

Assessment of UK's ability to meet the target under Article 5 of the Energy Efficiency Directive

Summary

1. Article 5 of the EU Energy Efficiency Directive (EED) requires Member States to achieve energy savings through renovation of a proportion of central government buildings that fail to meet minimum energy efficiency standards or demonstrate an equivalent savings through other means. This paper details the estimate of the required energy savings under the Article, as well as the extent to which this will be met by existing Government energy efficiency policies and measures, along with the methodology and assumptions used in the analysis.

2. The Article 5 energy savings target has been estimated through using a number of reference central government buildings (e.g. offices) with an assumed annual energy consumption before and after renovations and assigning these to the current stock of central government buildings within the scope of the article. The estimate of the savings that will be provided through existing Government policies and measures has come through analysis of the Greening Government Commitments (GGC) and devolved administration schemes and adjusting these to align with the scope of buildings covered by Article 5.

3. Table 1 shows the annual estimates for the Article 5 savings and those from existing Government policies and measures for the period over which the Article applies (2014-2020). This shows that, under current forecasts, existing schemes will meet the requirements of the Article by producing a greater total energy saving by 2020 of 441.5 GWh, compared to 163.6 GWh. Future estate rationalisation is taken into account by lowering the required savings accordingly and excluding this component from scheme savings to avoid double counting. We consider this conclusion to be robust given that the existing schemes savings estimate is a low scenario (with several departments not currently forecasting any savings within the period of the article) and a sensitivity analysis using very pessimistic assumptions around the standard of current energy efficiency in central government buildings only raised the article saving requirement to 255.3 GWh (excluding rationalisation).

Table 1: Estimated Energy Savings from Article 5 and existing Government Schemes¹

Year	Required Energy Savings under Article 5 (GWh)	Forecast Energy Savings from existing Government Schemes (GWh)
2014	63.3	398.9
2015	66.6	127.5
2016	51.4	6
2017	29.5	5.7
2018	31.7	5.1
2019	27.0	4.3
2014-20	269.5	547.5
2014-20 (excluding rationalisation)	163.6	441.5

¹ In 2012/13 total energy consumption across central government buildings was approximately 4,838 GWh (including Wales and Scotland, excluding Northern Ireland)

4. In conclusion, analysis indicates that under current plans for UK Government and Devolved Administration energy savings schemes, the requirements of Article 5 will be met by means of the alternative method.

Article 5 Savings Estimate Methodology

5. The interpretive note that relates to Article 5 gives Government several options for calculating the required response to the Article. The preferred method that DECC has selected involves using 'reference buildings' that were used as part of the Energy Performance of Buildings Directive² (EPBD). This involves using several standard building types (e.g. offices³) with assumed 'typical' annual energy consumption for pre and post renovations. These assumptions can be applied to the various building types in scope of the Article to estimate the total energy savings required.

6. Data on UK central government buildings has been obtained from the Cabinet Office's Epims database (with a snapshot as of September 2013) and from the MOD (a snapshot of military base offices and junior ranks accommodation as of July 2013). This has been filtered according to the scope conditions of article 5:

- All administrative departments whose competence extends over the whole territory of a Member State. There are also the following additional conditions:
 - Buildings with a floor area (Net Internal Area) greater or equal to 500m² (this reduces to 250m² on 9th July 2015)
 - Non-listed buildings
 - Defence single living accommodation (i.e. junior ranks accommodation) and offices (but not the rest of the defence estate)
 - Buildings that are 'owned & occupied' by the relevant department⁴
 - Buildings used for places of worship and religious activities are exempt

7. Table 2 shows the resulting distribution of floor areas by building type, showing that the most significant contributions to the in-scope floor area are from offices, prisons and MOD junior ranks accommodation. Several additional building types were also identified from the EPIMS database (e.g. museums, workshops, retail etc.). Given that these have quite varied usage and generally have a small contribution to the in-scope floor area, these building types have not been modelled individually. To simplify the analysis, these have been grouped together as an 'other' category which has been modelled on the basis of a 'mixed use' reference building.

² EPBD - UK Cost Optimal Report http://ec.europa.eu/energy/efficiency/buildings/implementation_en.htm

³ Energy Consumption Guide 19 <http://www.energybenchmarking.co.uk/Offices/ECON19reprintMarch03.pdf>

⁴ Epims holds data on the tenure of the building to determine ownership, but does not have occupation data at the same level, so have used an assumption from Cabinet Office that 8% of Government building floor space is commercially sub-let and will reduce the savings estimate accordingly.

Table 2: Floor area by reference building type for in scope buildings

Reference Building		Floor area (m2)
Office		5,454,308
Junior Ranks Accommodation		3,006,009
Court/Tribunal		683,867
Storage		403,897
Prison*		4,209,810
Laboratory		758,809
Residential**		80,120
Other	Vehicle Test Centre	75,674
	Mixed Use	378,723
	Museum	433,225
	Industrial	69,387
	School	48,700
	Hospitality	11,730
	Workshop	15,542
	Retail	8,004
	Blood Donation Centre	49,842
	Warehouse	9,241
	Sports	8,762
	Garages	15,745
Total Other		1,124,575
Total		15,721,395

* Floor area for prisons is Gross External Area

** Residential largely comprises of probation hostels

8. DECC has contracted BRE to provide advice on how to assign the buildings in scope of the article into reference buildings and to provide assumptions for their current energy consumptions. The buildings have been segmented by factors (for which data is available) that will have the greatest influence over their energy consumption and the impact of the renovations - this has resulted in the following segmentation scheme:

Building Use	Construction Date	Floor Area	Air Conditioned
Court/Tribunal	Pre 1980	<500m2	AC
Junior Ranks Accommodation	1980-89	501-2500m2	No AC
Laboratory	1990-1999	>2500m2	
Office	2000-2009		
Other	2010-2019		
Prison	Unknown*		
Residential			
Storage			

*Where construction date information is missing, then the reference building consumption is estimated as the weighted average of the buildings with known construction dates.

9. The pre-renovation annual energy consumption (expressed as kWh/m²) of each of these building types has been estimated using available benchmarks or updating these with actual energy consumption or DEC information where this is available in Epims data. The data sources used for this are shown in Annex A and the resulting reference building total energy consumptions is shown in Annex B.

10. To estimate the impact of energy efficiency renovations on the reference buildings it is necessary to first make assumptions about how the current energy consumption is divided between different end-uses which BRE have defined as:

- Heat Generation
- Cooling Generation
- Heat Distribution
- Cooling Distribution
- Mechanical Ventilation
- Hot Water
- Lighting
- Other Electricity Uses

11. This has been done through a simple steady state heat flow model using assumptions about building dimensions, glazing proportions and U-values of building components for each of the reference buildings.

12. Article 5 requires that buildings must be renovated up to 'minimum standards' of energy efficiency. Building regulations specify the minimum standards for renovations of existing buildings other than dwellings in an elemental fashion (e.g. a boiler must have above a particular efficiency or U-values must be below a certain value). The current 2010 Part L 2B standards will be replaced by 2013 standards to take effect from April 2014. For the purposes of this analysis BRE have used the elemental standards outlined in the Part L 2013 impact assessment⁵ as the minimum standards for buildings being renovated in the period of the article (2014-20). Details of the elemental standards assumed in the reference buildings before and after renovation are shown in Annex C.

13. BRE have calculated the post-renovation energy consumption for each reference building by inputting the 2013 standards into the heat flow model along with any efficiency improvements to building services (e.g. lighting). The post-renovation energy consumptions are detailed in Annex D.

14. To estimate the Article 5 energy saving, we have assigned each of the buildings in the Epims to a reference building type and calculated the annual energy saved from its renovation based on its pre and post-renovation energy consumptions and floor area. The Article states that Government buildings with the poorest energy performance should be a priority for energy efficiency measures. So for each year of the article we have identified the set of worst performing buildings (i.e. those with highest kWh/m²) that correspond to 3% of the total in-scope building floor area (taking into account the change in floor area in 2015) and calculated their total energy saving. We have assumed that renovating prisons would not be technically feasible or cost-effective so we have excluded these

⁵ Part L Impact Assessment

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/226965/Part_L_2013_IA.pdf

from the list of buildings to be renovated (though they still contribute to the in-scope floor area for the purpose of calculating the 3% target).

Table 3: Estimated annual energy savings required under article 5

Year	Total floor area in Scope (m ²)	Floor area to be renovated (m ²)	Number of buildings included	Total energy savings from renovation (GWh)
2014	14,063,524	421,906	39	63.3
2015 (to 9 th July)	13,621,975	204,330	71	30.8
2015 (from 9 th July)	13,912,066	209,249	57	35.9
2016	13,660,192	410,942	225	51.4
2017	13,251,419	400,061	257	29.5
2018	12,851,000	388,058	236	31.7
2019	12,463,568	376,332	208	27.0
Total		2,410,876	1,093	269.5

15. Table 3 shows the estimated annual energy savings required under article 5. The annual energy requirement reduces over the duration of the article as the worst performing buildings are renovated. The earlier years are dominated by large offices and laboratories, before large numbers of junior ranks accommodation in later years. These results have been scaled down by 8% using an assumption from the Cabinet Office to reflect that a proportion of these buildings will be commercially sub-let so outside the scope of the article.

16. We consider that these estimates present a pessimistic view (i.e. overestimate) of the level of savings required due to several assumptions:

- We assume that no buildings in scope of the article have already had any energy efficiency measures carried out (very little data is available on this in Epims), so energy consumption is determined by typical values for their construction date.
- The majority of the values for existing energy performance are derived from the Standard Building Energy Model (SBEM) databases which provide pessimistic default values.
- We have assumed that (for buildings other than prisons) that all energy efficiency measures are feasible and cost effective.

In addition, BRE have also provided reference building post- renovation consumption estimates where it is assumed that all buildings have the worst possible standard of equipment (e.g. boiler efficiencies) where a range is available. This gives a total savings estimate of 361.2 GWh compared to the current value of 269.5 GWh which is based on typical standards of equipment.

Existing Government Energy Savings Estimate Methodology

17. Article 5 allows member states to meet the requirements of the article through other means rather than physically renovating particular buildings (e.g. behavioural changes) as long as they generate equivalent energy savings in buildings within the scope of Article 5. We have identified several schemes that will count towards this 'alternative method' – the Greening Government Commitments⁶ (GGC) for UK Government Departments, the 2013 Carbon Management Plan (CMP) for the Scottish Government and Welsh Government's Climate Change Strategy⁷.

18. The GGC runs from 2010/11-2014/15 and involves departments reducing their emissions by 25% relative to their 09/10 baseline. We have departmental data covering actual results for 2010/11 – 2012/13 and forecast savings for 2013/14 and 2014/15. The departmental returns allow us to identify the emissions from buildings and provide average departmental factors to convert emissions savings into energy savings⁸.

19. The Scottish Government's CMP has a target of a 30% reduction in CO2 levels by 2020 and we have been provided with annual emissions savings forecasts from 2013-2020 (relating to energy saving projects in buildings) which we have converted into energy savings. The Welsh Government's Climate Change Strategy aims to cut emissions from the Welsh Government admin estate by 35% in 2019/20 from a 2010/11 baseline. We have actual emissions for 2012/13 and then have assumed an annual 3% reduction thereafter⁹, that we have again converted into an energy saving.

20. The schemes detailed above only report at a departmental/Devolved Administration (DA) level whereas the scope of Article 5 is defined at building level. We have assumed that forecast scheme savings will be achieved evenly over the relevant estate, so the amount of scheme savings in scope of the article will be determined by the proportion of the floorspace meeting the scope conditions. We have used the full set of Epims data and the scope definition of Article 5 to determine this, which is shown in Annex E (only for departments/DAs that have provided scheme saving forecasts), showing a large variation in coverage between departments/DAs mostly caused by the level of building ownership. These values have then been used to scale the forecast scheme savings to give estimates for the savings that will be achieved in buildings in scope of the article.

21. Table 5 shows the estimates of savings from existing schemes over the period covered by Article 5. GGC forecasts due to renewable generation have been excluded from this analysis (as while they will reduce CO2, it is not a guaranteed energy saving), but this has a very small effect on the overall forecast. In converting from financial years savings to calendar year savings, we have assumed that savings will be achieved equally over the course of the year. The results have been scaled down by 8% to reflect the Cabinet Office assumption about the proportion of Government buildings that are owned but not occupied.

⁶ <http://sd.defra.gov.uk/gov/green-government/commitments/>

⁷ <http://wales.gov.uk/docs/desh/publications/101006ccstratfinalen.pdf>

⁸ GGC forecasts only present savings as emissions (tCO2e). Departmental returns provide data on actual estate emissions and energy consumption for 2012/13 – these are used to convert the savings forecasts from emissions to energy consumption (GWh).

⁹ The Welsh Climate Change Strategy includes an annual 3% carbon reduction target.

Table 5: Forecast energy savings from existing Government schemes (in scope of article 5)

Year	Forecast Energy Savings (GWh)			Total
	GGC	CMP	WG Climate Change Strategy	
2014	395.8	2.4	0.7	398.9
2015	120.8	6.0	0.7	127.5
2016		5.5	0.5	6.0
2017		5.2	0.5	5.7
2018		4.6	0.5	5.1
2019		3.8	0.5	4.3
2014-20 Total Saving				547.5
2014-20 GGC rationalisation estimate				106.0
2014-20 Total Saving (excluding rationalisation)				441.5

22. GGC returns also allow us to identify how much of these savings will be delivered through rationalisation over the course of the article period – 106 GWh. The article states that future rationalisation should be accounted for by reducing the required article 5 energy saving estimate accordingly. This means that this component will be subtracted from the total required article 5 savings but will also be excluded from the estimate of savings from existing schemes (to avoid double counting).

23. We consider that this is a relatively low forecast as several departments have not detailed any forecast savings for the remainder of the GGC, which would currently cause them to miss the 25% saving target. We think it is likely that there will be additional activity to allow departments to meet the target which we estimate could result in an additional 27 GWh and 9 GWh being saved in 2014 and 2015 respectively in buildings in scope of the article (this does not include MoJ and MOD who have already confirmed they will achieve less than the 25% savings).

Comparison of Article 5 and Scheme savings

24. The Article allows member states to meet the required energy savings through an alternative approach (i.e. existing schemes) as long as by 2020 these produce an energy saving that is at least equivalent to the Article 5 requirement. To understand the UK's ability to meet the requirements of the article through the alternative method we need to compare the forecast annual energy savings required by the article with those that will be delivered through existing Government schemes. This is shown in Table 6.

Table 6: Estimated energy savings under article 5 and through existing Government schemes

Year	Required Energy Savings under Article 5 (GWh)	Forecast Energy Savings from existing Government Schemes (GWh)
2014	63.3	398.9
2015	66.6	127.5
2016	51.4	6
2017	29.5	5.7
2018	31.7	5.1
2019	27.0	4.3
2014-20	269.5	547.5
2014-20 (excluding rationalisation)	163.6	441.5

25. This shows that over the period of the article (2014-2020) we expect that existing government energy savings schemes will deliver savings far in excess of the requirement of the article – 441.5 GWh compared to 163.6 GWh. These forecasts exclude an estimate of savings from rationalisation from both the target (in line with the article) and the scheme saving estimate (to avoid double counting savings).

26. We consider the conclusion that existing schemes will meet the energy savings of the Article is robust. We consider that the savings schemes estimates present a relatively low scenario (with several departments presenting no forecasts) and that the Article 5 estimates present a pessimistic view of the savings required due to assumptions around the lack of previous renovations and that all aspects of the renovations would be feasible and cost effective (with the exception of prisons). Shifting the assumptions that buildings have the worst possible standard of equipment (e.g. boilers) as opposed to typical standards where there is a range only adds an additional 91.7 GWh to the Article 5 savings requirement, which is still well within the estimate of savings from existing schemes.

Annex A – Evidence sources for reference building benchmarks

Building Use	Benchmark	kWh/m2 electricity	kWh/m2 fossil	Source/Comments
Office	General office	95	120	TM46
Retail	General retail	165	0	TM46
Hospitality	Bar, pub or licensed club	130	350	TM46
Museum	Cultural activities	70	200	TM46
Sports	Dry sports and leisure facility	95	330	TM46
School	Schools and seasonal public buildings	40	150	TM46
Blood Donation Centre	Clinic	70	200	TM46
Residential	Long term residential	65	420	TM46
Junior Ranks Accommodation	General accommodation	60	300	TM46
Laboratory	Laboratory or operating theatre	160	160	TM46
Workshop	Workshop	35	180	TM46
Storage	Storage facility	35	160	TM47
Office, no A/C , <500	naturally ventilated cellular	43.2	120.8	CIBSE Guide F, Typical, excl. computer room, adjustment factor NIA:GIA = 1.25
Office, no A/C , >500	naturally ventilated open plan	67.2	120.8	CIBSE Guide F, Typical, excl. computer room, adjustment factor NIA:GIA = 1.26
Office, A/C, <2,500	a/c standard	180.8	142.4	CIBSE Guide F, Typical, excl. computer room, adjustment factor NIA:GIA = 1.27
Office, A/C, >2,500	a/c prestige	286.4	168	CIBSE Guide F, Typical, excl. computer room, adjustment factor NIA:GIA = 1.28
Prison	Prison	151	438	GPG289 - given as primary energy - ratio of fossil:electric =50:50 and primary energy factor for 2.9 for electric
Court/Tribunal	Schools and seasonal public buildings	40	150	TM46
Warehouse	Storage facility	35	160	TM46
Industrial	Workshop	35	180	TM46
Mixed Use	Mix as per	112.2	214	Average of 4 office types, Workshop, General Accommodation, Dry sports and leisure and Bar, pub or licenced club

Annex B – Total energy consumptions for pre-renovation reference buildings (kWh/m2)

Building Type	Air Conditioned	Floor Area (m2)	Construction Date							All Ages
			pre 1980	1980 - 1989	1990 - 1999	2000 - 2009	2010 - 2019	Unknown		
Court/Tribunal	AC	<500	380							380
Court/Tribunal	AC	500 - 2,500	180	191	171					180
Court/Tribunal	AC	>2,500	246	145	158				190	164
Court/Tribunal	No AC	<500	190		120				190	120
Court/Tribunal	No AC	500 - 2,500	183	182	173	190			224	211
Court/Tribunal	No AC	>2,500	143	152	159				211	181
Court/Tribunal	(blank)	<500								
Court/Tribunal	(blank)	500 - 2,500								
Court/Tribunal	(blank)	>2,500								
Junior Ranks Accomodation	AC	<500								
Junior Ranks Accomodation	AC	501 - 2,500								
Junior Ranks Accomodation	AC	>2,500								
Junior Ranks Accomodation	No AC	<500								
Junior Ranks Accomodation	No AC	500 - 2,500								
Junior Ranks Accomodation	No AC	>2,500								
Junior Ranks Accomodation	(blank)	<500	360	360	360	360	360	360	360	360
Junior Ranks Accomodation	(blank)	500 - 2,500	360	360	360	360	360	360	360	360
Junior Ranks Accomodation	(blank)	>2,500	360	360	360	360	360	360	360	360
Laboratory	AC	<500				320				320
Laboratory	AC	500 - 2,500	640			320				640
Laboratory	AC	>2,500			320	640				480
Laboratory	No AC	<500	320			320			320	320
Laboratory	No AC	500 - 2,500	320	320	282	320			427	389
Laboratory	No AC	>2,500	373	640	640	320	320		475	432
Laboratory	(blank)	<500								
Laboratory	(blank)	500 - 2,500								
Laboratory	(blank)	>2,500								
Office	AC	<500				323			323	323
Office	AC	500 - 2,500	323	323	323	323			323	323
Office	AC	>2,500	168	180	282	589			282	398
Office	No AC	<500	209	315	164	164			219	230
Office	No AC	500 - 2,500	195	167	128	258	188		264	229
Office	No AC	>2,500	177	189	184	235	265		202	198
Office	(blank)	<500	215	215	215	215	215		215	215
Office	(blank)	500 - 2,500	215	215	215	215	215		215	215
Office	(blank)	>2,500	215	215	215	215	215		215	215
Other	AC	<500				190			403	332
Other	AC	500 - 2,500	422		326				195	422
Other	AC	>2,500	270	450		298	540		540	510
Other	No AC	<500	190	177	326	165			215	165
Other	No AC	500 - 2,500	379	188	206	189			276	287
Other	No AC	>2,500	441	652		326	652		284	375
Other	(blank)	<500								
Other	(blank)	500 - 2,500								
Other	(blank)	>2,500								
Prison	AC	<500								
Prison	AC	500 - 2,500							589	589
Prison	AC	>2,500								
Prison	No AC	<500							589	589
Prison	No AC	500 - 2,500	589						589	589
Prison	No AC	>2,500	589	589					589	589
Prison	(blank)	<500								
Prison	(blank)	500 - 2,500								
Prison	(blank)	>2,500								
Residential	AC	<500								
Residential	AC	500 - 2,500								
Residential	AC	>2,500							485	485
Residential	No AC	<500	485						485	485
Residential	No AC	500 - 2,500	485	485	485	485			471	471
Residential	No AC	>2,500				485				485
Residential	(blank)	<500								
Residential	(blank)	500 - 2,500								
Residential	(blank)	>2,500								
Storage	AC	<500								
Storage	AC	500 - 2,500								
Storage	AC	>2,500	195							195
Storage	No AC	<500	195	195	195	195			195	195
Storage	No AC	500 - 2,500	293	293	195	195	195		173	173
Storage	No AC	>2,500	189	172					98	162
Storage	(blank)	<500								
Storage	(blank)	500 - 2,500								
Storage	(blank)	>2,500								

Annex C – Benchmarks for reference buildings

Building Age/Measure	Measure	Technology	existing	unit	source	new	unit	source	% energy saving	source
	space heating electric	heat generator efficiency	100%	EER	assume direct electric heating	220%	EER	NDBSCG:2010 heat pump for space heating	55%	
	space heating electric	heat pumps controls							8%	NDBSCG:2010 2% oversizing, 2% optimized stop, 2% full zone control, 2% monitoring and targeting. These are % heating credits which can be added
pre 1980 space heating	space heating gas	heat generator efficiency	63%	EER	CBSE TM63:2013 p 25 SEER of existing non condensing boilers range 45-80%	84%	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	26%	
1980 - 1989 space heating	space heating gas	heat generator efficiency	63%	EER	CBSE TM63:2013 p 25 SEER of existing non condensing boilers range 45-80%	84%	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	26%	
1990 - 1999 space heating	space heating gas	heat generator efficiency	63%	EER	CBSE TM63:2013 p 25 SEER of existing non condensing boilers range 45-80%	84%	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	26%	
2000 - 2009 space heating	space heating gas	heat generator efficiency	63%	EER	CBSE TM63:2013 p 25 SEER of existing non condensing boilers range 45-80%	84%	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	26%	
2010 - 2019 space heating	space heating gas	heat generator efficiency	84%	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	84%	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	0%	
	space heating gas oversizing	boiler oversizing							2%	NDBSCG:2010 these are heating efficiency credit %
	space heating gas multiple	multiple boilers							1%	NDBSCG:2010 these are heating efficiency credit %
	space heating gas controls	Full BMS linked to heating plant							4%	sequential control of multiple boilers, full soned time control and w eather compensation etc
pre 1980 packaged cooling	space cooling packaged	packaged cooling system (includes)	1.40	EER	NCM model guide	2.70	EER	2013 Part L non domestic impact assessment	48%	
1980 - 1989 packaged cooling	space cooling packaged	packaged cooling system (includes)	1.40	EER	NCM model guide	2.70	EER	2013 Part L non domestic impact assessment	48%	
1990 - 1999 packaged cooling	space cooling packaged	packaged cooling system (includes)	1.40	EER	NCM model guide	2.70	EER	2013 Part L non domestic impact assessment	48%	
2000 - 2009 packaged cooling	space cooling packaged	packaged cooling system (includes)	1.40	EER	NCM model guide	2.70	EER	2013 Part L non domestic impact assessment	48%	
2010 - 2019 packaged cooling	space cooling packaged	packaged cooling system (includes)	2.50	EER	NDBSCG:2010 existing buildings	2.70	EER	2013 Part L non domestic impact assessment	0%	
pre 1980 chiller	space cooling chillers	cooling generator	3.32	EER	Water cooled not on SEER SBEM database	4.25	EER	NDBSCG:2010 average for water cooled chillers	22%	
1980 - 1989 chiller	space cooling chillers	cooling generator	3.32	EER	Water cooled not on SEER SBEM database	4.25	EER	NDBSCG:2010 average for water cooled chillers	22%	
1990 - 1999 chiller	space cooling chillers	cooling generator	3.32	EER	Water cooled not on SEER SBEM database	4.25	EER	NDBSCG:2010 average for water cooled chillers	22%	
2000 - 2009 chiller	space cooling chillers	cooling generator	3.32	EER	Water cooled not on SEER SBEM database	4.25	EER	NDBSCG:2010 average for water cooled chillers	22%	
2010 - 2019 chiller	space cooling chillers	cooling generator	4.25	EER	NDBSCG:2010 average for water cooled chillers	4.25	EER	NDBSCG:2010 average for water cooled chillers	0%	
pre 1980 AHU	Air distribution	fan efficiency	3.82	SFP	CBSE TM63:2013 replacing existing motors with DC for axial fans can increase typical efficiencies from 50-75 to 85% - assume	2.2	SFP	NDBSCG:2010 central and mechanical ventilation system including heating and cooling	42%	
1980 - 1989 AHU	Air distribution	fan efficiency	3.82	SFP	CBSE TM63:2013 replacing existing motors with DC for axial fans can increase typical efficiencies from 50-75 to 85% - assume	2.2	SFP	NDBSCG:2010 central and mechanical ventilation system including heating and cooling	42%	
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2010 - 2019 AHU	Air distribution	fan efficiency	2.20	SFP	NDBSCG:2010 central and mechanical ventilation system including heating and cooling	2.2	SFP	NDBSCG:2010 central and mechanical ventilation system including heating and cooling	0%	
	Air distribution	insulate							2%	Expert assumption
	Air distribution	reduce ductwork leakage							10%	modern building services article http://www.modbs.co.uk/new s/fullstory.php?aid/6156/_65279;Energy-efficient_ductwork_or_k_is_a_matter_of_class.html
	Air distribution	fan coil units	0.3			0.6		NDBSCG:2010 fan coil units	50%	

Building Age/Measure	Measure	Technology	existing	unit	source	new	unit	source	% energy saving	source
pre 1980 lighting	lighting	luminaire efficiency	40	lumens per circuit watt	predominantly T12 Fluorescent - halophosphate - low frequency ballast	60	lumens per circuit watt	2013 Part L non domestic impact assessment	33%	
1980 - 1989 lighting	lighting	luminaire efficiency	44	lumens per circuit watt	predominantly T8 Fluorescent - halophosphate - low frequency ballast	60	lumens per circuit watt	2013 Part L non domestic impact assessment	27%	
1990 - 1999 lighting	lighting	luminaire efficiency	52	lumens per circuit watt	predominantly T8 Fluorescent - halophosphate - high frequency ballast	60	lumens per circuit watt	2013 Part L non domestic impact assessment	13%	
2000 - 2009 lighting	lighting	luminaire efficiency	55	lumens per circuit watt	NDBSCG:2010	60	lumens per circuit watt	2013 Part L non domestic impact assessment	8%	
2010 - 2019 lighting	lighting	luminaire efficiency	60	lumens per circuit watt	2013 Part L non domestic impact assessment assume predominantly T5 fluorescent triphosphor electronic ballast	60	lumens per circuit watt	2013 Part L non domestic impact assessment	0%	
	lighting	lighting controls daylight and occupancy							15%	NDBSCG:2010 efficiency credit % includes decentralisation and correct sizing
	hot water	hot water generator	100%	EER	assume direct electric heating	200%	EER	NDBSCG:2010 heat pump for domestic hot water	50%	
pre 1980 hot water	hot water	hot water generator	63%	EER	CBSE TM53:2013 p 25 SEER of existing non condensing boilers range 45-80%	0.84	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	26%	
1980 - 1989 hot water	hot water	hot water generator	63%	EER	CBSE TM53:2013 p 25 SEER of existing non condensing boilers range 45-80%	0.84	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	26%	
1990 - 1999 hot water	hot water	hot water generator	63%	EER	CBSE TM53:2013 p 25 SEER of existing non condensing boilers range 45-80%	0.84	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	26%	
2000 - 2009 hot water	hot water	hot water generator	63%	EER	CBSE TM53:2013 p 25 SEER of existing non condensing boilers range 45-80%	0.84	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	26%	
2010 - 2019 hot water	hot water	hot water generator	84%	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	0.84	EER	NDBSCG:2010 existing buildings 84% gas, 85% LPG, 86% oil	0%	
	hot water	hot water							4%	decentralisation and correct sizing
	hot water	insulate							10%	Expert assumption
pre 1980 wall	fabric pre 1980	wall u value	2.2	u value	Solid brick wall, 225 mm, uninsulated Pre 1919 SBEM database	0.28	u value	PartL2B w all	87%	
pre 1980	fabric pre 1980	window u value	5.75	u value	Typical glazing, pre-1995 SBEM database	1.8	u value	windows and glazed rooflights	69%	
pre 1980 roof	fabric pre 1980	roof u value	2.8	u value	Flat roof, concrete deck, uninsulated, U=2.8 SBEM database	0.18	u value	Part L2B flat roof or roof with integral insulation	94%	
pre 1980 floor	fabric pre 1980	ground floor u value	0.58	u value	Uninsulated floor (if floor type unknown), SBEM database	0.22	u value	PartL2B floor	62%	
pre 1980 air tightness	fabric pre 1980	air changes per hour	0.6	air changes per hour	upper quartile value for different building types pre 2002 constructions CBSE TM53:2013	0.3	air changes per hour	guess	50%	
1980 - 1989 window	fabric 1980 - 1989	wall u value	0.6	u value	Solid wall (E&W) 1980/85 Part L	0.28	u value	PartL2B w all	53%	
1980 - 1989 roof	fabric 1980 - 1989	wall u value	5.75	u value	Typical glazing, pre-1995	1.80	u value	Part L2B w indows roof windows and glazed rooflights	69%	
1980 - 1989 roof	fabric 1980 - 1989	roof u value	0.45	u value	Flat roof (E&W) 1980/85 Part L, light deck	0.18	u value	Part L2B flat roof or roof with integral insulation	60%	
1980 - 1989	fabric 1980 - 1989	ground floor u	0.58	u value	Ground floor (E&W) 1980/85 Part L (E&W)	0.22	u value	PartL2B floor	62%	
1980 - 1989 air tightness	fabric 1980 - 1989	air changes per hour	0.6	air changes per hour	upper quartile value for different building types pre 2002 constructions CBSE TM53:2013	0.30	air changes per hour	guess	50%	
1990 - 1999 window	fabric 1990 - 1999	wall u value	0.45	u value	Solid wall (E&W) 1990 Part L	0.28	u value	PartL2B w all	38%	
1990 - 1999 roof	fabric 1990 - 1999	wall u value	3.3	u value	Typical glazing, pre-1995	1.80	u value	Part L2B w indows roof windows and glazed rooflights	45%	
1990 - 1999 roof	fabric 1990 - 1999	roof u value	0.45	u value	Flat roof (E&W) 1990 Part L, light deck, U=0.45	0.18	u value	Part L2B flat roof or roof with integral insulation	60%	
1990 - 1999	fabric 1990 - 1999	ground floor u	0.45	u value	Ground floor (E&W) 1990 Part L	0.22	u value	PartL2B floor	51%	
1990 - 1999 air tightness	fabric 1990 - 1999	air changes per hour	0.6	air changes per hour	upper quartile value for different building types pre 2002 constructions CBSE TM53:2013	0.30	air changes per hour	guess	50%	
2000 - 2009 window	fabric 2000 - 2009	wall u value	0.35	u value	Solid wall (E&W) 2002 Part L	0.28	u value	PartL2B w all	20%	
2000 - 2009 roof	fabric 2000 - 2009	wall u value	2.2	u value	Typical glazing, 2002-05	1.80	u value	Part L2B w indows roof windows and glazed rooflights	18%	
2000 - 2009	fabric 2000 - 2009	roof u value	0.25	u value	Flat roof (E&W) 2002 Part L, lightweight deck, U=0.25	0.18	u value	Part L2B flat roof or roof with integral insulation	28%	
2000 - 2009	fabric 2000 - 2009	ground floor u	0.25	u value	Solid ground floor (E&W) 2002 Part L	0.22	u value	PartL2B floor	12%	
2000 - 2009 air tightness	fabric 2000 - 2009	air changes per hour	0.3	air changes per hour	changes	0.30	air changes per hour	guess	0%	
2010 - 2019	fabric 2010 - 2019	wall u value	0.28	u value	Part L2B	0.30	u value	internal insulation	0%	
2010 - 2019	fabric 2010 - 2019	wall u value	1.8	u value	Part L2B	1.80	u value	Part L2B	0%	
2010 - 2019	fabric 2010 - 2019	wall u value	0.18	u value	Part L2B	0.18	u value	Part L2B	0%	
2010 - 2019	fabric 2010 - 2019	wall u value	0.22	u value	Part L2B	0.25	u value	Part L2B	0%	
2010 - 2019 air tightness	fabric 2010 - 2019	air changes per hour	0.3	air changes per hour	changes	0.30	air changes per hour	guess	0%	

Annex D – Total post-renovation energy savings for reference buildings (kWh/m2)

Energy savings (kWh/m2) for buildings using fossil fuels and electricity			Construction Date					
Building Type	Air Conditioned	Floor Area (m2)	pre 1980	1980 - 1989	1990 - 1999	2000 - 2009	2010 - 2019	Unknown
Court/Tribunal	AC	<500	178	-	-	-	-	178
Court/Tribunal	AC	500 - 2,500	84	78	57	-	-	77
Court/Tribunal	AC	>2,500	113	59	53	-	-	64
Court/Tribunal	No AC	<500	89	-	38	-	-	80
Court/Tribunal	No AC	500 - 2,500	86	73	55	44	-	79
Court/Tribunal	No AC	>2,500	65	61	50	-	-	57
Court/Tribunal	(blank)	<500	-	-	-	-	-	-
Court/Tribunal	(blank)	500 - 2,500	-	-	-	-	-	-
Court/Tribunal	(blank)	>2,500	-	-	-	-	-	-
Junior Ranks Accomodation	AC	<500	-	-	-	-	-	-
Junior Ranks Accomodation	AC	500 - 2,500	-	-	-	-	-	-
Junior Ranks Accomodation	AC	>2,500	-	-	-	-	-	-
Junior Ranks Accomodation	No AC	<500	-	-	-	-	-	-
Junior Ranks Accomodation	No AC	500 - 2,500	-	-	-	-	-	-
Junior Ranks Accomodation	No AC	>2,500	-	-	-	-	-	-
Junior Ranks Accomodation	(blank)	<500	103	88	74	56	22	72
Junior Ranks Accomodation	(blank)	500 - 2,500	99	88	73	55	22	69
Junior Ranks Accomodation	(blank)	>2,500	98	87	73	54	22	63
Laboratory	AC	<500	-	-	-	81	-	81
Laboratory	AC	500 - 2,500	284	-	-	84	-	234
Laboratory	AC	>2,500	-	-	115	156	-	136
Laboratory	No AC	<500	138	-	-	76	-	117
Laboratory	No AC	500 - 2,500	137	118	97	75	-	122
Laboratory	No AC	>2,500	158	229	215	70	21	154
Laboratory	(blank)	<500	-	-	-	-	-	-
Laboratory	(blank)	500 - 2,500	-	-	-	-	-	-
Laboratory	(blank)	>2,500	-	-	-	-	-	-
Office	AC	<500	-	-	-	105	-	105
Office	AC	500 - 2,500	185	161	149	105	-	157
Office	AC	>2,500	80	60	113	171	-	123
Office	No AC	<500	75	147	44	33	-	67
Office	No AC	500 - 2,500	85	64	46	58	15	73
Office	No AC	>2,500	71	71	59	53	21	66
Office	(blank)	<500	112	94	83	59	17	87
Office	(blank)	500 - 2,500	108	93	82	57	17	81
Office	(blank)	>2,500	107	93	82	56	17	76
Other	AC	<500	-	-	-	45	-	45
Other	AC	500 - 2,500	172	-	113	-	-	143
Other	AC	>2,500	104	173	-	73	43	95
Other	No AC	<500	69	58	105	47	-	60
Other	No AC	500 - 2,500	161	71	66	44	-	105
Other	No AC	>2,500	176	239	-	75	58	158
Other	(blank)	<500	-	-	-	-	-	-
Other	(blank)	500 - 2,500	-	-	-	-	-	-
Other	(blank)	>2,500	-	-	-	-	-	-
Prison	AC	<500	-	-	-	-	-	-
Prison	AC	500 - 2,500	-	-	-	-	-	-
Prison	AC	>2,500	-	-	-	-	-	-
Prison	No AC	<500	-	-	-	-	-	-
Prison	No AC	500 - 2,500	189	-	-	-	-	189
Prison	No AC	>2,500	187	159	-	-	-	179
Prison	(blank)	<500	-	-	-	-	-	-
Prison	(blank)	500 - 2,500	-	-	-	-	-	-
Prison	(blank)	>2,500	-	-	-	-	-	-
Residential	AC	<500	-	-	-	-	-	-
Residential	AC	500 - 2,500	-	-	-	-	-	-
Residential	AC	>2,500	-	-	-	-	-	-
Residential	No AC	<500	118	-	-	-	-	118
Residential	No AC	500 - 2,500	119	103	83	61	-	97
Residential	No AC	>2,500	-	-	-	61	-	61
Residential	(blank)	<500	-	-	-	-	-	-
Residential	(blank)	500 - 2,500	-	-	-	-	-	-
Residential	(blank)	>2,500	-	-	-	-	-	-
Storage	AC	<500	-	-	-	-	-	-
Storage	AC	500 - 2,500	-	-	-	-	-	-
Storage	AC	>2,500	64	-	-	-	-	64
Storage	No AC	<500	58	48	40	29	-	48
Storage	No AC	500 - 2,500	86	72	40	29	13	59
Storage	No AC	>2,500	52	42	-	-	-	49
Storage	(blank)	<500	-	-	-	-	-	-
Storage	(blank)	500 - 2,500	-	-	-	-	-	-
Storage	(blank)	>2,500	-	-	-	-	-	-

Energy savings (kWh/m2) for all-electric buildings			Construction Date					
Building Type	Air Conditioned	Floor Area (m2)	pre 1980	1980 - 1989	1990 - 1999	2000 - 2009	2010 - 2019	Unknown
Court/Tribunal	AC	<500	307	-	-	-	-	307
Court/Tribunal	AC	500 - 2,500	145	141	121	-	-	139
Court/Tribunal	AC	>2,500	194	107	112	-	-	120
Court/Tribunal	No AC	<500	156	-	86	-	-	143
Court/Tribunal	No AC	500 - 2,500	150	136	124	112	-	144
Court/Tribunal	No AC	>2,500	113	113	114	-	-	113
Court/Tribunal	(blank)	<500	-	-	-	-	-	-
Court/Tribunal	(blank)	500 - 2,500	-	-	-	-	-	-
Court/Tribunal	(blank)	>2,500	-	-	-	-	-	-
Junior Ranks Accomodation	AC	<500	-	-	-	-	-	-
Junior Ranks Accomodation	AC	500 - 2,500	-	-	-	-	-	-
Junior Ranks Accomodation	AC	>2,500	-	-	-	-	-	-
Junior Ranks Accomodation	No AC	<500	-	-	-	-	-	-
Junior Ranks Accomodation	No AC	500 - 2,500	-	-	-	-	-	-
Junior Ranks Accomodation	No AC	>2,500	-	-	-	-	-	-
Junior Ranks Accomodation	(blank)	<500	281	255	246	207	193	235
Junior Ranks Accomodation	(blank)	500 - 2,500	271	254	244	205	193	231
Junior Ranks Accomodation	(blank)	>2,500	269	252	245	202	193	219
Laboratory	AC	<500	-	-	-	135	-	135
Laboratory	AC	500 - 2,500	352	-	-	138	-	298
Laboratory	AC	>2,500	-	-	158	267	-	212
Laboratory	No AC	<500	179	-	-	136	-	165
Laboratory	No AC	500 - 2,500	178	165	141	136	-	168
Laboratory	No AC	>2,500	207	325	317	133	127	210
Laboratory	(blank)	<500	-	-	-	-	-	-
Laboratory	(blank)	500 - 2,500	-	-	-	-	-	-
Laboratory	(blank)	>2,500	-	-	-	-	-	-
Office	AC	<500	-	-	-	131	-	131
Office	AC	500 - 2,500	172	160	152	131	-	157
Office	AC	>2,500	84	91	131	231	-	160
Office	No AC	<500	146	189	100	86	-	129
Office	No AC	500 - 2,500	123	97	70	118	80	113
Office	No AC	>2,500	108	109	102	105	119	107
Office	(blank)	<500	160	144	139	117	107	140
Office	(blank)	500 - 2,500	155	144	138	115	107	135
Office	(blank)	>2,500	155	143	138	114	107	131
Other	AC	<500	-	-	-	98	-	98
Other	AC	500 - 2,500	277	-	189	-	-	233
Other	AC	>2,500	171	269	-	145	242	190
Other	No AC	<500	130	112	193	80	-	108
Other	No AC	500 - 2,500	252	116	122	97	-	178
Other	No AC	>2,500	283	398	-	163	305	279
Other	(blank)	<500	-	-	-	-	-	-
Other	(blank)	500 - 2,500	-	-	-	-	-	-
Other	(blank)	>2,500	-	-	-	-	-	-
Prison	AC	<500	-	-	-	-	-	-
Prison	AC	500 - 2,500	-	-	-	-	-	-
Prison	AC	>2,500	-	-	-	-	-	-
Prison	No AC	<500	-	-	-	-	-	-
Prison	No AC	500 - 2,500	444	-	-	-	-	444
Prison	No AC	>2,500	439	403	-	-	-	429
Prison	(blank)	<500	-	-	-	-	-	-
Prison	(blank)	500 - 2,500	-	-	-	-	-	-
Prison	(blank)	>2,500	-	-	-	-	-	-
Residential	AC	<500	-	-	-	-	-	-
Residential	AC	500 - 2,500	-	-	-	-	-	-
Residential	AC	>2,500	-	-	-	-	-	-
Residential	No AC	<500	368	-	-	-	-	368
Residential	No AC	500 - 2,500	373	346	332	275	-	340
Residential	No AC	>2,500	-	-	-	275	-	275
Residential	(blank)	<500	-	-	-	-	-	-
Residential	(blank)	500 - 2,500	-	-	-	-	-	-
Residential	(blank)	>2,500	-	-	-	-	-	-
Storage	AC	<500	-	-	-	-	-	-
Storage	AC	500 - 2,500	-	-	-	-	-	-
Storage	AC	>2,500	129	-	-	-	-	129
Storage	No AC	<500	146	132	127	108	-	134
Storage	No AC	500 - 2,500	219	197	127	107	99	167
Storage	No AC	>2,500	133	114	-	-	-	128
Storage	(blank)	<500	-	-	-	-	-	-
Storage	(blank)	500 - 2,500	-	-	-	-	-	-
Storage	(blank)	>2,500	-	-	-	-	-	-

Annex E – Proportions of Floor Area in article 5 scope by department/DA

Department/Devolved Administration*	Floor Area in Scope of Article 5
Law Officers Department (LOD)	3.1%
Department of Health (DH)	40.9%
DEFRA	48.0%
HO	12.6%
DFID	23.2%
MoJ	82.2%
DECC	76.1%
ECGD	0.0%
ONS	82.3%
DCLG	63.2%
CMS	76.7%
Food Standards Agency	0.0%
DfE	27.3%
DfT	48.4%
FCO	68.1%
CO	28.0%
HMRC	0.0%
MoD	88.5%
BIS	61.9%
HMT	0.0%
The Welsh Government	100.0%
The Scottish Government	67.87%
Total	61.7%

*This is only done for departments / DAs that have provided forecasts for scheme savings