Rules of Thumb

Guidelines for building services (5th Edition)

By Glenn Hawkins

BG 9/2011

Acknowledgements

BG 9/2011 *Rules of Thumb* provides a valuable source of approximate engineering design, environmental performance and project cost data for building services projects. It is therefore an indispensable reference document for construction professionals.

The BG 9/2011 *Rules of Thumb* has been written by BSRIA's Glenn Hawkins and has been designed and produced by Ruth Radburn.

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Preface

The origin of the term "Rule of Thumb" is unclear. It is an expression that has been attributed to a diverse range of sources dating back hundreds of years. These include woodworkers using their thumbs as measurement devices, millers assessing the coarseness of ground flour by rubbing it between a thumb and forefinger, brewers testing the temperature of fermenting beers and farmers sowing seeds or setting plants at an approximate soil depth.

Whatever the application, a Rule of Thumb can be considered as a general principle or means of estimation derived from practice and experience, rather than precise theory. It represents a method for broad application that is not intended to be accurate for every situation. However, a Rule of Thumb can be easily learned and applied, which means that it can be extremely useful for approximately calculating a value, setting outline targets or rapidly comparing different options.

As a construction project progresses from a client's statement of need, through design and construction, and into operation and use, project teams seek increased certainty of criteria such as layout, fit, cost and performance. Rules of Thumb, such as those contained in this publication, can provide extremely useful guidance to inform the early stages of this process, such as briefing, feasibility studies and concept design. This may be in the assessment of space and weight requirements, the preparation of outline cost models, the configuration of environmental performance targets or the evaluation of heating, cooling and electrical loads, for example. Furthermore, Rules of Thumb can be employed throughout the project delivery process to sense-check precise calculations, quickly verify the work of junior construction professionals and rapidly perform what-if scenarios for different design options.

While every effort has been made to reflect current practice and contemporary building services plant, it is important to acknowledge that the Rules of Thumb are merely aids to the project delivery process. They must not be used in place of detailed design, cost or performance-in-use data. The responsibility for the safe and appropriate use of this data therefore rests with each construction professional.

This publication has been designed to be your own personal reference document. Use it, transfer your own data to it, and share what you know with others. And please let us know how it works and where it can be improved.

Glenn Hawkins
BSRIA, March 2011

Contents

About this book

This publication is the fifth edition of the *Rules of Thumb* first issued in 1995.

The Rules of Thumb have been created by referencing various contemporary sources in the building services industry and can reasonably be held to reflect current design practices. The sources include major building services design consultancies, concept and scheme design reports produced by construction project teams, leading plant and equipment manufacturers, the *Building Regulations* and information published by BSRIA, CIBSE and others.

This fifth edition contains greatly increased guidance about space and weight allowances that is presented in a new graphical format. CO_2 emissions benchmarks are included for the first time and are presented alongside energy consumption benchmarks. Guidance about costs has been made clearer and expanded to include energy consumption, maintenance, operation and life cycle cost information. The section about system features has been clarified and sub-divided into mechanical building services, electrical building services and natural ventilation. In order to reflect the increasing importance of low carbon design, guidance about compliance with *Part L* of the *Building Regulations,* renewable technologies and air permeability of buildings has also been included in this update.

Each section is colour-coded as follows:

- Space and weight
- System features – Mechanical building services, electrical building services and natural ventilation
- Cooling, heating and electrical loads
- Water consumption
- Internal and external design criteria
- Energy and carbon
- Costs

Readers are advised to use this new edition in place of the previous one, and to transfer over any personal Rules of Thumb they have compiled in the light of experience.

Space and weight allowances

How to use the charts of space and weight allowances:

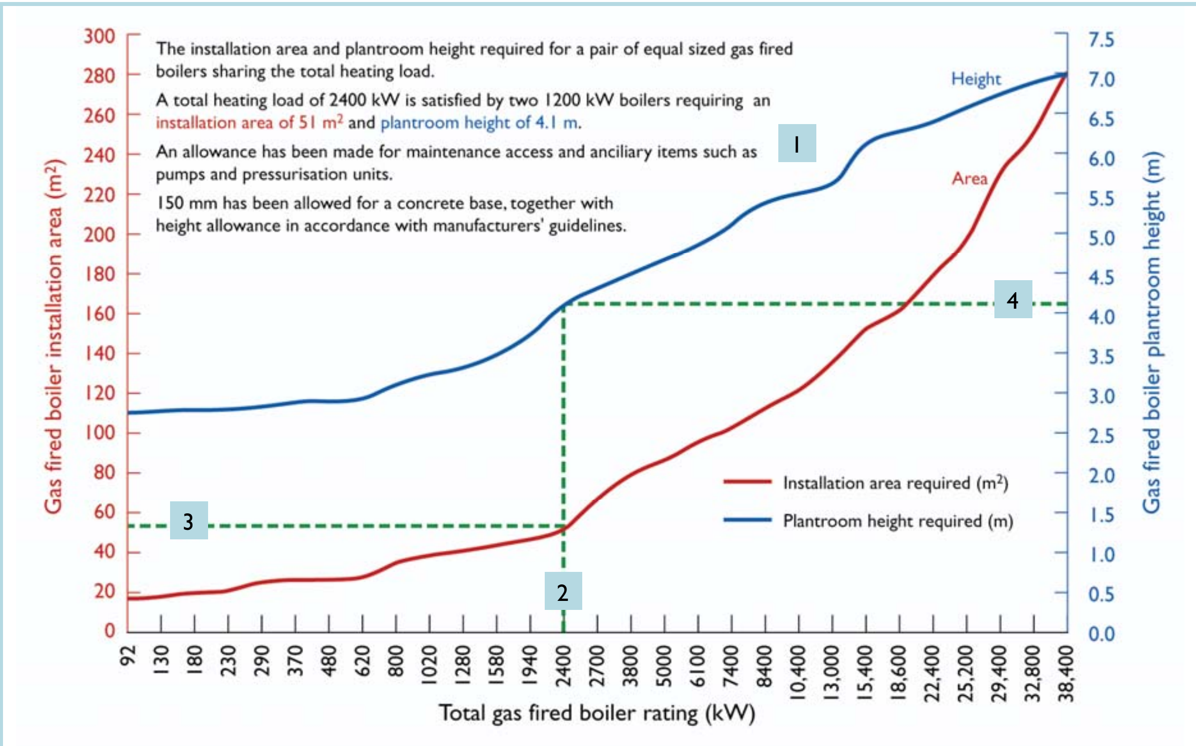
Step 1 Read the explanatory notes that accompany each chart

Step 2 Project a vertical line from the bottom axis at a point representing the appropriate plant performance requirements of your project

Step 3 At the point where the vertical line intersects the red line representing area requirements, project a horizontal towards the red vertical axis. Read off the area required for plant installation.

Step 4 At the point where the vertical line intersects the blue line representing height requirements, project a horizontal towards the blue vertical axis. Read off the height required area for plant installation.

Please note that although the two vertical axes have different units, they have the same number of tick marks. This means that a ruler can be used to project horizontal lines that are parallel to the bottom axis.



The example shown above applies to the dual-axis charts of area and height requirements. For the charts of operating weight, the following approach should be adopted:

Step 1 Read the explanatory notes that accompany each chart

Step 2 Project a vertical line from the bottom axis at a point representing the appropriate plant performance requirements of your project

Step 3 At the point where the vertical line intersects the green line representing operating weight, project a horizontal towards the green vertical axis. Read off the operating weight.

Figure 1: Air cooled condenser – area and height requirements

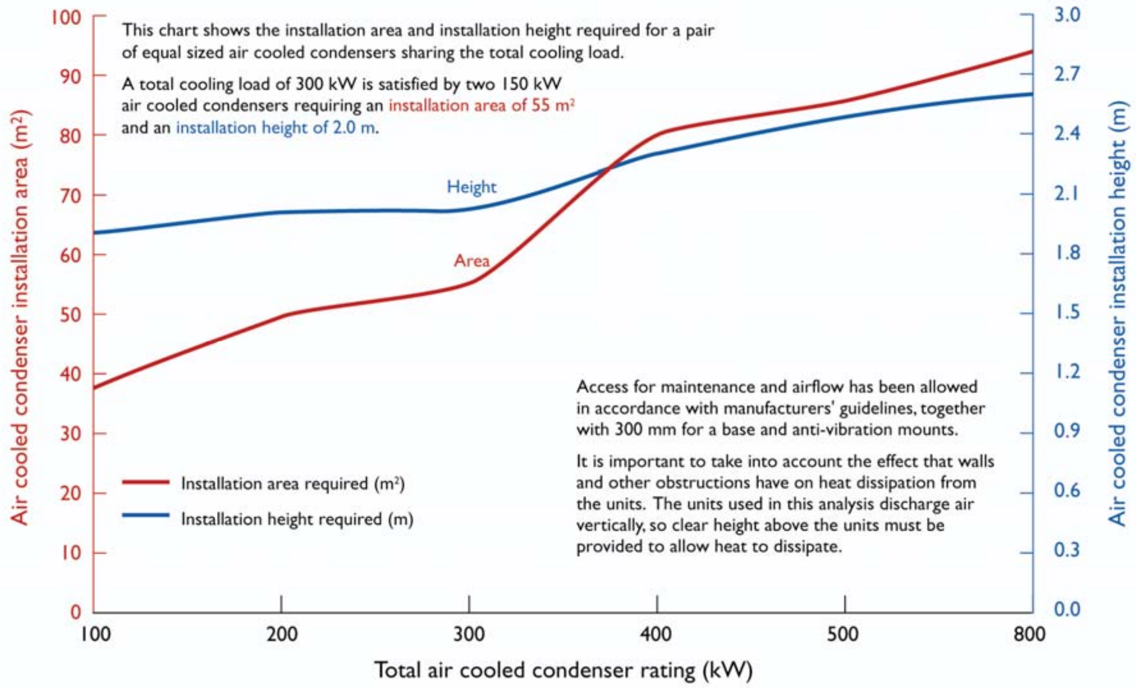
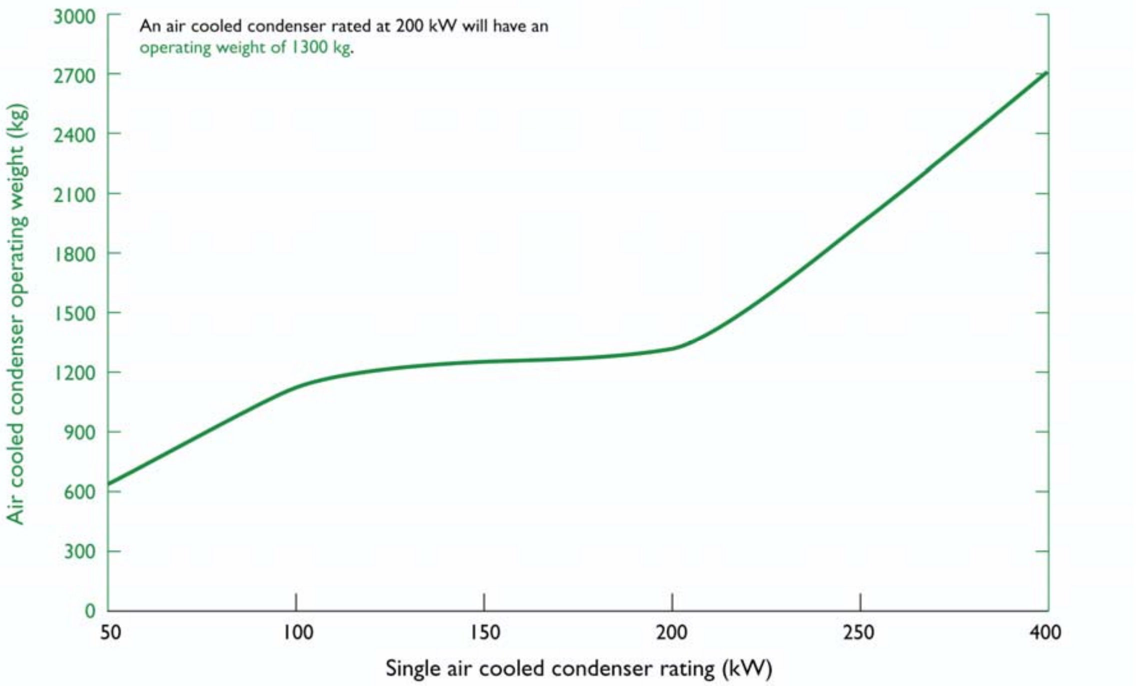


Figure 2: Air cooled condenser – operating weight



Your notes:

Figure 3: Air handling units – area and height requirements

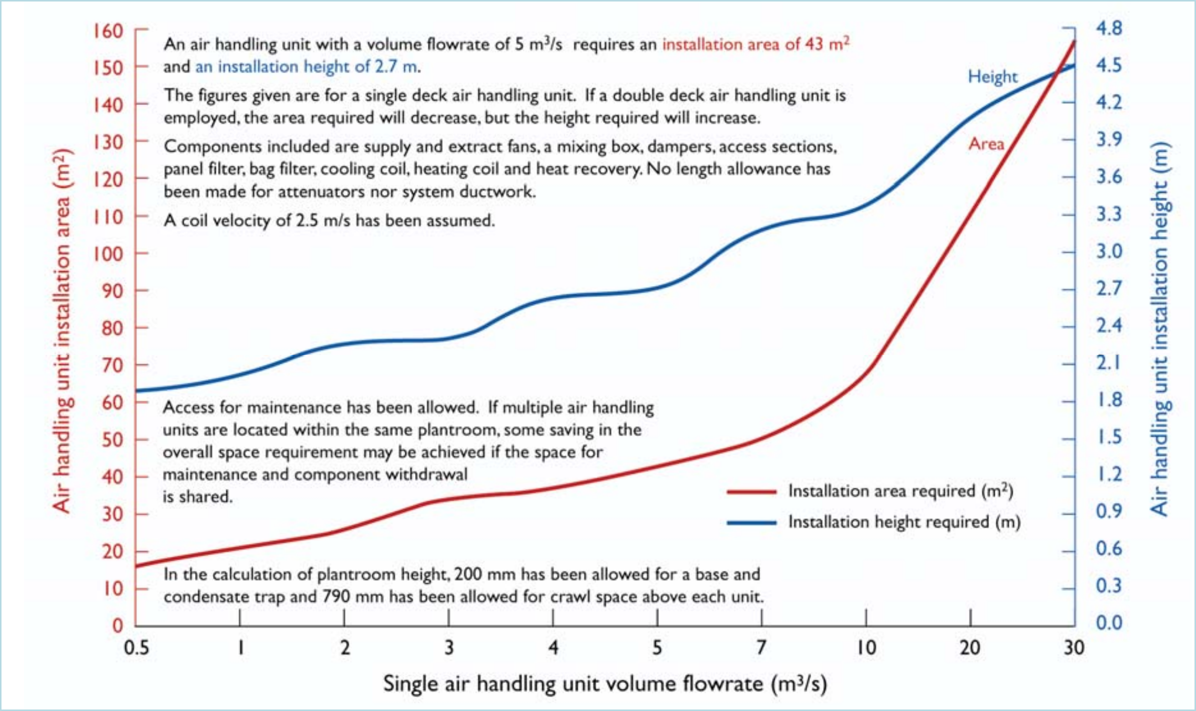
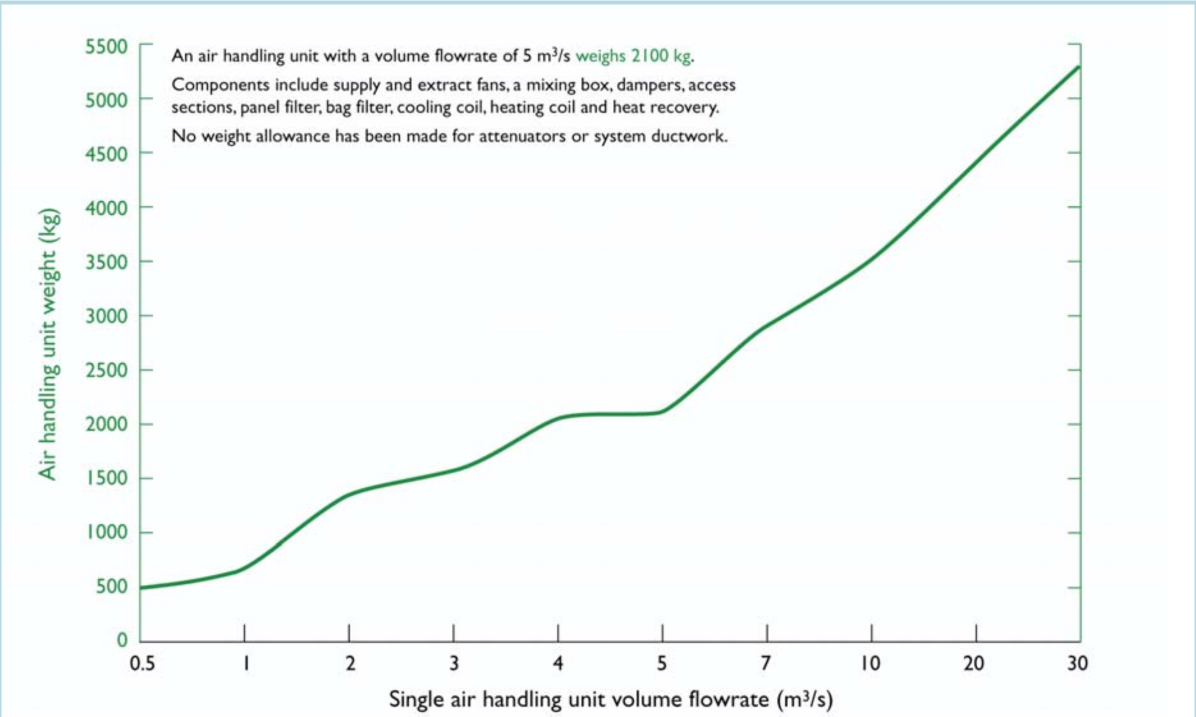


Figure 4: Air handling units – operating weight



Your notes:

Figure 5: Biomass boiler plantroom – area and height requirements

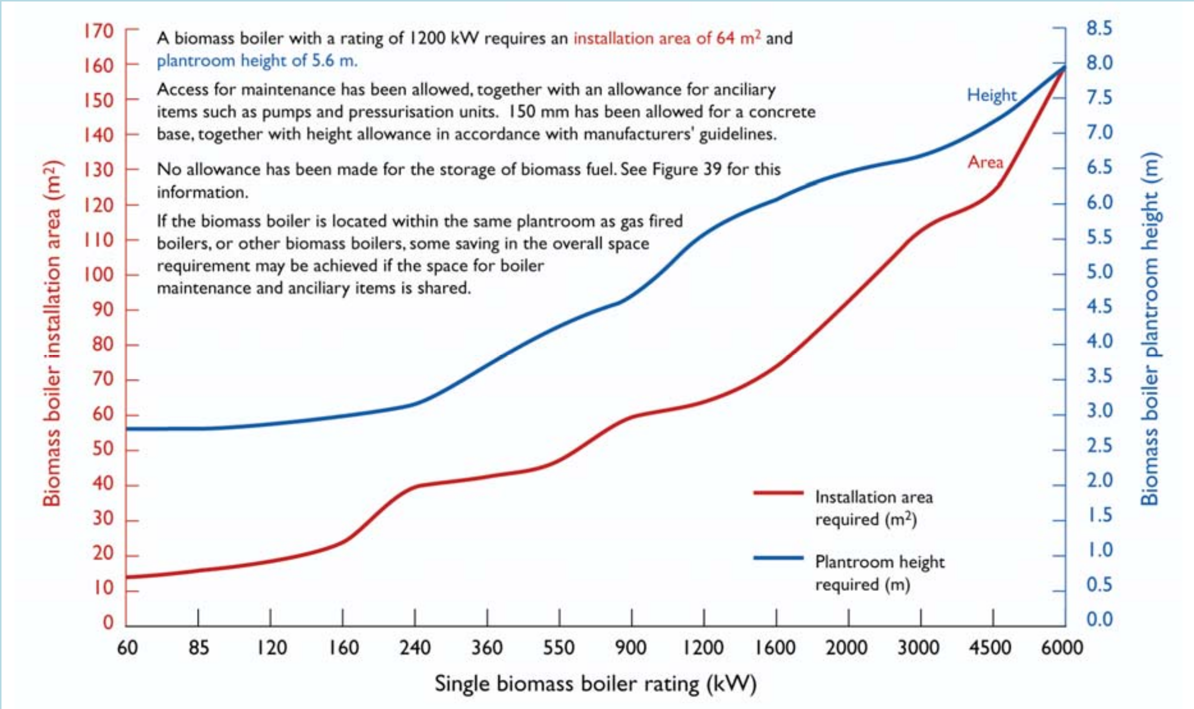
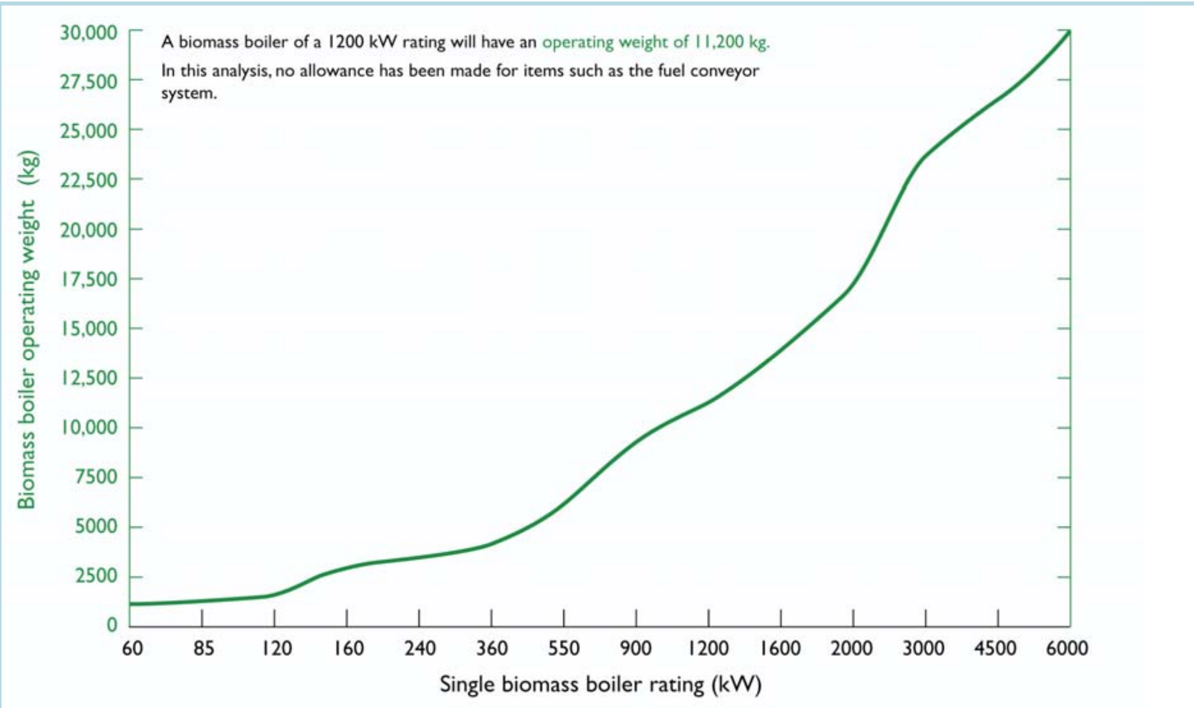


Figure 6: Biomass boiler – operating weight



Your notes:

Figure 7: Gas fired boiler plantroom – area and height requirements

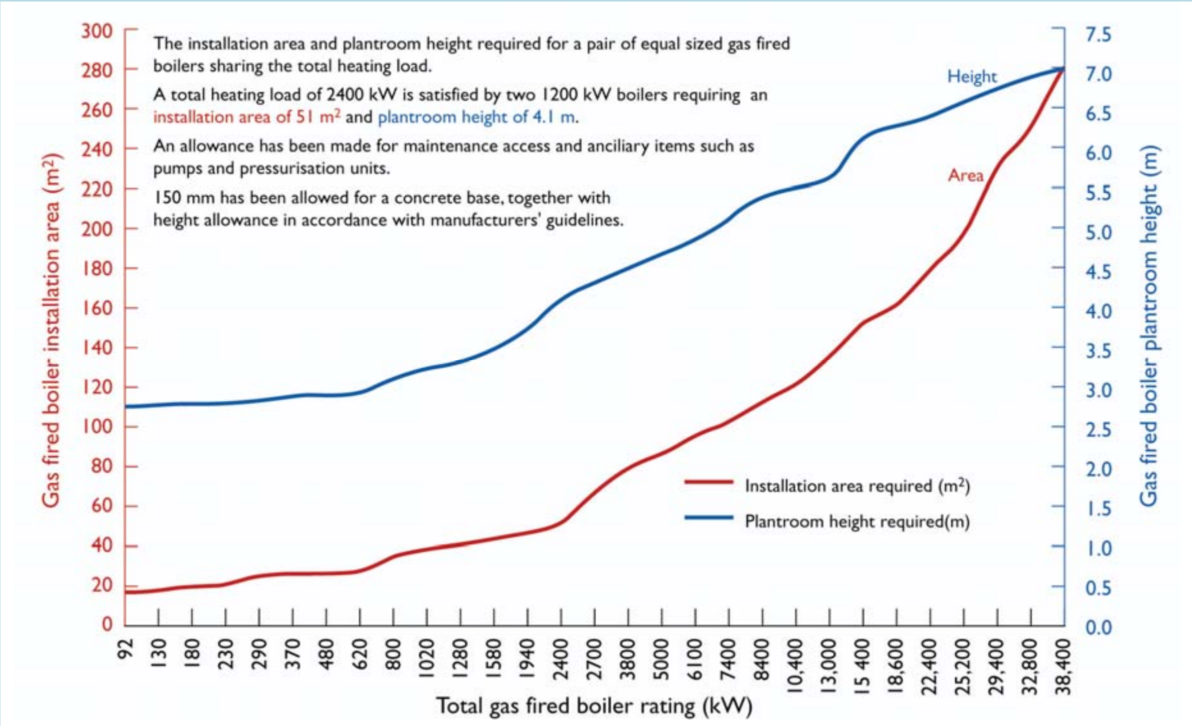
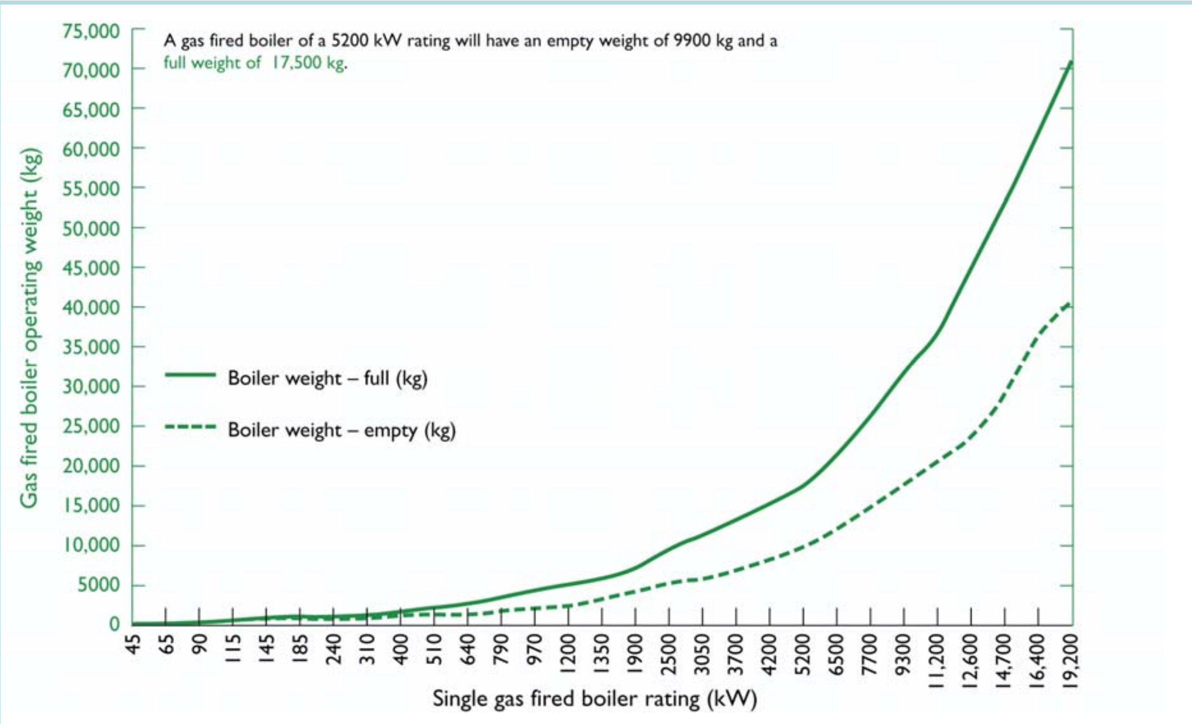


Figure 8: Gas fired boiler – empty and operating weight



Your notes:

Figure 9: Horizontal calorifiers – area and height requirements

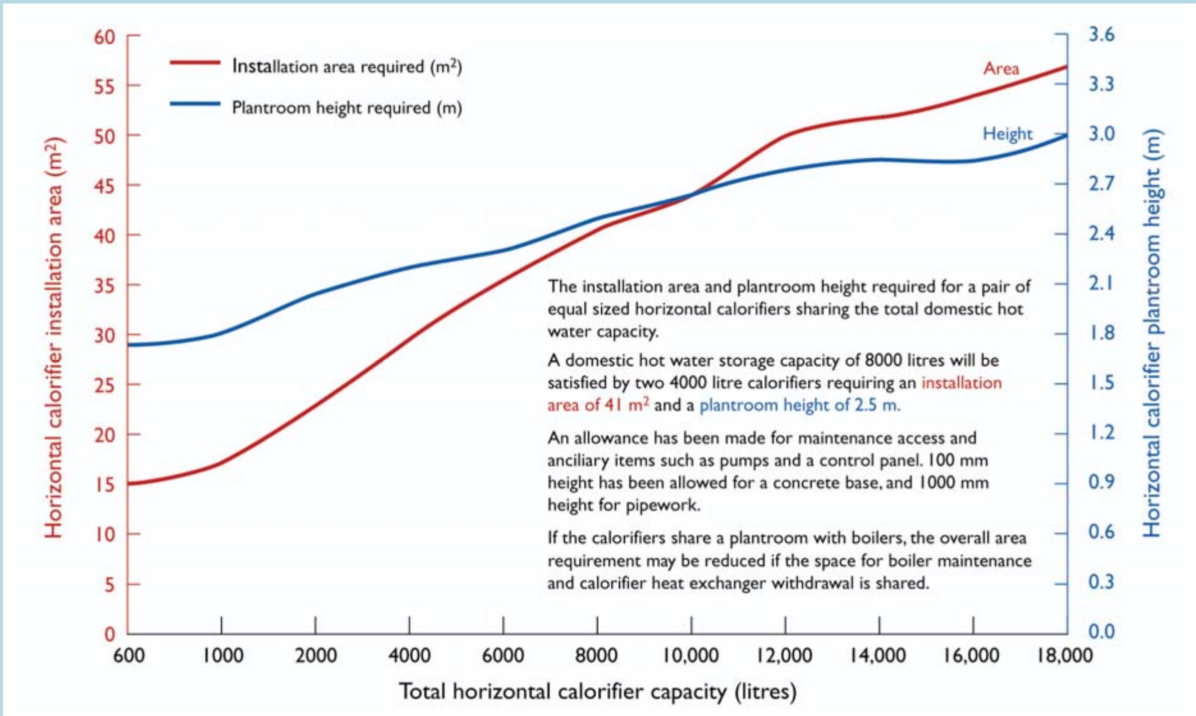
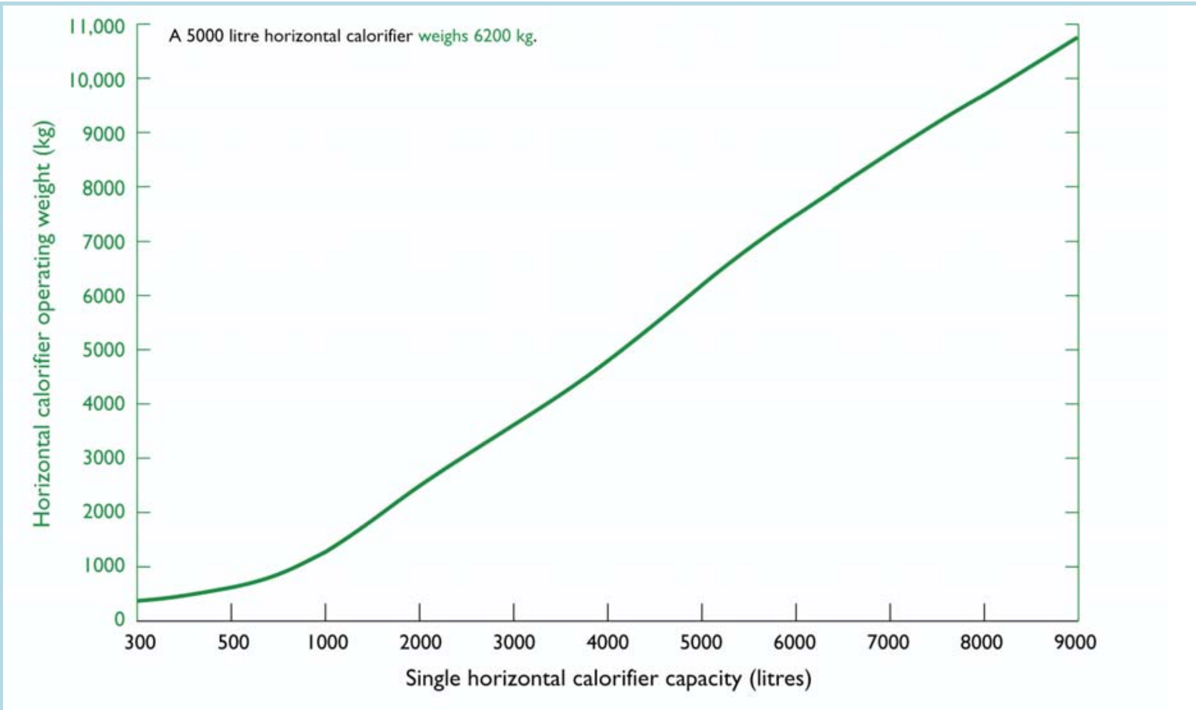


Figure 10: Horizontal calorifiers – operating weight



Your notes:

Figure 11: Vertical calorifiers – area and height requirements

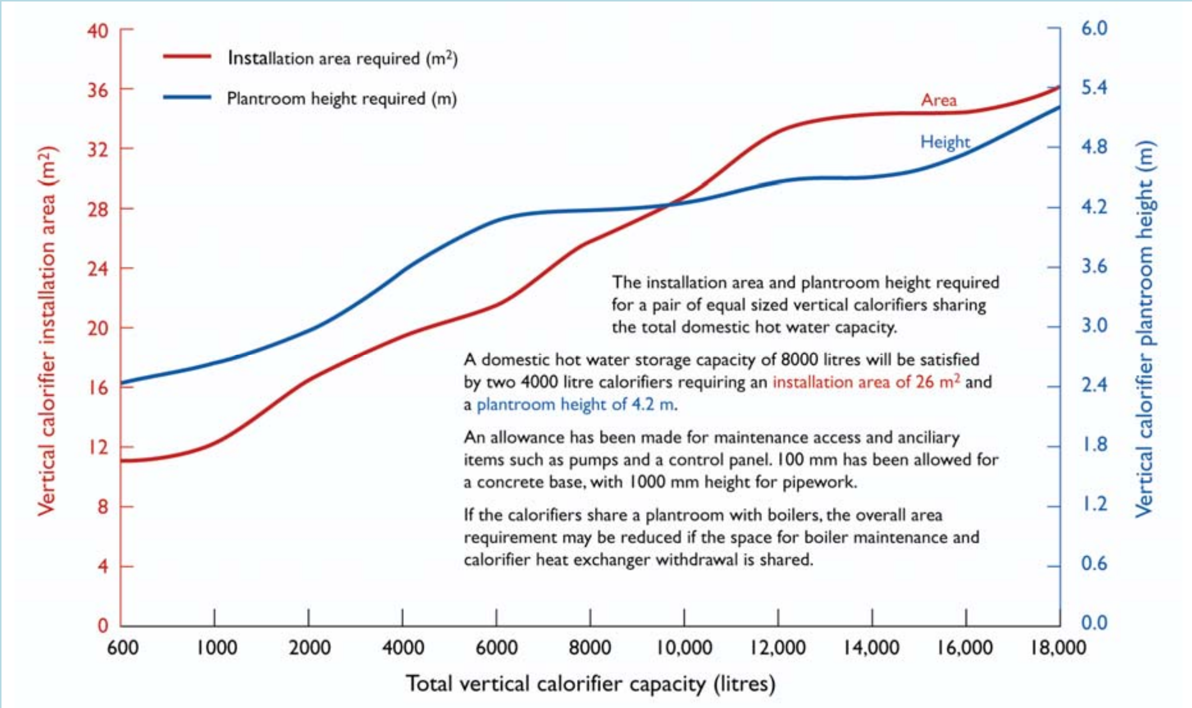
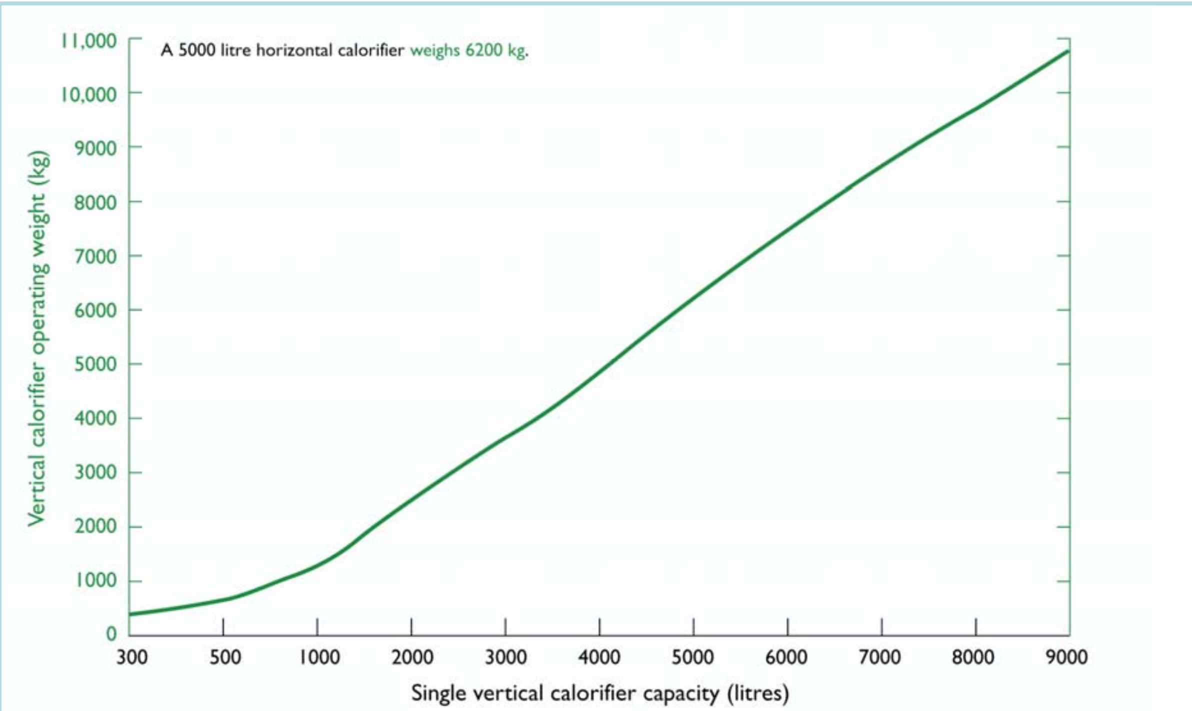


Figure 12: Vertical calorifiers – operating weight



Your notes:

Figure 13: Air cooled chillers – area and height requirements

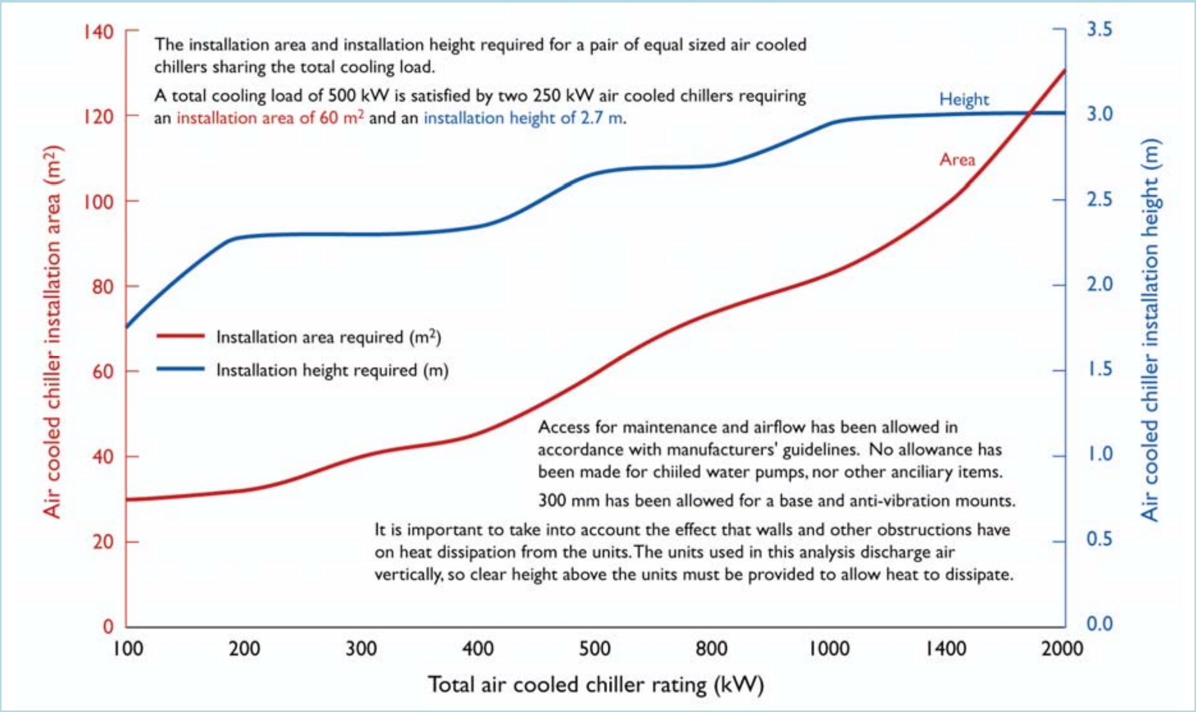
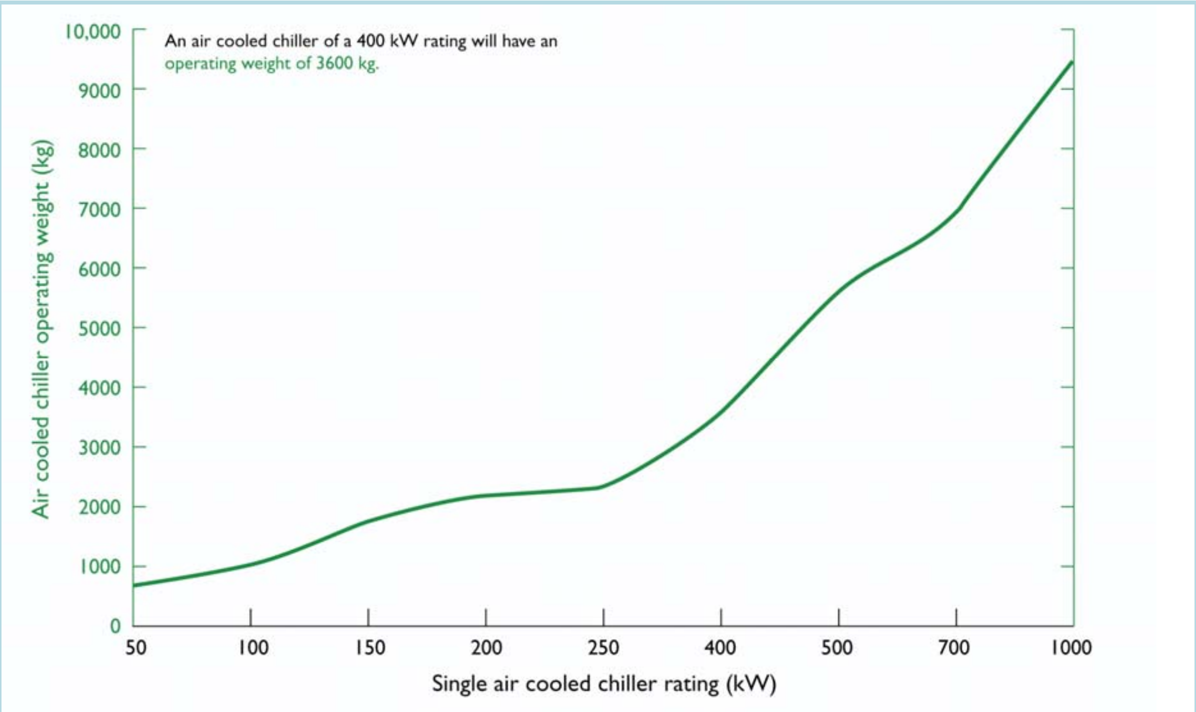


Figure 14: Air cooled chillers – operating weight



Your notes:

Figure 15: Water cooled chillers – area and height requirements

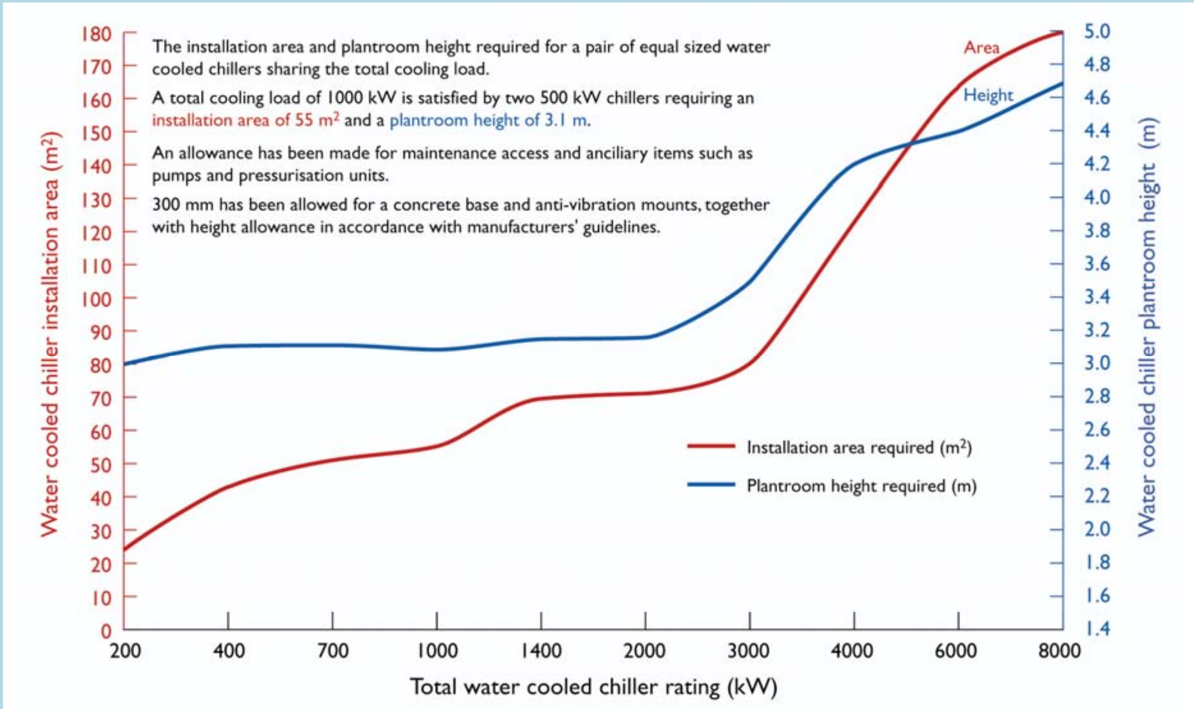
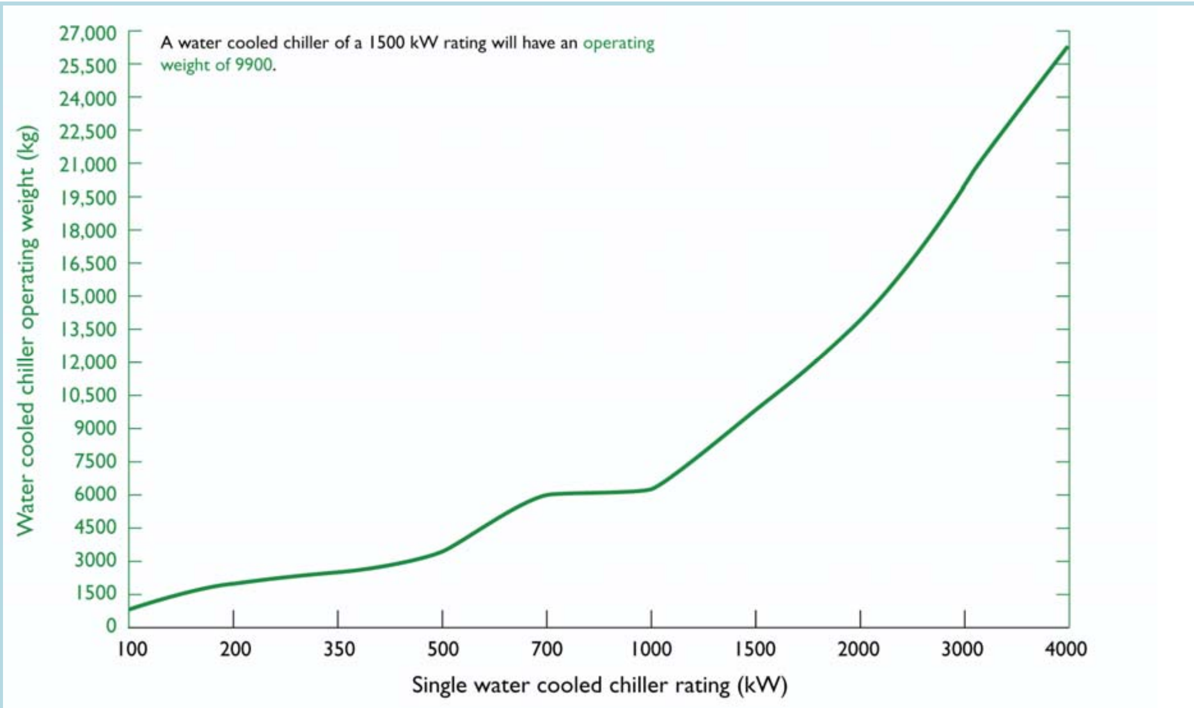


Figure 16: Water cooled chillers – operating weight



Your notes:

Figure 17: Forced draught cooling towers– area and height requirements

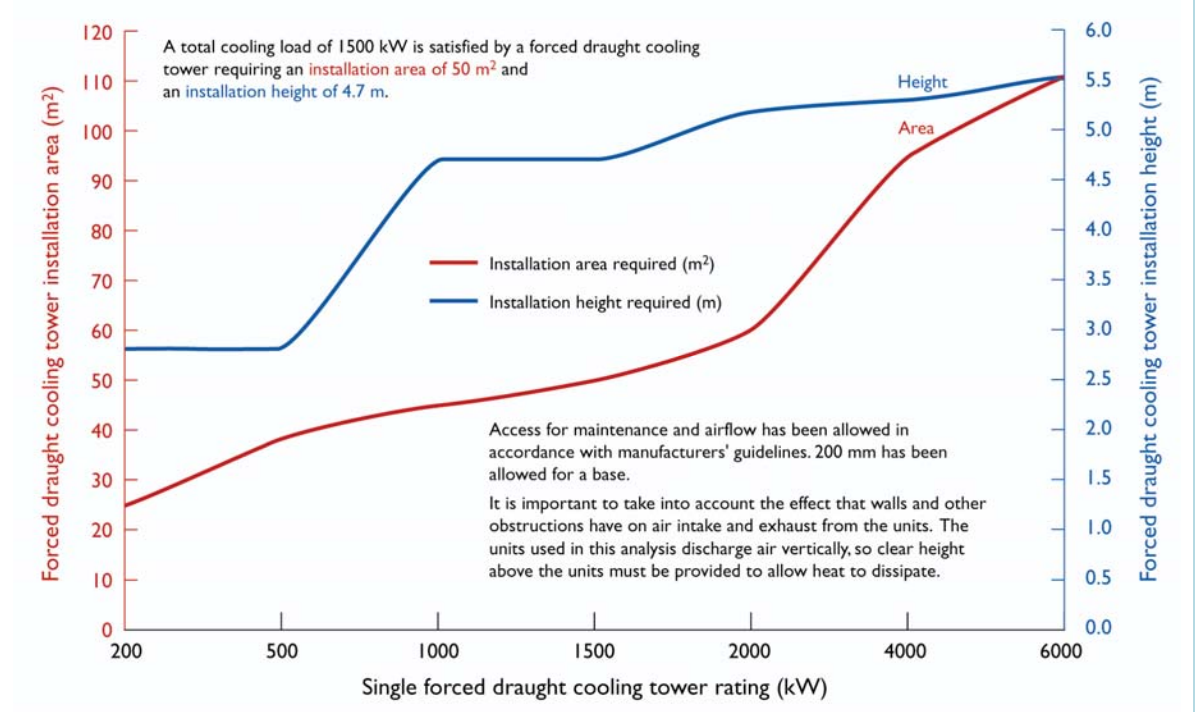
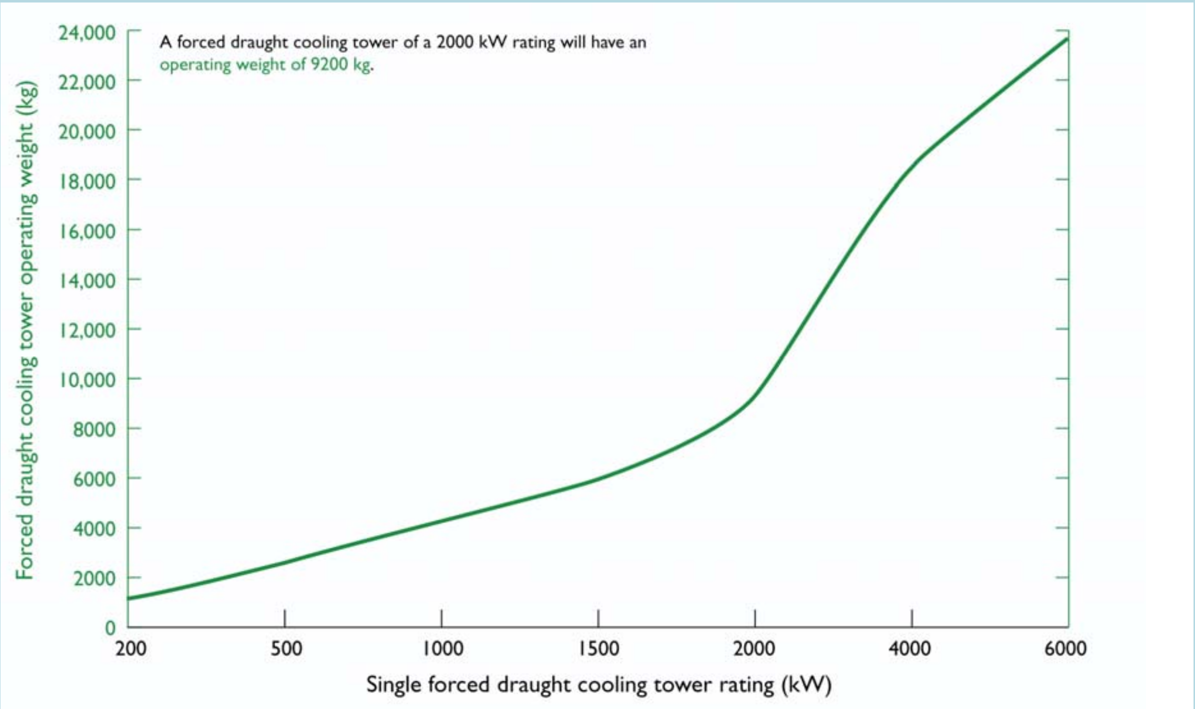


Figure 18: Forced draught cooling towers – operating weight



Your notes:

Figure 19: Induced draught cooling towers – area and height requirements

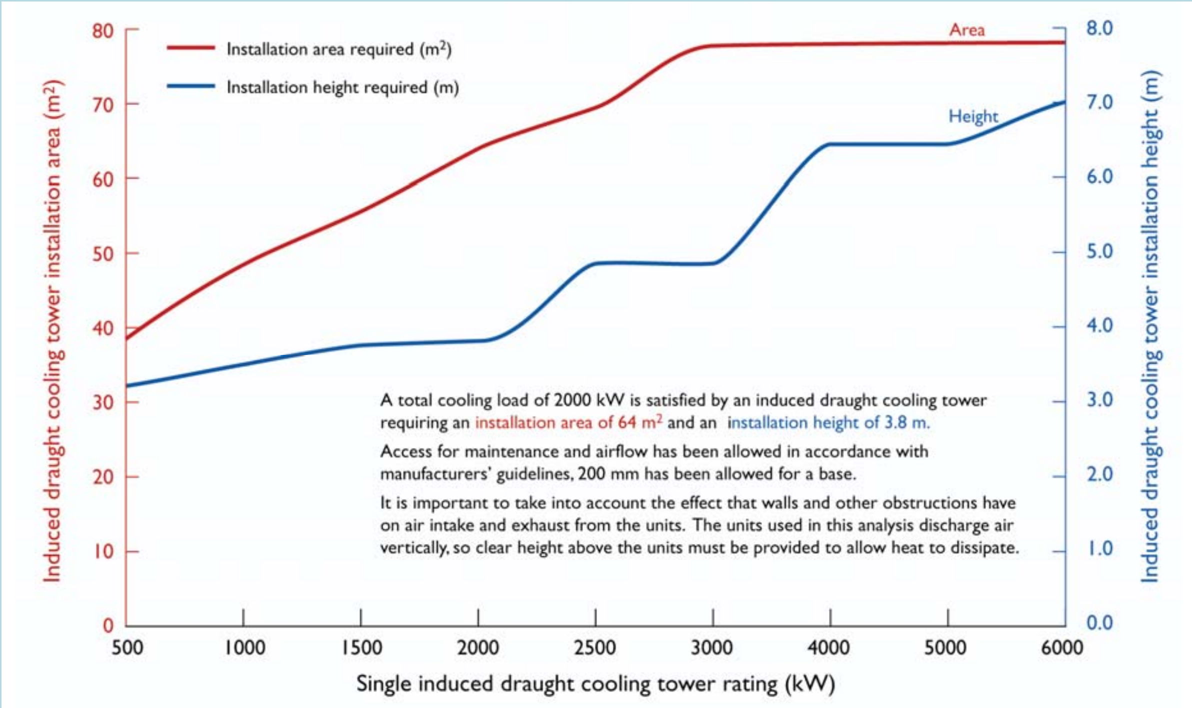
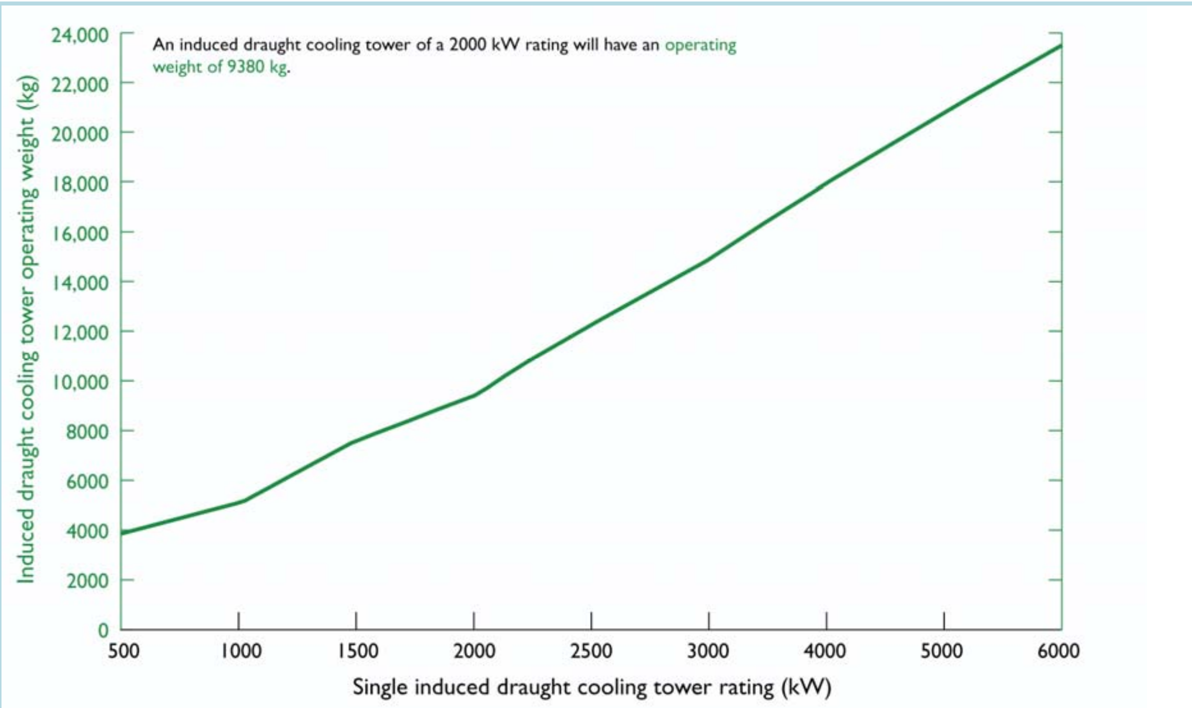


Figure 20: Induced draught cooling towers – operating weight



Your notes:

Figure 21: Cold water storage – area and height requirements

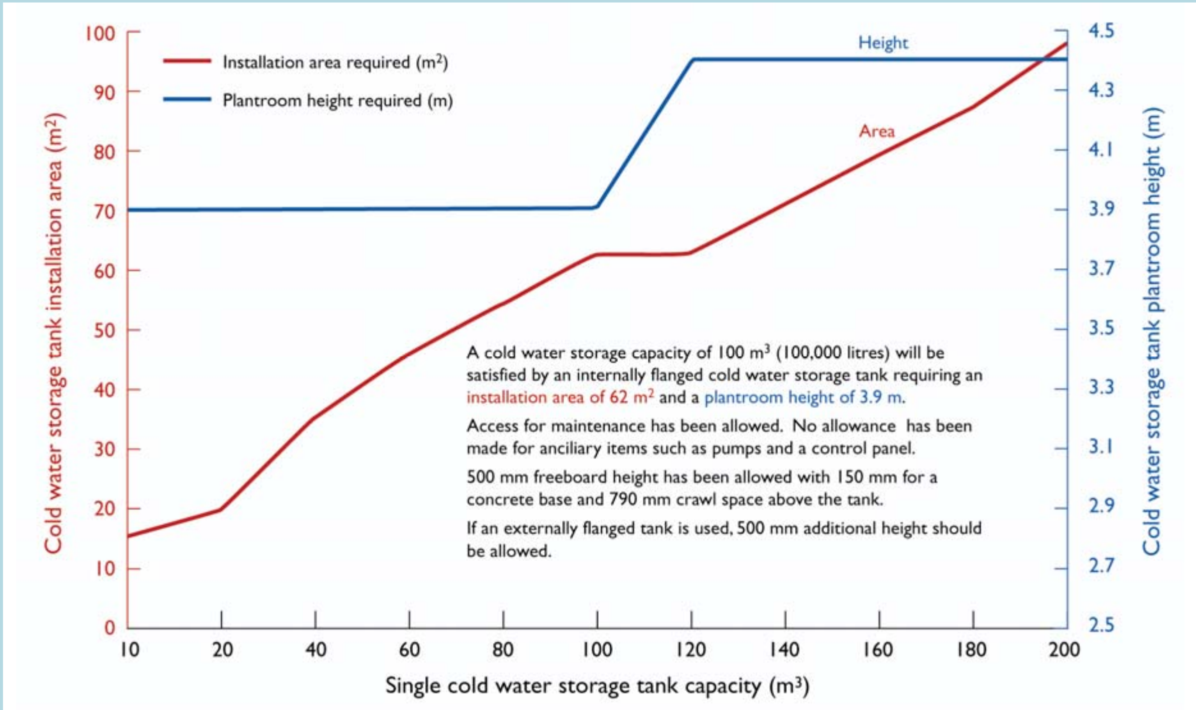
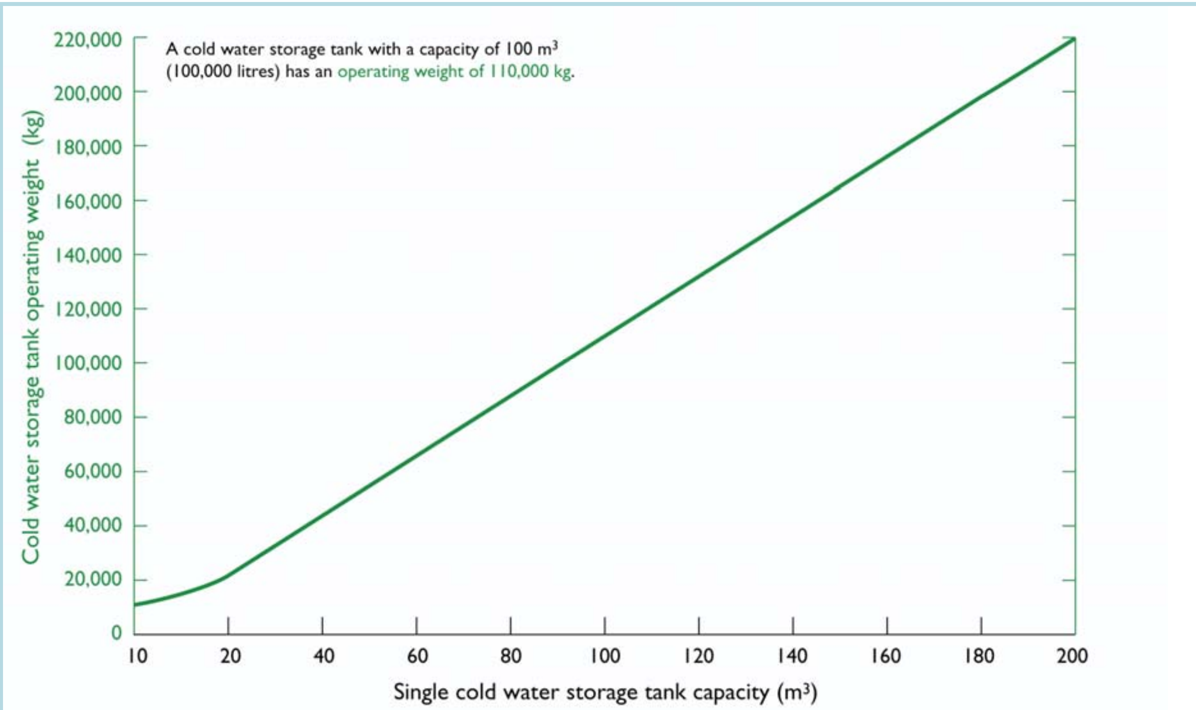


Figure 22: Cold water storage – operating weight



Your notes:

Figure 23: Diesel generators – area and height requirements

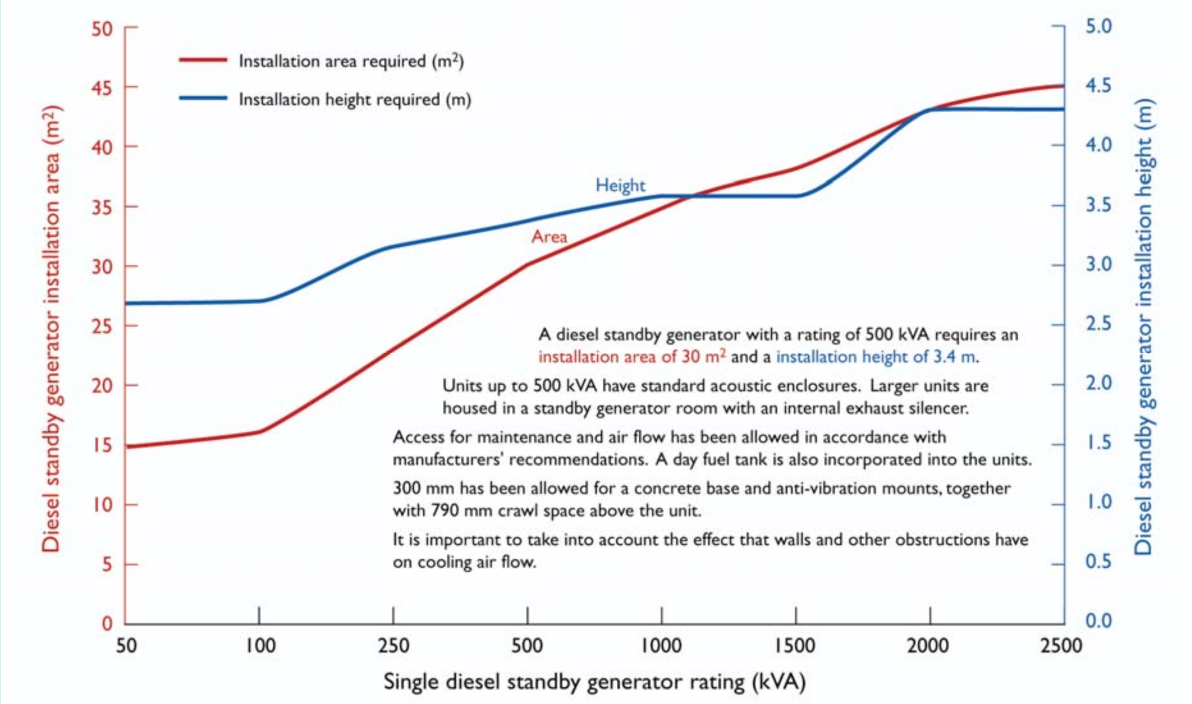
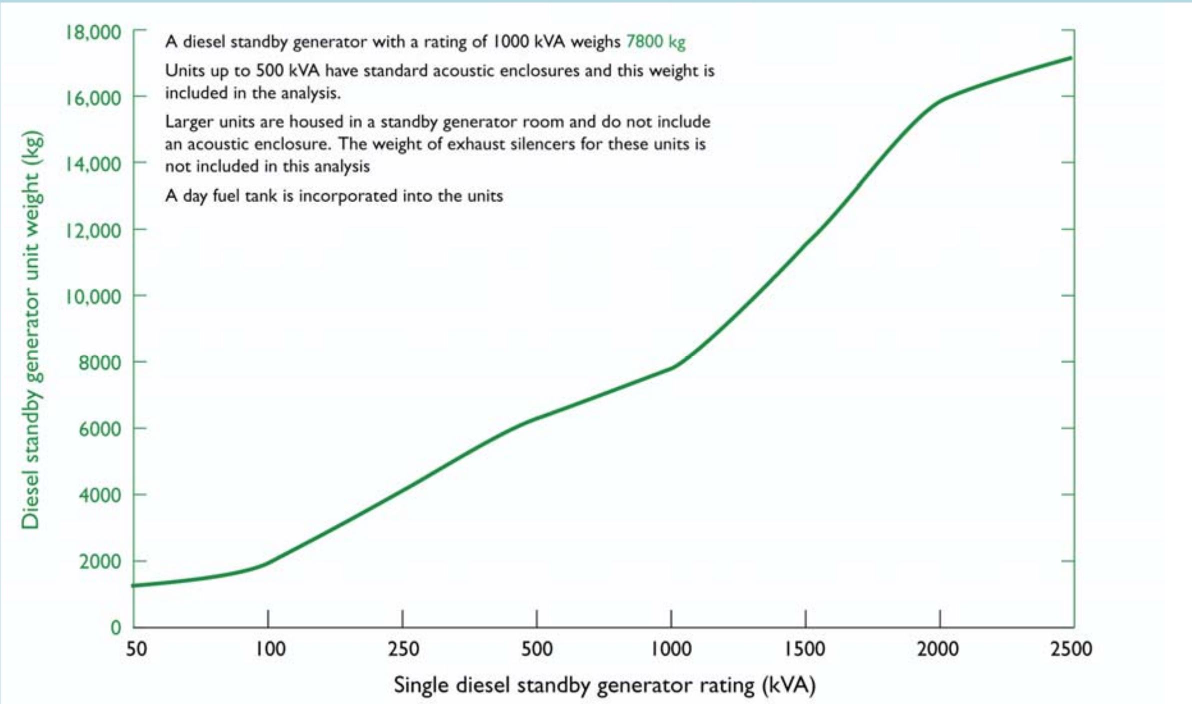


Figure 24: Diesel generators – operating weight



Your notes:

Figure 25: Diesel rotary UPS – area and height requirements

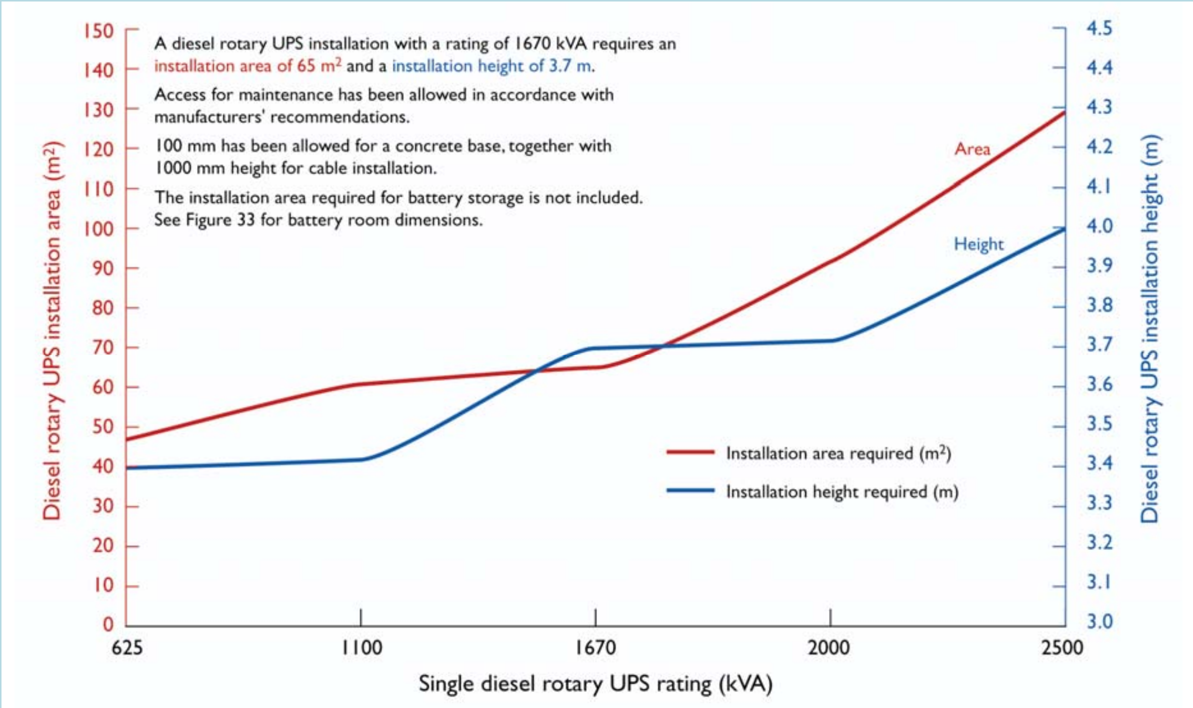
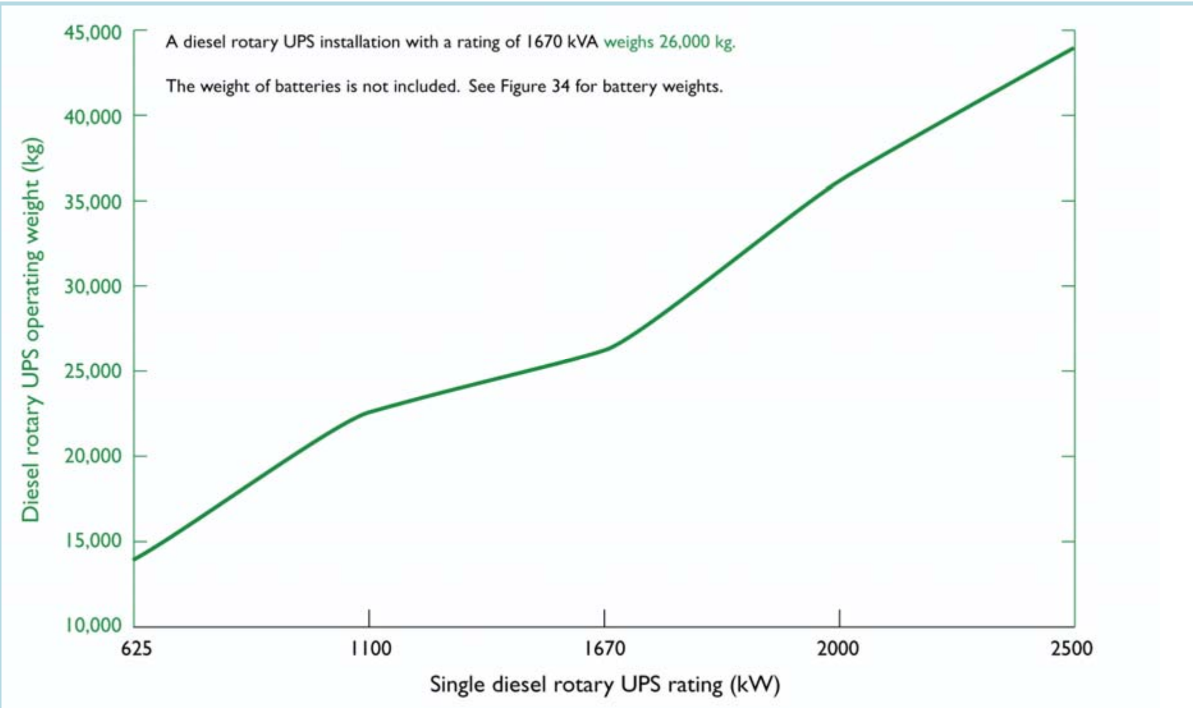


Figure 26: Diesel rotary UPS – operating weight



Your notes:

Figure 27: Hybrid rotary UPS – area and height requirements

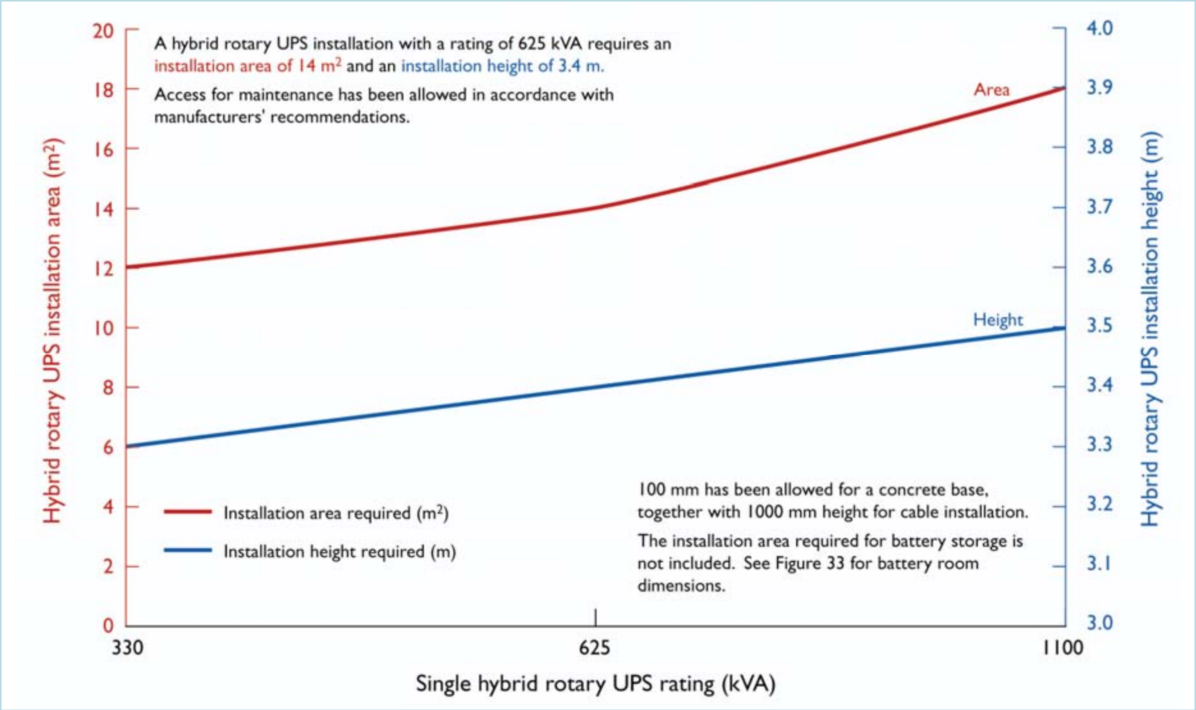
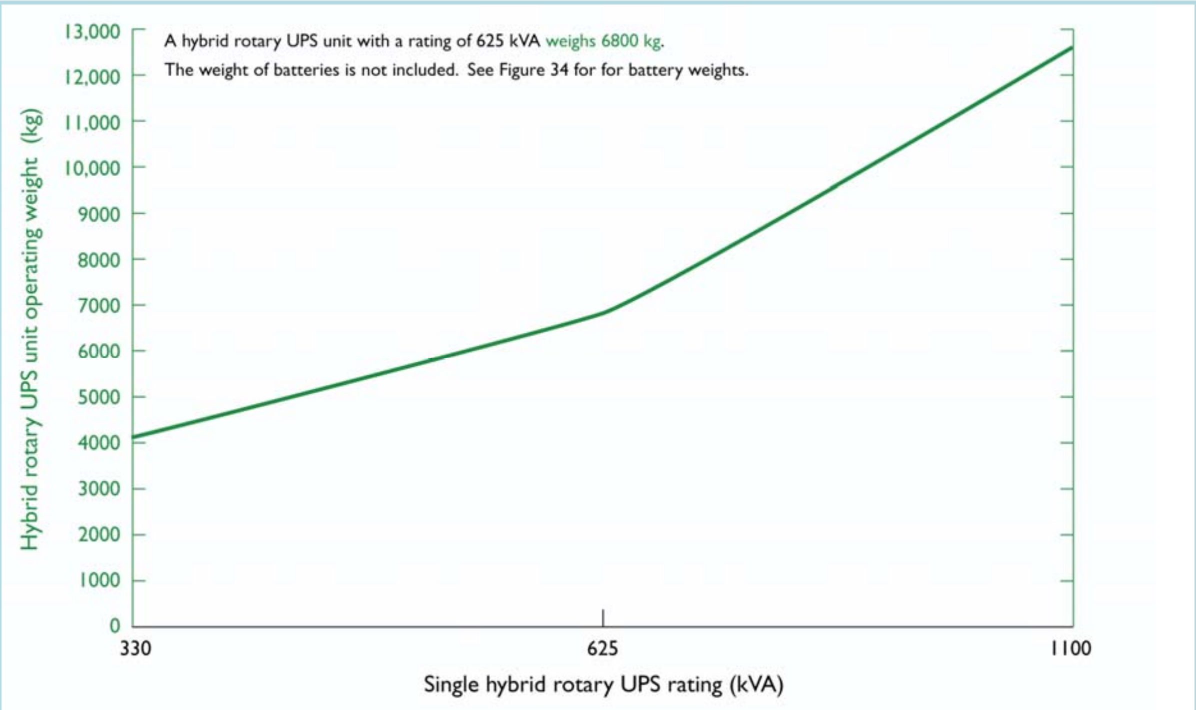


Figure 28: Hybrid rotary UPS – operating weight



Your notes:

Figure 29: Static UPS – area and height requirements

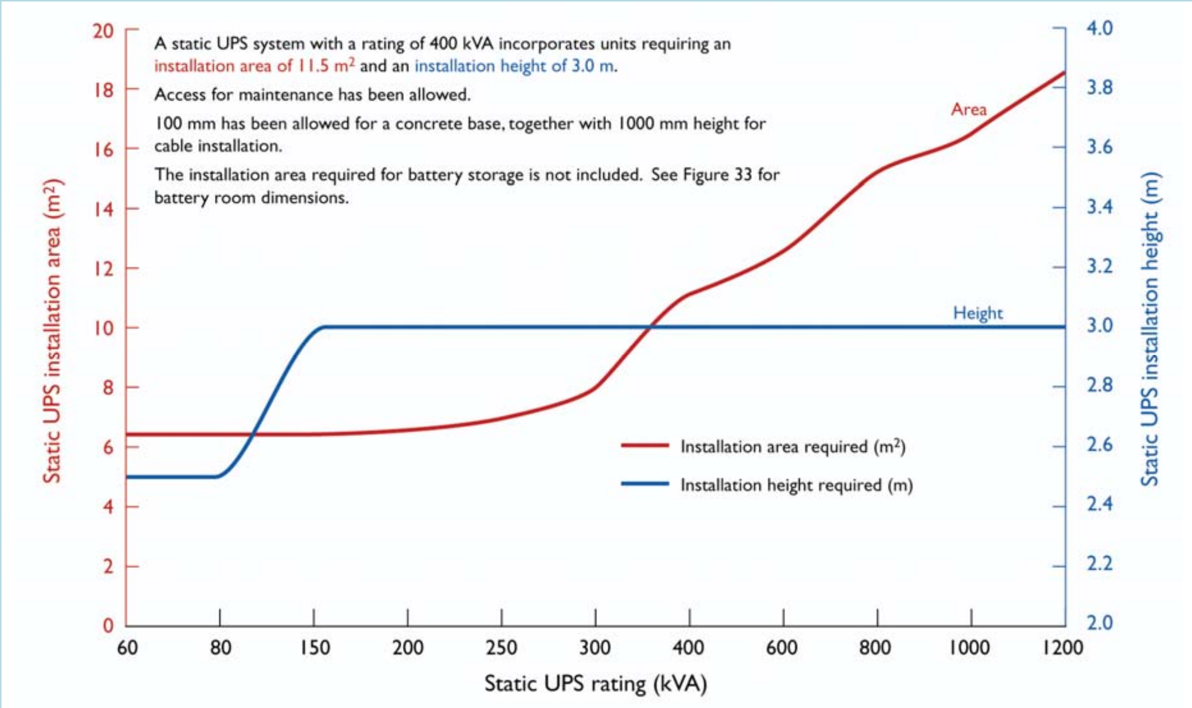
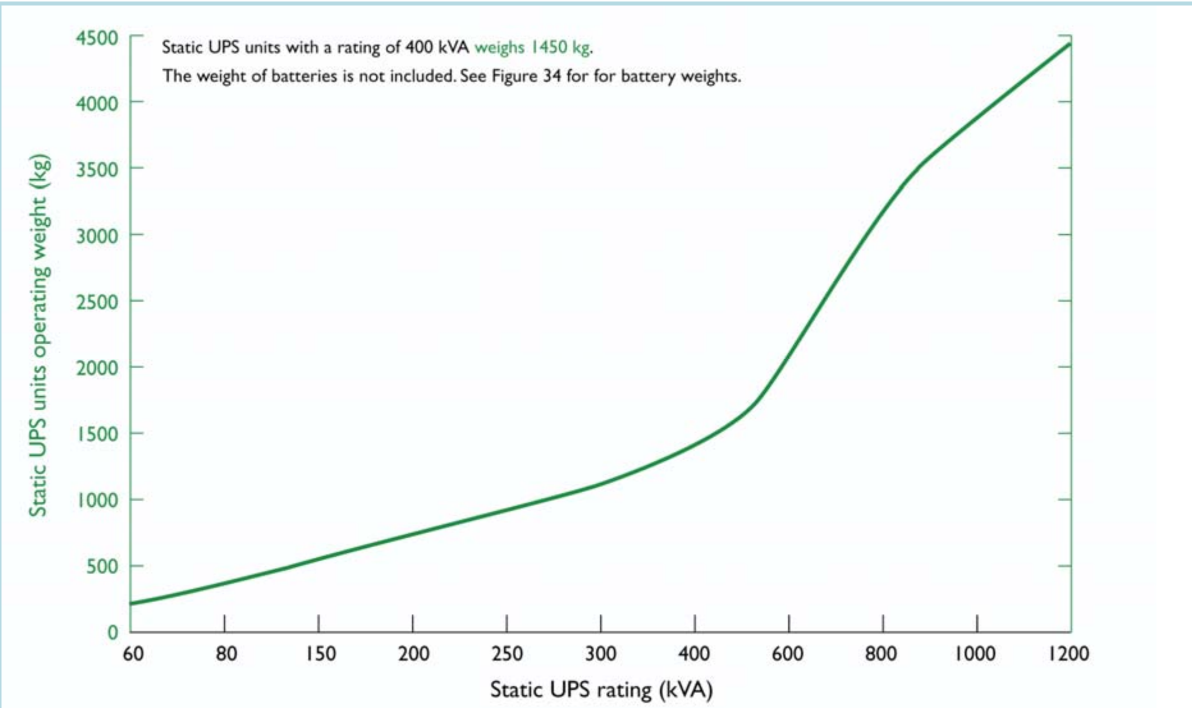


Figure 30: Static UPS – operating weight



Your notes:

Figure 31: Packaged substations – area and height requirements

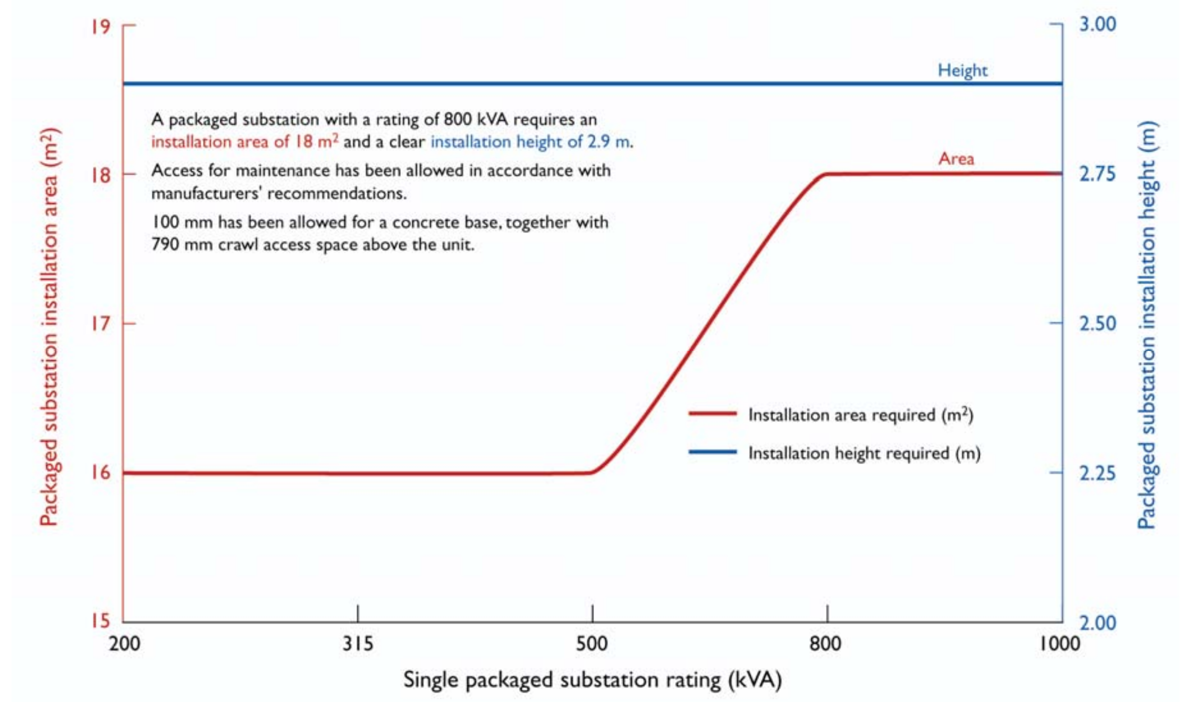
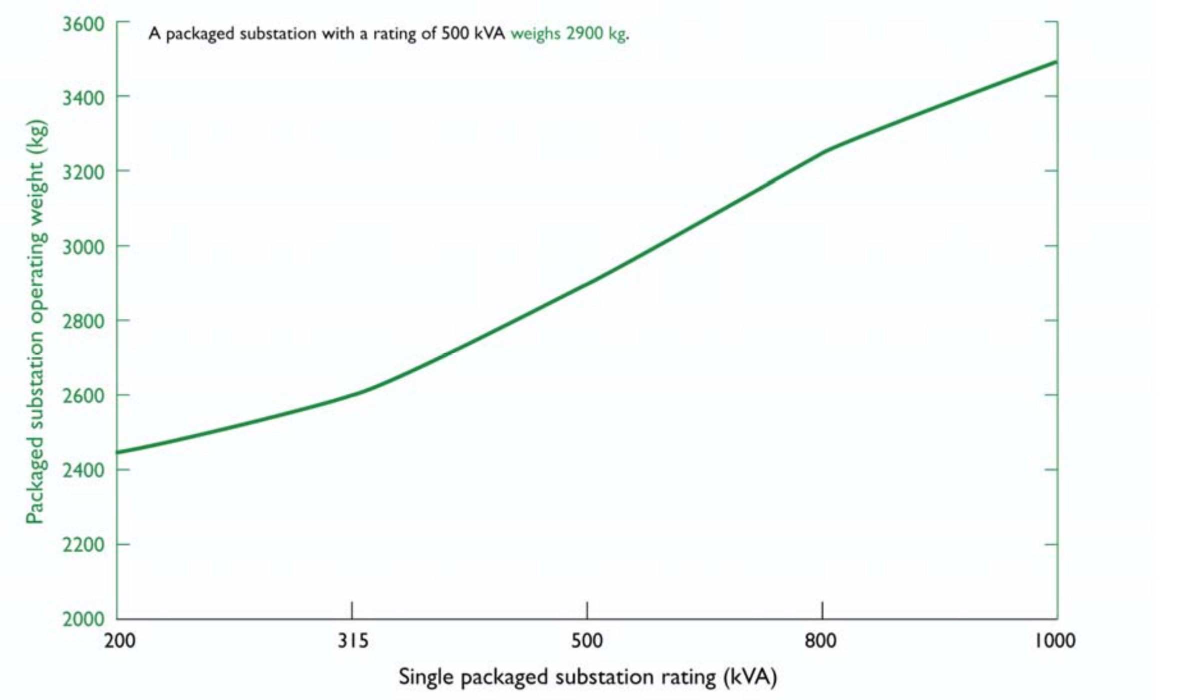


Figure 32: Packaged substations – operating weight



Your notes:

Figure 33: UPS battery rooms – area and height requirements

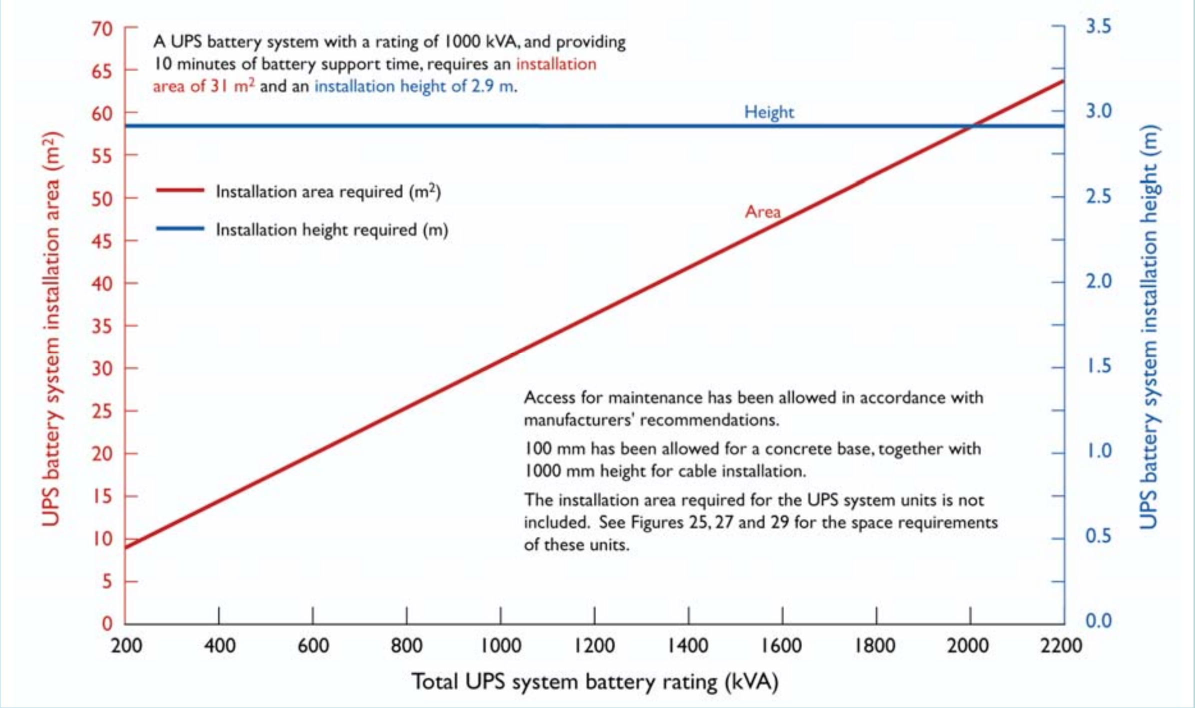
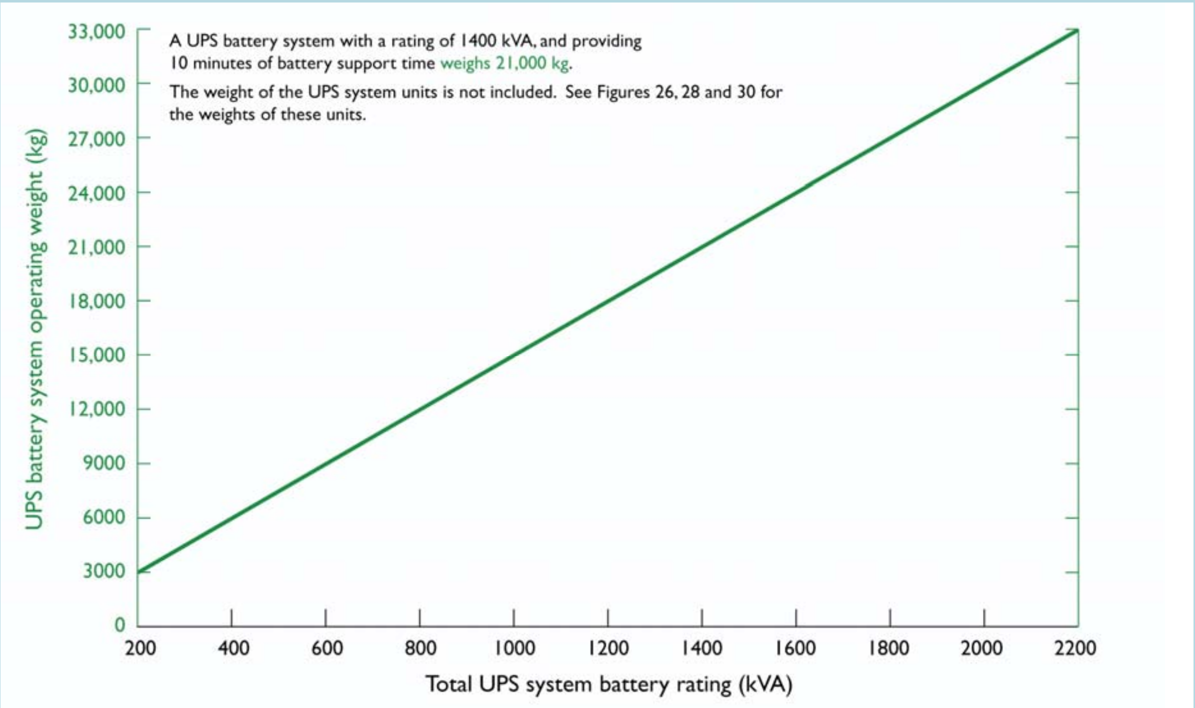


Figure 34: UPS battery systems – operating weight



Your notes:

Figure 35: Switchrooms – area and height requirements

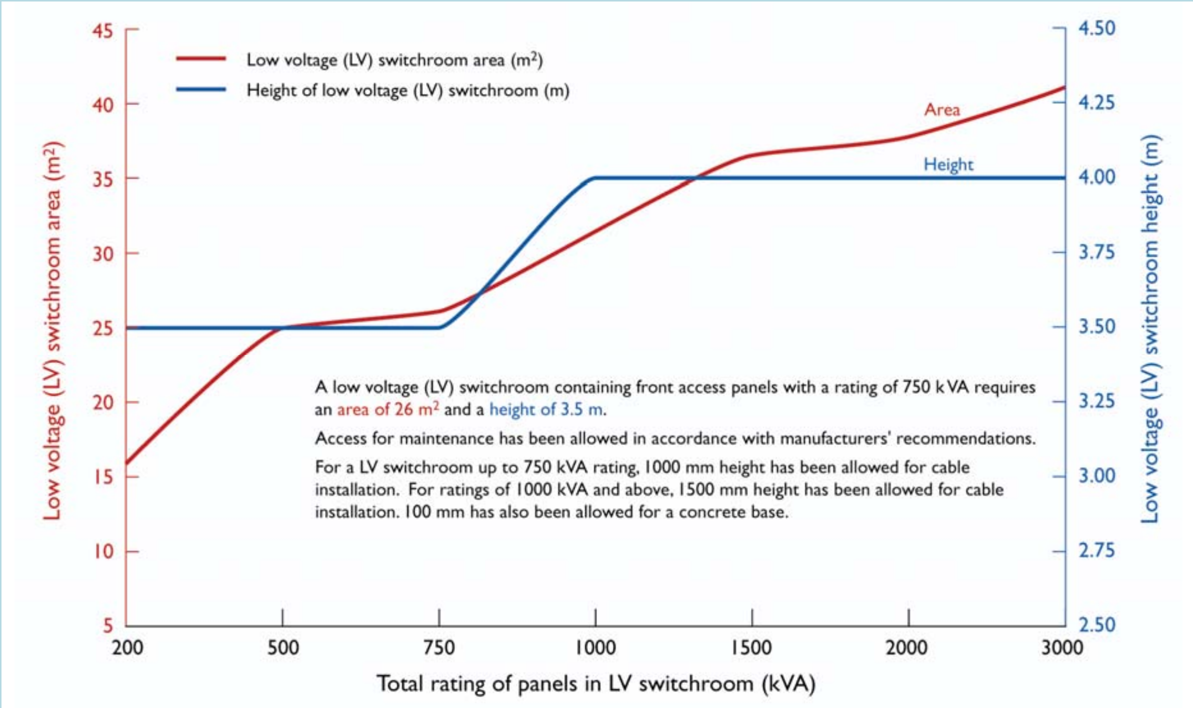
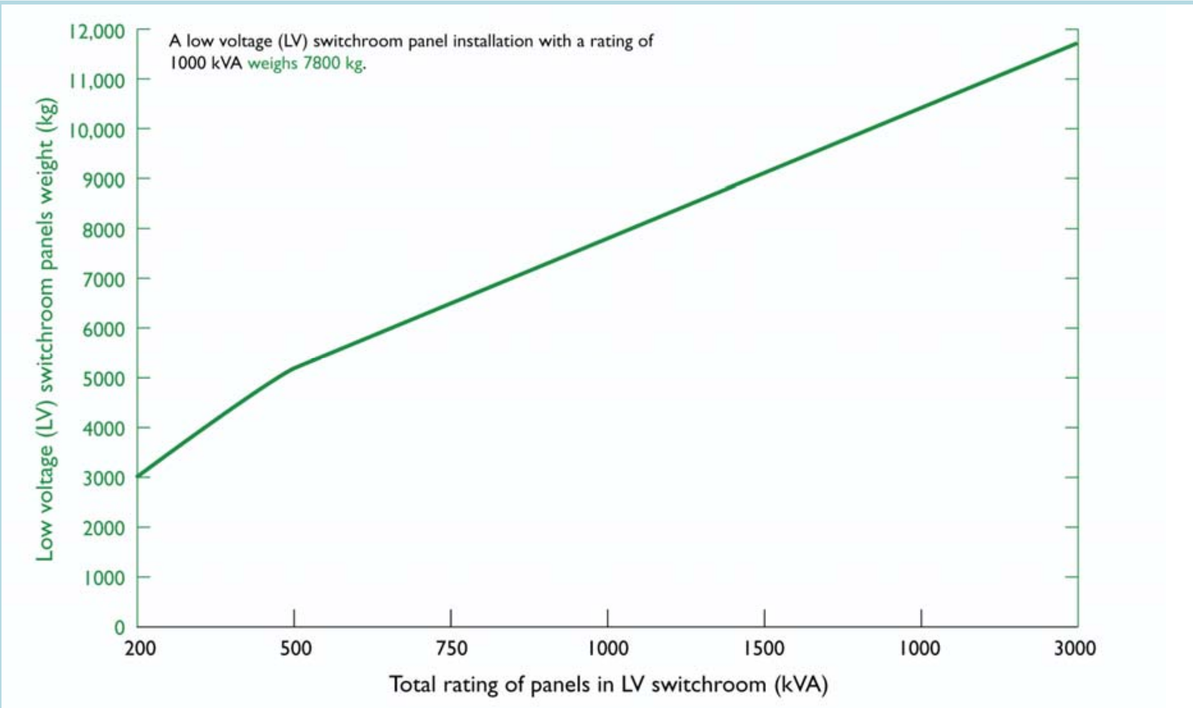


Figure 36: Switchroom panels – operating weight



Your notes:

Figure 37: Transformers – area and height requirements

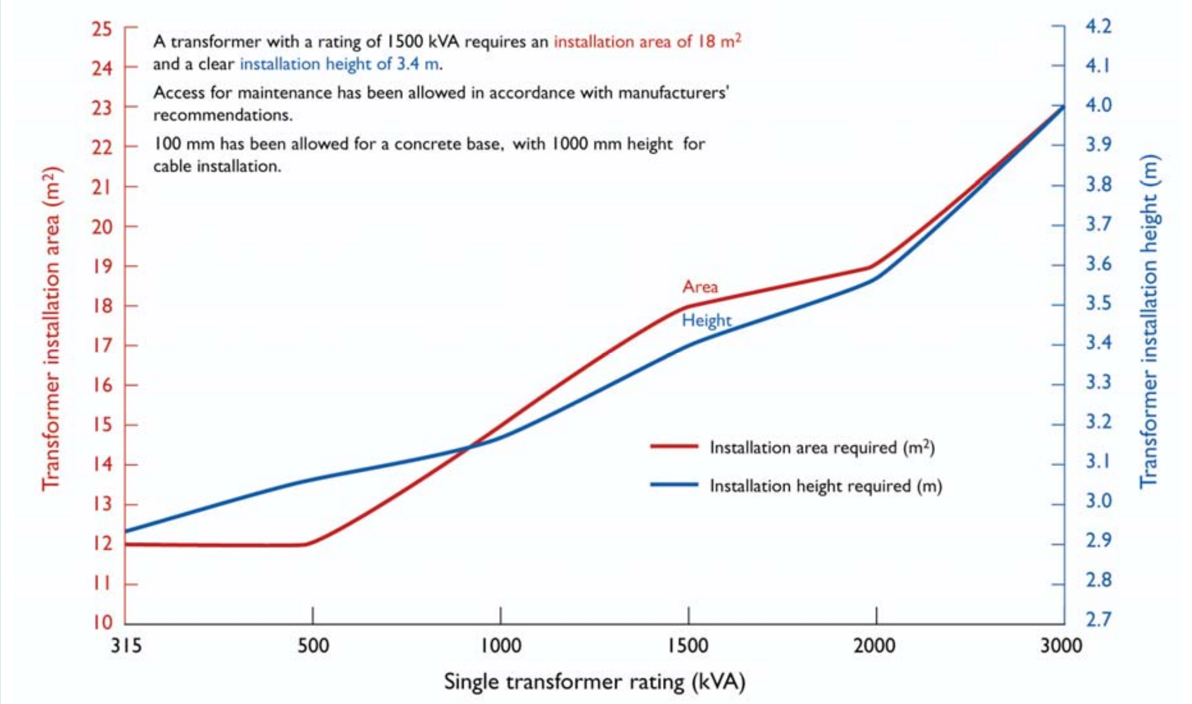
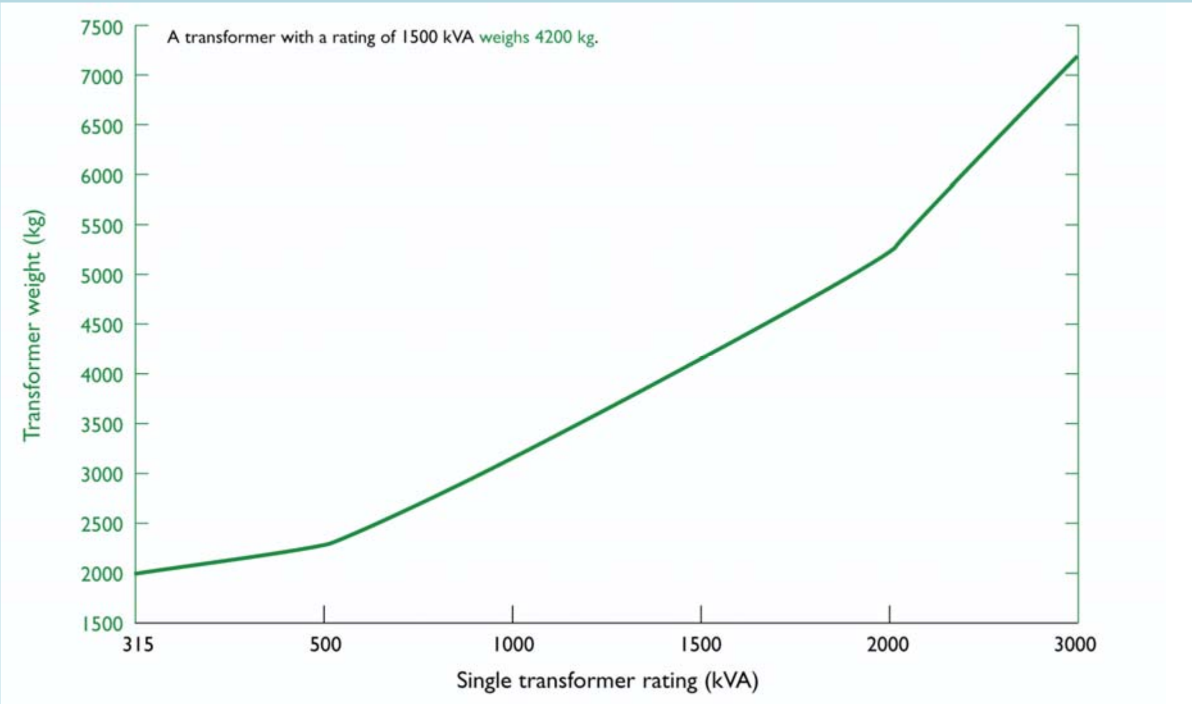
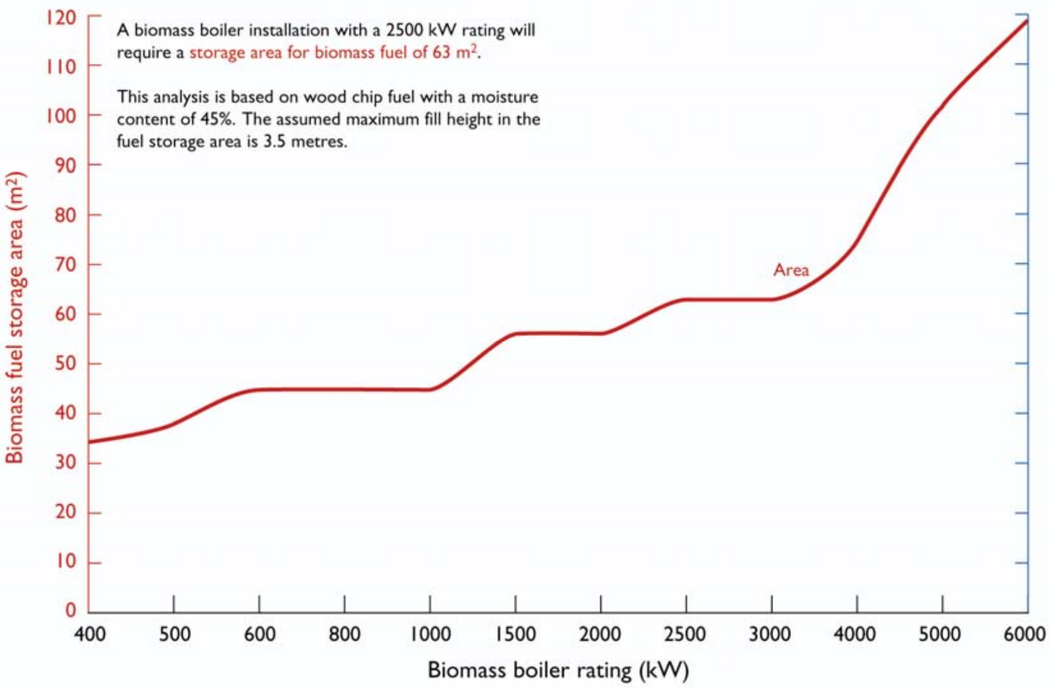


Figure 38: Transformers – operating weight



Your notes:

Figure 39: Biomass fuel storage – area requirements



Comments:

The following table shows how long the above storage capacities of wood chips will last at 100% load, 24 h per day.

Boiler rating (kW)	400	500	600	800	1000	1500	2000	2500	3000	4000	5000	6000
Fuel storage duration (days)	6.9	6.2	6.1	4.5	3.6	3.0	2.3	2.0	1.7	1.6	1.6	1.6

Your notes:

SPACE

Table 1: Space requirements for lift installations

Description	Rule of thumb			Comments	Ref
Lift rated load (persons/kg)	**Minimum lift well internal dimensions (mm)**	**Minimum headroom height (mm)**	**Minimum pit depth (mm)**	For guidance about building occupation densities, please refer to Table 3	1, 2
Lifts in residential buildings				Headroom height and pit depth are given for a rated speed of 1.6 m/s	
6/450	1600 x 1700	3800	1600		
8/630	1600 x 1900	3800	1600		
13/1000	1600 x 2600	3800	1600		
General purpose lifts				Headroom height and pit depth are given for a rated speed of 1.6 m/s	
10/800	1900 x 2200	4000	1600		
13/1000	2200 x 2200	4200	1600		
17/1275	2500 x 2350	4200	1600		
19/1350	2550 x 2350	4200	1600		
Intensive use lifts				Headroom height and pit depth are given for a rated speed of 2.5 m/s	
19/1350	2650 x 2400	5500	2200		
21/1600	2700 x 2500	5500	2200		
24/1800	3000 x 2500	5500	2200		
26/2000	3000 x 2600	5500	2200		

Comments:

BS ISO 4190 -1:2010, Lift (Elevator) Installation states that general purpose lifts shall be used mainly in low and medium-rise buildings, typically up to 15 floors, where lift speeds up to 2.5 m/s are suitable.

BS ISO 4190 -1:2010, Lift (Elevator) Installation states that lifts for intensive use shall be used mainly in high-rise buildings, typically above 15 floors, where lift speeds of at least 2.5 m/s are needed.

Please consult *BS ISO 4190 -1:2010* for guidance about headroom height and pit depth requirements for lifts with rated speeds different to those used in the above table.

The above table does not include guidance relating to healthcare lifts. Please consult *BS ISO 4190-1:2010* for this information.

Headroom height is the vertical distance between the finished floor of the highest landing served and the ceiling of the lift well.

Pit depth is the vertical distance between the finished floor of the lowest landing served and the bottom of the pit well.

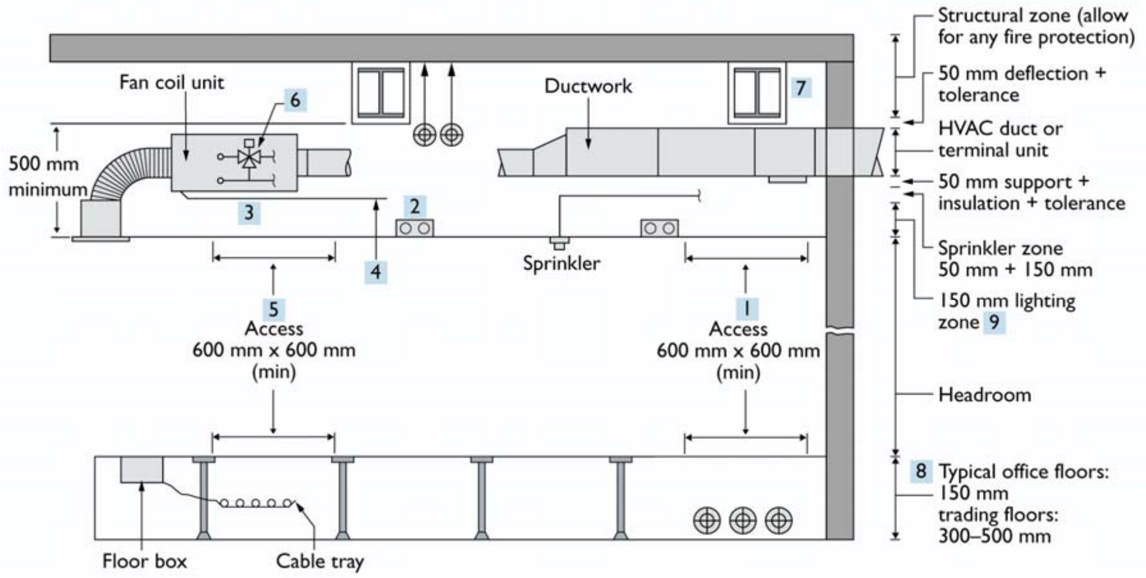
Your notes:

Table 2: Floor space allowances for building services in different types of building – as a percentage of gross internal area (GIA)

Description	Rule of thumb	Comments	Ref
		Please refer to the glossary for a definition of gross internal area (GIA) and net internal area (NIA)	
Hospitals			3
	9 –14%	This area includes internal space for mechanical and electrical plant and equipment, lifts and risers The upper figure is for a hospital of 5000 m^2 GIA and the lower figure is for a hospital of 50,000 m^2 GIA	
Offices			4
Air conditioned, city centre	8 %	This area includes internal space for mechanical and electrical plant and equipment, lifts and risers In the reference buildings examined, an area equivalent to 4% of GIA was also consumed by roof-mounted plant. The reference buildings had a gross internal area greater than 50,000 m^2 GIA	
Heating and mechanical ventilation	6 – 7.5%	The upper figure is for an office of 2000 m^2 GIA and the lower figure is for an office of 5000 m^2 GIA	
Heating and natural ventilation	2.5 – 3%	The upper figure is for an office of 2000 m^2 GIA and the lower figure is for an office of 5000 m^2 GIA	
Schools			5
	2.5%	The assumed ratio of net internal area to gross internal area is 70%	

Your notes:

Figure 40: Ceiling and floor voids in a generic office building



1 Ensure clear access to all fire dampers for inspection and testing

2 Clearance of 1.5 times the luminaire height to facilitate removal of the fitting

3 Clear access to the terminal unit for maintenance

4 Additional vertical space for condensate drains and their fall

5 Access to raised floor shown for the situation where all floor tiles may not be removable

6 Provision should be made for permanent access to all commissioning and control valves

7 Refer to BSRIA publication *Services Co-ordination with Structural Beams* (IEP2) for guidance about integrating building services with structural steelwork

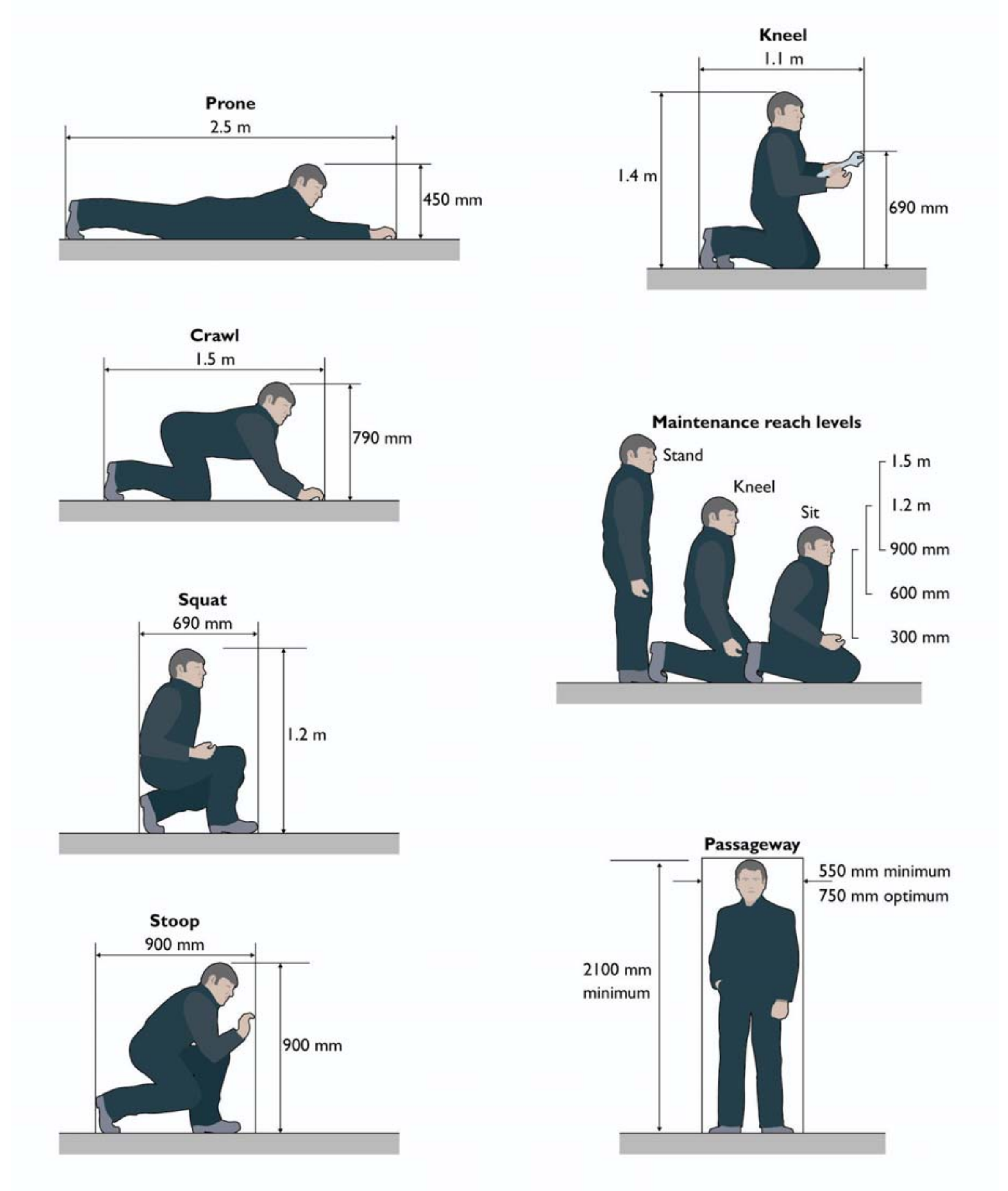
8 Greater depth may be required if air is supplied through the floor. Dimensions include thickness of the floor tile

9 Including thickness of ceiling tile.

Source: Based upon *MoD Design and Maintenance Guide 08*

Your notes:

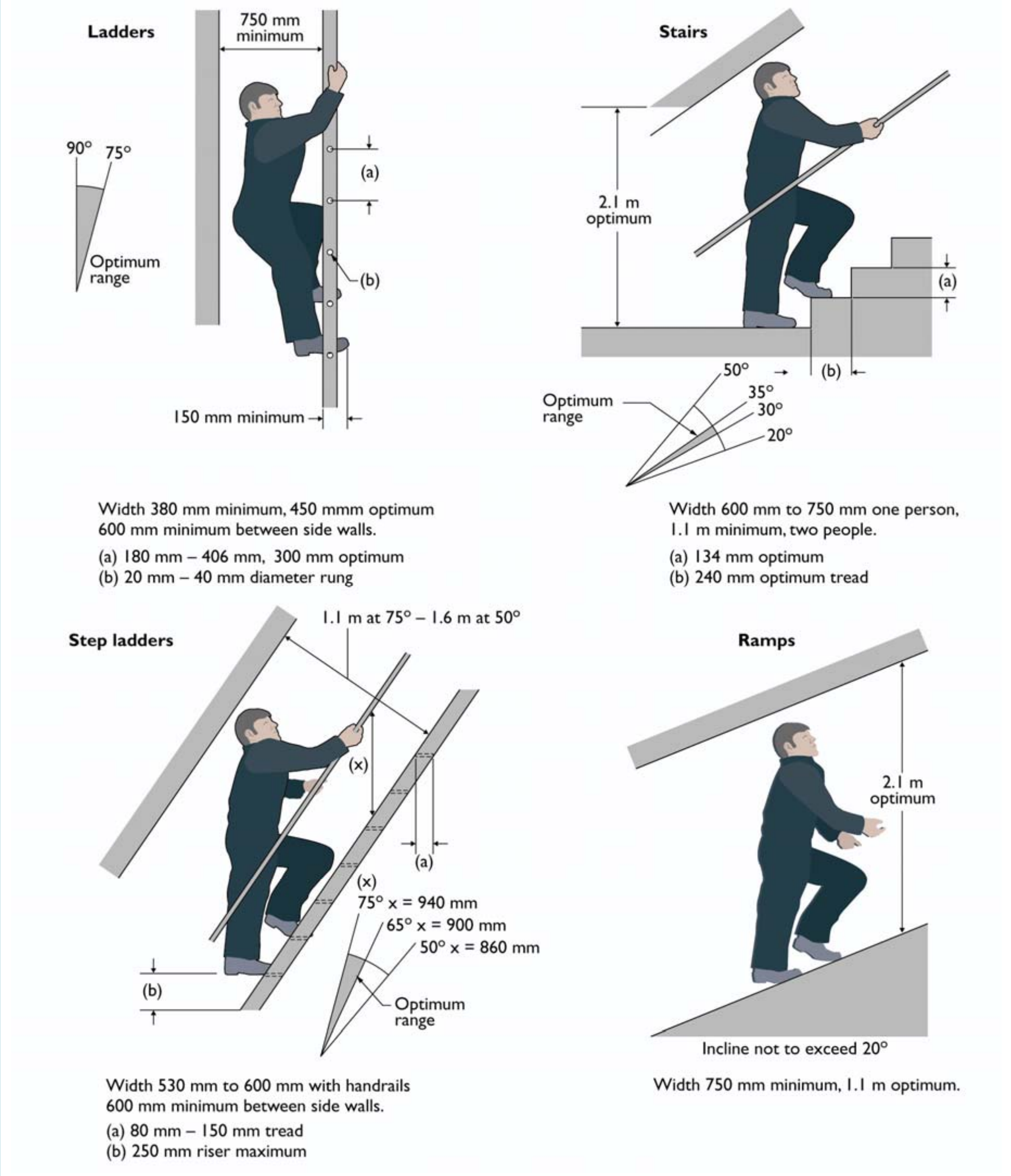
Figure 41: Space requirements and reach distances for installation and maintenance tasks



Source: *BS 8313:1997*

Your notes:

Figure 41: Space requirements and reach distances for installation and maintenance tasks (continued)



Source: *BS 8313:1997*

Your notes:

Table 3: Building occupancy densities

Description	Rule of thumb	Comments	Ref
General offices	10 m^2 per workspace	Use this figure for calculating air conditioning loads, outdoor air requirements and small power loads	6
	6 m^2 per person	Use this figure for calculating means of escape	6, 7
	12 m^2 per person	Use this figure for calculating requirements for core elements, such as lifts and toilets and for calculating cold water storage requirements	6
	8 –13 m^2 per workspace	Use this figure for calculating workplace density	6
Standing spectator areas and bars	0.3 m^2 per person	Use this figure for calculating means of escape	7
Assembly halls, dance floors or concert venues without fixed seating	0.5 m^2 per person	Use this figure for calculating means of escape	7, 8, 9
	0.83 m^2 per person	Use this figure for calculating air conditioning loads and outdoor air requirements	
Concourses or queuing areas	0.7 m^2 per person	Use this figure for calculating means of escape	7, 10
	0.83 m^2 per person	Use this figure for calculating air conditioning loads and outdoor air requirements	
Restaurants	1 m^2 per person	Use this figure for calculating means of escape	7, 10
	3 m^2 per person	Use this figure for calculating air conditioning loads and outdoor air requirements	
Retail establishments	5 m^2 per person	Use this figure for calculating air conditioning loads and outdoor air requirements. Refer to *Approved Document B* for guidance about occupation densities for fire safety engineering	7, 11, 12, 13
Art galleries or museums	5 m^2 per person	Use this figure for calculating air conditioning loads, outdoor air requirements and means of escape	7
Bedrooms	8 m^2 per person	Use this figure for calculating means of escape	7

Your notes:

Table 4: Minimum structural loadings

Description	Rule of thumb	Comments	Ref
Live loads: Offices - above ground floor	2.5 kN/m^2	The specification of a live load of 7.5 kN/m^2 over 5% of the lettable area improves the flexibility of the building to accommodate local storage areas	6, 14
Live loads: Offices - ground floor and below	3.0 kN/m^2	The specification of a live load of 7.5 kN/m^2 over 5% of the lettable area improves the flexibility of the building to accommodate local storage areas	6, 14
Live loads: Shopping areas	4.5 kN/m^2		14
Dead loads: High load areas, such as plantrooms	7.5 kN/m^2	If known, actual building services plant weights should be used to determine structural loads. Please refer to the charts in this section for this information.	12
Dead loads: Raised floors, ceilings and building services systems	0.85 kN/m^2		6, 14
Dead loads: Partitions	1.0 kN/m^2		6, 14

Your notes:

SYSTEM

System features – Mechanical building services

Table 5: Sizing and operating characteristics of hydronic heating and cooling systems

Description	Rule of thumb				Comments	Ref
Classification of water heating systems	**System design water temperature (°C)**		**Operating static pressure (bar absolute)**			15
Low pressure hot water (LPHW)	40 – 85		1 – 3			
Medium pressure hot water (MPHW)	100 – 120		3 – 5			
High pressure hot water (HPHW)	> 120		5 – 10		Account must be taken of varying static pressure in a tall building	
Maximum water velocities in pipework	**Maximum water velocity (m/s)**					16
	Copper pipework		Steel pipework			
15 – 50 mm nominal diameter	1.0		1.5		Nominal diameter is the approximate internal diameter of a pipe	
Over 50 mm nominal diameter	1.5		3.0			
Pressure drop for water distribution in pipework	**Pressure drop per metre run (Pa)**					17
Pipe sizing for optimum life cycle energy consumption	200					
Pipe sizing for optimum installation costs	300					
Water capacity per unit length of pipe	**Copper pipework (l/m)**		**Steel pipework (l/m)**			18, 19
	Nominal outside diameter		Nominal internal diameter			
	15 mm	0.14	15 mm	0.21		
	22 mm	0.32	25 mm	0.59		
	28 mm	0.54	40 mm	1.38		
	42 mm	1.23	50 mm	2.21		
	54 mm	2.10	65 mm	3.70		
	76 mm	4.20	80 mm	5.12		
	108 mm	8.66	100 mm	8.68		
	159 mm	18.87	150 mm	18.95		

Your notes:

Table 5: Sizing and operating characteristics of hydronic heating and cooling systems (continued)

Description	Rule of thumb		Comments	Ref
Maximum spacing of supports for horizontal pipework	**Spacing of supports (m)**		The spacing distances given can be employed for LTHW and CHW systems	20
	Copper pipework	Steel pipework		
15 mm nominal diameter	1.5	2.0		
25 mm nominal diameter	2.0	3.0		
40 mm nominal diameter	2.5	3.3		
50 mm nominal diameter	2.7	4.0		
65 mm nominal diameter	3.0	4.5		
80 mm nominal diameter	3.0	5.2		
100 mm nominal diameter	3.0	5.8		
125mm nominal diameter	3.0	6.7		
150 mm nominal diameter	3.6	7.0		
200 mm nominal diameter		9.5		
250 mm nominal diameter		10.5		
Total water volume of heating systems	**System water volume (litres)**		An additional 10% should be added for open vented systems	21
Domestic systems	6 litres per kW boiler rating			
Commercial systems using perimeter heating	6 litres per kW boiler rating		These systems include radiators and perimeter trench heaters, for example	
Commercial HVAC systems	8 litres per kW boiler rating		These systems include air handling units and fan coil units, for example	
Commercial systems using underfloor heating	23 litres per kW boiler rating			
Water volume of heating system elements	**Element water volume (litres)**			21
Boilers	1.8 litres per kW boiler rating			
Steel panel radiators	11 litres per kW radiator rating			
Cast iron radiators	14 litres per kW radiator rating			
Underfloor heating systems	**Temperature (°C)**			22
Maximum surface temperature of floor heating system	29			
Chilled ceilings	**Temperature (°C)**			23
Optimum soffit temperature of chilled ceiling	17			

Your notes:

Table 6: Sizing and operating characteristics of steam systems

Description	Rule of thumb		Comments	Ref
Classification of steam systems	**Gauge pressure (kPa)**			24
Low pressure steam system	Up to 1000 kPa gauge pressure		1000 kPa = 10 bar g	
High pressure steam system	Over 1000 kPa gauge pressure			
Velocity of steam in pipework	**Recommended design velocity (m/s)**			25, 24
Dry saturated steam	25 – 35			
Superheated steam	40 – 60			
Drainage of steam mains	**Fall**			26, 27
Fall of steam mains	10 mm per metre		The fall must be in the direction of steam flow	
Drain pocket sizes	**Drain pocket bore**	**Drain pocket depth**		26
Steam main up to 100 mm diameter	Same diameter as the steam main	At least 100 mm		
Steam main of 125 to 200 mm diameter	100 mm	At least 150 mm		
Steam main of 250 mm diameter and above	Half the diameter of the steam main	At least the diameter of the steam main		

Your notes:

Table 7: Commissioning of hydronic heating and cooling systems

Description	Rule of thumb		Comments	Ref
Minimum straight lengths of pipe upstream and downstream of flow measurement devices	**Number of upstream pipe diameters**	**Number of downstream pipe diameters**	Flow measurement devices should be selected so that the pressure differential signal generated at the design flowrate is at least 1 kPa	16
Fixed orifice and variable orifice double regulating valves	5	2		
Orifice plates installed alone or close-coupled to full bore isolating valves	10	5		
Venturi meters	As recommended by the manufacturer			
Tolerances for flow regulation in heating systems	**Tolerance**			16
Pipework branches: $\Delta T \leq 11$°C	+/- 10%			
Pipework branches: $\Delta T > 11$°C	+/- 7.5%			
Pipework mains	0 to +10%		This relates to the water flow from the pump	
Tolerances for flow regulation in cooling systems	**Tolerance**			16
Cooling coil with flowrate > 0.1 l/s	0 to +10%			
Pipework branches	0 to +10%			
Pipework mains	0 to +10%			
Operating range of manometers	**Operating range (kPa)**			28
Fluorocarbon	0 – 4.6			
Mercury	0 – 65			
Digital electronic	0 – 200		These devices should be calibrated regularly	
Analogue diaphragm	0 –100		These devices should be calibrated regularly	
Valve authority for control valves	**Valve authority**			
Valve authority	0.3 – 0.5		Please refer to the glossary for a definition of valve authority	17
Minimum incoming water main sizes	**Water main nominal diameter (mm)**		Correctly sized mains will help achieve minimum flushing velocities	29
System volume < 2000 litres	25		For guidance about system volumes, please refer to Table 5	
System volume 2000 – 10000 litres	40			
System volume > 10000 litres	50			

Your notes:

SYSTEM

Table 8: Minimum provision of sanitary appliances for staff in offices, shops and factories (for male and female staff where urinals are not installed)

Description	Rule of thumb			Comments	Ref
Minimum provision of sanitary appliances	**Number of people at work**	**Number of WC's**	**Number of washbasins**	For guidance about building occupation densities, please refer to Table 3	30
	1 – 5	1	1		
	6 –15	2	2		
	16 – 30	3	3		
	31 – 45	4	4		
	46 – 60	5	5		
	61 – 75	6	6		
	76 – 90	7	7		
	91 – 100	8	8		
	Above 100	Add 1 WC and washbasin for every 25 additional people			

Table 9: Minimum provision of sanitary appliances for staff in offices, shops and factories (for male staff only where urinals are installed)

Description	Rule of thumb				Comments	Ref
Minimum provision of sanitary appliances	**Number of people at work**	**Number of WC's**	**Number of urinals**	**Number of washbasins**	For guidance about building occupation densities, please refer to Table 3	30
	1 – 15	1	1	1		
	16 – 30	2	1	2		
	31 – 45	2	2	2		
	46 – 60	3	2	3		
	61 – 75	3	3	3		
	76 – 90	4	3	4		
	91 – 100	4	4	4		
	Above 100	Add 1 WC, washbasin and urinal for every 50 additional males				

Your notes:

SYSTEM

Table 10: Sizing and operating characteristics of public health systems

Description	Rule of thumb	Comments	Ref
Surface water drainage			
Surface water drainage – below ground: Minimum gradients	75 mm diameter – 1:100 100 mm diameter – 1:100 150 mm diameter – 1:150 225 mm diameter – 1:225		31
Design rainfall intensity	0.014 l/s per m^2	This figure is for normal situations. For high risk areas where ponding would lead to flooding of buildings, the drainage should be designed in accordance with *BS EN 752-4*	32
Foul water drainage			
Foul water drainage – below ground: Minimum gradients	75 mm diameter – 1:40 100 mm diameter – 1:40	These gradients are for a peak flow less than 1 l/s	33
Foul water drainage – below ground: Minimum gradients	75 mm diameter – 1:80 100 mm diameter – 1:80 150 mm diameter – 1:150	These gradients are for a peak flow greater than 1 l/s	33
Foul water drainage – below ground: Minimum self-cleaning velocity	0.7 m/s		34
Gas systems			35
Allowable pressure drop for systems metered at 21 mbar	1 mbar	This is the pressure drop between the primary meter and the point-of-use isolating valve. 1 mbar = 100 Pa	
Allowable pressure drop for systems where meter pressure is above 21 mbar	10% of the pressure at the meter	This is the pressure drop between the primary meter and the isolating valve at the point-of-use	

Your notes:

SYSTEM

Table 10: Sizing and operating characteristics of public health systems (continued)

Description		Rule of thumb	Comments	Ref
Design water flowrates for different sanitary fittings and appliances		**Design flowrate (l/s)**		36
WC cistern		0.13	This is to enable the cistern to fill in two minutes	
Urinal cistern (per position served)		0.004		
Washbasin		0.15		
Handbasin (pillar taps)		0.10		
Handbasin (spray or spray mixer taps)		0.05		
Bath (20 mm taps)		0.30		
Kitchen sink (20 mm taps)		0.30		
Washing machine		0.20		
Safe water temperatures for sanitary appliances		**Maximum discharge temperature (°C)**	The distribution temperature of the domestic hot water system should not exceed 60 °C	37, 38
Shower		41		
Washbasin		43		
Bath		48		
Minimum seal depths for sanitary appliances		**Minimum seal depth (mm)**		39
Shower		41		
Washbasin:	with plug	75		
	spray tap, no plug	50		
Sink		75		
Bath		50		
Water closet (WC)		50		
Bowl urinal		75		
Washing machine		75		

Your notes:

Table 11: Sizing and operating characteristics of ventilation systems

Description	Rule of thumb		Comments	Ref
Classification of ductwork systems	**Air leakage limit***	**Maximum design static pressure (pa)**	Formulae for calculating air leakage limits are shown below	40
Low pressure system (Class A)	6%	500 +ve 500 -ve	* $0.027 \times p^{0.65}$ l/s per m^2 of duct area where p is the differential pressure in pascals	
Medium pressure system (Class B)	3%	1000 +ve 750 -ve	* $0.009 \times p^{0.65}$ l/s per m^2 of duct area where p is the differential pressure in pascals	
High pressure system (Class C)	2%	2000 +ve 750 -ve	* $0.003 \times p^{0.65}$ l/s per m^2 of duct area where is the differential pressure in pascals	
Air velocities for low pressure ductwork systems	**Main ducts (m/sec)**	**Branch ducts (m/sec)**		41
Domestic bedrooms	3.0	2.5		
Theatres and concert halls	4.0	2.5		
Lecture halls and cinemas	4.0	3.5		
Hotel bedrooms	5.0	4.5		
Private offices and libraries	6.0	5.5		
General offices	7.5	6.0		
Department stores, supermarkets and shops	9.0	7.0		
Industrial buildings	10.0	8.0		
Maximum pressure drop for ventilation systems	**Maximum pressure drop (pa/m)**			42
Low velocity system	1		A low velocity system has an air velocity in the range 3 m/s to 6 m/s	
High velocity system	8		A high velocity system has an air velocity in the range 7.5 m/s to 15 m/s	
Face velocities for ventilation system elements	**Velocity (m/sec)**			43, 44
Inlet louvres	2.5 (through the louvre free area)		Recommended maximum pressure drop is 35 Pa	
Exhaust louvres	2.5 (through the louvre free area)		Recommended maximum pressure drop is 60 Pa	
Heating coil	2.5 – 4 (through the coil face area)		Recommended pressure drop is 50 to 125 Pa	
Cooling coil	1.5 – 2.5 (through the coil face area)		Recommended pressure drop is 60 to 180 Pa	
Flat panel filter	Same velocity as the duct in which the filter is located			

Your notes:

SYSTEM

Table 11: Sizing and operating characteristics of ventilation systems (continued)

Description	Rule of thumb		Comments	Ref
Face velocities for ventilation system elements	**Velocity (m/sec)**			43, 44
HEPA filter	1.3			
Kitchen hood (light duty)	0.25			
Kitchen hood (medium duty)	0.4			
Kitchen hood (heavy duty)	0.5			
Location of air intakes and exhausts for office buildings	**Distance (m)**		*Approved Document F* provides guidance about the positioning of air intakes and exhausts	45
Minimum height above ground level	10		This provides protection against extreme events	
Minimum distance between intakes and exhausts	10			
Minimum distance between air intakes and sources of pollution	20		Sources of pollution include boiler flues, car park vents and roads	
Filter classification	**Average arrestance (%)**	**Average efficiency (%)**	Examples of filters with different classification are shown below	46, 47
G1	50 – 65		Metal foil panel-filters	
G2	65 – 80		Metal foil plates. Disposable low efficiency panels and pads	
G3	80 – 90		Roll, panel and pad filters	
G4	> 90		Pleated panels and low efficiency bag filters	
F5		40 – 60	Low-medium efficiency bag filters	
F6		60 – 80	Medium efficiency bag filters	
F7		80 – 90	Medium-high efficiency bag filters	
F8		90 – 95	High efficiency bag filters	
F9		> 95	Rigid cell and HEPA rated bag filters	

Your notes:

Table 11: Sizing and operating characteristics of ventilation systems (continued)

Description	Rule of thumb	Comments	Ref
Floor plenum air leakage	**Maximum air leakage rate at a test pressure of 50 Pa (l/s per m² floor area)**		48
Maximum air leakage rate from floor plenums	0.5	Or 5% of the air volume flow rate supplied to the plenum at normal operating conditions, whichever is the lower	
Maximum spacing of supports for horizontal rectangular ductwork	**Maximum spacing distance of supports (m)**	Closer spacing may be required because of limitations imposed by the building structure or to achieve the required duct rigidity	49
Longer side length: 400 mm	3.0	Minimum drop rod diameter should be 8 mm	
Longer side length: 600 mm	3.0	Minimum drop rod diameter should be 8 mm	
Longer side length: 1000 mm	3.0	Minimum drop rod diameter should be 8 mm	
Longer side length: 1500 mm	2.5	Minimum drop rod diameter should be 10 mm	
Longer side length: 2000 mm	2.5	Minimum drop rod diameter should be 10 mm	
Longer side length: 3000 mm	2.5	Minimum drop rod diameter should be 12 mm	
Maximum spacing of supports for circular ductwork	**Maximum spacing distance of supports (m)**	Closer spacing may be required because of limitations imposed by the building structure or to achieve the required duct rigidity	49
Diameter: 315 mm	3.0	Minimum drop rod diameter should be 8 mm	
Diameter: 450 mm	3.0	Minimum drop rod diameter should be 8 mm	
Diameter: 800 mm	3.0	Minimum drop rod diameter should be 8 mm	
Diameter: 1100 mm	3.0	Minimum drop rod diameter should be 10 mm	
Diameter: 1500 mm	3.0	Minimum drop rod diameter should be 10 mm	

Your notes:

SYSTEM

Table 12: Sizing and operating characteristics of fire engineering systems

Description	Rule of thumb		Comments	Ref
Sprinkler systems	**Coverage of sprinkler head (m^2)**	**Maximum distance between sprinkler heads (m)**		50
Coverage and spacing of sprinkler heads: light hazard	21	4.6	Hospitals and schools are typically classified as light hazard. The maximum fire loading is 400 MJ/m^2	
Coverage and spacing of sprinkler heads: ordinary hazard	12	4.0	Hotels, offices, residential premises and retail premises are typically classified as ordinary hazard. The range of fire loading is 400 – 1000 MJ/m^2	
Coverage and spacing of sprinkler heads: high hazard	9	3.7	High hazard risks will be commercial and industrial premises having abnormal fire loads due to the process taking place, the type of goods being stored and the height to which goods are stored. The fire load is likely to be more than 1000 MJ/m^2	
Maximum travel distances for means of escape	**Maximum travel distance (m)**			51
	Escape available in one direction	Escape available in at least two directions		
Offices	18	45		
Shop and commercial premises	18	45		
Assembly buildings	18	45		
Assembly buildings with fixed seating in rows	15	32		
Industrial buildings	25	45		
Plantrooms	9	35	This is the travel distance within the plantroom	
High fire hazard building	9	18		
Minimum clear widths of exits	**Minimum exit width (mm)**		The width of escape routes and exits depends on the number of people needing to use them. For guidance about calculating building occupancies, refer to Table 3	52
Maximum of 50 people using exit	750			
Maximum of 110 people using exit	850			
Maximum of 220 people using exit	1050			
More than 220 people using exit	Add 5 mm per person to 1050 mm			

Your notes:

System features – Electrical building services

Table 13: Sizing and operating characteristics of electrical building services systems and components

Description	Rule of thumb	Comments	Ref
Voltage of electrical systems			53
Extra low voltage (ELV)	Not exceeding 50 V AC or 120 V DC between conductors or to earth	AC – Alternating current DC – Direct current	
Low voltage (LV)	Not exceeding 1000 V AC or 1500 V DC between conductors, or Not exceeding 600 V AC or 900 V DC between conductors and earth		
High voltage (HV)	Exceeding low voltage		
IP ratings of electrical equipment		An IP rating has two digits, such as IP 56	54
First digit	Level of protection	This is the level of protection against the ingress of solids	
0	No protection		
1	Protection against large solid objects of 50 mm diameter or more, such as hands		
2	Protection against small solid objects of up to 12.5 mm diameter, such as fingers		
3	Protection against small solid objects of up to 2.5 mm diameter, such as tools		
4	Protection against small solid objects of up to 1.0 mm diameter, such as wire		
5	Limits dust ingress so that satisfactory operation and safety is maintained		
6	Totally protected against dust ingress		
Second digit	Level of protection	This is the level of protection against the ingress of liquids	
0	No protection		
1	Protection against vertically falling drops of water		
2	Protection against vertically falling liquid when enclosure is tilted up to 15° from vertical		
3	Protection against water sprayed at an angle of up to 60° from vertical		
4	Protection against splashing from all directions		
5	Protection against water jets from all directions		
6	Protection against strong water jets from all directions		
7	Protection against temporary immersion		
8	Protection against continuous immersion		

Your notes:

SYSTEM

Table 13: Sizing and operating characteristics of electrical building services systems and components (continued)

Description	Rule of thumb			Comments	Ref
Minimum number of twin socket outlets to be provided in homes	**Small rooms (up to 12 m²)**	**Medium rooms (12 – 25 m²)**	**Large rooms (> 25 m²)**		55
Main living room	4	6	8		
Dining room	3	4	5		
Single bedroom	2	3	4		
Double bedroom	3	4	5		
Utility room	3	4	5		
Kitchen	6	8	10	It is recommended that wall-mounted socket outlets above a work surface are spaced at not more than 1m intervals	
Garage	2	3	4		
Conservatory	3	4	5		
Hallway	1	2	3		
Loft	1	2	3		
Installation height of socket outlets, switches and controls in dwellings	Between 450 mm to the bottom of the fitting and 1200 mm to the top of the fitting			All distances are from finished floor level	55, 56

Your notes:

Table 13: Sizing and operating characteristics of electrical building services systems and components (continued)

Description	Rule of thumb	Comments	Ref
Maximum spacing of supports for horizontal rigid metal conduit	**Maximum spacing distance of supports (m)**	These spacing distances allow for maximum fill of cables. Supports should be positioned within 300 mm of bends or fittings	55
Up to 16 mm diameter	0.75		
16 to 25 mm diameter	1.75		
25 to 40 mm diameter	2.00		
Over 40 mm diameter	2.25		
Maximum spacing of supports for horizontal metal cable trunking	**Maximum spacing distance of supports (m)**	These spacing distances allow for maximum fill of cables. Supports should be positioned within 300 mm of bends or fittings. These figures do not apply to lighting suspension trunking, where the manufacturers' instructions should be followed	55
Cross sectional area: 300 – 700 mm^2	0.75		
Cross sectional area: 701 – 1500 mm^2	1.25		
Cross sectional area: 1501 – 2500 mm^2	1.75		
Cross sectional area: 2500 – 5000 mm^2	3.00		
Cross sectional area: > 5000 mm^2	3.00		
Energy output of photovoltaic systems	**Energy output (kWh per annum per m^2)**	These figures are for a UK location, assuming reasonable tilt, orientation and system efficiency of the array	57
Mono crystalline or photocrystalline systems	90 – 110		
Amorphous thin film systems	30 – 70		

Your notes:

SYSTEM

SYSTEM

Table 14: Classification of fire detection systems

Description	Rule of thumb	Comments	Ref
Fire detection and alarm categories			58
Category L systems		Category L systems are automatic systems intended for the protection of life	
L1	Systems installed throughout all areas of a building, to offer the earliest possible warning of a fire to allow the longest possible time for escape	Areas include escape routes, stairs and voids	
L2	Systems installed in defined parts of a building. They should meet the requirements of a category L3 system, with the additional objective of providing early warning of fire in specified areas	Automatic detectors are typically installed along all escape routes, as well as high risk areas such as plantrooms and certain storage areas	
L3	Systems designed to give early warning of fire to enable all occupants, other than those in the room where a fire originates, to escape safely before the escape routes become impassable due to the presence of fire, smoke or toxic gases	Automatic detectors are typically installed within escape routes and in rooms that open onto escape routes	
L4	Systems installed within escape routes consisting of circulation areas and spaces such as corridors and stairways, to enhance the safety of the occupants by providing early warning of smoke		
L5	Systems that protect specific areas; the location of detectors is designed to satisfy a specific fire safety objective not covered by an L1, L2, L3, or L4 system		
Category M systems	Category M systems are manual systems and therefore incorporate no automatic fire detectors. They should only be used if no-one will be sleeping in the building	Manual systems can be non-electric, using hand bells and gongs. They rely upon building occupants acting to warn others by manually initiating an alarm	
Category P systems		Category P systems are automatic systems intended for the protection of property	
P1	Systems installed throughout all areas of the building, to offer the earliest possible warning of a fire in order to minimise the time between the ignition of the fire and the arrival of the fire fighters		
P2	Systems installed only in defined parts of a building, in order to provide early warning of a fire in high fire hazard areas or areas in which the risk to property or business continuity from fire is high		

Your notes:

System features – Natural ventilation

Table 15: Design of natural ventilation systems

Description	Rule of thumb	Comments	Ref
	Measurement of ventilation system area		59, 60
Maximum cooling capacity of a natural ventilation system	40 W/m^2	A natural ventilation system is unlikely to cope with heat gains exceeding 40 W/m^2	
Maximum effective room depth for single sided ventilation	Twice the floor to ceiling height	A 7 m room depth is considered the limit for effective single sided natural ventilation	
Maximum effective room depth for cross ventilation	Five times the floor to ceiling height	Cross ventilation is most effective in an open plan room configuration	
Minimum floor to ceiling height	3 m		
Partition height	Partitions should be a maximum of 1.2 m in height	In rooms with full height partitions, windows in the internal partitions or transfer grilles can be used. However, the resistance that these present to air flow must be taken into account	
Positioning of tall furniture	Tall cupboards and other furniture should be placed between windows on a perimeter wall		

Comments:

Part F of the *Building Regulations (England and Wales)* requires that there shall be adequate means of ventilation provided for people in a building. Guidance on ventilation rates in buildings is given in *Approved Document F: Means of Ventilation.*

Your notes:

Cooling and heating loads

Table 16: Cooling loads for different types of building (W/m^2 gross internal area, unless otherwise stated)

Description	Rule of thumb	Comments	Ref
	Cooling load (W/m^2)	Please refer to the glossary for a definition of gross internal area	61, 12
Banks	160		
Data centres	1500	This figure is based on the net area of the data hall	
Hotels	150	Depending on occupancy, a peak guest room cooling load between 1.5 kW and 2 kW will normally be adequate for the UK	
Offices	87	The project design reports analysed during the production of this document had an average total cooling load of 87 W/m^2 GIA*	
Restaurants	200		
Retail establishments	140		
Residential buildings	70		

LOADS

Comments:

*Solar gains vary with façade orientation and should fall in the range of 50 – 65 W/m^2 of the 4.5 m deep perimeter zone.

Please refer to Table 17 for guidance about internal heat gains in offices.

Your notes:

Table 17: Internal heat gains in offices (W/m² net internal area, unless otherwise stated)

Description	Rule of thumb	Comments	Ref
	Internal heat gain (W/m²)	Please refer to the glossary for a definition of net internal area	
Small power	25	This figure is based on 1 workspace per 10 m². When diversified over an area of 1000 m² or more, small power consumption rarely exceeds 15 W/m². This should be reflected in the assessment of overall building demand	45
Lighting	12	This figure includes task lighting and an allowance for occupier's fit-out installations	
Metabolic	12	This figure is based on 1 person per 10 m² and a mixture of males and females	45, 62

Your notes:

Table 18: Heating loads for different types of building (W/m² gross internal area, unless otherwise stated)

Description	Rule of thumb	Comments	Ref
	Heating load (W/m² GIA)	Please refer to the glossary for a definition of gross internal area	61
Educational buildings	87		
Industrial buildings	80		
Offices	70		
Residential buildings	60		
Retail buildings	100		

Your notes:

LOADS

Electrical loads

Table 19: Electrical loads for different types of building (W/m^2 gross internal area, unless otherwise stated)

Building type	Rule of Thumb	Comments	Ref
	Electrical load (W/m^2)	These electrical loads cover requirements for lighting, general power and mechanical power for building services systems. Please refer to the glossary for a definition of gross internal area and net internal area	4, 6, 12, 63, 64
Banks and building societies	50 (non-air conditioned) 150 (air conditioned)		
Car parks	10 (covered) 4 (surface)	An allowance should be added for any manned offices.	
Colleges (higher education)	55		
Data centres	1500	This figure is based on the net area of the data hall	
Department stores	150 – 250	Higher loads relate to stores with a high proportion of display lighting for fashion and cosmetic areas and/or catering provision	
Flats/ apartments	80	This figure is given for high specification flats with gas cooking and heating 3 kW per apartment can be employed for apartments with gas cooking and heating. 7.5 kW per apartment can be employed for apartments with all electric cooking and heating For apartment blocks a coincident diversity may be applied	
Hospitals	65	This figure is for a general hospital. It is expressed in W/m^2 NIA, based on a net to gross ratio of 80%. It includes medical power requirements Luxury air conditioned hospitals will have a higher electrical demand of 80 W/m^2 NIA	
Houses	5.5 kW per house	This figure is for a house with 3 or 4 bedrooms with gas central heating For housing estates, a coincident diversity may be applied	
Hotels	2.1 kW per bedroom	This figure is given for a hotel providing accommodation only. 1 kW per bedroom should be added for hotels with conference facilities	
Libraries	50		
Offices – air conditioned	87		
Offices – non air conditioned	62	Gas heating and mechanical ventilation has been assumed	
Prisons	1.5 kW per cell		
Restaurants	225	This figure is based on the use of gas cooking. A figure of 0.5 kW per cover can also be employed Fast food outlets typically have a higher electrical load of 500 W/m^2 GIA	

Your notes:

LOADS

Table 20: Electrical loads for different types of building – continued (W/m² gross internal area, unless otherwise stated)

Building type	Rule of Thumb	Comments	Ref
	Electrical load (W/m²)	These electrical loads cover requirements for lighting, general power and mechanical power for building services systems. Please refer to the glossary for a definition of gross internal area and net internal area	4, 6, 12, 63
Schools – naturally ventilated	35	A figure of 0.35 kW per student can also be employed	
Schools – mechanically ventilated	50	A figure of 0.5 kW per student can also be employed	
Shops	160	This figure is provided for small high street or shopping mall establishments	
Sports centres with swimming pool	50	This type of facility includes exercise rooms, a fitness room, racket courts and a restaurant	
Student residences/halls of residence	28	A figure of 1.6 kW per student can also be employed	
Supermarkets and hypermarkets	185	This figure is based on 30-40% of floor area consumed by fridges	
Warehouses/stores	17	Cold stores and refrigerated stores are not included	

Your notes:

Table 21: Small power and electrical loads in offices (W/m² net internal area, unless otherwise stated)

Description	Rule of thumb	Comments	Ref
	Electrical load (W/m²)	Please refer to the glossary for a definition of net internal area	
Small power	25	This figure is based on 1 workspace per 10 m² When diversified over an area of 1000 m² or more, small power consumption rarely exceeds 15 W/m². This should be reflected in the assessment of overall building demand	45
Lighting	12	This figure includes task lighting and an allowance for occupier's fit-out installations	

Your notes:

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Water consumption

Table 22: Maximum daily hot water demand and total water demand for different types of building

Description	Rule of thumb		Comments	Ref
	Maximum daily hot water consumption (l/person)	**Maximum daily total water consumption (l/person)**		
Houses			The *Code for Sustainable Homes* (2010) sets a maximum daily water consumption of 120 litres per person per day. 80 litres per person per day is proposed for the best performing homes	37, 65, 66
Economic, local authority	115	120		
Medium, privately owned	115	120		
Luxury, privately owned	120	120		
Flats			The *Code for Sustainable Homes* (2010) sets a maximum daily water consumption of 120 litres per person per day. 80 litres per person per day is proposed for the best performing homes	37, 65, 66
Economic, local authority	68	120		
Medium, privately owned	115	120		
Luxury, privately owned	120	120		
Other types of dwelling				65, 66, 67
Nursing staff accommodation	120	120		
Hostels	115	120		

Your notes:

WATER

Table 22: Maximum daily hot water demand and total water demand for different types of building (continued)

Description	Rule of thumb		Comments	Ref
	Maximum daily hot water consumption (l/person)	Maximum daily total water consumption (l/person)	For guidance about building occupation densities, please refer to Table 3	
Offices				67
Offices with canteen	15	45		
Offices without canteen	10	45		
Hotels			These figures are per bedroom	65, 67
2 star hotels	114	135		
5 star hotels	136	200		
Hospitals			These figures are per bed	67
District General hospitals	200	600		
Surgical wards	110	250		
Medical wards	110	220		
Paediatric wards	125	300		
Geriatric wards	70	140		
Educational buildings				65, 67
Primary schools	15	15		
Secondary schools	15	20		
Colleges	15	20		
Boarding schools	115	115		

Your notes:

Table 22: Maximum daily hot water demand and total water demand for different types of building (continued)

Description	Rule of thumb		Comments	Ref
	Maximum daily hot water consumption (l/person)	Maximum daily total water consumption (l/person)	For guidance about building occupation densities, please refer to Table 3	
Places of assembly			These figures are given for a building population, excluding staff	67
Art galleries and libraries	2	6		
Bars	2	4		
Museums	1	6		
Theatres and cinemas	1	3		
Nightclubs	1	4		
Restaurants				
Restaurants	6	7	These figures are per cover	67
Factories				65, 67
Factories with canteen	15	45		
Factories without canteen	10	40		
Sports changing facilities				67
Sports halls	20	35		
Swimming pools	20	20		
Field sports facility	35	35		
All weather pitch facility	35	35		

Your notes:

Table 23: Minimum storage of cold water for domestic purposes (hot and cold water outlets) in different types of building

Description	Rule of thumb	Comments	Ref
	Minimum cold water storage (litres)	Direct supply is preferred for the supply of drinking water For guidance about building occupation densities and space requirements for water storage, please refer to Table 3, and Figure 21	
Domestic dwellings	**Per dwelling**		68, 69
Houses and flats	227	For luxury accommodation with high usage showers and baths, and more than one toilet facility, a greater level of storage should be considered	
Other types of dwelling	**Per bedspace**		68, 69
Nursing staff accommodation	120		
Hostels	90		
Offices	**Per employee**		70
Offices without canteen	15	This figure should be based on an occupancy density of 1 person per 12 m^2	
Offices with canteen	Increase storage by 5 litres per employee	Assume that 60% of the building's population use the facility when calculating this additional water storage capacity	
Educational buildings	**Per pupil**		68, 69
Primary schools	15		
Secondary schools	20		
Colleges	20		
Boarding schools	90		
Hotels	**Per bedspace**		68, 69
2 star hotels	135		
5 star hotels	200		
Restaurants	**Per meal**		68, 69
Restaurants	7 litres		

Your notes:

Table 24: Minimum storage of hot water for domestic purposes in different types of building

Description	Rule of thumb	Comments	Ref
	Minimum hot water storage (litres)	Storage figures are based on a reheat period of two hours, an inlet temperature of 10 °C and a stored temperature of 65 °C The storage capacity can be reduced by using semi-instantaneous hot water boilers and generators, or eliminated by using instantaneous generators such as combi-boilers For guidance about building occupation densities and space requirements for water storage, please refer to Table 3, and Figure 21	67
Domestic dwellings	**Per dwelling**		
Houses and flats	115		
Other types of dwelling	**Per bedspace**		
Nursing staff accommodation	20		
Hostels	25		
Offices and general workplaces	**Per employee**		
Offices with canteen	5		
Offices without canteen	5		
Educational buildings	**Per pupil**		
Primary and secondary schools	5		
Colleges	5		
Boarding schools	25		
Hotels	**Per bedroom**		
2 star hotels	35		
4 and 5 star hotels	45		
Hospitals	**Per bed**		
District general hospitals	50		
Restaurants	**Per cover**		
Restaurants	6		

Your notes:

Table 24: Minimum storage of hot water for domestic purposes in different types of building (continued)

Description	Rule of thumb	Comments	Ref
	Minimum hot water storage (litres)	Storage figures are based on a reheat period of two hours, an inlet temperature of 10 °C and a stored temperature of 65 °C The storage capacity can be reduced by using semi-instantaneous hot water boilers and generators, or eliminated by using instantaneous generators such as combi-boilers For guidance about building occupation densities and space requirements for water storage, please refer to Table 3, and Figure 21	67
Places of assembly	**Per person**		
Art galleries and libraries	1		
Bars	1		
Museums	1		
Theatres and cinemas	1		
Nightclubs	1		
Sports changing facilities	**Per person**		
Sports halls	20		
Swimming pools	20		
Field sports facility	35		
All-weather pitch facility	35		
Factories	**Per person**		
Factories with canteen	5		
Factories without canteen	5		
Shops	**Per person**		
Shops with canteen	5		
Shops without canteen	5		

Your notes:

WATER

Internal and external design criteria

Table 25: Internal environmental design criteria for different types of building

Building type	Internal design operative temperature in air conditioned buildings (°C)		Noise Rating (NR)	Lighting level (lux)
	Summer	Winter		
Banks, building societies and post offices	21 – 23	19 – 21	35 – 40: counters 35 – 45: public areas	500 – counters 300 – public areas
Computer rooms	21 – 23	19 – 21	35 – 45	300
Education	21 – 23	19 – 21	25 – 35: lecture halls 25 – 35: teaching spaces	500 – lecture halls 300 – teaching spaces
Exhibition halls	21 – 23	19 – 21	40	300
Factories				
• Light work	None	16 – 19	50 and above	300
• Sedentary work	21 – 23	19 – 21	50 and above	300
Hospitals				
• Wards, consulting and treatment rooms	23 – 25	22 – 24	30	300 lux – general area of beds 100 lux – floor level between beds
• Operating theatres	17 – 19	17 – 19	30	1000 lux
Libraries				
• Lending and reference areas	21 – 23	19 – 21	30 – 35	200
• Reading rooms	24 – 25	22 – 23	30 – 35	500 [a)]
Museums and art galleries	21 – 23	19 – 21	30 – 35	200 – display areas [b)] 50 – storage areas
Offices	24 +/- 2	20 +/- 2	35 cellular offices 40 open plan offices	300 – 500 visual display unit use 500 paper-based tasks
Prison cells	21 – 23	19 – 21	25 – 30	100 [c)]
Retail				
• Supermarkets	21 – 23	19 – 21	40 – 45	750 – 1000
• Small shops	21 – 23	19 – 21	35 – 40	500
Sports halls				
• Changing rooms	24 – 25	22 – 24	35 – 45	100
• Halls	14 –16	13 –16	40 – 50	300
Swimming pools				
• Changing rooms	24 – 25	23 – 24	35 – 45	100
• Pool halls	23 – 26	23 – 26	40 – 50	Refer to the *SLL Lighting Handbook*
Television studios	21 – 23	19 – 21	25	Depends on production requirements

Your notes:

DESIGN

Ventilation fresh air (l/s per person)	Comments	Ref
		71, 72
10		
10		
10	The design operative temperature for indoor comfort in a non-air conditioned school buildings should be 25 ºC	
10		
	The figure for maintained illuminance is for a speculative factory unit	73
10		
10		
	Refer to the *SLL Lighting Handbook* for more specific guidance about hospital lighting	73
10		
0.65 – 1 m^3/s per person		
10		
10	a) Study tables and carrels require 500 lux	
10	b) Critical conservation levels may apply – refer to *Lighting Guide LG 8: Lighting in Museums and Art Galleries*	74
12 – 16	The Summer design temperatures given are for air conditioned offices. For mixed mode and naturally ventilated offices, the operative temperature should not exceed 25 °C for more than 5% of occupied hours and should not exceed 28 °C for more than 1% of occupied hours	6
10	c) Local illumination may be required for some tasks	
10		
10	The design operative temperature for indoor comfort in a non-air conditioned retail building should be 25 °C	
	Refer to the *SLL Lighting Handbook* for more specific guidance about lighting for sports facilities	73
6 – 10 air changes per hour		
10 air changes per hour		
10 air changes per hour		
0.5 l/s per m^2 of wet area	Refer to the *SLL Lighting Handbook* for more specific guidance about hospital lighting	73
10		

DESIGN

Table 26: External environmental design criteria for the UK

Description	Rule of thumb	Comments	Ref
	External design temperature (°C)		
Winter design temperature for heating			
Design of heating systems	-4 saturated	The rate of lowering external design temperature for any increase in altitude above sea level should be – 0.6 °C per 100 m	75, 12
Summer design temperatures			76, 12
Calculation of cooling loads for air conditioning systems	29 dry bulb/ 20 wet bulb		
Selection of heat rejection equipment	35		

Comments:

The above information is for general application to UK cities. Detailed guidance for specific UK and international locations can be found in *CIBSE Guide A: Environmental Design*.

Your notes:

DESIGN

Energy and carbon

Table 27: CO_2 emissions factors for different fuel types

Fuel type	Carbon emissions factor ($kgCO_2/kWh$)	Comments	Ref
Mains gas	0.198		77
LPG	0.245		
Heating oil	0.274		
Wood pellets	0.028		
Wood chips	0.009		
Grid supplied electricity	0.517		
Grid displaced electricity	0.529		
Waste heat	0.058		
Dual fuel (mineral + wood)	0.206		

Your notes:

ENERGY

Table 28: Annual energy consumption and CO_2 emissions benchmarks for different building types

Building type	Annual energy consumption benchmarks		Annual CO_2 emissions benchmarks			Comments
	Electricity (kWh/m²)	Fossil thermal (kWh/m²)	Electricity (kg CO_2/m²)	Fossil thermal (kg CO_2/m²)	Total (kg CO_2/m²)	
Bars, pubs or licensed clubs	130	350	67.2	69.3	136.5	These type of facilities serve drinks and snacks and have standing and seating areas for customers
Clinics	70	200	36.2	39.6	75.8	Doctors' surgeries, health clinics, veterinary surgeries and dentists
Cold storage	145	80	75.0	15.8	90.8	Refrigerated warehouses without public areas
Covered car parks	20	0	10.3	0.0	10.3	This type of building is a car park with roof and side walls
Cultural venue	70	200	36.2	39.6	75.8	Museums, art galleries and libraries
Dry sports and leisure facility	95	330	49.1	65.3	114.5	Dry sports halls, sports grounds with changing rooms, tennis courts with office and stadiums
Emergency services	70	390	36.2	77.2	113.4	Police, fire and ambulance stations
Entertainment hall venues	150	420	77.6	83.2	160.7	Cinemas, theatres, concert halls and bingo halls
Fitness and health centre	160	440	82.7	87.1	169.8	Fitness, aerobics and dance facilities
General accommodation	60	300	31.0	59.4	90.4	Boarding houses, university and school hostels and nursing homes
General retail	165	0	85.3	0.0	85.3	High street stores or local stores, corner shops, takeaways, hairdressers, laundrettes and dry cleaners
High street agency	140	0	72.4	0.0	72.4	Bank branches, estate agents, travel agents, Post Offices and betting shops
Hospitals (clinical or research)	90	420	46.5	83.2	129.7	Acute hospitals, specialist hospitals, teaching hospitals and maternity hospitals
Hotels	105	330	54.3	65.3	119.6	This building category includes all types of hotels

Comments:

Values for energy consumption are for delivered energy used per unit of floor area. Areas in m^2 are gross floor areas, measured as RICS gross internal area (GIA).

Figures for energy consumption are derived from *CIBSE TM 46: 2008, Energy benchmarks.*

CO_2 emission factors used to calculate CO_2 emissions benchmarks: Electricity: 0.517 kgCO_2/kWh, Fossil thermal: 0.198 kgCO_2/kWh (fuel assumed to be natural gas). (These figures are taken from The Government's *Standard Assessment Procedure for Energy Rating of Dwellings*, October 2010[77].)

Your notes:

ENERGY

Table 28: Annual energy consumption and CO_2 emissions benchmarks for different building types (continued)

Building type	Annual energy consumption benchmarks		Annual CO_2 emissions benchmarks			Comments
	Electricity (kWh/m²)	Fossil thermal (kWh/m²)	Electricity (kg CO_2/m²)	Fossil thermal (kg CO_2/m²)	Total (kg CO_2/m²)	
Houses	3300 kWh per house	18,000 kWh per house	1706 kg CO_2 per house	3564 kg CO_2 per house	5270 kg CO_2 per house	These figures are taken from the Department of Energy and Climate Change (DECC) publication Quarterly Energy Prices, December 2010
Laboratory or operating theatres	160	160	82.7	31.7	114.4	This building category includes research chemical laboratories and hospital operating theatres
Large food stores	400	105	206.8	20.8	227.6	Supermarkets and freezer centres
Large non-food retail	70	170	36.2	33.7	69.9	Retail warehouses, department stores, hypermarkets and large showrooms
Long-term residential	65	420	33.6	83.2	116.8	Residential homes, long-stay hospitals, detention centres and prisons
Offices	95	120	49.1	23.8	72.9	This is a general office benchmark for all offices, whether air conditioned or not
Public buildings with light usage	20	105	10.3	20.8	31.1	Churches, club houses and village halls
Public waiting or circulation	30	120	15.5	23.8	39.3	Bus stations, local train stations and shopping centre malls
Restaurants	90	370	46.5	73.3	119.8	Cafes, restaurants, canteens, refectories and mess halls
Schools and seasonal public buildings	40	150	20.7	29.7	50.4	Primary and secondary schools, nurseries, crèches, youth centres and community centres
Small food stores	310	0	160.3	0.0	160.3	Food stores, greengrocers, fish shops, butchers and delicatessens
Storage facility	35	160	18.1	31.7	49.8	Distribution warehouses without public areas and local authority depots
Swimming pool centres	245	1130	126.7	223.7	350.4	A swimming pool hall, changing and ancillary areas, without further sports facilities
Terminals	75	200	38.8	39.6	78.4	Large train stations and airport terminals
University campus	80	240	41.4	47.5	88.9	A typical campus mix for further and higher education, universities and colleges
Workshops	35	180	18.1	35.6	53.7	Facilities with industrial heating and lighting standards, such as vehicle repair workshops

Comments:

Values for energy consumption are for delivered energy used per unit of floor area. Areas in m^2 are gross floor areas, measured as RICS gross internal area (GIA).

Figures for energy consumption are derived from *CIBSE TM 46: 2008, Energy benchmarks.*

CO_2 emission factors used to calculate CO_2 emissions benchmarks: Electricity: 0.517 kgCO_2/kWh, Fossil thermal: 0.198 kgCO_2/kWh (fuel assumed to be natural gas). (These figures are taken from The Government's *Standard Assessment Procedure for Energy Rating of Dwellings*, October 2010[77].)

Your notes:

ENERGY

Table 29: Compliance with Part L of the Building Regulations 2010

Description	Rule of thumb		Comments	Ref
Minimum seasonal efficiency of a natural gas boiler	**Minimum seasonal efficiency (%)**		See glossary for definition	78
Single boiler system	86			
Multiple boiler system	82 for any individual boiler 86 for the overall multi-boiler system			
Minimum coefficient of performance (CoP) of heat pumps	**Minimum coefficient of performance**		See glossary for definition	78
All types of heat pump, except absorption heat pumps and gas engine heat pumps	2.2 for space heating 2.0 for domestic hot water			
Absorption heat pumps	0.5			
Gas engine-driven heat pumps	1.0			
Minimum seasonal performance factor of heat pump systems	**Seasonal performance factor**		See glossary for definition	78
	New buildings	Existing buildings		
Air to water	2.7	2.5		
Ground to water	3.5	3.3		
Water to water	3.8	3.5		
Minimum energy efficiency ratio (EER) of different types of comfort cooling systems	**Energy efficiency ratio**		See glossary for definition	78
Vapour compression cycle chillers – water cooled	< 750 kW: 3.85	> 750 kW: 4.65		
Vapour compression cycle chillers – air cooled	< 750 kW: 2.5	> 750 kW: 2.6		
Absorption cycle chillers	0.7			
Split and multi-split air conditioners (including (VRF):	2.5			
Packaged air conditioners	2.5			
Water loop heat pump	3.2			
Air distribution systems	**Dry heat recovery efficiency (%)**		Air supply and extract ventilation systems including heating and cooling should be fitted with a heat recovery system	78
Plate heat exchanger	50			
Heat pipes	60			
Thermal wheel	65			
Run around coil	45			

Comments:

This information applies to non-domestic buildings. It is important to note that many of these minimum standards will need to be exceeded if the building regulations target carbon dioxide emission rate (TER) for new buildings is to be met.

Your notes:

ENERGY

Table 29: Compliance with Part L of the Building Regulations 2010 (continued)

Description	Rule of thumb		Comments	Ref
Maximum permissible specific fan power (SFP) for air distribution systems	**Maximum SFP (W/(l/s))**		See glossary for definition	78
	New buildings	Existing buildings		
Central mechanical ventilation system including heating and cooling	1.8	2.2		
Central mechanical ventilation with heating only	1.6	1.6		
All other central mechanical ventilation systems	1.4	1.8		
Local ventilation units, local supply or extract units	0.4	0.5	Examples include window, wall or roof units serving a single area, such as toilet extract units	
Zonal supply system where the fan is remote from the zone	1.2	1.5	Examples include ceiling void or roof-mounted units	
Zonal extract system where the fan is remote from the zone	0.6	0.6		
Other local units, such as fan coil units	0.6	0.6		
Lighting efficacy	**Lighting efficacy**		See glossary for definition	78
General lighting in office, storage and industrial areas	55 luminaire lumens per circuit-watt			
General lighting in other types of space other than office areas	55 lamp lumens per circuit-watt			
Display lighting	22 lamp lumens per circuit-watt			
Energy meters	**Energy metering requirements**			79
Metering of end-use categories	Energy metering systems should enable at least 90% of the estimated annual energy consumption of each fuel to be assigned to end-use categories, such as heating, cooling and lighting		The metering provisions should be designed to facilitate the benchmarking of energy performance as set out in *CIBSE TM 46, Energy Benchmarks, 2008*	
Metering and useful floor area	Buildings with a total useful floor area greater than 1000 m^2 should have automatic meter reading and data collection facilities		The metering provisions should be designed to facilitate the benchmarking of energy performance as set out in *CIBSE TM 46, Energy Benchmarks, 2008*	

Extending SFP for additional components

Component	SFP W/(l/s)
Additional return filter for heat recovery	+ 0.1
HEPA filter	+ 1.0
Heat recovery – thermal wheel system	+ 0.3
Heat recovery – other systems	+ 0.3
Humidifier/de-humidifier (air conditioning system)	+ 0.1

Example:

For a central mechanical ventilation system including heating and cooling, together with heat recovery via a plate heat exchanger

SFP = 1.8 W/(l/s) for the central mechanical ventilation system including heating and cooling + 0.3 W/(l/s) for the heat plate exchanger = 2.1 W/(l/s)

Comments:

This information applies to non-domestic buildings. It is important to note that many of these minimum standards will need to be exceeded if the building regulations target carbon dioxide emission rate (TER) for new buildings is to be met.

Your notes:

Table 30: Air permeability for different building types

Building type	Rule of Thumb		Comments	Ref
	Air permeability in $m^3/(h.m^2)$ at 50 Pa		*CIBSE TM23* provides a simple method of estimating air infiltration from the air permeability	80, 81
	Normal practice	Best practice		
Offices				
• Naturally ventilated	7	3		
• Mixed-mode	5	2.5		
• Air-conditioned	5	2		
Factories and warehouses	6	2		
Superstores	5	1		
Schools	9	3		
Hospitals	9	5		
Museums and archival storage	1.5	1		
Cold stores	0.35	0.2		
Dwellings				
• Naturally ventilated	7	5		
• Mechanically ventilated	5	1		
• PassiveHaus Standard		< 1	0.6 air changes per hour @ 50 Pa	

Your notes:

ENERGY

Costs

Table 31: Building services installation costs for different building types

	Airport terminal		Shopping mall		Office – city centre (Shell and core)		Office – city centre (Cat A fit-out)	
Element of the mechanical and electrical services	£/m²	% of total M&E cost	£/m²	% of total M&E cost	£/m²	% of total M&E cost	£/m²	% of total M&E cost
Sanitaryware	2.7	0.3	0.7	0.2	6.48	1.8	0.0	0.0
Disposal installations	14.0	1.5	10.7	3.5	18.91	5.2	7.4	2.7
Water installations	16.3	1.7	10.7	3.5	12.74	3.5	0.0	0.0
Space heating and air treatment	347.3	37.0	62.4	20.5	106.46	29.5	140.6	50.5
Ventilating services	42.4	4.5	46.3	15.2	41.8	11.6	0.0	0.0
Electrical installation	259.9	27.7	110.7	36.3	97.99	27.2	77.8	27.9
Gas installation	1.8	0.2	0.8	0.3	1.24	0.3	0.0	0.0
Protection systems	46.9	5.0	13.5	4.4	30.59	8.5	21.3	7.6
Communication	156.7	16.7	33.3	10.9	23.11	6.4	12.6	4.5
Special installations*	49.6	5.3	15.8	5.2	20.98	5.8	19.0	6.8
Total cost	**937.6**	**100.0**	**304.7**	**100.0**	**360.3**	**100.0**	**278.6**	**100.0**

Comments:

Costs derive from the SPON'S 2011 M&E price book and have been cross-referenced with information provided by Sense Cost Consultancy. The costs do not include VAT. They do include preliminaries, profit and overheads for the building services contractor.

All areas are gross internal area (GIA) unless otherwise stated.

All prices apply to the London area. Apply the following factors to obtain regional prices: South East: 0.94, South West: 0.9, East and West Midlands: 0.85, East Anglia: 0.84, North East: 0.86, North West: 0.84, Scotland: 0.92, Wales: 0.88, Northern Ireland: 0.68.

Airport terminal: New build terminal building. 25,000 m² GIA. Costs exclude baggage handling, check-in systems, pre-check-in and boarding security systems, vertical transportation and services to aircraft stands. Heat source via district mains. Space heating and air treatment includes LTHW heating system, chilled water system, supply and extract air conditioning system and an allowance for services to communications rooms. Electrical installation includes HV/LV switchgear, standby generator, mains and sub mains installation, small power installation, lighting and luminaires, emergency lighting, and power to mechanical services. Communications installations include fire and smoke detection and alarms, voice/public address systems, intruder detection, security, CCTV and access control, wireways for telephones data and structured cable, structured cable installation, flight information display system.

Shopping mall: Two storey, naturally ventilated shopping mall of 33,000 m². Space heating and air treatment includes condenser water system, LTHW installation, air conditioning system and over-door heaters at entrances. Electrical installation includes LV distribution, standby power, general, external and emergency lighting, small power, mechanical services supplies and UPS for security and CCTV. Cost associated with tenants' fit-out and car parking are not included in this cost model.

Office – city-centre: Speculative 15 storey office in Central London of 19,300 m² GIA for multiple tenant occupancy. Four pipe fan coil unit system with roof mounted cooling towers, gas fired boilers and water cooled chillers in the basement. Ventilating services include toilet and basement extract and miscellaneous ventilation systems. Electrical installation includes generator, HV/LV supply and distribution, general lighting and power systems and electrical services to mechanical equipment. Fit-out costs are £/m² NIA, based on a NIA of 12,500 m².

* Building management system [BMS], unless otherwise stated.

Your notes:

COSTS

Table 31: Building services installation costs for different building types (continued)

	Office – out of town business park (shell and core)		**Office – out of town business park** (Cat A fit-out)		**Performing arts centre**		**Sports hall**	
Element of the mechanical and electrical services	£/m²	% of total M&E cost	£/m²	% of total M&E cost	£/m²	% of total M&E cost	£/m²	% of total M&E cost
Sanitaryware	5.4	2.4	0.0	0.0	12.67	1.8	10.0	5.1
Disposal installations	10.1	4.5	0.0	0.0	16.5	2.3	10.0	5.1
Water installations	8.6	3.9	0.0	0.0	17.0	2.4	15.0	7.7
Space heating and air treatment	113.6	51.1	61.6	50.6	157.0	22.2	45.9	23.4
Ventilating services	5.3	2.4	0.0	0.0	126.3	17.9	14.2	7.2
Electrical installation	43.2	19.4	48.4	39.8	189.0	26.8	61.7	31.5
Gas installation	1.42	0.6	0.0	0.0	2.67	0.4	0.8	0.4
Protection systems	4.8	2.2	1.2	1.0	2.7	0.4	3.3	1.7
Communication	11.5	5.2	4.8	4.0	87.7	12.4	35.0	17.9
Special installations*	18.2	8.2	5.7	4.7	94.8 [Ref 1]	13.4	0.0	0.0
Total cost	**222.1**	**100.0**	**121.7**	**100.0**	**706.3**	**100.0**	**195.9**	**100.0**

Comments:

Costs derive from the elemental costs section of the SPON'S 2011 M&E price book and have been cross-referenced with information provided by Sense Cost Consultancy. The costs do not include VAT. They do include preliminaries, profit and overheads for the building services contractor.

All areas are gross internal area (GIA) unless otherwise stated.

All prices apply to the London area. Apply the following factors to obtain regional prices: South East: 0.94, South West: 0.9, East and West Midlands: 0.85, East Anglia: 0.84, North East: 0.86, North West: 0.84, Scotland: 0.92, Wales: 0.88, Northern Ireland: 0.68.

Office - out of town business park: New build development of 9800 m² GIA within the M25. Office building is part of a speculative business park. A full air displacement system with roof mounted , air cooled chillers, gas fired boilers, LTHW heating and perimeter heaters, and air handling plant. Electrical installation includes LV supply and distribution, general lighting and power and electrical services to mechanical equipment. Fit-out costs are £/m² NIA, based on a NIA of 8100 m².

Performing arts centre: High specification development of 6000 m² GIA comprising dance studios and a theatre auditorium. High specification for the theatre systems and cooling to the auditorium. Electrical installation includes LV supply and distribution, general lighting and small power. Space heating and air treatment includes cooling to the auditorium with DX cooling to comms and amps rooms. Ventilating services include ventilation and extract systems to toilets, kitchen and workshop areas. Communication installation includes fire alarms and detection, voice and data, security, access control, disabled alarms and staff paging systems. **Ref 1:** Includes £58.7 /m² for containment and power wiring for theatre systems. Stage lighting, machinery and equipment associated with a modern theatre are not included in the cost model, but their containment and power wiring systems are included.

Sports hall: Single storey sports hall of 1200 m² GIA. Space heating and air treatment includes warm air heating to sports hall area and radiator heating to ancillary areas. Electrical installation includes main switchgear and sub-mains, small power and lighting installation and luminaires. Communication installation includes fire, smoke detection and alarm systems, intruder detection, CCTV installation, public address and music systems and wireways for telephone and data.

* Building management system [BMS], unless otherwise stated.

Your notes:

COSTS

Table 31: Building services installation costs for different building types (continued)

	Hotel		Stadium		Private hospital		School	
Element of the mechanical and electrical services	£/m^2	% of total M&E cost	£/m^2	% of total M&E cost	£/m^2	% of total M&E cost	£/m^2	% of total M&E cost
Sanitaryware	31.4	5.3	9.9	3.0	18.7	2.8	9.5	2.3
Disposal installations	27.1	4.6	14.5	4.3	25.3	3.7	16.2	3.8
Water installations	40.6	6.9	20.8	6.2	47.4	7.0	38	9.0
Space heating and air treatment	137.2	23.2	29.8	8.9	95.9	14.2	137.8	32.7
Ventilating services	40.6	6.9	49.6	14.9	122.8	18.1	16.2	3.8
Electrical installation	170.5	28.9	116.9	35.1	205.9	30.4	123.2	29.2
Gas installation	2.2	0.4	0.9	0.3	9.3	1.4	9.5	2.3
Protection systems	36.1	6.1	3.5	1.1	1.9	0.3	1.9	0.5
Communication	80.2	13.6	73.7	22.1	74.4	11.0	40.8	9.7
Special installations*	24.7	4.2	13.5	4.1	75.6 [Ref 2]	11.2	28.5	6.8
Total cost	**590.6**	**100.0**	**333.1**	**100.0**	**677.2**	**100.0**	**421.6**	**100.0**

Comments:

Costs derive from the elemental costs section of the SPON'S 2011 M&E price book and have been cross-referenced with information provided by Sense Cost Consultancy. The costs do not include VAT. They do include preliminaries, profit and overheads for the building services contractor.

All areas are gross internal area (GIA) unless otherwise stated.

All prices apply to the London area. Apply the following factors to obtain regional prices: South East: 0.94, South West: 0.9, East and West Midlands: 0.85, East Anglia: 0.84, North East: 0.86, North West: 0.84, Scotland: 0.92, Wales: 0.88, Northern Ireland: 0.68.

Hotel: 200 bedroom, 4 star hotel of 16,500 m^2 GIA. The development comprises a 10 storey building with large suites on each floor, banqueting, meeting rooms and leisure facilities. Space heating and air treatment includes air conditioning system, chillers, pumps, air handling units, duct work and fan coil units. Electrical installation includes HV/LV installation, standby power, lighting and small power installation and emergency lighting. Communication installation includes fire, smoke detection, alarm, security, CCTV and background music systems, AV wireways, telecommuncations, data and TV wiring.

Stadium: A three storey stadium of 85,000 m^2 GIA and incorporating 60,000 seats. Electrical installation includes HV/LV supply, LV distribution, general lighting, small power, power supply to mechanical equipment and pitch lighting. Communication installations include wireways for data, TV telecommunications and PA, public address, security, data, voice and fire alarm systems.

Private Hospital: An 80 bed, eight storey development of 15,000 m^2 GIA with six operating theatres, ITU/HDU department, pathology, diagnostic imaging, outpatient and physiotherapy facilities. All heat is provided from an existing steam boiler plant. Electrical installation includes HV distribution, LV supply and distribution, standby power, UPS, general power and lighting, emergency, theatre, external and specialist lighting systems and electrical supplies to mechanical equipment. Communication installation includes fire alarms and detection, voice and data, security and CCTV, nurse call and cardiac alarm systems, personnel paging and hospital entertainment systems. **Ref 2:** Includes £38.4 /m^2 for Group 1 equipment and pneumatic tube conveying systems.

School: Secondary school academy in Southern England of 10,000 m^2 GIA. The building comprises a three storey teaching block, including provision for music, drama, catering, sports hall, science laboratories, food technology, workshops and reception and administration. Space heating and air treatment includes gas fired boiler installation, LTHW heating system, DX cooling to ICT server rooms, mechanical supply and extract ventilation including DX type cooling to music, drama, kitchen, dining and sports hall areas. Electrical installation includes mains and sub-mains distribution, lighting and small power systems and luminaires. IT cabling is excluded from the cost model.

* Building management system [BMS], unless otherwise stated.

Your notes:

COSTS

Table 31: Building services installation costs for different building types (continued)

	Supermarket		Data centre		Distribution centre			
Element of the mechanical and electrical services	£/m²	% of total M&E cost	£/m²	% of total M&E cost	£/m²	% of total M&E cost		
Sanitaryware	1.9	0.5	0.0	0.0	0.0	0.0		
Disposal installations	2.6	0.7	33.0	0.4	8.5	4.0		
Water installations	9.5	2.7	23.5	0.3	1.7	0.8		
Space heating and air treatment	32.5	9.2	1425.5	17.3	22.5	10.6		
Ventilating services	14.3	4.0	417.0	5.1	5.0	2.4		
Electrical installation	66.1	18.8	5145.0	62.3	67.3	31.9		
Gas installation	2.8	0.8	0.0	0.0	0.6	0.3		
Protection systems	31.3	8.9	293.5	3.6	44.7	21.2		
Communication	42.3	12.0	421.0	5.1	19.0	9.0		
Special installations*	148.8 [Ref 3]	42.3	497.5	6.0	41.9 [Ref 4]	19.8		
Total cost	**351.9**	**100.0**	**8256.0**	**100.0**	**211.1**	**100.0**		

Comments:

Costs derive from the elemental costs section of the SPON'S 2011 M&E price book and have been cross-referenced with information provided by Sense Cost Consultancy. The costs do not include VAT. They do include preliminaries, profit and overheads for the building services contractor.

All areas are gross internal area (GIA) unless otherwise stated.

All prices apply to the London area. Apply the following factors to obtain regional pricesouth East: 0.94, South West: 0.9, East and West Midlands: 0.85, East Anglia: 0.84, North East: 0.86, North West: 0.84, Scotland: 0.92, Wales: 0.88, Northern Ireland: 0.68.

Supermarket: Single level, 4000 m² GIA development in South East England with main sales, coffee shop, bakery, offices, amenities and warehouse areas. Electrical installation includes panels, boards, containment, general lighting and small power systems and electrical supply to mechanical services. Communication systems include fire alarm and detection, public address, CCTV, intruder alarm and store security systems, telecommunication and structured cabling installations. Space heating and air treatment includes heating and ventilation with cooling via DX units. **Ref 3**: Includes 141.5 £/m² for refrigeration installation comprising plant, cold stores and cabinets.

Data centre: Data centre of 3500 m² GIA comprising 2500 m² net technical area, 250 m² of office space, 250 m² of ancillary space and 100 m² of internal plant space. Power and cooling to technical space of 1500 W/m². Costs are expressed as £/m² net technical area. Space heating and cooling includes chilled water plant to provide N+1 redundancy, chilled water distribution to free-standing cooling units, office space and ancillary areas and floor grilles. Free-standing cooling units are single coil with redundancy of N + 20% and 30% of cooling units have humidification. Electrical installation includes HV installation including transformers with N + 1 redundancy, containerised generator installation with N + 1 redundancy, static UPS system with 2 x (N + 1) redundancy and 10 minute battery autonomy, LV switchgear, LV distribution, power distribution units, cabinet supplies and lighting installation.

Distribution centre: A single level, 75,000 m² GIA development in London, including a refrigerated cold box of 17,500 m² GIA. Includes an office area, vehicle recovery unit, gate house and plantrooms. Electrical installation includes generator, HV installation, LV distribution, lighting and small power systems. Space heating and air treatment includes heating and ventilation to offices and displacement system to main warehouse space. Communication installation includes fire alarm and detection, public address and CCTV systems. **Ref 4:** Includes £36.21 /m² for the refrigeration installation.

* Building management system [BMS], unless otherwise stated.

Your notes:

COSTS

Table 31: Building services installation costs for different building types (continued)

	Affordable residential development (shell and core)		Affordable residential development (fit-out)		Private residential development (shell and core)		Private residential development (fit-out)	
Element of the mechanical and electrical services	£/m^2	% of total M&E cost	£/m^2	% of total M&E cost	£/m^2	% of total M&E cost	£/m^2	% of total M&E cost
Sanitaryware	1.7	1.2	22.5	8.9	1.1	0.5	49.7	12.4
Disposal installations	12.7	8.6	9.2	3.7	18.8	8.9	8.1	2.0
Water installations	18.2	12.3	30.8	12.2	24.0	11.4	36.1	9.0
Space heating and air treatment	2.8	1.9	55.8	22.2	49.1	23.3	151.7	38.0
Ventilating services	16.2	11.0	27.1	10.8	8.4	4.0	31.6	7.9
Electrical installation	30.6	20.7	46.3	18.4	36.3	17.2	73.7	18.5
Gas installation	4.4	3.0	10.8	4.3	2.7	1.3	0.0	0.0
Protection systems	29.1	19.7	15.4	6.1	29.2	13.9	9.0	2.3
Communication	23.2	15.7	27.5	10.9	24.5	11.6	36.9	9.2
Special installations*	8.8	6.0	6.3	2.5	16.7	7.9	2.7	0.7
Total cost	**147.7**	**100.0**	**251.7**	**100.0**	**210.8**	**100.0**	**399.4**	**100.0**

Comments:

Costs derive from the elemental costs section of the SPON'S 2011 M&E price book and have been cross-referenced with information provided by Sense Cost Consultancy. The costs do not include VAT. They do include preliminaries, profit and overheads for the building services contractor.

All areas are gross internal area (GIA) unless otherwise stated.

All prices apply to the London area. Apply the following factors to obtain regional prices: South East: 0.94, South West: 0.9, East and West Midlands: 0.85, East Anglia: 0.84, North East: 0.86, North West: 0.84, Scotland: 0.92, Wales: 0.88, Northern Ireland: 0.68.

Affordable residential development: A 12 storey, 50 apartment development of 3400 m^2 GIA and 2400 m^2 NIA in London. The development does not include a car park. LTHW radiator heating system with local gas combination boiler exhausting through the building façade. Kitchens and bathrooms are ventilated through the building façade. There are pendant light fittings, an audio entry system, and telephone and satellite installation. There is a full sprinkler installation throughout.

Private residential development: A 20 storey, 250 apartment development of 22,750 m^2 GIA and 20,415 m^2 NIA in London. The development does not include a car park. Included is a central boiler and hot water installation with perimeter trench heating to each apartment and 30% LTHW radiators to supplement a four pipe fan coil unit installation. Central air cooled chiller system. No gas to apartments. Whole house ventilation system. Wet riser with full sprinkler installation. Video entry, TV and satellite installation. Flood wiring for home automation and sound system.

* Building management system [BMS], unless otherwise stated.

Your notes:

Table 32: Building services installation costs expressed as a percentage of total construction costs for different building types

Building type	Installation costs for building services as a percentage of total construction cost (%)	Comments
Ambulance stations	33	
Bars, pubs or licensed clubs	29	
Clinics, health centres and group practice surgeries	35	
Factories	26	
Fire stations	29	
Flats/ apartments	23	
Hospitals	45	
Hotels	35	
Libraries	31	
Offices – air conditioned	34	
Offices – non air conditioned	30	
Police stations	39	
Primary schools	31	
Restaurants	42	
Secondary schools	31	
Sports centres (dry)	30	
Sports centres with swimming pool	36	
Stadia	20	
Student residences/halls of residence	33	
Supermarkets and hypermarkets	38	
Swimming pools	38	
Universities	32	
Warehouses/stores	21	Cold stores and refrigerated stores are not included
Average	**31**	

Comments:

All costs are derived from the Building Cost Information Service (BCIS) database 2010:

Total construction cost is the cost of the building, excluding external works. Professional fees are also not included.

Building services includes those parts of a building categorised as element 5 of the BCIS Standard Form of Cost Analysis (SFCA). This includes the following buildings services systems: Plumbing, internal drainage and sanitaryware, heating, ventilation and air conditioning, lifts, escalators and moving walkways, electric power, lighting and controls, and other mechanical and electrical installations such as fire and intruder alarms and emergency lighting.

Your notes:

Table 33: Supply and installation cost of primary building services plant and equipment

Type of building services plant and equipment	Units	Range of capital cost (£/)	Comments
Gas fired boilers	£/kW	30 - 35	Costs include gas train and controls
Air Handling Units - packaged supply and extract units	£ per m^3/s	5500 – 7500	Costs include LPHW pre-heat and heating coil, cooling coil, heat recovery, pre-filter and main filter, inverter drive, motorized volume control dampers. The cost range is largely dependent on the type of heat recovery unit used
Water cooled chillers	£/kW	75 - 100	Costs include control panel and anti-vibration mountings
Air cooled chillers	£/kW	110 - 130	Costs include control panel and anti-vibration mountings
Cooling towers – forced draught, closed circuit	£/kW	60 – 75	The upper cost value is based upon stainless steel manufacture
Cooling towers – forced draught, open circuit	£/kW	40 – 57	The upper cost value is based upon stainless steel manufacture
Dry air coolers	£/kW	90 – 110	
Transformers - cast resin	£/kVA	15 – 20	Costs include electrical terminations
Transformers - oil filled	£/kVA	14 – 18	Costs include electrical terminations
Diesel standby generator set - LV	£/kVA	215 – 340	Costs include control panel, oil day tank and attenuation
Diesel standby generator set - HV	£/kVA	240 – 390	Costs include control panel, oil day tank and attenuation
Static UPS	£/kVA	170 – 300	Costs include control panel, automatic bypass, DC isolator and batteries for 30 minutes standby
Rotary UPS	£/kVA	325 – 400	Costs include control panel, automatic bypass, DC isolator and batteries for 30 minutes standby
Diesel rotary UPS	£/kVA	360 – 450	Costs include control panel and choke transformer
HV switchgear	£/section	15,000 – 20,000	Costs are for a cubicle section HV switch panel, form 4, type 6 including air circuit breakers, meters and electrical terminations
LV switchgear	£/Amp £ per isolator	5 – 8 1745 – 2715	Costs are for a LV switch panel, form 3 including all isolators, fuses, meters and electrical terminations
Power distribution units	unit cost	7500 – 10,000	Costs are for a basic (3 x 24 way) unit
Power distribution units	unit cost	15,000 – 18,000	Costs are for a basic (3 x 24 way) unit with enhanced metering
Power distribution units	unit cost	25,000 – 30,000	Costs are for a basic (3 x 24 way) unit with enhanced metering and branch power monitoring

Comments:

These costs are derived from the SPON'S 2011 price book and information provided by Sense Cost Consultancy.

The costs do not include VAT. They do include preliminaries, profit and overheads for the building services contractor.

Your notes:

Table 34: Supply and installation cost of renewable energy plant and equipment

Type of renewable energy plant and equipment	Units	Range of capital cost (£)	Comments
Wind turbine – horizontal axis			
Tower-mounted wind generators (100 kW to 2000 kW)	£/kWp	455 – 655	Large scale wind turbines. Situated on land. Cost range inclusions: Rotor, mast tower, generator, inverter, electrical works, kWp = kilowatt-peak
Mast-mounted wind generators (≥20 kW to ≤100 kW)	£/kWp	4000 – 5000	Medium Sized Wind Turbines. Medium sized turbines are between 15– 20 m high and have a rotor diameter of 5–10 m. Cost range inclusions: Rotor, mast tower, generator, inverter, electrical works
Building-mounted micro wind (≤20 kW)	£/kWp	2500 – 3500	Small, building-mounted wind turbines between 1 and 3 m high with a rotor diameter of 1 – 1.5 m. Cost range inclusions: Turbine, mast generator, inverter, electrical works
Photovoltaic installations			These costs can offset other building costs for cladding and roofing systems.
Photovoltaic roof mounted tiles	£/m^2 tiled area	1000 – 1200	Cost range inclusions: Tiles, inverters, local electrical wiring
Photovoltaic roof mounted panels	£/m^2 of panel £/kWp	700 – 800 3800 – 4500	Cost range inclusions: Panels, inverters, local electrical wiring
Photovoltaic roof mounted panels integrated with roof lining	£/m^2 roof area	400 – 500	Cost range inclusions: Panels, inverters, local electrical wiring
Photovoltaic panels façade mounted	£/m^2 of panel	800 – 1200	Cost range inclusions: Panels, inverters, local electrical wiring
Photovoltaic façade panels integrated with glazed cladding	£/m^2 of panel	350 – 500	This is an extra-over cost per m^2 of cladding. Cost range inclusions: Panels, inverters, local electrical wiring
Biomass installations			
Biomass boilers	£/kWth	250 – 280	Cost range inclusions: Boiler, flue, hopper. Distribution pipework is not included, kWth = kilowatt-thermal
Biomass – combined heat and power	£/kWe	2000 – 2800	Cost range inclusions: Boiler, flue, hopper. Distribution pipework is not included, kWe = kilowatt-electrical
Gas-fired CHP			
Gas fired CHP (Co-generation) Natural gas CHP unit for LTHW (≥2000 kWe)	£/kWe	600 – 1200	Cost range inclusions: 415 V generator, engine, control panel, internal wiring, heat exchangers, acoustic enclosure; placing in position, excludes flues and silencers, electrical and heating connections, distribution and interconnecting pipework
Gas fired CHP (Co-generation) Natural gas CHP unit for LTHW (≤2000 kWe)	£/kWe	1000 – 1250	Cost range inclusions: 415 V generator, engine, control panel, internal wiring, heat exchangers, acoustic enclosure; placing in position, excludes flues and silencers, electrical and heating connections, distribution and interconnecting pipework
Fuel cells			
Hydrogen fuel cell	£/kWe	3000 – 3250	

Comments:

These costs are derived from information provided by Sense Cost Consultancy and the SPON'S 2011 price book for the supply and installation of the plant and equipment. The costs do not include VAT.

The cost ranges exclude: Builders Work in Connection (BWIC), overhead and profit (OHP), preliminaries and special attendance, and consideration of grants and other funding sources that may be available.

Some renewable energies are eligible for Enhanced Capital Allowances.

Costs are based upon grid connected buildings.

Your notes:

COSTS

Table 35: Annual building services maintenance costs and annual utility costs for different building types

Building type	Annual maintenance costs for building services systems (£/m²)	Annual utility costs (£/m²)	Comments
Ambulance stations	9	24	
Banks and building societies	23.5	28	
Bars, pubs or licensed clubs	16	32	
Clinics, health centres and group practice surgeries	11	26	
Factories	9.5	16.5	
Fire stations	12	25.5	
Flats/ apartments	9.5	16.5	
Hospitals	19.5	30	
Hotels	16	32	
Libraries	18	24	
Museums	15	32	
Nursing homes and hospices	12.5	24	
Offices – air conditioned	21.5	44	
Offices – non air conditioned	15	20	
Police stations	14	26.5	
Primary schools	14	13	

Comments:

All costs are given for gross internal area (GIA). The costs do not include VAT.

Building services maintenance is considered as the maintenance of those parts of a building categorised within element 5 of the BCIS Standard Form of Cost Analysis (SFCA). This includes the following buildings services systems: Plumbing, internal drainage and sanitaryware, heating, ventilation and air conditioning, lifts, escalators and moving walkways, electric power, lighting and controls, and other mechanical and electrical installations such as fire and intruder alarms and emergency lighting.

Services maintenance includes repair and replacement. Associated decoration and cleaning of the elements are measured separately.

Utilities costs include all fuels together with water rates and effluent and drainage charges.

All costs are derived from the Building Cost Information Service (BCIS) database 2010.

Your notes:

Table 35: Annual building services maintenance costs and annual utility costs for different building types (continued)

Building type	Annual maintenance costs for building services systems (£/m²)	Annual utility costs (£/m²)	Comments
Restaurants	20	63	
Secondary schools	13	12	
Shops (non food)	12.5	30	
Sports centres (dry)	15	25	
Sports centres with swimming pool	19	38	
Student residences/halls of residence	11.5	19	
Supermarkets and hypermarkets	16.5	68.5	
Swimming pools	19.5	49	
Universities	17	21.5	
Warehouses/stores	7.5	14	

Comments:

All costs are given for gross internal area (GIA). The costs do not include VAT.

Building services maintenance is considered as the maintenance of those parts of a building categorised within element 5 of the BCIS Standard Form of Cost Analysis (SFCA). This includes the following buildings services systems: Plumbing, internal drainage and sanitaryware, heating, ventilation and air conditioning, lifts, escalators and moving walkways, electric power, lighting and controls, and other mechanical and electrical installations such as fire and intruder alarms and emergency lighting.

Services maintenance includes repair and replacement. Associated decoration and cleaning of the elements are measured separately.

Utilities costs include all fuels together with water rates and effluent and drainage charges.

All costs are derived from the Building Cost Information Service (BCIS) database 2010.

Your notes:

COSTS

Table 36: Life cycle costs of building services over a 30 year period for different building types

Life cycle costs for building services installations (£/m^2 GIA) over a 30 year period							
Building type	**Initial capital cost**	**Maintenance cost**		**Utilities cost**		**Total cost: Capital, maintenance, utilities**	
		Future cash	**Net present value**	**Future cash**	**Net present value**	**Future cash**	**Net present value**
Ambulance stations	312	471	160	1176	441	1959	913
Banks and building societies	510	1089	389	1378	519	2977	1418
Bars, pubs or licensed clubs	290	724	263	1568	589	2582	1142
Clinics, health centres and group practice surgeries	371	531	195	1274	478	2176	1044
Factories	153	498	169	809	303	1460	625
Fire stations	411	628	214	1250	469	2289	1094
Flats/ apartments	196	443	159	809	303	1448	658
Hospitals	669	916	333	1470	552	3055	1554

Comments:

All costs are given for gross internal area in a UK mean location. The costs do not include VAT.

Future cash calculations adjust costs each year to take into account the effects of inflation. In the calculation of life cycle cost based on future cash, the assumed rate of inflation is 3.0%. These figures are used to estimate actual cumulative expenditure over the 30-year period for a chosen building type.

Net present value (NPV) calculations reduce all future costs to their equivalent value at the time of capital cost. In the calculation of life cycle cost based on net present value, the assumed discount rate is 3.5%. These figures are used to compare one building type with another as potential investment or development projects.

Building services includes those parts of a building categorised as element 5 of the BCIS Standard Form of Cost Analysis (SFCA). This includes the following buildings services systems: Plumbing, internal drainage and sanitaryware, heating, ventilation and air conditioning, lifts, escalators and moving walkways, electric power, lighting and controls, and other mechanical and electrical installations such as fire and intruder alarms and emergency lighting.

The life cycle cost of an asset is the total costs of that asset over a defined period of time. It will normally include design, construction, maintenance, operation, occupancy and end of life costs.

Utilities costs include all fuels together with water rates and effluent and drainage charges.

Services maintenance includes repair and replacement. Associated decoration and cleaning of the elements are measured separately.

All costs are derived from the Building Cost Information Service (BCIS) database 2010.

Your notes:

Table 36: Life cycle costs of building services over a 30 year period for different building types (continued)

Life cycle costs for building services installations (£/m² GIA) over a 30 year period							
Building type	**Initial capital cost**	**Maintenance cost**		**Utilities cost**		**Total cost: Capital, maintenance, utilities**	
		Future cash	**Net present value**	**Future cash**	**Net present value**	**Future cash**	**Net present value**
Hotels	431	725	250	1568	589	2724	1270
Libraries	390	803	283	1176	441	2369	1114
Museums	438	695	248	1575	594	2708	1280
Nursing homes and hospices	370	566	196	1176	441	2112	1007
Offices – air conditioned	507	1001	359	2156	809	3664	1675
Offices – non air conditioned	332	699	251	980	368	2011	951
Police stations	605	652	234	1299	487	2556	1116
Primary schools	347	637	225	637	239	1621	811
Restaurants	697	927	331	3101	1169	4725	2197

Comments:

All costs are given for gross internal area in a UK mean location. The costs do not include VAT.

Future cash calculations adjust costs each year to take into account the effects of inflation. In the calculation of life cycle cost based on future cash, the assumed rate of inflation is 3.0%. These figures are used to estimate actual cumulative expenditure over the 30-year period for a chosen building type.

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Services maintenance includes repair and replacement. Associated decoration and cleaning of the elements are measured separately.

All costs are derived from the Building Cost Information Service (BCIS) database 2010.

Your notes:

Table 36: Life cycle costs of building services over a 30 year period for different building types (continued)

Life cycle costs for building services installations (£/m² GIA) over a 30 year period							
Building type	**Initial capital cost**	**Maintenance cost**		**Utilities cost**		**Total cost: Capital, maintenance, utilities**	
		Future cash	**Net present value**	**Future cash**	**Net present value**	**Future cash**	**Net present value**
Secondary schools	331	549	180	588	221	1468	732
Shops (non food)	237	579	207	1477	557	2293	1001
Sports centres (dry)	230	679	247	1225	460	2134	937
Sports centres with swimming pool	550	860	312	1862	699	3272	1561
Student residences/ halls of residence	411	521	180	931	349	1863	940
Supermarkets and hypermarkets	351	765	273	3372	1271	4488	1895
Swimming pools	728	918	339	2401	901	4047	1968
Universities	453	757	268	1054	395	2264	1116
Warehouses/stores	116	393	134	686	257	1195	507

Comments:

All costs are given for gross internal area in a UK mean location. The costs do not include VAT.

Future cash calculations adjust costs each year to take into account the effects of inflation. In the calculation of life cycle cost based on future cash, the assumed rate of inflation is 3.0%. These figures are used to estimate actual cumulative expenditure over the 30-year period for a chosen building type.

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Utilities costs include all fuels together with water rates and effluent and drainage charges.

Services maintenance includes repair and replacement. Associated decoration and cleaning of the elements are measured separately.

All costs are derived from the Building Cost Information Service (BCIS) database 2010.

Your notes:

Table 37: Annual energy cost benchmarks for different building types (£/m² GIA unless otherwise stated)

Building type	Annual energy cost benchmarks (£/m²)			Comments
	Electricity	Gas	Total	Category
Bars, pubs or licensed clubs	11.1	8.8	**19.8**	These type of facilities serve drinks and snacks and have standing and seating areas for customers
Clinics	6.0	5.0	**11.0**	Doctors' surgeries, health clinics, veterinary surgeries and dentists
Cold storage	12.3	2.0	**14.3**	Refrigerated warehouses without public areas
Covered car parks	1.7	0.0	**1.7**	A car park with roof and side walls
Cultural venue	6.0	5.0	**11.0**	Museums, art galleries and libraries
Dry sports and leisure facility	8.1	8.3	**16.3**	Dry sports halls, sports grounds with changing rooms, tennis courts with office and stadiums
Emergency services	6.0	9.8	**15.7**	Police, fire and ambulance stations
Entertainment hall venues	12.8	10.5	**23.3**	Cinemas, theatres, concert halls and bingo halls
Fitness and health centres	13.6	11.0	**24.6**	Fitness, aerobics and dance facilities
General accommodation	5.1	7.5	**12.6**	Boarding houses, university and school hostels and nursing homes
General retail	14.0	0.0	**14.0**	High street stores or local stores, corner shops, takeaways, hairdressers, laundrettes and dry cleaners
High street agency	2	0.0	**11.9**	Bank branches, estate agents, travel agents, Post Offices and betting shops
Hospitals (clinical or research)	7.7	10.5	**18.2**	Acute hospitals, specialist hospitals, teaching hospitals and maternity hospitals
Hotels	8.9	8.3	**17.2**	All types of hotels
Houses	415.8	648.0	**1063.8**	These figures represent average total annual energy costs per house
Laboratory or operating theatres	13.6	4.0	**17.6**	Research chemical laboratories and hospital operating theatres
Large food stores	34.0	2.6	**36.6**	Supermarkets and freezer centres

Comments:

Values for energy consumption are for delivered energy used per unit of floor area. For information about energy consumption and CO_2 emissions benchmarks, please refer to Table 28.

Areas in m² are gross floor areas, measured as RICS gross internal area (GIA).

The unit costs of commercial electricity and gas are: 8.5 p/kWh for electricity and 2.5 p/kWh for gas. These figures are from information provided by Department of Energy and Climate Change (DECC) publication Quarterly Energy Prices, December 2010 and utilities companies, cross-referenced with feedback from the BSRIA O&M benchmarking club.

The unit costs of domestic electricity and gas are: 12.6 p/kWh for electricity and 3.6 p/kWh for gas. These figures are from information provided by the Department of Energy and Climate Change (DECC) publication Quarterly Energy Prices, December 2010 and utilities companies.

Your notes:

COSTS

Table 37: Annual energy cost benchmarks for different building types (continued)

Building type	Annual energy cost benchmarks (£/m²)			Comments
	Electricity	Gas	Total	Category
Large non-food retail	6.0	4.3	**10.2**	Retail warehouses, department stores hypermarkets and large showrooms
Long-term residential	5.5	10.5	**16.0**	Residential homes, long-stay hospitals, detention centres and prisons
Offices	8.1	3.0	**11.1**	This is a general office benchmark for all offices, whether air conditioned or not
Public buildings with light usage	1.7	2.6	**4.3**	Churches, club houses and village halls
Public waiting or circulation	2.6	3.0	**5.6**	Bus stations, local train stations and shopping centre malls
Restaurants	7.7	9.3	**16.9**	Cafes, restaurants, canteens, refectories and mess halls
Schools and seasonal public buildings	3.4	3.8	**7.2**	Primary and secondary schools, nurseries, crèches, youth centres and community centres
Small food stores	26.4	0.0	**26.4**	Food stores, greengrocers, fish shops, butchers and delicatessens
Storage facility	3.0	4.0	**7.0**	Distribution warehouses without public areas and local authority depots
Swimming pool centres	20.8	28.3	**49.1**	A swimming pool hall, changing and ancillary areas, without further sports facilities
Terminals	6.4	5.0	**11.4**	Large train stations and airport terminals
University campus	6.8	6.0	**12.8**	A typical campus mix for further and higher education, universities and colleges
Workshops	3.0	4.5	**7.5**	Facilities with industrial heating and lighting standards, such as vehicle repair workshops

Comments:

Values for energy consumption are for delivered energy used per unit of floor area. For information about energy consumption and CO_2 emissions benchmarks, please refer to Table 28.

Areas in m^2 are gross floor areas, measured as RICS gross internal area (GIA).

The unit costs of commercial electricity and gas are: 8.5 p/kWh for electricity and 2.5 p/kWh for gas. These figures are from information provided by Department of Energy and Climate Change (DECC) publication Quarterly Energy Prices, December 2010 and utilities companies, cross-referenced with feedback from the BSRIA O&M benchmarking club.

The unit costs of domestic electricity and gas are: 12.6 p/kWh for electricity and 3.6 p/kWh for gas. These figures are from information provided by the Department of Energy and Climate Change (DECC) publication Quarterly Energy Prices, December 2010 and utilities companies.

Your notes:

COSTS

Glossary of terms

Term	Description	Ref
Boiler efficiency (%)	$$\frac{\text{The energy delivered by the water as it leaves the boiler to supply the heat emitters}}{\text{The energy (based on gross calorific value) in the fuel delivered to the boiler}}$$ Seasonal boiler efficiency (%) is a weighted average of the efficiencies of a boiler at 15%, 30% and 100% of the boiler output	78
Building services	A collective term for the systems required for the safe, comfortable and efficient operation of the built environment. This includes energy supply and distribution, heating, air-conditioning, ventilation, refrigeration, lighting, lifts, escalators, ICT networks, security, alarms, fire detection and fire protection	82
Category A fit-out	Category A fit-out works extend central services out on to floor plates and provide a background for Category B works. Category A works comprise services, life safety elements and basic fittings and finishes for the operation of lettable work space, including: • Suspended ceilings • Raised floors and skirtings • Cooling and heating systems • Office ventilation systems • Open plan base lighting solution • Life safety systems, such as fire alarms, sprinklers and emergency lighting • Distribution boards • Office carpet and floor boxes • Blinds • Basic statutory signage • Basic security systems and wireways	6
Category B fit-out	Category B works, or bespoke fit-out, may include: • Suspended ceiling upgrades • Special area fitting out, such as auditoria, kitchens, restaurants and meeting rooms • Upgrade to core finishes • Internal partitioning • Additional floor finishes • Mechanical, electrical and lighting upgrades • Installation of below-floor and overhead/drop-down power distribution • IT and telecommunications installations and distribution (data cabling) • Enhanced WC provision, if required • Occupier standby generation and uninterruptible power supplies (UPS) • Adaptation of life safety systems • Decoration and branding • Fixtures and fittings • Furniture • Security installation enhancements • Audio-visual installations • Corporate and way-finding signage • Vertical transportation enhancements • Feature staircase links between floors	6

Term	Description	Ref
Coefficient of performance (CoP)	A measure of the efficiency of heat pumps: Heating CoP = heat output/power input	78
Energy efficiency ratio (EER)	Chiller EER = $\frac{\text{The cooling energy delivered into the cooling system}}{\text{The energy input to the cooling plant, as determined by } \textit{BS EN 14511}}$	78
Freeboard	The vertical distance in a water tank between the maximum water level and the top of the tank	
Gross internal area (GIA)	The area of a building measured to the internal face of the perimeter walls at each floor level.	83
Gross external area (GEA)	The area of a building measured to the external face of the perimeter walls at each floor level.	83
Lighting efficacy	The amount of light (luminous flux) produced by a light bulb or other light source, usually measured in lumens, as a ratio of the amount of power consumed to produce it, usually measured in watts	82
Net internal area (NIA)	The usable area of space within a building measured to the internal face of the perimeter walls at each floor level. The rules of measurement of NIA are defined in the RICS new rules of measurement.	83
Seasonal performance factor (SPF)	The operating performance of an electric heat pump over the season. It is the ratio of the heat delivered and the total energy supplied over the season	78
Shell and core	In a shell and core development: • The entrance hall, staircases, common/circulation areas, toilets, vertical transportation and cores will be fully furnished • Base build services plant and equipment will be terminated at breakout points to each floor • Life safety infrastructure, such as sprinkle pumps, tanks, risers, main fire alarm panel and emergency standby generators will be installed • The finishes to the office face of core walls and finishes to the inside face of external walls and to columns should be of a level of finish ready to receive direct decoration	6
Specific fan power (SFP) of an air distribution system	$\frac{\text{The sum of the design total circuit-watts, of the fans that supply and exhaust air (including losses through switchgear and controls such as inverters)}}{\text{The design air flowrate for the system}}$	78
Valve authority	$\frac{\Delta P_1}{\Delta P_1 + \Delta P_2}$ Where: ΔP_1 = Pressure drop across a fully open control valve ΔP_2 = Pressure drop across the remainder of the circuit $\Delta P_1 + \Delta P_2$ = Pressure drop across the whole circuit	

Your notes:

International system of units (SI units)

Table 38: SI base units

SI unit base quantity	SI base unit name	SI base unit symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Your notes:

Table 39: Examples of SI derived units

SI derived unit quantity	SI derived unit name	SI derived unit symbol
area	square metre	m^2
acceleration	metre per second squared	m/s^2
angular acceleration	radian per second squared	rad/s^2
angular velocity	radian per second	rad/s
current density	ampere per square metre	A/m^2
dynamic viscosity	pascal second	Pa.s
electric charge density	coulomb per cubic metre	C/m^3
electric field strength	volt per metre	V/m
electric flux density	coulomb per square metre	C/m^2
electric resistance	ohm	Ω
electrical potential difference	volt	V
energy	joule	J
energy density	joule per cubic metre	J/m^3
frequency	hertz	Hz

Table 39: Examples of SI derived units (continued)

SI derived unit quantity	SI derived unit name	SI derived unit symbol
force	newton	N
heat capacity, entropy	joule per kelvin	J/K
heat flux density, irradiance	watt per square metre	W/m^2
luminance	candela per square metre	cd/m^2
luminous flux	lumen	lm
magnetic field strength	ampere per metre	A/m
mass density	kilogram per cubic metre	kg/m^3
moment of force	newton metre	N.m
power	watt	w
pressure	pascal	Pa
specific energy	joule per kilogram	J/kg
specific heat capacity, specific entropy	joule per kilogram kelvin	J/(kg.K)
specific volume	cubic metre per kilogram	m^3/kg
speed, velocity	metre per second	m/s
surface tension	newton per metre	N/m
thermal conductivity	watt per metre kelvin	W/(m.K)
volume	cubic metre	m^3

Your notes:

Conversion factors

Table 40: Conversion factors from imperial to SI units

Unit	Imperial	SI (Exact)	SI (Approximate)
Length	1 inch	25.4 mm	25 mm
	1 foot	0.3048 m	0.3 m
	3.28 feet	1 m	
	1 yard	0.9144 m	0.9 m
	1 mile	1.609 km	1.6 km
Area	1 sq. in	645.2 mm^2	650 mm^2
	1 sq. ft	0.093 m^2	0.1 m^2
	10.77 sq. ft.	1 m^2	
	1 sq. yd	0.836 m^2	0.84 m^2
Volume	1 cu. in	16.39 cm^3	16 cm^3
	1 cu ft	28.32 litre	28 litre
	35.32 cu ft	1m^3	
	1 pint	0.568 litre	0.6 litre
	1 gallon	4.546 litre	4.5 litre
Mass	1 pound	0.4536 kg	0.45 kg
	2.205 pounds	1 kg	
	1 ton	1.016 tonne	1 tonne
Density	1 lb/cu.ft	16.02 kg/m^3	16 kg/m^3
Volume flow rate	1 gall/minute (g.p.m)	0.076 litre/s	0.08 litre/s
	1 cu.ft/minute (c.f.m)	0.472 litre/s	0.5 litre/s
Velocity	1 foot/minute	0.0051 m/s	0.005 m/s
	197 feet/minute	1.0 m/s	
	1 mile/hour	0.447 m/s	0.5 m/s
Heat	1 British thermal unit (Btu)	1.055 kJ	1 kJ
	1 'Old' therm (100 000 Btu)	105.5 MJ	100 MJ
Heat flow rate	1 Btu/hour	0.2931 W	0.3 W
	1 horsepower	745.7 W	750 W
	1 tonne refrigeration (12 000 Btu/hour)	3.517 kW	3.5 kW
Intensity of heat flow rate	1 Btu/hour sq. ft	3.155 W/m2	3 W/m2
Transmittance (U value)	1 Btu/hour sq. ft oF	5.67 W/m2K	6 W/m2K
Conductivity (k value)	1 Btu inch/hour sq. ft oF	0.1442 W/mK	0.15 W/mK

Table 40: Conversion factors from imperial to SI units (continued)

Unit	Imperial	SI (Exact)	SI (Approximate)
Calorific value	1 Btu/lb	2.326 kJ/kg	2.5 kJ/kg
	1 Btu/cu.ft	37.26 kJ/m^3	37 kJ/m^3
Pressure	1 pound force per sq. in (lb f/sq. in or Psi)	6895 Pa or 68.95 mbar	7000 Pa 70 mbar
	1 inch w.g. (at 4°C)	249.1 Pa or 2.491 mbar	250 Pa or 2.5 mbar
	1 inch mercury (at 0°C)	3386 Pa 33.86 mbar	3400 Pa 34 mbar
	1 atmosphere (standard)	101 325 Pa	1 bar
Pressure drop	1 inch w.g/100 ft	8.176 Pa/m	8 Pa/m
Latent heat of fusion of ice	144 Btu/lb	334kJ/kg	
Steam flow rate	1 lb/hour	0.126 g/s	
Illumination	1 footcandle	10.76 lux	11 lux

Your notes:

Table 41 Conversion factors for energy units

From/to (multiply by)	GJ	kWh	therm	toe	kcal
Gigajoule (GJ)	1	277.78	9.47817	0.02388	238,903
Kilowatt hour(kWh)	0.0036	1	0.03412	0.00009	860.05
Therm	0.10551	29.307	1	0.00252	25,206
Tonne oil equivalent (toe)	41.868	11,630	396.83	1	10,002,389
Kilocalorie (kcal)	0.000004186	0.0011627	0.000039674	0.000000100	1

Your notes:

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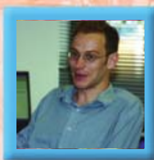

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