 principles.

3.4.2 An assessment of the Sensitivity of the context or host environment, together with a judgement of the likely Magnitude of landscape and visual change that may result as consequence of the development, will establish the indicative overall Degree or Level of Effect. This, considered with the Purpose and Users of the visualisation, will help determine which Visualisation Type would best suit the circumstances of the proposal and aid informed decision making.

3.4.3 Sensitivity and Magnitude, as determinants of Degree or Level of Effect, are extensively discussed in GLVIA3, as amended by GLVIA3 Statement of Clarification 1/13 (10-06-13)[3].

3.4.4 The broad principles of assessment are set out in GLVIA3 Figure 3.5. These principles apply to both landscape and visual effects and have clear contributory factors:

- susceptibility and value for Sensitivity;
- size / scale, extent, duration and reversibility for Magnitude.

3.4.5 When assessing Sensitivity and Magnitude and arriving at a judgement of indicative overall Degree or Level of Effect, consideration should be given to the landscape and visual effects of the project as a whole, rather than against individual viewpoints or receptors.

[3] statements of clarification 3 and 4 clarify and augment GLVIA3 paras 3.32-3.36, p.40-41.

3.5 Selecting the Appropriate Visualisation Type

3.5.1 Drawing these threads together, identifying the Visualisation Type, proportionate to the project under consideration, involves combining its Purpose / Users with the indicative overall Degree or Level of Effect of the proposed development. This, in turn, requires an understanding of:

- the landscape / townscape and visual context within which the development may be seen;
- the type of development proposed, its scale and size; and
- the likely overall landscape and visual effect of introducing the development into the existing environment.

3.5.2 The four Visualisation Types proposed in this guidance comprise the following (from least to most sophisticated, in terms of equipment, processing and presentation):

Type 1 annotated viewpoint photographs;
Type 2 3D wireline / model;
Type 3 photomontage / photowire;
Type 4 photomontage / photowire (survey / scale verifiable).

3.5.3 The most sophisticated Visualisation Types are appropriate when the Purpose / User requires the highest levels of accuracy, and the Sensitivity and Magnitude combine to generate the highest Degree or Level of indicative overall Effect.

3.5.4 The Visualisation Types are summarized in Table 2 and described in more detail in Section 4. Types 1-4 are typically all 'static' visualisations (i.e. capable of being printed).

3.5.5 'Dynamic' visualisations such as Augmented and Virtual Reality (AR / VR) are dealt with separately in Section 4.6.

3.5.6 Table 1 provides a broad indication as to appropriate Visualisation Types for different Purposes and Users. Note that Categories 'A' to 'D' illustrate four convenient levels along a scale, not four fixed interpretations.

Table 1: Relationships between Purpose, User and Visualisation Types

Category	Purpose and Users	Appropriate Visualisation Types
A	Evidence submitted to Public Inquiry, most planning applications accompanied by LVIA (as part of formal EIA), some non-EIA (LVA) development which is contrary to policy or likely to be contentious. Visualisations in public domain.	2 - 4
B	Planning applications for most non-EIA development accompanied by LVA, where there are concerns about landscape and visual effects and effective mitigation is required. Some LVIAs for EIA development. Visualisations in public domain.	1 - 4
C	Planning applications where the character and appearance of the development is a material consideration. LVIA / LVA is not required but supporting statements (such as Planning Statements and Design and Access Statements) describe how the proposal responds to landscape context and policies. Visualisations in public domain.	1 - 3
D	To inform the iterative process of assessment and design with client, and / or pre-application consultations with the competent authority. Visualisations mainly confidential.	1 - 2

3.5.7 The decision as to appropriate Visualisation Type should be based on a proportionate approach, taking account of its Purpose / Users and indicative overall Degree or Level of Effect (based on Sensitivity and Magnitude) of the proposed development. In all cases, professional judgement should be applied, and agreement reached with the competent authority wherever possible.

3.5.8 A combination of simpler and more sophisticated graphics may be appropriate to illustrate specific points. So, for example, 3D models, or annotated viewpoint photos (Types 1 and 2) at less important locations, may usefully support more sophisticated (Types 3 and 4) visualisations at key locations.

3.5.9 However, different interpretations of scale between visualisations should be avoided unless there is a specific reason to do so, which should be explained in the Visualisation Type Methodology, the subject of the next section.

3.5.10 When making a final choice it will be important to consider:

- The contextual Sensitivity and Magnitude of landscape and visual effects of the development overall (rather than that applying to a single location) and the application of a proportionate and consistent approach.

- Cost of the visualisation; several factors are relevant here. Firstly, it depends on what readily available technologies are available to the landscape professional. Secondly, it depends on the nature (type, size and scale) of the development and thirdly, on the degree of realism required. For example, wind farm visualisations are less expensive to prepare than for mixed use or other forms of development, because wind farms consist of a number of single objects of the same size and shape with the same surface finish. However, subject to the proportionality principle, cost considerations should not override the reasonable requirement for appropriate visualisations.

- Available technology – some techniques are dependent on particular technologies / software (e.g. digital photo / panoramic viewers) which not all of those preparing visualisations will have access to. Nor will competent authorities necessarily be able to view particular technologies.

- The nature of the development and how it may best be illustrated. For example, where a development is predominantly screened from view, a photowire image may be more helpful than a photomontage, as it can indicate the position of the development beyond any screening.

3.6 Introducing Visualisation Types 1-4

3.6.1 Table 2 below sets out the general aims of Visualisation Types 1-4, together with indications of appropriate locational accuracy, photographic equipment and presentational approaches.

3.6.2 Note that it is not possible to categorise every possible kind of visualisation into Types 1-4; some inevitably straddle categories. If a visualisation does not fit neatly into one of the four categories, that does not make it unacceptable, provided it is fit for purpose and not misleading, and is clearly explained in the Visualisation Type Methodology.

<table>
<tr><th colspan="2" rowspan="2">Table 2
Visualisation
Types 1-4</th><th>Type 1</th><th>Type 2</th><th>Type 3</th><th>Type 4</th></tr>
<tr><th>Annotated Viewpoint Photograph</th><th>3D Wireline / Model (non-photographic)</th><th>Photomontage / Photowire</th><th>Photomontage / Photowire Survey / Scale Verifiable</th></tr>
<tr><td colspan="2">Aim of the Visualisation</td><td>To represent context and outline or extent of development and of key features</td><td>To represent 3D form of development / context</td><td>To represent appearance, context, form and extent of development</td><td>To represent scale, appearance, context, form, and extent of development</td></tr>
<tr><td rowspan="3">Photographic Equipment</td><td>Tripod</td><td>Recommended but discretionary</td><td>Not relevant</td><td>Recommended</td><td>Necessary</td></tr>
<tr><td>Panoramic head</td><td colspan="2">Not relevant</td><td>Recommended for panoramas</td><td>Necessary for panoramas</td></tr>
<tr><td><u>Minimum</u> Camera / Lens</td><td>Cropped frame or FFS + 50mm</td><td>Not relevant</td><td>Cropped frame or FFS + 50mm</td><td>Full Frame Sensor (FFS) + 50mm FL lens [1]</td></tr>
<tr><td rowspan="2">Locational Accuracy</td><td>Source of camera/viewpoint location data</td><td>GPS, OS Maps, geo-referenced aerial photography</td><td>Varies according to technology</td><td>Use good quality data:
GPS, OS Maps, geo-referenced aerial photography, LiDAR</td><td>Use best available data:
High resolution commercial data, LiDAR, GNSS, or measured / topographic surveys</td></tr>
<tr><td>Survey-verified [2]</td><td colspan="3">Not relevant</td><td>When appropriate</td></tr>
<tr><td rowspan="7">Data & Presentation</td><td>Verifiable (SNH) [3]</td><td colspan="3">Not relevant</td><td>Required</td></tr>
<tr><td>3D model</td><td>Not required</td><td colspan="3">Required</td></tr>
<tr><td>Image Enlargement [4]</td><td>Typically 100%</td><td>Not relevant</td><td>Typically 100%</td><td>100% - 150%</td></tr>
<tr><td>Form of Visualisation</td><td>sketch / outline / arrows</td><td>massing / wireline / textured</td><td colspan="2">wireline / massing / rendered / textured to agreed AVR level [5]</td></tr>
<tr><td>Viewpoint mapping</td><td colspan="3">Dedicated viewpoint location plan</td><td>Dedicated viewpoint location plan, + individual inset maps recommended</td></tr>
<tr><td>Reporting of methodology and data sources</td><td colspan="2">Outline description of sources and methodology recommended</td><td>Data, sources and methodology recommended</td><td>Verifiable data, sources and methodology required</td></tr>
</table>

Table 2 footnotes:

1 FFS+50mm FL - note exceptions to 50mm lens FL. See Section 4 and Appendices 01 and 06.

2 Survey-verified means the camera position and survey features being recorded by highly accurate survey processes. See Section 4 Locational Accuracy & Appendix 14.

3 Verifiable (SNH) has the same meaning as in SNH 2017 - the photographic process and image scaling is capable of being verified to agreed standards by reference to the original photograph with metadata. See Appendices 6 & 11.

4 Image Enlargement - see 3.8 below.

5 AVR level - see Appendix 6.4.

3.7 Visualisation Type Methodology

3.7.1 For any given project for which visual representation may be required, the proposed approach to visualisation should be set out in a brief description, explaining:

- the anticipated Purpose / Users;
- the indicative assessment of Sensitivity and Magnitude and resulting likely indicative overall Degree or Level of Effect; and
- other factors influencing the selection of the Visualisation Type.

3.7.2 This may be combined with a preliminary selection of proposed viewpoints and submitted to the competent authority and, ideally, agreed prior to submission of any planning application. See also GLVIA3 para 6.18.

Examples

3.7.3 The following are examples of using Tables 1 and 2 to arrive at an appropriate Visualisation Type 1-4. Letters A-D refer to the 'Category' column in Table 1 above.

*(1) **A single house**, submitted as a planning application in a prominent location within a designated landscape, might be regarded as:*

- *Purpose / User C, Planning Application;*
- *High-Medium Sensitivity, Small-Negligible Magnitude;*
- *likely Slight-Moderate Degree or Level of Effect.*

*This would suggest **Type 1** visualisations - perhaps an annotated photograph (40° at A3 width) indicating the extent (width / height, or outline) of the proposed development.*

*(2) Pre-application discussions with developer over **proposals to re-work a large clay waste tip** on the edge of a National Park, screened as requiring EIA. Accurate output from a 3D model is required to understand the nature and magnitude of visual impacts from key sensitive locations and determine the need for fully rendered photomontage to form part of a formal LVIA.*

- *Purpose / User D, pre-application discussions;*
- *High Sensitivity context, Large Magnitude;*
- *likely Substantial Degree or Level of Effect.*

*This would suggest **Type 2** (3D modelling) - outputs required for informed discussion, not determination of planning application.*

*(3) **A small quarry / extension**, submitted as a planning application, in a landscape considered of medium to high sensitivity to the proposed change, might be regarded as:*

- *Purpose / User B, accompanying an LVA;*
- *Medium Sensitivity, Medium Magnitude;*
- *likely Moderate Degree or Level of Effect.*

*This would suggest **Type 3** - photowires or photomontages (40° at A3 width or 90° at A1) indicating the appearance of the proposed development.*

*(4) **A large housing site**, submitted as a planning application with potential implications on a local designation (e.g. Conservation Area or Important Landscape Area) might be regarded as:*

- *Purpose / User B, accompanying an LVA;*
- *High-Medium Sensitivity context, Large-Medium Magnitude;*
- *likely Substantial Degree or Level of Effect.*

*This would suggest **Type 3** photowires or photomontages, or possibly **Type 4** (surveyed) if close-proximity sensitive views were required.*

*(5) **A large wind farm** in a locally-designated landscape area, the subject of a public inquiry, might be regarded as:*

- *Purpose / User A, part of an EIA;*
- *High-Medium Sensitivity, Large Magnitude;*
- *likely Substantial Degree or Level of Effect.*

*This would suggest **Type 4** visualisations, where surveyed locational accuracy is not necessary but image enlargement, to illustrate perceived scale, would be appropriate.*

*(6) Planning application for **a very large energy from waste plant** building with 90m twin stacks and plume emissions on an edge of town industrial estate, within potential visual range of important views from a Grade 2 Registered Historic Park (designated heritage asset):*

- *Purpose / User A / B (Planning / Public Inquiry);*
- *High Sensitivity, Large-Medium Magnitude;*
- *likely Substantial Degree or Level of Effect.*

*This would suggest **Type 4** visualisations, where surveyed locational accuracy may not be necessary but image enlargement, to illustrate perceived scale, would be appropriate.*

*(7) **A proposed new tower block** with potential implications on a designated landscape / townscape, subject to a planning application, might be regarded as:*

- *Purpose / User A / B (Planning / Public Inquiry);*
- *High Sensitivity, Large Magnitude;*
- *likely Substantial or Very Substantial Degree or Level of Effect.*

*This would suggest **Type 4** visualisations. In addition, if the precise visual relationship between the tower block and other buildings is of particular importance, surveyed locational accuracy may be appropriate.*

3.7.4 The preceding examples are just that - examples - and should not be regarded as templates. This approach can be used in preparing a Visualisation Type Methodology. It is not a sophisticated LVA / LVIA, but a review of basic criteria, known early in the project, to inform selection of appropriate Visualisation Types.

3.7.5 The selected Visualisation Type (1-4) should be clearly stated on all visualisation pages, such that recipients can understand the approach being taken.

3.8 Viewing Distance and Image Enlargement

3.8.1 Table 2 introduces the concept of 'image enlargement', which is carried forward into the detail of Visualisation Types 3-4 , described in the next section.

'Monocular' and 'Binocular' viewing

3.8.2 Printed photographic images have a theoretical viewing distance at which the scale of the view is reconstructed, although this assumes that cameras and humans have similar optical systems, which they do not. The essential difference is that cameras (for this purpose) are monocular, and humans are generally binocular. In addition, the fact that reality is viewed as a 3D space, whereas photographs are viewed as 2D projections, combine to alter perceptions of 'scale' and 'depth' between reality and photography. See Section 5 'Further Reading' for more information.

3.8.3 Whilst mathematical viewing distances have historically been quoted alongside visualisations, it is generally regarded that viewing distances of between 500mm – 550mm (approximately arm's length) are the most practical and widely used. All scale-representative views should, therefore, be accompanied by a note: "To be viewed at comfortable arm's length".

100% Reference Image

3.8.4 A 'mathematically correct' image is established for a 50mm FL approximately 39.6 Horizontal Field of View (HFoV) image, printed at a size of 390mm x 260mm on an A3 sheet, and held at 542mm[1] from the eye. This 'monocular view' represents a reference point of 100% in this guidance note, against which enlargements, such as 150%, can be described. For example, a 50% increase in image size can be described as a 150% enlargement.

3.8.5 Changes in the relative size of printed images are described in other documents as the 'Effective Focal Length' (EFL) at which an image is presented. 50mm EFL equates to 100% and 75mm EFL equates to 150%. For simplicity, this guidance describes the enlargement by percentage, related to the 100% reference image.

150% Enlargement Factor

3.8.6 Whilst presenting a 50mm FL image (39.6° HFoV) at A3 size is a straightforward use of the camera image, this approach has been found to be lacking in respect of expansive projects in open landscapes or seascapes, such as windfarms. This is because, for a 50mm FL image printed at A3 and held at comfortable arm's length, the scale of the viewed image is smaller than reality.

3.8.7 As a result of research in Scotland over the last decade (see Section 5 - Further Reading) there is a consensus that increasing the printed image size by 150% (as if a 75mm FL lens had been used) provides a better impression of scale for most viewers using two eyes (binocular vision). This is particularly appropriate for projects such as windfarms, whether viewed on a desktop or on site.

3.8.8 The approach of this guidance is, therefore, to recognise that, for larger-scale projects with more distant components such as windfarms, the approach taken in SNH 2017 (put simply, a 150% enlargement) is appropriate.

3.8.9 This brings with it some issues:

a) Paper size or constrained Field of View

Adding 50% to the image size increases the presentation size (digital or paper). Conversely, the site can only be represented

[1] Note that 542mm simply establishes a mathematical reference point. Generally, there is no need to hold the image at such a specific distance.

if it can be accommodated within an A3 sheet (27°HFoV x 18.2° VFoV) or A1 sheet (53.5°HFoV x 18.2°VFoV). If it occupies a greater vertical or horizontal FoV, then alternatives must be considered.

This is accounted for in the SNH Guidance, in that exceptions to its standard can be discussed and agreed with SNH.

b) Appropriateness in all situations

Whilst the 150% enlargement overcomes the scale issues for the expansive projects for which it was designed, it may over-compensate for projects in more constrained environments, such as urban or small-scale enclosed landscapes. In these situations, less enlargement may be appropriate.

3.8.10 Research by the LI Working Group in the preparation of this guidance, carried out across several cities, suggests that, in mid- to smaller-scale landscapes / townscapes, an enlargement around half-way between 100% and 150% results in a binocular relationship between the presented image and reality.

3.8.11 In addition, there will be situations - for example very close urban contexts or developments of considerable height or width - where scaling at less than 150% may provide more flexibility to fit an image on the page.

3.8.12 In these instances, the landscape professional should present the logic, behind opting for a particular enlargement factor, to the competent authority.

3.8.13 Notwithstanding the above, SNH considers that consistent use of 150% enlargement is beneficial.

Other means of achieving enlarged images

3.8.14 An A3 (50mm FL, 39.6° HFoV) sheet, when printed at A2 size, is enlarged by 141%. This provides a basic way to create a printed page with improved image scaling, simply by printing an A3 figure, enlarged to fill an A2 sized sheet. This will, however, result in some loss of resolution compared to an image which is created to be placed in an A2 sheet at full resolution. It should not, therefore, be used in the more rigorous context of Visualisation Type 4.

3.8.15 A 35mm FL lens on a FFS camera will capture a HFoV of 54.4°, which is very close to the requirements of an SNH 2017 planar A1 panorama (53.5° HFoV). Whilst it will not satisfy SNH 2017 Guidance (which requires the 50mm / FFS combination) a 35mm FL image of sufficient resolution and clarity may, therefore, provide an A1-width planar panoramic image, without stitching and re-projecting of multiple 50mm images.

3.8.16 In either case, the practitioner should ensure that image quality is appropriate for the Purpose, and set out the approach in the Visualisation Type Methodology (3.7) and Technical Methodology (Appendix 10).

4 Description of Visualisation Types 1-4

4.1 Visualisation Types 1-4

4.1.1 The main characteristics of Visualisation Types 1-4 are introduced below. More detail on these 'static' visualisations is provided in the sections which follow, including a separate subsection on 'dynamic' visualisations, namely AR / VR.

Type 1 Annotated Viewpoint Photograph:

Reproduced at a size which aids clear understanding of the view and context, these simply show the extent of the site within the view, and annotate any key features within the view.

Type 1 is the most basic form of visual representation with a focus on the baseline information.

Type 2 3D Wireline / Model:

This covers a range of computer-generated visualisation, generally without a photographic context. Wirelines and other 3D models are particularly suited to graphically describing the development itself.

Type 2 visualisations use basic graphic information to assist in describing a proposed development and its context.

Type 3 Photomontage / Photowire:

This Type encompasses photomontages and photowires which will commonly be produced to accompany planning applications, LVAs and LVIAs. They provide a reasonable level of locational and photographic accuracy, but are not suitable for the most demanding and sensitive of contexts. Type 3 visualisations do not need to be accompanied by verification data, nor is a precise survey of features and camera locations required. Although minimum standards are set for image presentation, the visualisations do not need to be reproduced with scale representation.

Type 3 visualisations offer an appropriate level of detail and accuracy for a range of EIA and non-EIA projects.

Type 4 Photomontage / Photowire (survey / scale verifiable):

Type 4 photomontages and / or photowires require the use of equipment and processes which provide quantifiable verification data, such that they may be checked for accuracy (as per industry-standard 'AVRs' or 'Verified Views'). Precise survey of features and viewpoint / camera locations may be included where warranted. Type 4 visualisations are generally reproduced with scale representation.

Type 4 visualisations represent the highest level of accuracy and verifiability for use in the most demanding of situations. See also Appendix 11, Verified Photomontages.

4.1.2 In providing flexibility across Visualisation Types 3 and 4, there is inevitably some degree of overlap between them, for example in terms of image scaling or presentation size. Whilst Type 3 will be acceptable in many situations, only Type 4 methodology and equipment can provide the levels of verifiable accuracy which are appropriate to high Sensitivity contexts and Purposes.

4.2 Type 1: Annotated Viewpoint Photograph

4.2.1 Viewpoint photographs are often used in LVIAs and LVAs and may usefully be annotated to show the extent or position of the site and other features. 3D-modelling is not required - the annotations of site extent (horizontally) may be estimated by reference to site features such as field or plot boundaries.

4.2.2 Single images will be planar (i.e. as captured by the camera). Alternative lens types may be considered - see Appendix 1. Where single images can capture the site (e.g. 39.6° x 27°) and be presented at A3, they may be supported by two baseline panoramic images (maximum 60° HFoV) presented on an A3 sheet. This is purely to show the location of the full-size single image frame in its context and, as such, should be noted as being 'for context only'. Wide panoramas on an A3 sheet are too small to provide a representation of the proposed development.

4.2.3 Where panoramic images are required to capture the site, they may be presented as cylindrical panoramas of up to 90° HFoV at A1 width with an image size of 820mm x 250mm (see Appendix 8). This sizing equates to around 96% image 'enlargement'.

4.2.4 Locational accuracy is moderately important, and reasonably precise locations can be determined from GPS data, OS maps or aerial photography.

4.2.5 Refer also to the Technical Methodology, Appendix 10.

Table 3: Suitable photographic / print formats (Type 1):

Camera / lens	FFS + 50mm lens	Cropped frame + 28 or 35mm lens
Sheet size	A3	
Image size (mm)	390 x 260	
Presented Field of View (H x V)	39.6° x 27°	Either 35mm = slightly narrower than FFS+50mm, or crop 28mm image to match FFS+50mm
Sheet size	Cylindrical Panoramic image @ A1 width	
Presented Field of View (H x V)	90° x 27° (VFoV as appropriate)	
Image size (mm)	820 x 250 minimum (height as appropriate)	

Type 1 Summary

Type 1 visualisations are simple, annotated photographic illustrations which often accompany LVAs.

- Use a Full Frame Sensor camera with 50mm lens, or cropped-frame sensor camera with 35mm or 28mm fixed lens. See Appendix 1.
- Images will typically be presented with a single frame on an A3 sheet.

4.3 Type 2: 3D Wireline / Model

4.3.1 This Type covers the use of 'static' presentation of 3D models which are visual representations distinct from photographically-based photomontages.

4.3.2 The main examples are computer-generated 3D wirelines (also described as 'wireframes') and 'massing' models, potentially with computer-generated context, such as buildings, terrain or other surrounding features.

4.3.3 'Dynamic' visual representations, such as 'augmented reality' or 'virtual reality' (AR or VR), are dealt with separately in Section 4.6 below.

4.3.4 Images to be included in reports should be of sufficient size to communicate a sense of the scale of the development. An A3 Sheet, as with Types 1 and 3, would generally be appropriate. An image based on a 3D model to show proposed development layout (for example, an aerial view) need have no specific FoV or location reference, but should have a realistic sense of perspective.

4.3.5 Computer models generally do not convey landscape context unless they are extremely sophisticated. Most planning applications should be accompanied by photographs or photomontages, rather than solely relying on Type 2 visualisations to convey an impression of a development proposal.

4.4 Type 3: Photomontage / Photowire

4.4.1 Type 3 visualisations are photomontages or photowires (photographs with wireline overlays) where site photography forms the basis of the imagery, which is then overlaid by a 3D wireframe, massing or rendered model. Type 3 are suitable for representing proposals where precise perception of scale of the printed image, and the highest levels of locational accuracy, are not necessary. If the key criteria for Type 4 cannot be guaranteed, then the visualisation will be classified as a Type 3. 'Type 3' should be clearly stated on all visualisations.

Table 4: Suitable photographic / print formats (Type 3):

Camera / lens	FFS + 50mm lens	Cropped frame + 28 or 35mm lens
Presented Field of View (H x V)	39.6° x 27°	Either 35mm = slightly narrower than FFS+50mm, or crop 28mm image to match FFS+50mm
Sheet size	A3	
Image size (mm)	390 x 260	
Enlargement relative to FFS / 50mm	100%	100 - 120%
Sheet size	Cylindrical Panoramic image @ A1 width	
	90° x 27° (VFoV as appropriate)	
Enlargement relative to FFS / 50mm	96%	
Image size (mm)	820 x 250 minimum (height as appropriate)	

Lens and Camera

4.4.2 Full-Frame Sensor cameras (FFS) are appropriate. Cropped-frame cameras (e.g. Canon APS-C / Nikon DX) are acceptable when a fixed lens of 35mm FL is used. Alternatively a 28mm lens could be used and the resulting photographs cropped to achieve the same FoV as a 50mm FL lens with an FFS. See Appendix 1.2. Note that different cropped-frame lens / camera combinations will result in slightly different FoV and enlargement factors.

Purpose

4.4.3 Type 3 visualisations are intended to represent design, form and context to a reasonable degree of objectivity and accuracy, one which can be understood and relied on by competent authorities and others. This category covers a wide range of applications including non-verifiable viewpoint locations, such as those from moving vehicles / drones and other such situations where the viewpoint coordinates cannot be replicated with the same degree of accuracy / precision as Type 4 visualisations. It would also be appropriate where photographs have been taken by a 3rd party, provided these are prepared in accordance with the principles set out in this guidance and supported by a clear methodology.

4.4.4 Type 3 visualisations should not be selected when printed scale representation is required.

4.4.5 Single images are planar (i.e., as captured by the camera). Alternative lens types may be considered - see Appendix 1.

4.4.6 Where single images can capture the site (e.g. 39.6° x 27°) and be presented at A3, they may be supported by two baseline panoramic images (maximum 60° HFoV) presented on an A3 sheet. This is purely to show the location of the full-size single image frame in its context and, as such, should be noted as being 'for context only'. Wide panoramas on an A3 sheet are too small to provide a representation of the proposed development. They do not replace baseline photographs, which should be presented at the same size and scale as their corresponding visualisations.

Presentation

4.4.7 Imagery will typically be presented as two related sheets: Baseline photograph and photomontage. These should be presented at the same size to allow direct comparison. A wireframe may be included to explain alignment between the 3D model and site features.

4.4.8 Visualisations should be accompanied by a Technical Methodology, setting out the criteria listed in Appendix 10.

Panoramas

4.4.9 Where panoramic images are required to capture the site for visualisation, they may be presented as cylindrical panoramas of up to 90° HFoV at A1 width with an image size of 820mm x 250mm (see Appendix 8). This sizing equates to around 96% image 'enlargement' (i.e. a slight reduction from the 100% reference). When a wider FoV than 90 degrees needs to be captured, this should be done by using adjoining A1 sheets.

Locational Accuracy

4.4.10 It is important to disclose the level of locational accuracy of Type 3 visualisations, which should be determined on the basis of proximity of viewpoint to the site and on Sensitivity of receptors / importance of the view. The level achieved should be clarified in the methodology and the same approach should be taken for all visualisations presented. Typically, horizontal accuracy of 1-2 metres can be obtained from aerial photography. However, this may vary according to the aerial photography source and location (see Appendix 14) and this should be considered when reporting on locational accuracy in the methodology.

Type 3 Summary

Type 3 visualisations will be appropriate for many planning applications, LVAs and LVIAs, where photomontage is required but a verifiable process and printed scale representation are not needed.

- Use a Full Frame Sensor camera with 50mm lens or cropped-frame sensor camera with 35mm or 28mm fixed lens.
- Images will typically be presented with a single frame on an A3 sheet, providing an enlargement in the range 100-120% subject to camera / lens combination.
- The enlargement factor should be stated on each page, together with the label 'Visualisation Type: 3'.
- For very wide linear infrastructure, consider presenting cylindrical panoramas up to 90° at A1 width, with multiple sheets for very wide panoramas.
- Accompany visualisations with a Technical Methodology (see Appendix 10).

4.5 Type 4: Photomontage / Photowire (survey / scale verifiable)

4.5.1 Type 4 visualisations are photomontages or photowires, produced using quantifiable data, with procedural transparency and appropriate levels of accuracy. This involves using a defined camera / lens combination and establishing the camera location with sufficient locational accuracy to enable accurate scaling and location of the 3D model within the view. In addition, the print presentation size can be determined to provide binocular image scaling when appropriate (see Section 3.8). Note that, due to the variable nature of digital viewing devices, images cannot be assumed to provide a perception of scale unless printed at the specified size. See Appendix 7 for more details. 'Type 4' should be clearly stated on all visualisations.

4.5.2 See Appendix 6 'Preparing Photomontages' and Appendix 8 'Panoramas'.

Lens and Camera

4.5.3 Base photography should be carried out with a Full Frame Sensor (FFS) camera and 50mm Focal Length prime lens, unless there are exceptional conditions where wider-angle lenses are required to fully capture the scene (e.g. tall tower blocks - see below). In such cases, any departures from FFS + 50mm FL should be explained and agreed with the competent authority.

4.5.4 Table 5 represents the range of approaches suitable for Type 4 visualisations. Note that the stated percentage enlargement figures are relative to a 50mm FL image printed on an A3 sheet at 390mm x 260mm image size (para 3.8.4, 100% Reference Image).

Table 5: Suitable photographic / print formats (Type 4)

Camera / lens	FFS + 50mm lens	
Option	1	2
Captured Field of View (HFoV x VFoV)	39.6° x 27°	
Image scaling (see 3.8)	'Monocular'	'Binocular'
Sheet size	Single image @ A3	
Projection (see App 8)	Planar	
Image size (mm)	390 x 260	
Presented Field of View (H x V)	39.6° x 27°	27° x 18.2°
Enlargement relative to FFS / 50mm	100%	150%
Sheet size	Panoramic image @ A1 width	
Projection (see App 8)	Cylindrical (for baseline and very wide linear infrastructure)	Planar
Presented Field of View (H x V)	90° x 27°	53.5° x 18.2°
Enlargement relative to FFS / 50mm	96%	150%
Image size (mm)	820 x 250 minimum (height as appropriate)	

Note that exceptions to lens and image sizes are acceptable if explained and agreed with the competent authority

Presentation

4.5.5 Imagery will typically be presented as three related sheets: Baseline photograph; wireline / wireframe or photowire composite; and photomontage. These should be presented at the same size to allow direct comparison.

4.5.6 Visualisations should be accompanied by a Technical Methodology, setting out the criteria listed in Appendix 10. In addition, a clear written description should be provided to explain the procedures involved in image capture and processing.

Locational Accuracy

4.5.7 For Type 4, the minimum level of locational accuracy is similar to the upper end of the Type 3 range.

4.5.8 The degree of accuracy should be determined on the basis of proximity of viewpoint location to the site and on Sensitivity of receptors / importance of the view. Typically, horizontal accuracy within 1-2 metres can be obtained from aerial photography. See Appendix 14.

4.5.9 In situations where the subject of the photomontage is close and the Sensitivity is high (typically in important urban and heritage contexts) high levels of locational accuracy may be required to establish intervisibility between the viewpoint, the subject of the photomontage and other elements in the scene, e.g. when assessing if a development interrupts a sensitive skyline or not. Such accuracy may be obtained from survey techniques providing sub-metre accuracy (see Appendix 11.4, survey-verified photography).

Image Scaling

4.5.10 The objective of Type 4 visualisation is to present a printed image which gives a realistic impression of scale and detail. Where scale-verifiable output is not possible (Appendix 1.1.7), verified photomontages can still be regarded as Type 4, provided they are supported by quantifiable data and a technical methodology, and agreed by the competent authority.

Table 5, Option 1: 100% enlargement

4.5.11 This is a 39.6° HFoV photograph presented within a 390 x 260mm frame. This option does not provide for binocular image scaling when printed. Nonetheless, it is included within Type 4 for the following reasons:

- where 150% enlargements would be problematic for large / close sites (due to impractical paper sizes), an option is still required for use in the planning process which maintains high levels of accuracy (e.g. levels 'A' or 'B' in Table 1);

- even though a 100% enlargement image will not provide 'binocular' perception scaling, it may still be useful and practical in its own right.

- once the 50mm / FFS combination is engaged, the EXIF metadata of the source RAW / JPG photographs can be interrogated and verified (as per SNH 2017), irrespective of how they are presented - see Appendix 11.2; and

- appropriately captured source photographs are capable of meaningful survey and verification when required - see Appendix 11.4.

4.5.12 In the majority of situations, and wherever context is important to understanding of the proposal, an A1 width 90° cylindrical baseline photograph will provide a 100% enlargement contextual reference.

Table 5, Option 2: 150% enlargement

4.5.13 SNH 2017 effectively requires an image enlargement of 150%, in other words 50% over that which is 'mathematically correct for monocular vision' (see Section 3.8). Option 2 of Table 5 corresponds with this approach. This is regarded as the default enlargement factor for Type 4 visualisations.

4.5.14 The SNH 2017 guidance is endorsed by the LI for windfarms and similar projects which are viewed in expansive landscapes over medium to far distances. Refer directly to the SNH 2017 guidance for full details and requirements.

4.5.15 The image capture and presentation process should be capable of being verified, in accordance with SNH 2017 guidance. See Appendix 11, Verified Photomontages.

4.5.16 As noted at 3.8.10, in mid- to smaller-scale landscapes or townscapes, enlargement factors around halfway between 100% and 150% may be a more appropriate. This guidance does not propose any definitive rule, but considers that this reduced level of enlargement may provide an option for consideration by practitioners and the competent authority.

4.5.17 In either case, the principle, of producing an image which represents the scale of the proposal, is maintained. The proposition, that different approaches may be applied to image scaling, recognises that this depends on context and distance. However, a consistent approach to image scaling should be applied within any project.

Other Approaches

4.5.18 There are circumstances where it may be appropriate to depart from using a 50mm lens on site and from setting up pages with a 150% enlargement. These are described below.

Wider Vertical Field of View (VFoV)

4.5.19 The proposed development, viewed at close quarters, may not be captured by a 50mm lens with FFS camera, or fit within the A3 or A1 width x A4 height page sizes - for example, a tall building or high-voltage overhead lines. Alternative lenses may be required in exceptional circumstances - see Appendix 1.

4.5.20 In such instances, alternatives such as increasing the vertical height of the page (to A2 landscape, A1 landscape width with A3 landscape or even A1 landscape width and height) may be appropriate. Reasons for adopting such dimensions should be set out in the Technical Methodology. Wherever practical, 150% enlargement should be maintained.

Wider Horizontal Field of View (HFoV)

4.5.21 The edge distortion of planar panoramas results in them being unsuitable for images with a wide HFoV. Where the required HFoV exceeds 53.5°, multiple planar panoramas of 53.5° may be butted, or overlapped by 25-50% to provide a wider total HFoV. The extent of overlap may be determined by the total HFoV to be shown. In either case (butting / overlapping) the approach should be clearly explained.

4.5.22 If there is a particular reason to show very wide panoramas, (for example, for linear infrastructure occupying a wide FoV) the use of cylindrical projection (Table 5, Option 1, A1 width) may be considered and, if justified, the reasons explained in the Technical Methodology and the projection set out clearly on the presentation page.

Type 4 Summary

Type 4 visualisations enable the highest level of locational accuracy and image scaling where required:

- For sites / settings which can be captured either as single images or panoramically, use a 50mm lens with Full Frame Sensor camera.
- If the site / setting cannot be captured with the 50mm lens (e.g. close, tall buildings), consider alternative lenses - see Appendix 1.
- Images will typically be presented with a 150% enlargement (27°@ A3, or 53.5° @ A1)
- The enlargement factor should be stated on each presentation page, together with the label 'Visualisation Type: 4'.
- Present Planar projection panoramas for views up to 60° HFoV.
- 100% size (39.6° HFoV @ A3) may be considered and agreed with the competent authority where higher levels of enlargement are not practical.
- For wider view angles, use overlapping or butted planar panoramas.
- For very wide linear infrastructure, consider presenting cylindrical panoramas up to 90° at A1 width, with multiple sheets for very wide panoramas.
- Wherever wider context is important to understanding of the proposal, include an A1 width 90° cylindrical baseline photograph.
- Accompany visualisations with a Technical Methodology (see Appendix 10) including a clear written description of procedures involved in image capture and processing.

4.6 Dynamic Visualisations

4.6.1 Emerging visualisation technologies such as Augmented Reality (AR) and Virtual Reality (VR) currently require specialist skills and technology / software and may have significant cost implications and may, therefore, be beyond the scope of many landscape professionals, their clients and competent authorities. However, as these technologies develop, they are likely to become more widely available and used.

Augmented Reality

4.6.2 Augmented Reality (AR) visuals typically use phones, tablets or headsets. AR visuals have the advantage of being able to present moving elements (such as vehicles or turbines) within the view, and, if used on site, of moving the viewpoint. Images can be captured on site and subsequently used off site. Depending on the viewing screen size, visuals will be presented at a range of scales, so care is needed when interpreting their outputs. Similarly, the cameras of such devices are likely to be wide-angle (in the region of 30-35° HFoV). Note that levels of locational accuracy can be improved with surveying techniques, and that specialist devices with precision lenses, or connected to digital cameras, may come into use. It is likely that, under such circumstances, AR could in the future satisfy the requirement of Type 3 visualisations.

Virtual Reality

4.6.3 Virtual Reality (VR) headsets use computer-modelled backgrounds rather than photographic backgrounds, due to their ability to move location within the model. This is a disadvantage in terms of realism, but an advantage in terms of being able to study movement within or around a development. As such, they present an alternative approach to visualising development. Subject to the quality of the hardware used, image resolution may be relatively poor, compared to print outputs.

Summary

4.6.4 AR and VR visuals are under constant development. Although their preparation and use is beyond the scope of this guidance, they are expected to become increasingly important and common in visualisation, as the technologies mature and improve. For more information on Augmented and Virtual Reality, refer to the LI Digital Realities Technical Information Note.

5 Further Reading

Best Practice Guidance

Landscape Institute and IEMA (2013) - Guidelines for Landscape and Visual Impact Assessment 3rd edition (GLVIA3)

Scottish Natural Heritage (2017) - Visual Representation of Wind Farms: good practice guidance (version 2.2) (SNH 2017)

The Highland Council (2016) - Visualisation Standards for Wind Energy Developments

London View Management Framework Supplementary Planning Guidance (2012)

Research

Alan Macdonald (2012) - Windfarm Visualisation

University of Stirling (2012) - Report on perception of scale and depth in landscape photographs

Appendices

Methodology

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On Site

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Technical Information Notes (LI web site)

Appendix 1 - Camera Equipment

1.1 50mm FL + FFS - Visualisation Types 1,3,4

Cameras

1.1.1 The following specifications are based on a 50mm Focal Length (FL) and Full Frame Sensor (FFS) combination, and are suitable for all types of photography and visualisation. See 1.2 below for an alternative specification (cropped frame) which is acceptable for Types 1 and 3.

1.1.2 Whilst 35mm film itself is largely outdated for technical applications, it is worth being aware of the origin of the term 'Full Frame Sensor'. The point of reference for FFS as a term of specification is the frame size of pre-digital (35mm film strip width) film frames, which is 36mm x 24mm. Whilst Medium and Large Format camera equipment can be used for this work it is considered that this equipment is beyond the scope of this guidance.

Lenses

1.1.3 Lens / camera combinations result in images which capture a Field of View (FoV). The Horizontal Field of View (HFoV) is the angle between the left and right edges of the image. The Vertical Field of View (VFoV) is the angle between the top and bottom of the image. A 'standard' lens (50mm FL + FFS) in landscape orientation typically captures a HFoV of just under 40° and a VFoV of 27°.

1.1.4 50mm FL sits between 'wide-angle' lenses, which can create distortion towards the edges of images, and telephoto lenses, which can create an unnatural visual 'stacking' effect. Whilst both of these can be effective in artistic photography, the 40° HFoV image captured by a 50mm lens is regarded as being the closest to human eyesight, albeit that we typically have wider peripheral vision.

1.1.5 A fixed 50mm FL lens is considered the benchmark for landscape technical photography. A fixed FL lens ensures that the image parameters of every photograph are the same, simplifies the construction of panoramas, and ensures compatibility of photography for all viewpoints. In addition, 50mm FL lenses minimise optical distortion and allow for verification, where required (See Appendix 11).

1.1.6 Where a site or proposal would exceed the VFoV of a landscape-orientated photograph, the camera may be used in portrait orientation, giving HFoV 27° and VFoV 39.6°.

Non-50mm FL Lenses

1.1.7 If a 50mm FL lens cannot capture the view in landscape or portrait orientation (for example, if the highest point of the development is approaching 18° above horizontal) the use of wider-angled prime lenses should be considered, working through the following sequence of fixed lenses in this order: 35mm FL > 28mm FL > 24mm FL > 24mm FL Tilt-Shift. Tilt-Shift Lenses are considered at Appendix 13. In these unusual situations, the reasoning for the choice and the approach used should be documented, and the agreement of the competent authority should be sought (see Appendix 10 Technical Methodology).

1.1.8 Zoom lenses should not be used for the principal photograph from any location, but can sometimes be helpful for distant views to clarify detail, where that is not readily apparent in a 50mm lens image. If presented for such purposes, they should be shown alongside a 50mm FL photograph with a clear explanation that a zoom lens has been used, and with a statement as to the reasons for its use.

Lens quality

1.1.9 The optical quality of the lens is important. Despite high resolution sensors, it may be that the sharpness of a photograph is limited more by the quality of the lens than by the camera sensor's quoted megapixel count.

1.1.10 A simple check is on the speed / aperture of the lens. A lens with a large maximum aperture (e.g. f/1.8 or 'faster' - see Glossary), combined with good build quality, is generally a suitable lens.

1.1.11 A lens hood will assist in reducing unwanted flare when, for example, sunlight falls onto the front of the lens.

Sensor

1.1.12 FFS digital cameras set a photographic standard which is reliable, well-understood and consistent with professional requirements.

1.1.13 The pixel count of a sensor will determine the maximum resolution that could be achieved in a final image.

1.1.14 A camera with a fairly high resolution (typically 20 megapixel or more) will be required to produce sufficiently good-quality images to be reproduced at the required size. The critical requirement is that the camera should be capable of producing a sharp image when printed at the required page size.

Fig A1.1 *Illustration of Cropped-frame and Full-Frame Sensors (FFS): Canon 7D (cropped APS-C, left) and 6D (full-frame, right)*

1.2 Crop-frame sensor with fixed lens - Visualisation Types 1+3 only

Cropped-frame sensors

1.2.1 Whilst FFS is regarded as the professional standard for digital photography, cropped frame cameras have been developed as the 'pro-sumer' or entry level in digital photography for many years. The overall image quality (in normal lighting situations) is often regarded, for example in camera reviews, as comparable with, or only slightly inferior to, FFS.

1.2.2 The main difficulty arising with cropped-frame cameras is that the image sensor is some 1.5- (Nikon DX standard) to 1.6- (Canon APS-C standard) times smaller than a FFS (see Figure A1.1). Other cropped-frame sizes exist. Whilst image resolution (pixel count) can be maintained with a cropped frame, the smaller sensor effectively crops the image projected through the lens.

1.2.3 The size of a 'Standard' lens is dictated by its focal length in proportion to the diagonal of the film plate or digital sensor. Thus, for example, a fixed 50mm FL lens is regarded as a 'standard' lens on a FFS camera.

1.2.4 Therefore, if a 50mm lens is used on a cropped-frame sensor, because the sensor is smaller, the result is that the image is based on a smaller part of the scene, such that, effectively, it appears 'zoomed'. Thus a 50mm lens on a (1.6x smaller) APS-C camera will result in an image equivalent to 1.6 x 50mm, giving an 80mm effective FL. This (and the variations in cropped-sensor sizes across different brands and models) does not allow for the degree of control or certainty required for a verifiable process within Type 4 visualisations.

1.2.5 If a cropped-frame camera is to be used for Visualisation Types 1 or 3, then the use of a 35mm prime lens is recommended. This will result in photographs with slightly narrower FoV than for the 50mm / FFS benchmark and slightly increased enlargement factors. This is not problematic, provided the site can be captured within these FoVs. Alternatively, a 28mm fixed lens can be used and cropped to the equivalent of a 50mm / FFS FoV (39.6° HFoV).

1.2.6 Cropped-frame photography will present greater difficulties, if wide-angle (28-35mm FFS equivalent) images are required. In these situations, a much wider-angle fixed lens would be required, leading to increased levels of distortion.

1.2.7 Whilst most cropped-frame limitations can be overcome, doing so introduces more scope for error and demands a higher degree of technical competence than working with FFS cameras. For these reasons, the LI and regulators, such as SNH, specify the use of FFS for Type 4 visualisations and prefer it for Type 3.

Appendix 2 - Camera Settings

2.1 Camera Settings - Manual vs Auto

2.1.1 Auto camera settings may be appropriate for single images and may assist less-experienced photographers in capturing acceptable single images. However, auto-focus may focus the image on scene elements which are too far away (the horizon) or too close (e.g. foreground vegetation) and should be avoided.

2.1.2 Panoramic photography should be undertaken using manual controls to avoid the camera creating unwanted differences (focus, exposure, white balance, ISO) between adjacent shots of a panorama. This Appendix outlines appropriate manual settings, whilst the LI TIN 'Camera Auto Settings' explains the issues with Auto settings.

2.1.3 The following fixed (manual) settings are not prescriptive but will provide consistent results, which are essential for panoramic photography.

2.2 Settings

ISO

2.2.1 ISO measures the sensitivity of the image sensor. The lower the number, the less sensitive the camera is to light. Typically, ISO 100-200 will be appropriate on a clear bright day, with higher settings if light levels are low. Higher ISO settings will tend to introduce more image noise and reduce dynamic range.

Aperture

2.2.2 In most cases, the aperture should be set around f/5.6 - f/8 (roughly the middle of most lenses' range) to produce the sharpest image, although an aperture of f/11 - f/16 will provide the greatest depth of field.

Shutter Speed

2.2.3 As a simple rule of thumb, use shutter speeds (in fractions of second) well in excess of the focal length of the lens. For example, with a 50mm FL lens, aim for speeds of greater than 60th/second. Where zoom lenses are used to capture fine detail around the site for reference (not for principal photography) an 85mm FL lens should exceed 100th/second, and a 300mm FL lens should exceed 300th/second, etc.

2.2.4 This is less important when cameras are tripod-mounted, but camera shake (e.g. from a DSLR internal mirror lifting during exposure) can still occur, and its effects are minimised by suitably high shutter speeds. Use of a shutter release cable will reduce camera movement which might otherwise occur when the camera shutter button is pressed.

White Balance

2.2.5 Select an appropriate daylight setting e.g. Sun / Cloud / Shade (review at each viewpoint in case conditions change). Auto White Balance may vary the white balance from shot to shot and is particularly detrimental for panoramas (see Appendix 8).

Focus

2.2.6 For close sites / subjects, the focus should be close to the intervening distance. This will ensure that the sharpest focus occurs where it is most needed. Note that due to the lens depth of field, it is not necessary to focus at infinity in order to have distant objects in focus. For example, a 50mm lens set to f/5.6 and focussed at 15m distance, will result in distant objects being in focus. In addition, by focussing closer than infinity, more of the foreground will be in focus. For more information, search for 'hyperfocal distance'.

2.3 Night-time and low-light photography considerations

2.3.1 If agreed as a specific project requirement with the competent authority, night-time photography will require particular consideration and approaches. These are outlined in Appendix 5.

2.4 Image format: JPG / RAW

2.4.1 All digital cameras offer a range of formats in which the image will be stored on the camera's memory card. Typically these will be JPG at a variety of quality (resolution and compression) settings, and RAW at a variety of resolutions.

2.4.2 Choice of image format is discretionary, but to take advantage of its maximum available resolution, the camera must be set to its highest resolution and, in the case of JPG, minimum compression settings.

2.4.3 RAW formats store the contents of the sensor unaltered hence 'raw' together with a series of parameters recording the camera's current settings. Thus post-processing stages, such as white balance and sharpening, are recorded as parameters but not actually applied to the image. RAW provides the user with the maximum possible opportunity to get the best quality from the image and may be helpful for distant views of development sites, particularly in challenging lighting conditions.

2.4.4 The disadvantage of RAW over JPG is that the file sizes will be 2-6 times larger, requiring more storage space on memory cards and computers and also requiring more time and effort to post-process.

2.4.5 Note that some authorities specify RAW. Otherwise, the choice is down to the user and may be regarded as one of proportionality. Some cameras provide the option of simultaneously storing both RAW and JPG, which allows the choice of format to be made on an image by image basis, but of course requires even more storage space than RAW alone.

2.5 Post Processing for exposure

2.5.1 It can be a challenge to achieve acceptable levels of exposure of both a bright sky and a dark landscape. High Dynamic Range (HDR) photography typically combines three 'bracketed' images (correct, over- and under-exposed) to obtain a final image which has a higher dynamic range (better displays dark and light areas in the image) than can be obtained from a single exposure. Nikon's ADL, Canon's ALO, and other manufacturers' corresponding features achieve a similar effect in-camera, although these only work when shooting JPG, not RAW. The photographer may wish to consider this technique in difficult lighting situations, although it should never be taken so far as to produce a visible 'artistic effect'. It is also worth noting that post-processing of a RAW image allows for good adjustment of shadows and highlights to improve the appearance of the image and bring it closer to what is perceived by the naked eye, without the trouble of producing full HDRs.

Appendix 3 - Site Equipment

3.1 Tripods (Visualisation Types 3-4)

3.1.1 Tripods are used to assist with camera stability (to avoid camera-shake) and to provide levelling in the horizontal and vertical axes. When taking photographs with a view to creating stitched panoramic images, tripods provide adjacent images of consistent level and overlap.

3.1.2 It may be necessary for the camera to 'look up' or 'look down', especially in hilly terrain or close to tall existing or proposed objects. Such vertical orientation will not translate correctly into a stitched panoramic image, and should only be considered for single images. An alternative to 'looking up or down' is to use a 'tilt shift lens' - see Appendix 13. In the majority of situations the camera should remain level to avoid converging verticals, which can be more pronounced, especially when vertical structures are close to the viewpoint.

3.1.3 Camera height is fixed at 1.5m in SNH / THC wind-turbine guidance and this should be adhered to where that guidance is regarded as applying. For other project types, camera height should be set comfortably for the photographer and recorded / stated as noted at Appendix 10. Additional height may be required to represent a proposed change to a viewpoint's finished level e.g. a raised highway.

3.2 Camera mounts (Visualisation Types 3-4)

3.2.1 A Panoramic ('Pano') Head, mounted on top of a tripod, will control the angle between adjacent photographs. With a 50mm lens of approximately 39.6° view angle, setting a 20° interval between shots will give a 50% overlap between adjacent shots. Such an overlap will be useful when stitching photographs later, will minimise edge distortion, and also gives a helpful guide to the view angle of any given panoramic shots. However, it is for the practitioner to determine the amount of overlap which suits their hardware / software.

3.2.2 As noted previously, the camera may need to be mounted in portrait orientation to capture a greater VFoV in which case an overlap between images of around 50% i.e. 15° (or to suit hardware / software) would be suitable.

3.2.3 A correctly set-up Pano head eliminates parallax errors. For close subjects (or close foreground features such as fences) the Pano head allows the camera to pivot around the nodal point of the lens. This prevents parallax errors (where foreground objects appear to move relative to background objects as the camera is rotated) which would otherwise occur if the camera was set on a standard tripod mount.

3.2.4 A 'leveller' (or tribrach) is separate to the Pano head and allows the camera to be levelled in the horizontal and vertical planes. Levelling checked with a small spirit level on the mounting plate will generally be more accurate and easier to read than a bubble level mounted into the leveller. The camera can be rotated through 90° between level checks.

3.2.5 The levelling of the panorama will ensure a better match between the resultant camera image and your 3D model view.

3.3 Taking Panoramas (Visualisation Types 3-4)

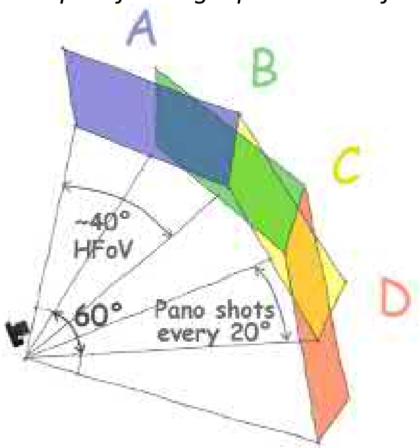
3.3.1 Set the exposure to be correct for the subject / site area, as this is the most important area of the panorama to have suitably lit. If there is no one subject, set the exposure for a point at 90° to the sun's direction (this is an average light level for a panorama). Note that shadows can be lifted (i.e. lightened) whereas clipped highlights cannot be recovered, so slight under-exposure may be useful for panoramas.

3.3.2 Taking photographs in a clockwise direction (left-to-right) will give consistency and avoid the Pano head unscrewing from the tripod. A further benefit is that when image thumbnails are viewed side-by-side, in image management software, they will appear in the correct sequence.

3.3.3 Use the detents on the Pano head to provide constant angles and overlaps between the photographs, such as the 20° with 50% overlap, suggested above.

3.3.4 As far as possible, avoid movement in the scene between adjacent images, such as pedestrian or vehicle movement.

Figure A3-1: *Example of taking a panorama of 4 shots with 20° overlap*



3.4 Recording camera position (Visualisation Types 3-4)

3.4.1 GPS-equipped cameras (with GPS function turned on) will record the location of the shot in the EXIF data, but typically with only around 5-10m accuracy. Hand-held GPS and most Smartphones will provide a similar level of positional accuracy. This is useful in areas with no other visible references (e.g. mountain sides) and when the subject is some distance away. Where visible fixed references are close to the camera location (e.g. trig points, gates, surface features) referring to aerial photography within a GIS system may provide greater positional accuracy for the photograph viewpoint than GPS. See Appendix 14 for comparisons of locational accuracy.

3.4.2 OS grid coordinates should be recorded where known, or converted from other (e.g. GPS latitude / longitude) positional data (for example by using UK gridreferencefinder.com website).

3.4.3 Where a tripod is used for Type 4 visualisations, it should be photographed in a way which assists future confirmation or verification of the viewpoint location. This is a useful technique for all tripod-based photography.

3.4.4 Where there are no visible references and standard GPS would not be of sufficient accuracy, enhanced GNSS (e.g. GNSS RTK) may be hired or provided by a surveyor. The highest levels of locational accuracy are relevant to Type 4 visualisations (survey-verifiable).

3.4.5 If the viewpoint position needs to be recorded accurately and a surveyor is not on site with the photographer, the position of the tripod can be marked (using a plumb line hanging under the tripod head) using spray paint or a survey nail and photographed so that the exact location of the viewpoint can be accurately relocated and surveyed at a later date.

Appendix 4 - In the field

4.1 Viewpoint selection and timing

4.1.1 Viewpoint selection approaches and criteria, for the purposes of photomontage for LVIA / LVA, are set out in GLVIA3 paras 6.16 - 6.28, in particular para 6.18. It is likely that a final selection cannot be made until the viewpoints have been visited and the captured photography is reviewed.

4.1.2 Considerations might include a need for evening / night photography or, in the case of Seascape effects, for morning, daytime or evening images. The illustration of seasonal variations, specifically differences in vegetation cover, should be demonstrated whenever possible and may be a requirement of the competent authority. In particular, instances where key views are available in winter, but not in summer, should be represented (see para 6.28 of GLVIA3). The role of the photographer is to locate the camera such that foreground screening does not obscure the site, unless that is a characteristic of the view / area which is intended to be illustrated.

4.1.3 Section 2 'Guiding Principles' states that photography should *"be based on good quality imagery secured in good, clear weather conditions wherever reasonably possible"*.

4.1.4 It is recognised that, occasionally, it may be difficult to meet this requirement, especially in more remote mountainous locations and in winter months. It is also recognised that the timetable for photography and visualisations may further constrain the ability to take good quality photography. Competent authorities should be advised of these difficulties and a reasonable compromise reached by mutual agreement. The landscape professional should not use 'poor weather' as an excuse for questionable photography and the competent authority should not unreasonably demand good clear weather conditions when the landscape professional has demonstrated reasonable endeavours to obtain good quality photography.

4.1.5 Views should include the full extent of the site / development and show the effect it has upon the receptor location. Additional photographs may illustrate relevant characteristics, such as degree and nature of intervening cover along a highway or footpath, without showing the site / proposal.

4.1.6 Consideration of private residential viewpoints is relevant to Residential Visual Amenity Assessment (RVAA) but generally LVIA will use public viewpoint locations (refer to GLVIA3 paras 6.16 - 6.17). See also Residential Visual Amenity Assessment (RVAA) LI TGN 2/19. Viewpoints on private land which is publicly accessible may be relevant, e.g. open gardens, monuments, communal access points, National Trust land etc.

4.1.7 Where feasible, plan and time site visits such that the sun is not directly over the site in the view, but will be to one side or behind. Planning site photography clockwise from NE to NW is advisable. This is particularly important in the winter when the sun is lower in the sky. Shielding the lens from direct sun (e.g. using a lens hood) is advisable to avoid flare.

4.1.8 Locating the site in advance, on Google Earth or other 3D software, may help locate it on the ground in built-up or open landscapes. Consider preparing draft renders of the 3D model from the proposed viewpoint locations to evaluate extent of visibility and height of development, to ensure that the whole development and appropriate context is captured.

4.2 Capturing the view

4.2.1 The proposal under consideration and its relevant landscape context will determine the FoV (horizontal and vertical) required for photography and photomontage from any given viewpoint. This will, in turn, determine whether a single-frame image will suffice or whether a panorama will be required. Good composition of the scene is important. Views may appear different in winter compared to summer, which may affect the exact location selected, so forward planning is useful if seasonal visualisations are to be prepared in future.

4.2.2 A well-considered approach to baseline photography is necessary in order to provide suitable quality photographs for the production of visualisations.

4.2.3 A 'standard' lens (50mm FL on a FFS camera) typically captures a HFoV of just under 40 degrees. This may be suitable for some purposes, but a single-frame photograph based on this FoV may not convey the breadth of visual information required to represent a proposed development and relevant context. Where it is greater than 40 degrees, a panoramic image, produced by the careful 'stitching' together of single-frame images, can provide a more informative representation of the visibility of a development in the landscape. (See Appendix 8 Panoramas).

4.2.4 As noted in Appendix 1, wider-angle lenses may be appropriate, for example, where tall buildings form part of the scene, but the scale of the presented image is also a consideration (see Appendix 7).

4.2.5 The general requirement is to capture enough of the scene to represent the landscape / townscape setting and the likely visibility of the proposal. Capturing 360° is not always necessary, but may assist in establishing the viewpoint's location and potentially assist in illustrating cumulative effects, if applicable.

4.3 Camera orientation

4.3.1 Where a single image can capture an appropriate HFoV, the view should be aligned to the centre of the development. This will help in matching the perspective of the photograph to that of any subsequent computer-generated image. If the photograph and image do not align, their perspective will not be an accurate match, particularly if, for example, the computer image is placed to the extreme left or right of the photograph.

4.3.2 There may be occasions when the proposed site needs to be offset, such as a view from a window, along an avenue of trees or a well-known 'framed' viewpoint, for example. Where this is necessary, the computer-generated image should use the same horizontal orientation as the photograph.

4.4 Recording image data

4.4.1 Data to be recorded should include: Camera model, Lens focal length, Date and Time. Note that these parameters will be automatically recorded in the EXIF dataset on most digital cameras. Date and time need to be set accurately on the camera. On a GPS-equipped camera, location may also be recorded in the EXIF data. Otherwise it may be recorded with external GNSS equipment.

4.4.2 Other factors which should be recorded in the field include weather, lighting conditions and direction of view - although these may be apparent from the photographs themselves and the location of the camera.

4.4.3 It should be noted that some information within the image, such as people (including children) and car number plates, when associated with time and locational data that has been recorded, could be regarded as 'sensitive information' and appropriate safeguards should be observed.

4.4.4 A full set of details, to be recorded and presented with the project photography overall, and for each viewpoint, is set out on Appendix 10 Technical Methodology.

Appendix 5 - Night-time Photography

The following is an extract from a forthcoming LI-supported publication: Landscape and Visual Assessment: Artificial Light and Lighting (with thanks to Karl Jones of the LI Technical Committee). It provides an outline of considerations specific to night-time photography for the purpose of LVIA.

5.1 Fieldwork

5.1.1 Fieldwork requires suitable weather conditions and consideration of the phase of the moon to get accurate sky darkness results and to accurately record views of the existing night time environment, noting that as temperatures cool in the evening, mist or rain may form. Online weather forecasts targeted for astronomers can assist with predicting the appropriate time to undertake the fieldwork (e.g. www.clearoutside.com or by using smartphone apps (e.g. www.metoffice.gov.uk/datapoint/showcase/scope-nights).

5.1.2 Before undertaking the fieldwork, ensure you know:

- the sunset time;
- where, within the study area, potential viewpoints that need to be checked (for day time and night time effects) are located;
- how to identify the main types of lighting (for recording accurately those already present at the site) and how existing lighting will appear in photographs;
- what potential existing night-time landscape features (e.g. prominent lit important architecture) maybe present;
- how long the night-time work is likely to take (factoring-in time for checking of photographs and the time needed for each exposure (generally taking tens of seconds per photograph); and
- the locations of likely sensitive night landscapes (e.g. dark-sky areas, existing light pollution, 'remote' policies).

5.2 Equipment

5.2.1 Additional equipment, beyond that normally required for daytime fieldwork may usefully include:

- a tripod (to allow long exposure shots to be taken without incurring fuzzy photographs), ideally with luminous or high visibility
- reflective strips on legs to prevent trip hazards;
- a camera lens hood (to avoid glare from lights of passing vehicles or other obliquely located sources of light);
- a head torch (working at night requires additional lighting whilst keeping hands free to work the camera, record notes etc.);
- a tablet (helpful to view photographs, on location, to ensure that the exposure and colour balance reflects the scene viewed with the naked eye, and to record differences);

- UV marker chalk or pegs and black light torch (useful to temporarily record and mark the exact location of daytime viewpoints, to reposition the camera to the same viewpoint in the dark – bearing in mind that the location can look very different in the daytime compared to the night time);

- spare batteries or portable battery charger (as it is generally significantly colder at night, batteries may discharge more quickly, e.g. for mobile phone and camera);

- warm clothing, PPE and appropriate safety equipment.

5.2.2 Further detail will be provided within the LI publication 'Landscape and Visual Assessment: Artificial Light and Lighting' on the topics of exposure, ISO settings etc. Such detail is beyond the scope of this guidance.

5.2.3 Any presented night-time photography should be accompanied by day-time photography from the same location and direction, to give a direct comparison. Photographs taken at half-hour intervals, from dusk to deep night, may be useful in sensitive locations - noting that only one viewpoint sequence can be taken per camera per day.

5.2.4 Note that SNH 2017, paras 174-177, provides useful guidance on illustration of lighting and night-time effects.

5.2.5 Notwithstanding that this is technical guidance, sensible health and safety procedures should be undertaken in respect of night-time work, including risk assessment, reviewing access, and lone working review.

Appendix 6 - Preparing Photomontages

6.1 Common requirements

6.1.1 A digital photomontage consists of a base photograph composited digitally with a computer-generated image of the proposal under consideration. This compositing process will typically include digitally blending the base photography with the computer-generated image, taking into account any masking by foreground features. Compositing necessarily requires digital manipulation, carried out with visual skill, judgement and objectivity.

6.1.2 Incorrect image production and presentation can render otherwise correctly photographed images unfit for purpose. It is crucial that the size of the proposal and its location within the scene depicted in the photograph are accurately represented. In order to achieve this, it is necessary to match the perspective parameters of the photograph accurately, to record viewpoint location and camera settings, and to use 3D software correctly. Additional reference photography whilst on site can be beneficial when existing items in the scene are to be removed as part of the proposals (e.g. the view 'behind' a building / tree to be removed).

6.2 Project stages

6.2.1 It may be necessary to illustrate different time periods associated with the proposal, such as upon completion, and with different stages of establishment of mitigation. Visualisation of the construction period may be relevant if it would be particularly lengthy and distinctly different from the completed project - for example, tall cranes in a sensitive landscape. This should be proportionate and be related to the LVIA / LVA and whether it identifies the construction period as a distinct issue.

6.2.2 Baseline and photomontage images should be produced with identical views presented at the same size, to aid comparison and consideration of the change illustrated.

6.2.3 Where the proposal is to be presented as photo-realistic photomontage, the lighting conditions (sunny, cloudy, direction of light and position of shadow) of the proposal should match the background photograph as far as practically possible.

6.2.4 Techniques for matching photography and 3D modelling are set out in Appendix 12.

6.3 Wirelines and Photowires

6.3.1 The accuracy of a photomontage may usefully be illustrated by means of a wireline image incorporating sufficient topographic or other features to allow a comparison to be made between the wireline and the photograph. The wireline should be presented as a separate image at the same size and scale as the main photograph / photomontage.

6.3.2 A visual presentation which is an overlay of wireline upon the photograph is known as a photowire. A photowire does not replace a photomontage where rendered texture and detail is required, but is sufficient to indicate scale and placement. Where the site cannot be seen from a viewpoint, a photowire could indicate the site's relative size and location within the view (for example, to confirm that it would be hidden from view or to indicate that it may be more visible in winter).

6.4 Relationship to London View Management Framework AVR Levels 0-3

6.4.1 The London View Management Framework (2012) proposes four levels of 'Accurate Visual Representation' (AVR), based on the degree of sophistication of the imagery representing the proposed development. The *graphical* approaches to producing the AVRs (photowire to photomontage) may be applied to Visualisation Types 3 and 4 in this guidance. Selection of these levels of detail should be based on what is required to illustrate the proposal, and may assist in taking a proportionate approach.

6.4.2 **AVR Level 0:** Location and size of proposal. This equates to a photowire and provides an outline of the proposal overlaid onto the photograph base.

6.4.3 **AVR Level 1:** Location, size and degree of visibility of proposal. This shows the massing of the proposal within a 3D context represented by the photograph - that is, what can and cannot be seen.

6.4.4 **AVR Level 2:** As level 1 + description of architectural form. This illustrates architectural form such as doors, windows and floors, and gives a sense of the form and shading of the development within its context.

6.4.5 **AVR Level 3:** As level 2 + use of materials. This is a fully rendered photomontage, usually photo-realistic with texture, shading and reflections as appropriate.

Figure A6-1: *Accurate Visual Representation (AVR) Levels 0-3 (Images ©Nicholas Pearson Associates)*

Appendix 7 - Media and Presentation

7.1 Digital vs Paper

The move towards digital

7.1.1 There is a clear move towards digital media in all aspects of the development process, which impacts on the issues surrounding visualisation presentation. Digital media is readily transferable and reproducible. It may be the case that, for many stakeholders, digital images are the only ones they are likely to see, for example when downloaded from planning portals. Paper-based presentation requires resources (paper, ink, printing) as well as means of transfer or delivery. For large projects with many viewpoints and baseline / wireline / photomontage versions, paper prints may present practical difficulties, particularly where panoramic images are required (Visualisation Types 3 and 4).

Benefits of paper

7.1.2 Paper prints have specific benefits. If based on high-resolution images and using good-quality printing techniques, they can present photomontages at higher resolution than screen-based equivalents of the same size. They are capable of being viewed on the desktop or out on site without technical equipment.

7.1.3 Importantly, they also fix the size of the image (independent of any 'viewing device') to allow a consistent impression of scale. All consideration of 'scale' (as at Section 3.8) only becomes meaningful when a visualisation is printed to the correct-sized sheet of paper.

Benefits of digital

7.1.4 Digital presentation has some benefits over paper, for example, the ability to zoom into an image (effectively magnifying it) and also the ability to switch between pages (e.g. of a PDF) or between multiple files, to obtain a clearer impression of the illustrated change than might be obtained from flipping between paper images.

7.1.5 Additionally images are easily accessible across the internet and can be accessed via file-sharing systems.

Issues with digital

7.1.6 The obvious issue with digital media is the variable screen size and resolution of the receiving devices, from phones to large, high-resolution screens. These potentially constrain the size of the image and result in uncertainty as to what size it should ideally be viewed at.

Best endeavours

7.1.7 Given that the image should contain information on its ideal viewing size, the digital user should attempt to view at or near that size, if it is within the capability of their equipment. It is not uncommon for computer monitors to have a width of around 500mm (laptops and tablets are usually smaller). Notwithstanding the issues noted above, the A3 landscape format is well-suited to this size of monitor. Wider images might be viewed in a two-monitor arrangement which mimics the width of an A1 sheet.

7.1.8 Where communication of scale is considered to be of great importance (this is the defining characteristic of Type 4 visualisations) then paper-based media will provide the most reliable impression of scale. However, manageability of paper may be an issue, and it is for competent authorities to determine their requirements accordingly.

Printed outputs

7.1.9 Inkjet printing, laser printing and digital press technologies all have different colour rendition and resolution issues. A minimum image resolution of 300 pixels per inch will generally be required for high-quality printing.

7.1.10 In most cases, given suitable photographic paper, inkjet printing will provide the highest resolution, colour depth and dynamic range of any print technology. Inkjet prints are also likely to smear / run if wet, but could be laminated / encapsulated to allow multiple use for site viewpoint visits - although this will prevent them being folded. Where the highest quality of printing is appropriate, consideration should be given to the use of inkjet technology, although commercial laser prints may be perfectly acceptable if good quality paper is used.

7.1.11 Critically, when producing documents for print, it is important to check that a print proof shows what you expect it to, that the image is sharp and that there is enough clarity and colour faithfulness to convey what is intended. Ensure that the final prints will be printed with the same printer used for the proofs.

7.1.12 At the request of the competent authority, and particularly for more sensitive sites, the photomontage producer should provide high-quality printed outputs which match the criteria specified above.

Digital outputs

7.1.13 These will typically be in the form of PDFs generated from graphics software. When creating PDFs, there are usually options to set DPI (re-sampling of images) and compression ratio to reduce the overall size of the output file. 300dpi should be the minimum for photomontages (ordinary photographs may be as low as 200dpi but clarity may suffer).

7.1.14 Multi-page PDFs are convenient, but the file size may exceed limitations for upload to planning portals (often 5MB, occasionally 10MB). Combining visualisations with plans etc. into a multi-page document is likely to result in large documents, unless high levels of compression are used. However, compression (usually based on JPG image compression) results in image artefacts which become increasingly visible with greater compression levels. This adversely affects image quality and should, therefore, be avoided.

7.1.15 A single page image-based A3 PDF can be created, with minimal compression, well below 5MB. For more sophisticated visualisations (e.g. Type 4 at A1 width) and where there is a limitation on file size, it follows that each page of a photomontage series (Baseline, Photowire, Photomontage) will need to be produced as a single, high-resolution, low-compression document.

7.1.16 Digital photo / panoramic viewers are an effective way of sharing panoramic images online. They re-project from cylindrical source images to a planar view on-screen. However, although used by some competent authorities and consultants, no standard approach has been widely adopted.

7.2 Accompanying information

Visualisation Type Methodology

7.2.1 This is discussed at Section 3.7. It is intended to provide an early basis for agreement, with the competent authority, as to the appropriate Visualisation Type(s) to accompany the application.

Technical Methodology

7.2.2 A Technical Methodology should be provided as an Appendix to Type 3 and 4 visualisations. This will assist recipients with understanding the level of technical approach and also explain reasoning for any departures from standards. This should be proportionate to the requirements of the assessment and the required images. See Appendix 10.

Information with each Visualisation

7.2.3 Appendix 10 'Per Viewpoint' lists the information which should support each viewpoint, to communicate the equipment used and the approach taken.

Viewpoint Locations

7.2.4 Viewpoints should be clearly located on a map-based figure. Location coordinates (eastings / northings) should be provided. It is helpful to provide small location maps as an inset to site photographs / photomontages, provided they take up a small amount of the page and do not dominate or obscure any of the photograph / photomontage content. See SNH 2017 Guidance for suitable examples.

Appendix 8 - Panoramas

8.1 Generally

8.1.1 Please refer to Section 4 on requirements for Type 3 and 4 visualisations. See also Appendix 11, Verified Photomontages.

8.1.2 All parties should recognise that printed panoramic images are an imperfect way of attempting to recreate the experience of viewing the breadth of a scene. Nonetheless, where it is important to communicate the wide-angle nature or context of the view, panoramas are preferable to limiting the view by cropping.

8.2 Lens distortion

8.2.1 Subject to software and workflow, it may be helpful to correct lens distortion before stitching images into a panorama.

8.3 Cylindrical Panoramas

8.3.1 Panoramic images are required to capture a wide field of view appropriate to certain types of more linear or widespread development (e.g. power lines, transport corridors, solar farms etc) and to provide sufficient landscape context. However, they do come with difficulties in respect of viewing printed images. Cylindrical images need to be curved around the viewer to represent real-world viewing angles. Alternatively they could be viewed flat by moving the head to maintain at a constant viewing distance across the panorama. Both of these options are unlikely to be followed by viewers. They are more likely to be viewed flat from a single position. This may not matter for distant viewpoints, but for close viewpoints (e.g. looking at a site across a road) cylindrical panoramas will look unrealistic. A third option is to use a panoramic viewer which re-projects the cylindrical panorama to planar, but these are not in common use.

8.4 Planar Panoramas

8.4.1 Planar projection overcomes the 'curved distortion' which can occur with a cylindrical image. A panorama projected as a planar image will provide a more realistic impression of the scale of a development, but only from an eye position which is specific and central to that panorama. There will be increasing distortion towards the edges of the panorama in order to maintain the correct impression when it is viewed flat. Planar projection should not, therefore, be used beyond a HFoV of around 60°.

8.5 Reprojecting

8.5.1 In SNH 2017 guidance, baseline photography is presented in cylindrical projection. It is helpful to work in cylindrical projection whilst creating wirelines and renders and matching them to background photography. They may then be re-projected to planar (rectilinear) for the presentation image. See Figure A8.1 below.

8.5.2 Cylindrical to planar projection may be achieved by a variety of software, for example: Hugin (open-source), Photoshop (with or without the Flexify plugin), The GIMP (with G'MIC (open-source) or Flexify plugins). No recommendations are made and searching online will reveal other options which will suit specific platforms and work flows.

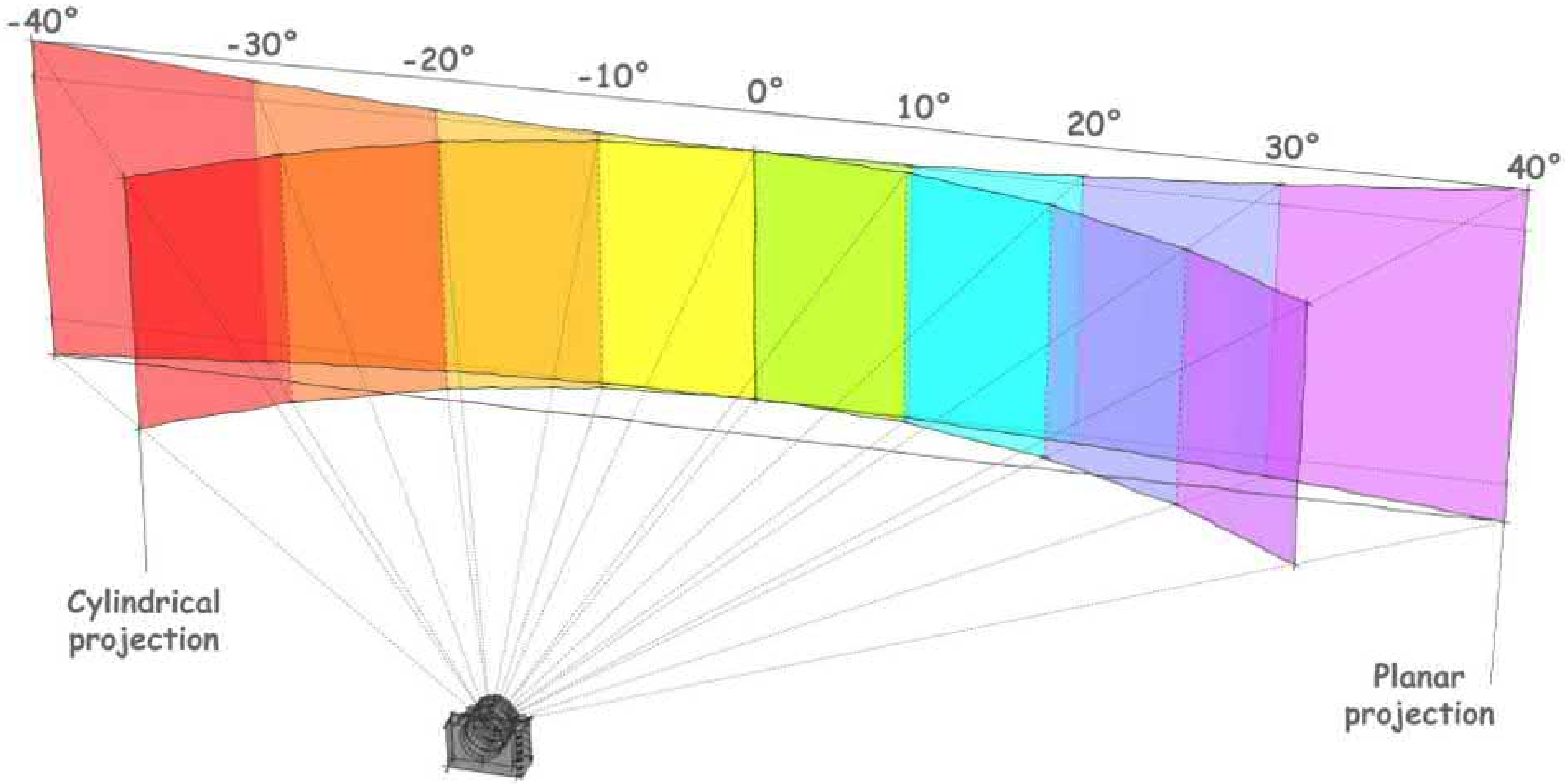


Figure A8-1: *Cylindrical to Planar Projection*

Beyond around 30° to either side of centre (60° HFoV) planar projection becomes increasingly distorted, both laterally (towards the outer edges) and vertically. This limits the usefulness of planar projection for wide panoramas and accounts for the limitation of 53.5° HFoV in SNH 2017 and Type 4 visualisations.

8.6 Calculating view angles

8.6.1 For a panorama created from overlapping frames taken with a stepped Pano head, the view angle can be determined mathematically, based on the stops on the Pano head (see Appendix 1 above). For example, with a 20° stop from centre to centre of adjacent frames, the HFoV of the panorama, from edge to edge, will equal (number of frames x 20°) + 20°, so 3 frames = (3 x 20°)+20° = 80°.

8.6.2 An alternative is to take and stitch a full 360° panorama at each location. Since the completed image must occupy 360° and the image width, in pixels, will be known, any angle can be calculated based on the horizontal count of pixels.

8.6.3 An approximate view angle may be determined from map or aerial data corresponding with what is visible within the panorama frame. For example, the Google Earth measurement tool shows the angle of any line relative to geographic north. Draw a line from the camera position to an object at the left side of the frame, note the angle (say 210°), repeat for the right side of the frame (say 290°) and deduct the first angle from the second angle (290 - 210 = 80° HFoV).

Appendix 9 - Acetates

9.1 Acetates

9.1.1 Acetates may be produced at A3 using a 39.6° HFOV photograph sized at 360mm x 240mm on the page. When viewed at the viewpoint on site, through one eye, the acetate, when held at 500mm from the eye, can be positioned for mathematically correct sizing for that viewpoint. This should confirm that the geometry of the image matches the real landscape.

9.1.2 Provided that the development overlay has been correctly positioned (scale and location) in the image, the acetate will verify the scale and location of development in the view.

9.1.3 Some authorities (for example, SNH) take the view that acetates do not convey any more useful information than a correctly-scaled paper photomontage. Both formats rely on the correct scaling and positioning of the development within the view.

9.1.4 Where a decision-maker considers that they need additional information about scale and position from a site viewpoint, which is not supplied by a paper photomontage, they may request an acetate, but acetates are not regarded as a standard requirement for inclusion in an LVIA or LVA.

9.1.5 The photographic image is usually presented in monochrome on the acetate, with the outline of the proposed development in colour (e.g. red, green) to highlight the proposed change.

Figure A9-1: *Acetate in use © Mike Spence*

Figure A9-2: *Example acetate © Mike Spence*

Appendix 10 - Technical Methodology

Indicative Listing - For the project:

for the indicated Visualisation Types, this information should be supplied within an overall Technical Methodology

Visualisation Types 1	2	3	4	Photography	Example Responses
✓	✓	✓	✓	Visualisation Types Methodology (see 3.7)	
		✓	✓	Method used to establish the camera location (e.g. handheld GPS/GNSS, GNSS/RTK, survey point, visual reference)	Aerial photography in GIS system
		✓	✓	Likely level of accuracy of location (#m, #cm etc)	Better than 1m
		✓	✓	If lenses other than 50mm have been used, explain why a different lens is appropriate	28mm lens required to capture the height of the development from views 1 and 3
			✓	Written description of procedures for image capture and processing	
			✓	If panoramas used: make and type of Pano head and equipment used to level head	Manfrotto Pano head and leveller
			✓	If working outside the UK, geographic co-ordinate system (GCS) used (e.g. WGS-84)	N/A
				3D Model / Visualisation	
		✓	✓	Source of topographic height data and its resolution	Combination LiDAR + OS Terrain 5m
		✓	✓	How have the model and the camera locations been placed in the software?	Based on survey coordinates
			✓	Elements in the view used as target points to check the horizontal alignment	Existing buildings, telegraph poles, LiDAR DSM
			✓	Elements in the view used as target points to check the vertical alignment	Topography, existing buildings
			✓	3D Modelling / Rendering Software	*As used on project*
				Generally	
✓		✓	✓	Any limitations in the overall methodology for preparation of the visualisations?	Timing of photography e.g. winter / summer

Per Viewpoint:

this information to be provided on each page, within the photograph / visualisation figure notes

Visualisation Types 1	2	3	4	Photography	Example responses
✓	✓	✓	✓	Visualisation Type	Type 3
✓		✓	✓	Projection	Planar or Cylindrical
✓		✓	✓	Enlargement factor for intended sheet size	e.g. 100% @ A3 or 150% @ A1
✓		✓	✓	Date and Time of captured photography	3 March 2019, 13:05
✓		✓	✓	Make and model of camera, and its sensor format	Canon 6D, FFS
✓		✓	✓	Make, focal length of the camera lens(es) used.	Canon / Nikon / Sigma etc 50mm
✓		✓	✓	Horizontal Field of View (HFoV) of photograph / visual	39.6°
✓		✓	✓	Direction of View: bearing from North (0°) or Compass Direction	'90° from N' or 'Looking east'
		✓	✓	Camera location grid coordinates: eastings & northings to relevant accuracy; height of ground in mAOD	E123456, N654321 123m AOD
		✓	✓	Distance to the nearest site boundary, or key development feature, as most appropriate.	1200m to site boundary / turbine
			✓	Height of the camera lens above ground level and, if above 1.65m or below 1.5m, why?	1.5m
				Additional imagery	
		✓	✓	Baseline photograph	
			✓	A composite view generated by overlaying multiple layers of image data: the photograph, 3D model of terrain (LiDAR DTM) and / or 3D model of LiDAR DSM, 3D model of proposed development, 3D model of landscape mitigation. This can explain how the photomontage has been generated.	
			✓	A photograph of the tripod location to confirm the camera / tripod location	

Appendix 11 - Verified Photomontages

11.1 Introduction

11.1.1 There is no industry-standard definition as to what constitutes a 'verified photomontage' and when it is required. Two main applications of the term have come into use, which relate to:

a) verification of image scaling (SNH 2017) of the visualisation (11.2 below); and

b) survey-verification of camera / subject positioning at the viewpoint. These may also be referred to as Visually Verifiable Montages (VVMs), Verified Visual Images (VVIs) or, in the case of the London View Management Framework, Accurate Visual Representations (AVRs).

11.2 SNH 2017: Verification of Image Scaling

11.2.1 SNH's Visual Representation of Wind Farms Guidance (2017) allows for verification that the process described in its guidance has been correctly followed.

11.2.2 SNH 2017 states (para 117):

"In some cases the determining authority may wish to verify the accuracy of the image produced. This is possible using the original image data recorded by the camera (to check camera format and lens used) and a simple template (to check that the image dimensions have been correctly adjusted (by cropping and then enlarging)). This process is described in Annex E. Camera metadata should be provided by the applicant on request."

11.2.3 In the above statement, 'accuracy' refers to:

a) the FoV of the source photograph (based on a camera / lens combination FFS / 50mm); and

b) correct cropping and scaling of the photographs for presentation.

11.2.4 The LI concurs with this approach, where verification of image scaling is required.

11.2.5 SNH 2017 does not require survey-verified photography to determine the position and orientation of the camera, noting that *"167 - An accurate GPS position, taken when the photography was carried out, is almost always sufficient for wind farm applications"*.

11.3 Accurate Visual Representation (AVR)

11.3.1 Other guidance, such as the London View Management Framework Supplementary Planning Guidance (2012) states (para 463):

"An AVR is a static or moving image that shows the location of a proposed development as accurately as possible; it may also illustrate the degree to which the development will be visible, its detailed form or the proposed use of materials. An AVR must be prepared following a well-defined and verifiable procedure so that it can be relied upon by assessors to represent fairly the selected visual properties of a proposed development. AVRs are produced by accurately combining images of the proposed building (typically created from a three-dimensional computer model) with a representation of its context; this usually being a photograph, a video sequence, or an image created from a second computer model built from survey data."

11.3.2 The guidance goes on to require a methodology and information about each AVR including location and coordinates of the camera.

11.4 Survey-verified photography

11.4.1 Survey-verified photography involves using a surveyor, or survey equipment, to capture camera locations and relevant target points within the scene, which are then recreated in the 3D-model and used to match the camera image with a high degree of precision.

11.4.2 Surveying equipment allows the camera location and fixed target points in the view to be calculated down to centimetre accuracy. Highly accurate visualisations may be produced by correctly matching the 3D model camera position and geometry of the view to the original photograph, using pixel level data, resulting in a survey-verified photomontage.

11.5 Summary

11.5.1 Although the terminology is similar, there is a clear distinction between verification of image size and scaling (SNH 2017) and survey-verification of viewpoint / camera location and related data in order to allow resulting imagery to be verified. The first is concerned with image scale (see 3.8), the second with the accuracy of camera position and the precision of subsequent visualisation overlays.

11.5.2 Regarding positional accuracy, the LI takes the view that a proportionate approach is required. Where high levels of positional accuracy are essential to the validity and purpose of the photomontages being produced, for example in sensitive urban contexts, survey-verified photomontage may be required. In other situations, 1-2 metre accuracy, which may be achieved using aerial photography, may be sufficient - see Appendix 14 for further information. Where the subject matter is at close quarters, higher levels of accuracy will be required. However, where the subject is at distances beyond a few kilometres, the level of accuracy of standard GPS (at around 5m horizontal) may be sufficient, noting that ground / camera height can usually be derived more accurately from height data. As Global Navigation Satellite Systems (GNSS) are enhanced, and the cost of equipment reduces, higher levels of locational accuracy will become the norm.

11.5.3 In all cases, as stated at the beginning of this guidance, visualisations should provide a fair representation of what might be seen if the proposed development was built. The level of viewpoint location / camera position accuracy, and how it has been achieved, should be set out in the Technical Methodology (Appendix 10). Where the competent authority has particular expectations or requirements, these should be set out and agreed in advance of site visits.

11.5.4 Visualisation Types 3 and 4, discussed in Section 3 and 4 of this guidance, take account of a range of requirements for viewpoint locational accuracy.

Appendix 12 - Matching Photography and 3D Modelling

12.1 3D-modelling software-based matching

12.1.1 The combination of 50mm FL lens and FFS, is usually quoted as having a HFoV of 39.6°. However, there are no precise 50mm lenses and all models will have a range of effective focal lengths depending on the point of focus. Therefore the HFoV cannot be assumed to be 39.6°and may range from 37-42°. The practitioner should calculate HFoV for the sensor / lens combination being used, if they wish to use this data to match software-generated 3D models to the photographic image.

12.1.2 Given accurate FoV data and orientation, some 3D software is able to output visuals which are perfectly matched, in terms of FoV and pixel size, to the reference photographs. If this mathematical model is relied upon to determine the size of the visualisation within the photograph, the FoV must be known to a high degree of accuracy. Making assumptions as to FoV may result in renders which are out of scale with the background photograph, either larger or smaller.

12.1.3 Using software to directly provide a render, based on accurate FoV data and target points, there should be no need for resizing or repositioning, relative to the background photograph.

12.1.4 Care should be taken when using software or mathematical approaches to determine the size of the render within the photograph. A 'sense-check' will help ensure that overall placement is correct. For example, if there is a low foreground rise in the view, but the development is placed in front of it, when it should be behind, not only will it be in the wrong place geographically, but it will also appear to be too small, because what should be a distant object appears to be 'closer'.

12.2 Image matching

12.2.1 An alternative approach is to use key reference or 'target' points which occur within the 3D model and the background photograph. These will allow alignment and sizing of a visualisation to match the background photograph. It is important, however, if resizing a visualisation within a photograph, to retain its 1:1 aspect ratio. Alteration of the aspect ratio will result in a visual which is either too tall or too short, compared to its background photograph.

12.2.2 Resizing any object or layer in photo-editing software is likely to lead to some loss of resolution and blurring. Resizing should, therefore, be kept to a minimum by, for example, re-sizing in one step rather than in multiple increments. If the background photograph and rendered image are sufficiently high resolution, this is unlikely to be an issue. Some software, e.g. Photoshop, offers 'smart' objects: editing processes (such as resizing) which are non-destructive, with no noticeable loss of resolution. However, the optimal solution is to generate the rendered image to match the resolution of the photograph without resizing.

12.2.3 When using target points within the photograph and targets in the 3D model, these should be accurately geo-referenced, and vertical heights of 3D elements confirmed from either survey or terrain model data (e.g. LiDAR DSM).

Appendix 13 - Tilt Shift Lens

13.1 Tilt Shift Lens

13.1.1 The tilt shift lens is increasingly being used in architectural photography in urban locations. It can also be employed for taking photographs up or down slope. The lens comes in a range of focal lengths including 17mm, 24mm, 45mm and 90mm. The 24mm tilt shift is typically used for visualisation work where viewpoints are located close to a development and the normal range of prime lenses will not capture the proposed site (see example below).

13.1.2 The tilt function allows the lens to be swung about either a vertical or horizontal axis so that the axis of the lens is not perpendicular to the picture plane of the sensor.

13.1.3 The shift function allows the lens to be offset vertically or horizontally so that the axis of the lens remains perpendicular to the plane of the sensor but no longer passes through it centre point.

13.1.4 It is only the shift function which is relevant to photography and visualisations.

13.1.5 The tilt shift lens can be used to direct the eye upwards or downwards, depending on the selected portion of the overall view used. This can be used to (wrongly) accentuate the extent of sky or the extent of foreground in the view, resulting in an over-emphasis on the amount of sky or foreground in the printed image / visualisation, creating an unbalanced view towards a development which doesn't reflect what the camera, or the human eye, would see under normal circumstances.

13.1.6 Prime lenses have a single point of perspective in the middle of the single frame image. With the tilt-shift this point of perspective will vary depending on where the lens is positioned.

13.1.7 Before using a tilt shift, the normal suite of 50mm, 35mm, 28mm and 24mm prime lenses should be explored in both landscape and portrait orientation. Assuming the 24mm lens in portrait will not pick up the verticality of a proposed building, then the tilt shift can be employed.

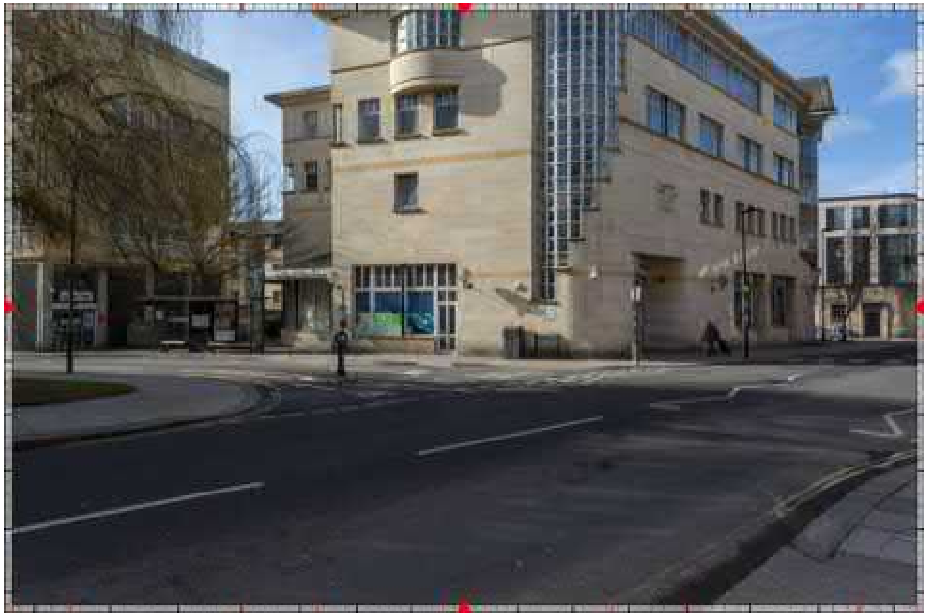
13.1.8 Images produced with the tilt shift should be stated as such and be presented with clear markings on the image to identify the point of perspective. See examples on following page at Figures A13-1 and A13-2.

13.1.9 The reasons for using tilt shift should be clearly explained in the Technical Methodology.

Figure A13-1: *This image shows the use of a 24mm tilt-shift lens to capture the full vertical extension of the building, whilst avoiding converging verticals.*

In both cases the red arrows indicate the vertical and horizontal points of perspective (Optical Axis) whilst the 'graticules' represent the horizontal and vertical fields of view.

Figure A13-2: *This is a standard 24mm image, levelled horizontally, which does not capture the extent of the building. Tilting this camera/lens combination upwards would result in the vertical elements of the photograph appearing to converge.*



Appendix 14 - Locational Accuracy

14.1 How much does locational accuracy matter?

If you are looking at an object 10m away, which is directly east of you (90° from north), and you move 1m north, the object will appear to shift by 5.7°, and will now be at an angle 95.7 degrees from north.

If the object is 100m away, it will appear to shift 0.57°, to 90.57° from north.

If the object is 1000m away, it will appear to shift 0.057°, to 90.057°.

If the object is 10,000m away, it will appear to shift 0.006°, to 90.006°.

Clearly, a small shift in location can make a large difference to the apparent location of objects when they are close to you. This is especially important due to the effect of parallax, or the apparent shifting of objects' positions based on how near or far they are from you.

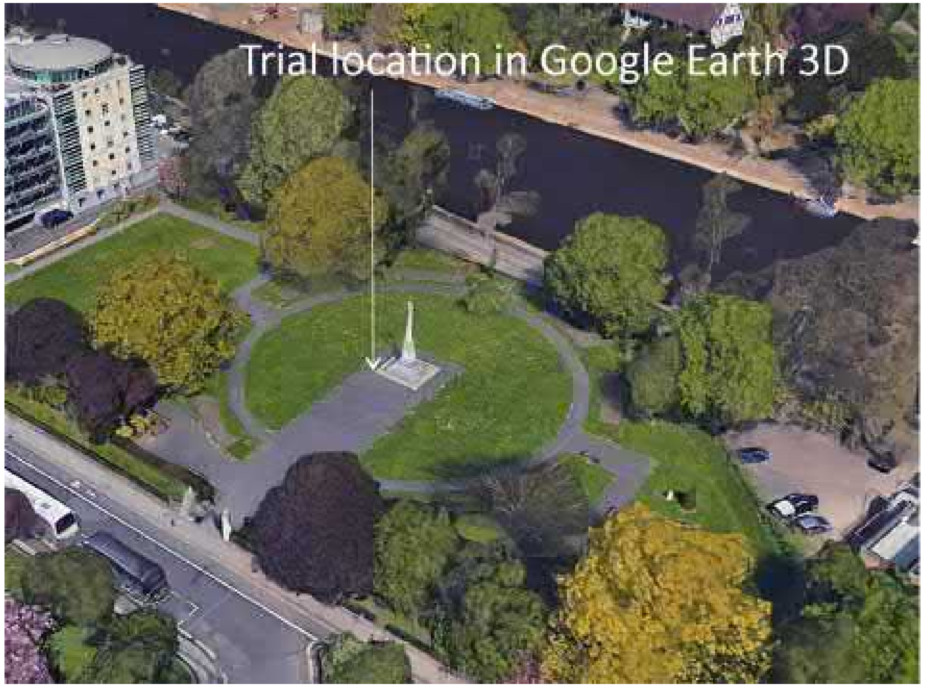
In the photo of the War Memorial in Memorial Gardens, York, if we faced the memorial and stepped 1m to our right, we would no longer be able to see the south tower of York Minster.

War Memorial in Memorial Gardens, York, 2016

This is because the war memorial is close to us and appears to shift substantially, relative to a more distant object such as the Minster.

So if we wanted to accurately 3D model the geometry of the war memorial and match a render to the photograph above, we would need a very accurate understanding of our camera position (x,y,z or easting, northing, height). However, if we were modelling an extension to York Minster south tower, it would not be as critical to know our exact camera position.

In summary, knowing the precise location of the camera, relative to the site, matters more when the subject (site) is closer to the viewpoint, than when it is further away.



14.2 How accurately can a viewpoint be located?

When undertaking research photography for this guidance, one location used was the stepped south-west corner of the War Memorial in Memorial Gardens, York (see photo and Aerial view, previous page). This was selected, in part, because it would be clearly visible in aerial photography. The following images show the location within GIS software, with some of the available means of identifying the location of the corner of the monument.

For each source of aerial photography, the corner position was visually estimated and compared to the base reference.

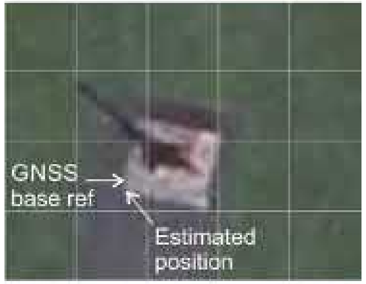
The images below have a 5m grid overlay. This exercise shows that dedicated survey equipment offers a high level of accuracy relative to mapped sources.

Hand-held GPS devices (all of which were allowed to 'settle') offered accuracy from around 8m to 2m.

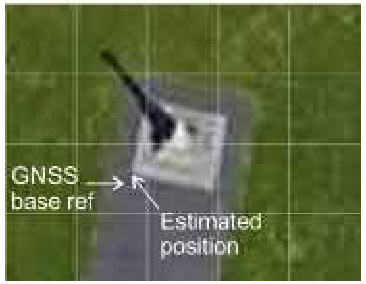
Aerial photography varied subject to source: hi-res OS performing best in this instance (accuracy within tolerance of GNSS device) with other sources providing location within 1m from the base ref. Note that performance will vary by location and subject to date, accuracy and resolution of source - this exercise cannot establish the best source in all cases.

For this clearly-identifiable location, in an urban area with tall buildings and trees (which could compromise GPS signals), aerial photography proved to be more accurate than hand-held or camera GPS. However, the results might be reversed on an open mountainside with no distinguishing locational features.

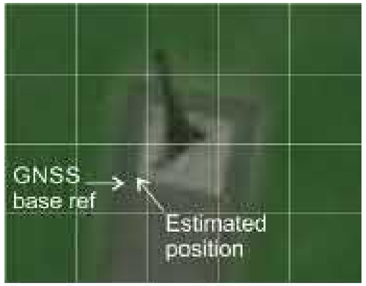
GNSS (without RTK), approx 0.18m accuracy. With RTK enhancement, this could have provided sub-cm accuracy. Position reported as E459833.69, N451917.82. Assumed as base reference (ref) for this exercise. Vector outline is OS MasterMap, corner is 0.352m from base ref. Aerial photography is OS Aerial hi-res (2007). Estimated position is 0.073m from base ref.



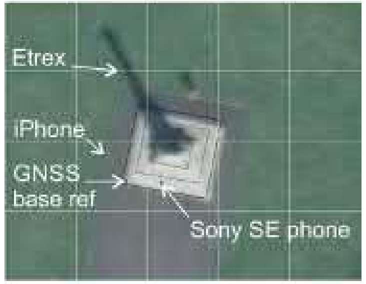
Aerial photography is Bing Imagery, accessed within GIS. Estimated position is 0.634m from base ref.



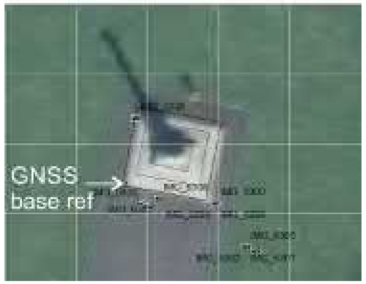
Aerial photography is Google Imagery, accessed within GIS. Estimated position is 0.785m from base ref.



Aerial photography is World Imagery, accessed within GIS. Estimated position is 0.785m from base ref.



GPS sources plotted against OS background. Reported coordinates were to the nearest metre: iPhone GPS 2.414m from base ref; Sony SE phone 2.478m from base ref; Garmin Etrex Vista HCx (GPS) 7.889m from base ref.



GPS sources plotted against OS background: Canon 6D internal GPS: multiple exposures at base location, recorded GPS coordinates are variable, average 5m from base ref.

This Guidance Note replaces LI Advice Note 01/11, 'Advice on Photography and Photomontage' and Technical Guidance Note 02/17, 'Visual Representation of Development Proposals'. It was prepared by members of the Landscape Institute (LI) Technical Committee, in consultation with LI members and technical experts experienced in photography, photomontage and landscape and visual impact assessment.

Meetings took place with, and comments were received from, the LI Technical Committee and other interested parties, including public sector representatives.

A consultation draft was produced in June 2018. Over fifty responses were received from practitioners and public authorities. Many respondents commented on the need for striking an appropriate balance between the principles of TGN 02/17 and ensuring that any visualisations were fit for purpose, depending on their role and use in the planning, development and consenting process, and including, when necessary, appropriate verifications. The result is this guidance, which combines TGN 02/17 with a thoroughly updated AN 01/11.

Consequently, this document provides a single, new LI Technical Guidance Note on the topic, which considers a range of approaches to visualisation.

It was prepared on behalf of the LI by a working group including the following members:

- Bill Blackledge (Chair) CMLI
- Ian McAulay
- Marc van Grieken FLI
- Mike Spence CMLI, REIA, FRGS
- Simon Odell CMLI

With particular thanks to:

- Chris Hale of Nicholas Pearson Associates
- Christine Tudor CMLI
- Matt Burnett of Scottish Natural Heritage
- Melanie Croll CMLI of Devon County Council
- Michelle Bolger CMLI

The copy editor was Gavin David CMLI.

This guidance is dedicated to the late Mark Turnbull, former chair of the LI Technical Committee.

Approved by LI Technical Committee

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Camera make & model	- CANON EOS 5D Mk III	Viewpoint height (AOD)	- 18.120mAOD	Accuracy Level*	- Type 4
Lens make & focal length	- Sigma 50mm, f/1.1,4	Distance to Site	- 524 metres	Visualisation (AVR) Type*	- AVR2
Date & time of photograph	- 22/8/21 16:18	Projection	- Cylindrical	Horizontal Field of View	- 2 x 90˚
OS grid reference	- 298708.051 513649.144	Enlargement / Sheet Size	- 100% @ A1 wide	Page size / Image size (mm)	- 2 x 841 x 297 / 815.6 x 245.8

* Landscape Institute Technical Guidance Note (TGN)06/19

Proposed Metallurgical Coal Project, Kells, Whitehaven, Cumbria

Existing View

6. Stephenson Halliday Viewpoint 12, High House Road

Public Inquiry | Photography by Mike Spence FRGS

PINS REF: APP/H0900/V/21/3271069

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Proposed Metallurgical Coal Project, Kells, Whitehaven, Cumbria

3D Model View

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3D Model View

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Proposed Metallurgical Coal Project, Kells, Whitehaven, Cumbria

3D Model View (Year 15)

6. Stephenson Halliday Viewpoint 12, High House Road

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PINS REF: APP/H0900/V/21/3271069

Camera make & model - CANON EOS 5D Mk III Viewpoint height (AOD) - 18.120mAOD Accuracy Level* - Type 4
Lens make & focal length - Sigma 50mm, f/1.1,4 Distance to Site - 524 metres Visualisation (AVR) Type* - AVR2
Date & time of photograph - 22/8/21 16:18 Projection - Cylindrical Horizontal Field of View - 2 x 90˚
OS grid reference - 298708.051 513649.144 Enlargement / Sheet Size - 100% @ A1 wide Page size / Image size (mm) - 2 x 841 x 297 / 815.6 x 245.8
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Proposed Metallurgical Coal Project, Kells, Whitehaven, Cumbria
3D Model View (Year 15)
6. Stephenson Halliday Viewpoint 12, High House Road
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Proposed Metallurgical Coal Project, Kells, Whitehaven, Cumbria

Composite View (Year 1)

6. Stephenson Halliday Viewpoint 12, High House Road

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Proposed Metallurgical Coal Project, Kells, Whitehaven, Cumbria

Composite View (Year 1)

6. Stephenson Halliday Viewpoint 12, High House Road

* Landscape Institute Technical Guidance Note (TGN)06/19

Public Inquiry | Photography by Mike Spence FRGS

your means to envision

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Proposed Metallurgical Coal Project, Kells, Whitehaven, Cumbria

Existing View (Planar)

6. Stephenson Halliday Viewpoint 12, High House Road

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Public Inquiry | Photography by Mike Spence FRGS

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Proposed Metallurgical Coal Project, Kells, Whitehaven, Cumbria

3D Model View (Planar)

6. Stephenson Halliday Viewpoint 12, High House Road

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Public Inquiry | Photography by Mike Spence FRGS

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Composite View (Planar)

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