MITSUBISHI ELECTRIC

Mitsubishi Electric Guide to the Updated Building Regulations 2021

Information Guide 77

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Mitsubishi Electric Guide to the Updated Building Regulations 2021

This is an independent guide produced by Mitsubishi Electric to enhance the knowledge of its customers and provide a view of the key issues facing our industry today.

This guide accompanies a series of seminars, all of which are CPD certified.

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Introduction

In 2020, the UK government set out a roadmap for the country to achieve net zero greenhouse gas emissions by 2050. One vital step on this road is that our domestic and commercial buildings become more energy efficient and adopt low-carbon technologies for space heating and hot water.

At the same time, the importance of wellbeing in our homes and other buildings has grown in both the public and political arenas. As a result, the government has also been looking into improving indoor air quality and tackling overheating, particularly in modern housing.

In December 2021, the government released updates to Approved Documents Part L (energy efficiency) and Part F (ventilation) to further its net zero agenda. It also introduced a new Part O which deals with the issue of overheating in modern dwellings.

Importantly, these 2021 updates are 'interim'. That is, they are intended to raise standards in the design and construction of buildings in preparation for new legislation which is due in 2025. It is expected that when they are introduced, the Future Buildings Standard and Future Homes Standard will set higher targets for energy efficiency and adoption of low-carbon technologies.

This Guide will look at the main areas of the updated Approved Documents that impact the design, installation and operation of heating, ventilation and air conditioning systems. It will also consider the implications for the adoption of low-carbon technologies, and techniques to achieve this for homes and other buildings.

Regulations around the United Kingdom

Parts L, F and O of the Building Regulations apply in England and Wales. Scotland and Northern Ireland have their own regulations dealing with building energy use and carbon emissions. Wales is also taking its own approach to delivering on some targets.

Scotland

At the end of 2021, the Scottish government closed a consultation on Section 6 (Energy) of the Scottish Building Standards. Scotland has been ahead of England in targeting emissions cuts, aiming for net zero by 2045. The proposed updates for carbon reduction targets for Scottish dwellings is either 32% or 52% - both higher than those required in Part L. For non-dwellings the proposed carbon reduction targets are either 16% or 25%. Other proposals include air tightness testing for all new homes, along with higher U-values.

Scotland has already introduced its Heat in Buildings Strategy document which highlights the use of electric heat pumps, heat networks and hydrogen as vital for reducing the country's emissions. In February 2022, there was a first meeting of Scotland's new Green Heat Finance Taskforce, which will oversee the government's capital funding of £1.8 billion and also coordinate with the private sector to develop other financing and delivery mechanisms.

Also, in February 2022 the Scottish government set aside a £300 million fund to develop zero emission heat networks. The fund is open to small and medium sized registered social landlords, who can apply for financial support for zero emissions heating within their housing stock.

The Scottish government will publish its response to the Building Standards consultation in Spring 2022. This will also include thoughts on consequential changes to ventilation provision arising from the improved energy standards, with a view to mitigating overheating risk in new dwellings. One key goal for the future is that by 2024, Scotland will introduce a *New Build Heat Standard* which will set minimum standards for new building work.

Northern Ireland

Northern Ireland is expected to contribute its share of emissions cuts to the Net Zero 2050 goal. A Climate Change Act for Northern Ireland is currently being progressed and remains a priority for delivery during the current Assembly mandate by March 2022. The Northern Ireland Executive is also developing a multi-decade Green Growth Strategy which will be delivered through a series of Climate Action Plans. These will set out sector-specific greenhouse gas emissions targets.

Wales

In March 2021, the Welsh Senedd passed several regulations to set a Net Zero Wales 2050 target. Before the COP26 meeting, Wales published a document: *Net Zero Wales*. This comprehensive document sets out a broad range of policies for reducing Wales' carbon emissions. For the built environment, targets include setting 'demanding' energy efficiency targets for new-build and existing properties, with the social housing sector leading the way. Low carbon heat is also expected to help phase out reliance on fossil fuel heat sources. For example, the Welsh Senedd states that by 2025 it aims to increase the amount of heat that is electrified by 3% and by 2025 all affordable homes built in Wales will be 'built to net zero carbon standards'. Furthermore, around 148,000 existing homes around Wales will receive retrofit measures to reduce heat loss.

The Welsh Senedd has also stated that it will make further changes to energy efficiency requirements in the Building Regulations in 2025, raising the bar to require new homes produce a minimum of 75% less carbon emissions than those built to 2021 requirements. For non-dwellings, Wales is proposing the launch of a Property Energy Efficiency Rating Scheme (PEERS) which will collect data on energy use from commercial and industrial buildings so that building owners can see how their performance compares with industry averages. This would be a scheme for Wales and England, and a mandatory scheme for offices could be launched into the office sector in 2023 – with roll out to other commercial buildings from 2024.

1. Background
The road to Net Zero 2050

The December 2021 updates to the Building Regulations are critical to the UK government goal of achieving net zero carbon emissions by 2050.

Our homes and other buildings make a significant contribution to UK carbon emission by using electrical energy which may be produced by fossil-fuel powered power stations, or through the direct use of natural gas-fuelled boilers for space heating and hot water.

Decarbonising our heating and hot water production in buildings will be an important step. The UK has been relatively successful in lowering the carbon footprint of its electricity grid in the past decade, investing in the construction of wind farms on land and offshore and reducing its reliance on coal.

The government's report *Powering our Net Zero Future*[1] published in December 2020, highlights that from April to June 2020, there were 67 days of coal-free electricity production in the UK. In 2019, greenhouse gas emissions ($MtCO_2e$) from electricity generation were 13% lower than 2018 levels - 72% lower than 1990 levels. The government *Energy Trends Report*[2] for December 2021 shows that renewables share of electricity generation was 35.9%.

With our greener electricity grid in mind, government aims to encourage adoption of low-carbon electricity for heating in homes and other buildings. Electric heat pumps are viewed as a key technology to meet this challenge, along with systems such as heat networks and, to a smaller extent, hydrogen.

For more on the UK Net Zero 2050 Roadmap, see our CPD Guide:

https://library.mitsubishielectric.co.uk/pdf/book/Issue_75_UK_Net_Zero_2050_Roadmap_and_the_Built_Environment#page-1

Meanwhile, the issue of air quality in our homes and workplaces has also risen in importance. This is not only linked to keeping indoor spaces virus-free, but also to preventing the ingress of outdoor pollutants and diluting indoor pollutants. Indoor air quality is not simply about delivering a baseline of health, but also about creating indoor environments that are comfortable and productive for occupants.

For more on Indoor Air Quality see our CPD Guide:

https://library.mitsubishielectric.co.uk/pdf/book/Indoor_Air_Quality#page-1

2. Overview of the updated Building Regulations

The documents introduced in December 2021 will be in force from 15th June 2022. They are:

Approved Document L (Conservation of energy)
Volume 1: Dwellings and Volume 2: Buildings other than Dwellings

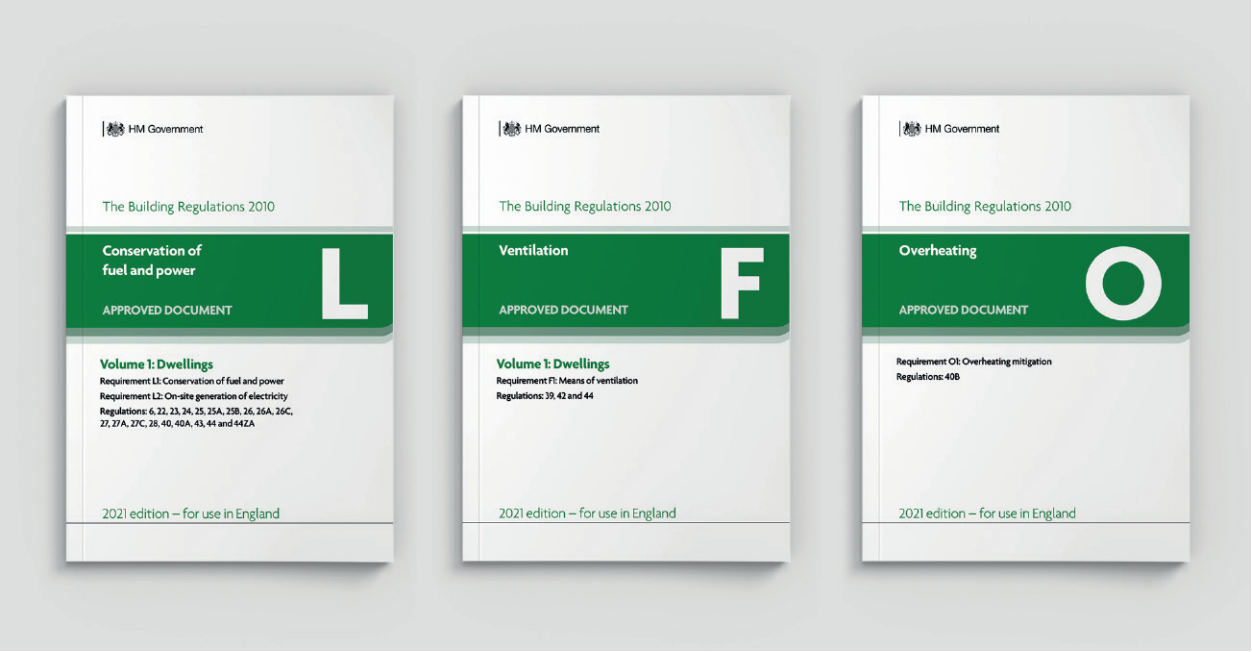
Approved Document F (Ventilation)
Volume 1: Dwellings and Volume 2: Buildings other than Dwellings

Approved Document O (Overheating)

The overarching aim of the government in updating the Building Regulations is to drive the construction and property sectors to deliver lower-carbon energy efficient homes and other buildings that make greater use of green energy and decarbonised heating.

In addition, government has set out to mitigate against the problem of overheating with the introduction of Part O (Overheating). It applies in new houses, flats and other residential buildings such as care homes for the elderly. As regulations required more air-tight and insulated residential buildings (to achieve greater energy efficiency) this has caused overheating, exacerbated by poor ventilation and our increasingly hot UK summers.

The next sections of this Guide highlight some of the key changes under the updated Building Regulations for homes and non-dwellings.



3. Updates to the Building Regulations - Part L 2021: Volume 1: Dwellings

New homes

Under Part L of the Building Regulations, a new dwelling must achieve a 'minimum standard of total energy performance'. This is tested by comparing the dwelling's performance against that of a 'notional' dwelling of the same size and shape.

The government's Standard Assessment Procedure was updated in early 2022 to accompany the new Part L and version SAP10.2 will be in force from summer 2022[3]. SAP sets out the full and detailed properties for the notional dwelling. The notional dwelling has standardised properties for elements such as fabric and services (space heating, hot water production, lighting etc). The total energy performance of this notional dwelling is described using three key metrics shown here:

Dwelling primary energy rate (kWh_{PE}/m^2 per year)

The dwelling primary energy rate (DPER) represents the annual primary energy use of the building per m^2 of floor area for space heating, water heating, ventilation and lighting. It is adjusted for any renewable primary energy that is generated on the site of the dwelling.

Dwelling emission rate ($kgCO_2/m^2$ per year)

The dwelling emission rate (DER) is equal to the amount of CO_2 emissions per m^2 of floor area for space heating, water heating, ventilation and lighting. It is adjusted for any emissions saved by energy generation technologies. One of the most significant changes in Part L 2021 and SAP 10.2 is that they set a target dwelling emission rate that is 30% lower than the requirements of Part L 2016.

Dwelling fabric energy efficiency (kWh/m^2 per year)

Fabric energy efficiency refers to the space heating and cooling requirements per square metre of floor area.

The performance of the notional dwelling in terms of these three factors sets the 'Target rates' for the actual dwelling. It must meet these performance standards to comply with the Building Regulations. The comparison between the actual and notional dwellings must be carried out both at the design stage and once construction is complete. The new dwelling should comply at both stages in order for Building Control to sign off the work.

The 2021 notional building sets higher standards for fabric efficiencies in terms of U-values for floors, walls, ceilings and windows. It also changes the requirement for airtightness from $5m^3/(h.m^2)$ @50pa to $8m^3/(h.m^2)$ @50pa – demonstrating a focus on indoor air quality over energy efficiency for new homes.

SAP 10.2 also includes the latest carbon factors for fuels such as gas and electricity. As the UK has increased its use of renewable generation, the allocated emissions of CO_2 (equivalent) per kWh for electricity have been reduced from 0.398 to 0.136. The difference means that use of fossil fuels such as gas become less attractive option for new home designs, and alternatives such as electric heat pumps become more attractive.

The regulations state that: “Where a (dwelling) is erected it must be a nearly zero-energy building”. The definition of “nearly zero-energy” is given as a dwelling that meets the target emission rate and that an analysis has been made of the technical, environmental feasibility of using, “high-efficiency alternative systems which include decentralised energy supply systems based on energy from renewable sources”.

The Regulations highlight the approaches below as suitable high-efficiency systems:

- Decentralised energy supply systems based on energy from renewable sources
- Cogeneration
- District or block heating or cooling, particularly where it is based entirely or partially on energy from renewable sources
- Heat pumps

Part L 2021 states that, as long as a new dwelling meets the requirements for fabric energy efficiency, it can meet the targets for primary energy and emissions using any combination of the following:

- Fabric efficiency
- Efficient building services
- Low and zero carbon technologies integrated in an ‘appropriate mix’

This focus on fabric efficiency reflects the importance of reducing the need for heating in our homes to make the switch to electric heat pumps without placing an unmanageable burden onto the electricity grid.

This requirement is also supported by the updated rules on airtightness testing. Previous rules required testing on a sample of new dwellings; Part L 2021 has removed that option so that all homes on a development must be tested for airtightness.

Clear guidance is also given on sizing heating systems in new homes, with 55ºC set as the maximum system temperature. This rule applies where a wet heating system is either installed in a new dwelling or fully replaced (i.e., with new heating appliance, emitters and pipework) in an older home.

Where it is not possible to operate the system at 55ºC, the space heating system must be designed to the lowest temperature possible that will still meet the heating needs of the dwelling.

Another point raised in Part L for new dwellings is a requirement to limit heat gains and losses. A newly introduced Part O of the Building Regulations (covered in more detail later in this Guide) focuses on reducing overheating in dwellings as a response to the impact of climate change on the UK's summer temperatures, particularly in urban areas. However, Part L also states that reasonable provision must be taken to limit heat gains and losses:

- Through thermal elements and other parts of the building fabric
- And from pipes ducts and vessels used for space heating, space cooling and hot water services.

The regulations require insulation of primary and secondary hot water and heating pipework. And for district heat networks in particular, pipework must be insulated to meet standard BS EN 253 for pre-insulated pipes (or an equivalent performance for conventionally insulated pipes). Where pipework is above ground, the performance of pipe insulation should be at least as high as the insulating performance of the pipework in the buried part of the system.

An important aspect of the Building Regulations 2021 is that the government has recognised the importance of closing the performance gap between buildings 'as designed' and buildings as they operate. One way the 2021 Regulations address this for new homes is to require BREL (Building Regulations England Part L) compliance reports at both the design and the completion stages.

The BREL completion stage report must document the calculations for the dwelling primary efficiency rate, emission rate and fabric energy efficiency rate.

The report must also include photographic evidence of each dwelling on a development, showing details including building services associated with space heating, hot water, ventilation and any low or zero-carbon technology used within or on the building. The Regulation states that: "Photographs should be digital and of sufficient quality and high enough resolution to allow a qualitative audit of the subject detail".

Existing dwellings - improvements

Part L 2021 does not require existing homes to be brought up to the new standards. However, where changes are made, they must meet the new Regulations for U-values for doors, walls, windows etc.

As previously noted, when a wet heating system is fully replaced in a home, it must be designed to operate at 55ºC. If this isn't possible, it must operate at the lowest temperature possible while meeting the heating needs of the dwelling.

If a dwelling is extended, SAP must be used to calculate the dwelling primary energy rate, emission rate and fabric energy efficiency. These factors must not exceed targets set, by using the notional dwelling plus a notional extension which is the same size and shape as the proposed extension. A conservatory or porch must have thermal separation from the existing dwelling, otherwise they will be treated as an extension for compliance purposes.

Part L 2021: Volume 2: Buildings other than dwellings

New buildings

Buildings (other than dwellings) demonstrate compliance with Part L by meeting targets established with a notional building that is the same size and shape as the actual building. The full detail of the notional non-dwelling is set out using the National Calculation Methodology (NCM) Modelling Guide[4]. This model is applied to a project using government-approved software such as the Simplified Building Energy Model (SBEM).

The energy performance of the notional building establishes two main targets for the energy performance of the actual building. To comply with the Regulations, a building must meet both targets:

- Target primary energy rate in kWh/m^2 per year.
- Target emission rate in $kgCO_2/m^2$ per year. Part L 2021 sets a target emission rate for new buildings that is 27% lower than the requirements of Part L 2016.

In line with the regulations for dwellings, Part L 2021 states: “Where a building is erected it must be a nearly zero-energy building”. The definition of “nearly zero-energy” is a building that meets the target emission rate, and where an analysis has been made of the technical, environmental feasibility of using, ‘high-efficiency alternative systems which include decentralised energy supply systems based on energy from renewable sources’.

Part L highlights the approaches below as suitable high-efficiency comfort heating and cooling systems for buildings:

- Decentralised energy supply systems based on energy from renewable sources
- Cogeneration
- District or block heating or cooling, particularly where it is based entirely or partially on energy from renewable sources
- Heat pumps

Software such as SBEM is used to calculate the performance of the actual building against the targets set by a notional building. Calculations must be shown for the design stage and as-built stage. Again, this reflects the government’s determination to close the performance gap for buildings in relation to energy use.

When construction is complete, the calculations for primary energy and emission rate must include any changes made to specifications during construction as well as the measured air permeability of the building. Under Part L 2021, building specification can change during construction - but the actual building must still meet the targets.

The Regulations include an uplift in requirements for fabric performance including lower U-values for fabric elements as well as requirements to mitigate against thermal bridging, which must be addressed at the design stage. Permitted air leakage is 8.0$m^3/(m^3.h)$ @50Pa

Minimum performance standards for fabric elements such as walls, roof, floor and windows are not dissimilar to those currently required, but the targets in the notional building for any project will depend on the use of the building and the type of heating system installed. Part L 2021 for non-dwellings states that if the building satisfies these minimum fabric standards, then the target primary energy rate and emission rate can be met by a combination of:

- Fabric energy efficiency
- Efficient building services
- Low and zero-carbon technologies integrated in an appropriate mix

Regarding control of services, Part L 2021 states (section 6.35) that controls for comfort cooling systems should meet BS EN 15232 B and C. These are designed 'Standard BACS' (building automation and control systems) in the Standard and are essentially environment zone controls for temperature or ventilation rates.

However, for building automation and control system specification (section 6.72) Part L 2021 states that controls should achieve the following:

- Fully comply with BS EN ISO 16484 (Building automation and control systems)
- Continuously monitor, log, analyse and allow for adjusting energy use
- Benchmark the building's energy efficiency
- Allow communication with connected fixed building services and other appliances in the building - and it should be "interoperable with fixed building services across different types of proprietary technologies, devices and manufacturers".

If a building automation control system, or building energy management system (BEMS) as it is more commonly known, meets these criteria then under BS EN 15232 (Energy performance of buildings: impact of building automation, controls and building management) it would achieve classification A.

Existing non-dwellings

A 'consequential improvements' rule is triggered in buildings with a floor area greater than 1000m^2. This applies if the proposed extension is both greater than 100m^2 and more than 25% of the total useful floor area of the building.

In addition, the installation of new fixed building services or an increase to the capacity of fixed building services will trigger the same rule. In these cases, consequential improvements must be carried out in the building to bring it up to Part L 2021 standards if these improvements are: "technically, functionally and economically feasible".

The regulation states that the value of the works for consequential improvements must not be less than 10% of the value of the principal works. In the case of installing new or extending the capacity of fixed building services, the consequential improvements should include making energy efficiency improvements to the fixed building services to meet the requirements of Part L 2021. Again, these improvements must be technically, functionally and economically feasible.

Table D1 of Part L highlights the acceptable energy efficiency measures which should 'usually' be installed when consequential improvements are required. They include upgrading heating systems, cooling systems or air-handling systems that are more than 15 years old, by providing new plant or improved controls.

Equipment efficiencies

The update to Part L also includes some important changes to requirements for building services equipment, specifically how energy efficiencies are measured and demonstrated. This includes a minimum COP for heat pumps in new and existing buildings as shown below:

MINIMUM COP FOR HEAT PUMPS IN NEW AND EXISTING BUILDINGS	
Heat pump type	Minimum COP (at rating conditions in BS EN 14511-2)
All types (except air-to-air with output ≤12kW, absorption and gas-engine) for space heating	2.5
All types (except absorption and gas-engine) for domestic hot water heating	2.0
Absorption	0.5
Gas-engine	1.0

(Table 6.8 from Approved Document L2 2021, page 50)

Comfort cooling equipment (Section 6.33) must also meet minimum seasonal energy efficiency ratio (SEER) requirements (set out in Table 6.6). BS EN 14825 is the standard that must be used to calculate SEER and SCOP (seasonal coefficient of performance).

Unfortunately, at the time of writing this Guide, there is ambiguity within the document regarding the inclusion of air conditioning indoor units in the SEER calculation. BS EN 14825 does not include the power consumption of the connected indoor units when determining the SEER of the outdoor unit. There is no official recognised calculation for SEER that includes indoor unit power consumption.

Mitsubishi Electric wants to act in the spirit of the legislation and include indoor unit power consumption in our SEER calculations. This can be achieved by using equation 6.7 from the Approved Document (page 48) and correcting for indoor power consumption. In addition to this, we must reference the minimum full system SEER of 4.4 for the notional building, stated in the *National Calculation Methodology (NCM) Modelling Guide (for buildings other than dwellings) 2021*.

MINIMUM SEASONAL ENERGY EFFICIENCY RATIO (SEER)[1] FOR COMFORT COOLING		
Type		Cooling unit SEER
Packaged air conditioners	Single-duct type	3.0
	Other types	3.0
Split and multi-split air conditioners >12kW		5.0
Split and multi-split air conditioners ≤12kW		5.0
Variable refrigerant flow/volume (VRF/VRV) systems[2]		5.0
Water-to-water chillers <400kW		5.0
Water-to-water chillers 400–1500kW		6.0
Water-to-water chillers ≥1500kW		6.5
Vapour compression cycle chillers, air-cooled <400kW		4.0
Vapour compression cycle chillers, air-cooled ≥400kW		4.5
Absorption cycle chillers[3]		EER 0.7
Gas-engine-driven variable refrigerant flow		1.6

(Table 6.6 from Approved Document L2 2021, page 47)

NOTES:
1. Seasonal space cooling energy efficiency as defined by the Ecodesign Commission Regulation No. 206/2012 Annex II, at average rating conditions where applicable.
2. For VRV/VRF systems, SEER is for the full system including indoor units.
3. For absorption chillers an EER (energy efficiency ratio) has been used instead. This should be determined according to **BS EN 14511-2.**

In addition to performance requirements for equipment, new non-dwellings over 1000m^2 must provide the building owner with a forecast of 'the actual energy use of the building'. This must be in kWh per year and broken down by fuel type. The forecast is expected to be detailed, including all metered energy uses and unregulated loads. Part L 2021 cites CIBSE's TM54 (*Evaluating operational energy use at the design stage*[5]) as an example forecasting methodology.

And in existing buildings, when a new or replacement system (for example a heating system including heating appliance, pipework and emitters) is installed, then the energy performance of that new system must be assessed. Again, the results of the test must be handed to the owner. There are several methods that can be used to document test results, including a new energy performance certificate; or an assessment produced in accordance with Ecodesign and associated energy labelling requirements.

Part F 2021:
Volume 1: Dwellings

New dwellings

The new Part F of the Building Regulations reflects a growing understanding of the impact of indoor air quality on occupant health. The updated regulations state that ventilation must minimise the entry of external pollutants. However, any means of ventilation applied in a dwelling must also:

- Produce low levels of noise
- Offer easy access for maintenance
- Provide protection from cold draughts

There are now higher minimum whole-dwelling ventilation rates, depending on the number of bedrooms in a dwelling.

VENTILATION RATES		
No. of Bedrooms	Part F 2013 - litres per second l/s	Part F 2021 - litres per second l/s
1	13	19
2	17	25
3	21	31
4	25	37
5	29	43

(Part F 2021: Volume 1, figures from Table 1.3, page 10; Part F 2013 figures from Table 5.1a, page 19)

For dwellings with mechanical ventilation with heat recovery (MVHR), each habitable room should have mechanical supply ventilation. The minimum total continuous rate of MVHR is the same as the 2021 figures for whole-dwelling ventilation rates shown above.

The requirement for purge ventilation in each habitable room remains at a minimum four air changes per hour directly to the outside. However, the new Part F notes (1.27) that to comply with the new Part O on Overheating, it is likely that higher ventilation rates may be required.

Existing dwellings

When work is carried out on an existing dwelling, such as replacing a window or door or carrying work to improve energy efficiency the ventilation rate must be improved to Part F 2021 standards - or not be ‘less satisfactory’ than when the work was carried out.

This is an important point since many existing buildings rely on 'infiltration' rather than purposeful ventilation. Adding energy efficiency measures such as better insulation may well have a negative impact on ventilation in the home. Part F 2021 therefore includes a list of 'Energy efficiency measures' that should be used as a checklist to identify types of work most likely to affect the ventilation in a dwelling. This can be found at Table 3.1 of the Approved Document shown here.

ENERGY EFFICIENCY MEASURES	
	Category of measure
Roof insulation	
a. Renewing loft insulation, including effective edge sealing at junctions and penetrations	Minor
b. Loft conversions or works that include changing a cold loft (insulation at ceiling level) to a warm loft (insulation at roof level)	Minor
Wall insulation	
c. Installing cavity wall insulation to any external wall	Minor
d. Installing external or internal wall insulation to less than or equal to 50% of the external wall area	Minor
e. Installing external or internal wall insulation to more than 50% of the external wall area	Major
Replacement of windows and doors[1]	
f. Replacing less than or equal to 30% of the total existing windows or door units	Minor
g. Replacing more than 30% of the total existing windows or door units	Major
Draught-proofing (other than openings)[2]	
h. Replacing a loft hatch with a sealed/insulated unit	Minor
i. Sealing around structural or service penetrations through walls, floors or ceiling/roof	Minor
j. Sealing and/or insulating a suspended ground floor	Major
k. Removing chimney or providing another means of sealing over chimney, internally or externally	Major

(Table 3.1 Energy efficiency measures from Approved Document Part F, page 23)

All installations of mechanical extract ventilation and installations of new background ventilators must be supplied with guidance on why ventilation is important for the health of buildings and their occupants.

NOTES:
1. If the energy efficiency works involve only replacing windows, then the guidance in paragraphs 3.14 to 3.16 may be followed as an alternative means of demonstrating compliance.
2. Draught-proofing measures might not, on their own, constitute building work. This work may be controllable under the Building Regulations if carried out as part of other building work.

Part F 2021 Volume 2: Buildings other than dwellings

New non-dwellings

As with dwellings, the emphasis in the updated Part F is on creating high standards for indoor air quality to support occupant health in non-dwellings. There are new standards on minimising the intake of external air pollutants if they exceed limits set out in Part F (see table 2.1 from the Approved Document) - or if the building is located close to sources of pollution. This might include buildings close to busy roads; near combustion plant such as heating systems or discharges from industrial processes.

TABLE 2.1 - LIMITING VALUES FROM SCHEDULE 2 TO THE AIR QUALITY STANDARDS REGULATIONS 2010		
Pollutant	Exposure limit	Exposure time
Carbon monoxide	10mg/m^3	8-hour average
Sulphur dioxide	350µg/m^3	1-hour average
	125µg/m^3	1-day average
Nitrogen dioxide	200µg/m^3	1-hour average
	40µg/m^3	1-year average
Benzene	5µg/m^3	1-year average
Lead	0.5mg/m^3	1-year average
$PM_{2.5}$	25µg/m^3	1-year average
PM_{10}	50µg/m^3	1-day average
	40µg/m^3	1-year average

(Table 2.1 from Part F: Volume 2, page 16)

Part F notes that ventilation intakes should always be away from direct impact of the sources of location, and that where buildings are next to busy roads “mechanical ventilation may be the most practical way of achieving this requirement”.

The main guidance in Part F Volume 2 focuses on offices, and the general supply rate remains 10l/s per person. In proposals for the Part F update, there had been some discussion about allowing for increased ventilation in the presence of viruses, but this has not been included in Part F 2021.

Part F 2021 sets out guidance values on indoor air pollutants (Table B1, page 28) which include carbon monoxide, ozone and total volatile organic compounds (TVOC).

INDOOR AIR POLLUTANTS GUIDANCE VALUES			
Pollutant	Exposure limit	Exposure time	Guidance
Carbon monoxide (CO)	100mg/m^3	15-minute average	WHO, 2010
	30mg/m^3	1-hour average	WHO, 2010
	35mg/m^3 (occupational exposure)	8-hour average	HSE, 2020
Nitrogen dioxide (NO_2)	200µg/m^3	1-hour average	WHO, 2010
	40µg/m^3	1-year average	WHO, 2010
Formaldehyde (CH_2O)	100µg/m^3	30-minute average	WHO, 2010
	10µg/m^3	1-year average	PHE, 2019
TVOC	300µg/m^3	8-hour average	ECA, 1992 / WHO, 2010
Ozone	100µg/m^3		DETR, 1994

(Table B1 from Part F: Volume 2, page 28)

The document notes that TVOC represents “all airborne volatile organic compound (VOC) concentrations”. TVOC should not be used as a direct indicator of health, but may be used as an indicator for the purposes of ventilation control strategies.

The updated regulations allow designers to use individual VOC limits should they prefer, though it is noted that: “testing against these metrics is likely to be more complex than testing against TVOC”.

Indoor air quality monitoring is required under Part F 2021 in new non-dwellings. Measuring CO_2 is the new requirement. The regulation advises against ‘snapshot’ readings as these can be misleading and instead advises on continuous monitoring throughout the day. It’s also important that CO_2 measurements are used as a “broad guide to ventilation” within a space, rather than safe thresholds.

Monitors should be positioned at head height, but at least 500mm away from room occupants to avoid misleading high readings. Readings must be taken “at key times throughout the day”. Building managers must record CO_2 levels, number of occupants, type of ventilation in use at the time and the date of the reading.

An average CO_2 concentration of 1500ppm over the occupied period is an indicator of poor ventilation and action should be taken to improve the situation if readings are consistently high.

Existing non-dwellings

Work carried out on existing non-dwellings must not result in any degradation of the ventilation standards in the building. However, when that building work in an existing building includes the ventilation system, then it must meet the relevant standards in the updated Part F 2021.

Part O 2021: Overheating

Part O is a new addition to the Building Regulations in 2021. The aim of Part O is to protect the health and welfare of occupants in dwellings and other residential buildings by reducing the occurrence of high indoor temperatures.

In the UK's increasingly warm climate, rising temperatures are impacting people's health. The UK Health Security Agency[6] states that in Summer 2020 there were over 2,500 deaths attributable to excess heat. It is also projected that the number of heat-related deaths in the UK will triple by 2050. The hottest summers on record in recent years will become our new 'normal'.

The regulation applies in residential buildings, specifically:

- Dwellings - houses and flats
- Residential buildings where people sleep on the premises e.g., elderly or other care homes
- Student accommodation

A unit that contains living accommodation and workspace should be treated as a residential building, as long as the workspace can revert to residential use.

The focus on reducing the UK's carbon footprint means that legislation is driving the development of airtight homes to save energy and reduce heating requirements. These dwellings are energy efficient and more comfortable in colder months, but more prone to suffer overheating in summer. A balance is required, and that is what Part O attempts to achieve.

There are therefore two key objectives under Part O:

- Limit unwanted solar gains in summer
- Provide an adequate means of removing excess heat from the indoor environment

There are two methods to demonstrate compliance with Part O. One is to use CIBSE TM59 Design methodology for the assessment of overheating risk in homes[7]. This is a dynamic thermal modelling approach that provides a standard method to account for the many factors that influence overheating in homes, such as dwelling layout, shading strategy and ventilation method.

The second method to show compliance with Part O is referred to as the 'simplified method'. This is based firstly on an overheating risk category, which depends on the geographical location of the dwelling. Most areas of England are considered 'moderate risk'. However, 'high risk' locations include urban and some suburban parts of London, as well as some parts of central Manchester. Part O documentation offers a list of postcodes to identify high risk areas accurately.

The second risk factor is whether the dwelling has cross-ventilation or not. Cross-ventilation is defined as: "The ability to ventilate using openings on opposite facades of a dwelling. Having openings on facades that are not opposite is not allowing cross-ventilation e.g., a corner flat."

Using these factors, designers can then use Part O to identify how to limit solar gains. As might be expected, dwellings without cross-ventilation and in a high-risk location must have more protection from solar gains. See tables 1.1 and 1.2 (from page 6 of Part O) below:

TABLE 1.1 - LIMITING SOLAR GAINS FOR BUILDINGS OR PARTS OF BUILDINGS WITH CROSS-VENTILATION[1]

	High risk location		Moderate risk location	
Largest glazed façade orientation	Maximum area of glazing (% floor area)	Maximum area of glazing in the most glazed room (% floor area of room)	Maximum area of glazing (% floor area)	Maximum area of glazing in the most glazed room (% floor area of room)
North	15	37	18	37
East	18	37	18	37
South	15	22	15	30
West	18	37	11	22

Buildings or parts of buildings with no cross-ventilation should not exceed the maximum glazing areas in Table 1.2

TABLE 1.2 - LIMITING SOLAR GAINS FOR BUILDINGS OR PARTS OF BUILDINGS WITHOUT CROSS-VENTILATION[1]

	High risk location		Moderate risk location	
Largest glazed façade orientation	Maximum area of glazing (% floor area)	Maximum area of glazing in the most glazed room (% floor area of room)	Maximum area of glazing (% floor area)	Maximum area of glazing in the most glazed room (% floor area of room)
North	15	26	18	26
East	11	18	18	26
South	11	11	15	15
West	11	18	11	11

NOTES:
1. Floor area and floor area of room are as defined in Appendix A.

Acceptable strategies for reducing overheating risk are fixed shading devices such as shutters, external blinds or overhangs. Glazing design can also reduce overheating through size, orientation, g-value or depth of window reveal.

Methods for removing excess heat allowed under Part O are:

- Opening windows (a method which is improved by cross-ventilation)
- Ventilation louvres in external walls
- A mechanical ventilation system
- A mechanical cooling system

Part O requires that passive means for overheating are prioritised and that mechanical methods are only used when all practical passive means have been used first, but mechanical means are not prohibited. In addition, a system for purge ventilation is required in each habitable room to comply with Part F.

There are some important overlaps between Part O and Part L that designers need to consider. For instance, solar gains in winter can reduce the amount of heating required. Reducing summer overheating by limiting glazed areas will impact solar gains and increase the need for space heating. Also, poorly insulated pipework, particularly in community heating schemes can be a major contributor to overheating. Control of heat losses from pipework is also covered in Part L.

A usable overheating mitigation system

One of the significant sections of Part O deals with ensuring that the overheating mitigation strategy is 'usable'. Given that this regulation is focused on delivering important health outcomes in dwellings, it is vital that the measures provided by occupants can be used.

For instance, in the high-risk urban areas there are other factors to consider apart from overheating; such as noise, pollution and security. While openings in a building may reduce overheating, they may allow ingress of pollutants and cause so much noise that occupants cannot be comfortable in their homes. And opening windows may be acceptable in higher storeys, but could compromise security in a ground-floor dwelling.

To deal with noise, for dwellings in urban areas, the overheating strategy must assume that during sleeping hours (11pm to 7am) windows will be closed if the noise within bedrooms exceeds these limits:

- 40 dB $L_{Aeq, T}$ averaged over 8 hours (23:00 - 07:00)
- 55 dB L_{AFmax} maximum no more than 10 times a night (23:00 - 07:00)

There is an overlap here with Part F: Volume 1 of the Building Regulations which requires that where mechanical ventilation systems are used, the following noise requirements apply:

- 30 dB $L_{Aeq, T}$ averaged over 8 hours for noise-sensitive rooms (e.g., bedrooms and living rooms) when a continuous mechanical ventilation system is running on its minimum low rate.

- 45 dB $L_{Aeq, T}$ averaged over 8 hours in less noise-sensitive rooms (e.g., kitchens and bathrooms) when a continuous operation system is running at the minimum high rate, or an intermittent operation system is running. (Section 1.7)

Homeowners must be provided with information in non-technical language about the overheating mitigation strategy in their home. This should include details on the locations of controls and instructions on how to set them (e.g., using a timer) as well as information on cleaning and maintenance.

A 'Home User Guide' is required under Part L Volume 1, and this should contain a section titled 'Staying cool in hot weather' which provides non-technical advice on approaches to reducing overheating in hot weather.

4. Other drivers for change in buildings

As noted in the Introduction, the 2021 updates to Parts L and F are interim steps on the way to 2025 when the new Standards will introduce further requirements for cutting carbon emissions and increasing energy efficiency in homes and non-dwellings.

Government has also set out its intentions to reduce the UK's reliance on natural gas for heating and hot water provision. The Heat and Buildings Strategy highlights the importance of technologies such as heat pumps and district heating to provide alternatives to the gas boiler for homes and other buildings.

There are also local requirements to consider, such as the London Plan which is also looking to reduce the capital's reliance on fossil fuels by encouraging greater use of heat pumps in all buildings, as well as extending the development of heat networks. The Plan also requires new large projects to provide energy use figures during the first five years of building operation - making a public commitment to reducing building energy use in London.

One important future development on the drawing board is a new Part Z of the building regulations, which will cover the embodied carbon in buildings. Many leading engineering consultancies and construction clients support the development of this regulation to bring more focus on whole-life carbon assessments.

The proposed document[8] has been authored by a joint panel including representatives of CIBSE, Institution of Structural Engineers, RIBA and RICS. Part Z proposes limiting embodied carbon emissions for all "major building projects".

The issue of whole-life carbon is not new but has come to the fore in recent years as many major construction clients focus on reducing the embodied carbon from their buildings to achieve corporate net zero carbon goals.

CIBSE TM65: Embodied carbon in building services[9] offers a calculation methodology for assessing the embodied carbon of products linked to mechanical, electrical and public health systems.

5. Building Regulations: impact on building services

Building regulations which focus on energy use, overheating, occupant health and decarbonisation will inevitably have a significant impact on the specification and operation of building services.

Ventilation and efficiency

The drive to reduce the carbon footprint of homes and other buildings means that it is essential to consider the energy performance specified equipment. What's more, as we see higher requirements for building fabric to support energy efficiency, designers must balance these conditions with occupant comfort across the seasons.

Climate change is already impacting the UK, and our need to reduce overheating without compromising energy efficiency grows with every annual heatwave. While the regulations require passive ventilation measures to be considered first, it is important to note that the issues of noise and pollution also impact those areas considered 'high risk' for overheating - our city centres. We are therefore likely to see the wider application of solutions such as mechanical ventilation with heat recovery (MVHR), particularly in city-centre dwellings.

Mechanical ventilation with heat recovery (MVHR) provides a useful solution for designers trying to balance reduced overheating needs with energy efficiency.

Modern MVHR systems extract stale air continuously and efficiently from spaces like bathrooms, kitchens, toilets, and utility rooms where air can become polluted with high humidity, fumes and chemicals. The system replaces indoor air with filtered fresh air from outside. It also minimises the amount of energy lost by recovering the heat from the extracted air and transferring it to the supply of fresh air, so that it is nearer to the required indoor temperature.

The latest MVHR systems (for example the Mitsubishi Electric Residential Lossnay) operate continuously at ultra-low noise levels (meeting the requirements of Part F) so that occupants can enjoy the benefits of good ventilation in comfort.

In addition, it is now possible to include filters for NOx (nitrogen oxide) and particulate matter in MVHR systems so that even in polluted city centres, the system can provide good indoor air quality.

And MVHR is also available for commercial buildings, providing the same energy efficient approach to supporting good indoor air quality.

Decarbonised heating

Decarbonisation of heating will lead to major changes in the choice of equipment for all buildings. Government has set a target of 600,000 heat pump installations per year by 2028 and we are already seeing the application of this technology rising.

The UK's increasingly 'green' electricity grid is what's behind the adoption of heat pumps for heating and hot water provision in homes and other buildings. Not only do heat pumps enable the shift away from gas boilers, but they are also energy efficient.

This is an important point. While the UK aims to produce more renewable electricity, we cannot be profligate in our use of that energy in our buildings. The costs to householders and building owners also must be taken into account. Government has therefore consistently highlighted heat pump technology as crucial for reducing our reliance on fossil fuels.

Heat pump technology has advanced significantly in the past five years, resulting in developments that are also suited to meet the heating and hot water demands of non-dwellings. For example, commercial heat pumps can now achieve a hot water temperature of 90ºC (e.g., Mitsubishi Electric's Ecodan QAHV). This reduces the need to rely on gas boilers and can be used even in environments with high peak hot water demands, such as student accommodation and sports centres.

Heat pump technology is also being applied within or alongside other building services systems to enhance energy efficiency. For example, heat pump VRF systems can provide energy efficient cooling and heating for commercial buildings - again, offering an alternative to gas boilers for heating.

Government is also expecting district heating or heat networks to play an important role in shifting homes and other buildings away from reliance on fossil fuels. District heating is targeted to increase from 2% of the UK's heat provision to over 15%.

The latest developments in district heating work in tandem with heat pump technology in what are known as 'Fifth generation' or ambient heat loops. They operate at low temperatures between 10ºC and 30ºC. The use of such a low temperature means that multiple water-source heat pumps (for example Mitsubishi Electric's Ecodan Hydrodan) can use the network as a heat source or a heat sink, depending on the need for heating or cooling. The network is thereby used as an energy store to share rejected energy from cooling plant with the heat injection needs of heating plant.

The added benefit of the lower temperatures in an ambient loop is that there is no high temperature pipework, removing the cost and time required for insulation (as required under Part L). It is also a particularly useful approach for mixed-use developments where heat extracted by office cooling systems, for example, can be used as a heat source for nearby dwellings, or in the same building in the case of mixed-use tall buildings.

Balancing the loop creates a challenge for designers, however the benefits in terms of energy efficiency and re-use of rejected heat outweigh the learning curve.

Air conditioning

In non-dwellings, clients are changing approaches to building services as much as the regulations. With more corporations making public commitments to net zero goals, their choice of building services equipment is coming under scrutiny. For example, low-GWP (global warming potential) refrigerants are increasingly important to lower building carbon footprints - even though they are currently covered by the F Gas rules rather than Building Regulations. But these changes must be balanced against Regulatory requirements for building energy efficiency.

The use of refrigerants such as R32 is therefore becoming more common. The introduction of R32 systems can pose challenges since it is designated A2L (mildly flammable). As a result, BS EN 378 requires the application of leak detection in spaces where R32 is present. However, there are alternatives such as City Multi Hybrid VRF from Mitsubishi Electric, which uses water to transfer heating and cooling energy in the occupied space – retaining R32 refrigerant between the outdoor unit and hybrid branch controller.

As we move forward, the use of other low-GWP refrigerants is becoming more widespread. For example, hydrofluoroolefins (HFOs) such as R1234ze and R1234yf have GWPs of 7 and 4 respectively. Chillers from Mitsubishi Electric's Climaveneta brand are already using R1234ze, and they have been designed specifically to work with the characteristics of this refrigerant.

For designers, the decision to use equipment with these relatively new refrigerants means understanding new performance criteria and ensuring that they are working with manufacturers who can provide good support throughout the design process.

Monitoring and controls

CO_2 sensors are required in offices under the new Part F to monitor indoor air quality. However, sensors and controls are also crucial elements in achieving energy efficient, comfortable buildings.

The presence of CO_2 sensors can also be used to build a demand-driven HVAC system, which only operates when required. For instance, if sensors detect rising levels of CO_2, caused by the presence of occupants in a space, this can automatically initiate increased ventilation. When CO_2 levels fall, the ventilation switches to 'Off', which will be the default setting.

However, as noted, Part L 2021 recommends a Class A (BS EN 15232) control system for non-dwellings which sets high standards for monitoring, control and benchmarking. The Regulation also requires that all control systems for fixed building services are interoperable, so it would be sensible to ensure that specified building services can utilise an open BEMS protocol such as native BACnet, for example.

6. Conclusions

The interim updates to the Building Regulations in 2021 point the construction industry in the direction of much higher standards for delivering energy efficient, low-carbon buildings. The impact on specification of building services should not be underestimated. There is a drive to cut the UK's reliance on fossil fuels, which is leading to significantly different approaches to heating for this country.

Many of the requirements of the new Regulations can be met with technology that is available today. However, their application and use require new ways of thinking about design and operation for consultants, building managers and the building occupants. Although there is a certain amount of new learning required, it could be regarded as an opportunity to adopt new and better ways of heating, cooling and managing our buildings.

The changes outlined in this document are by no means the final word on Building Regulations. These interim changes are exactly that - a stepping stone towards 2025 when the Future Buildings Standard and Future Homes Standard are introduced.

References

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Note: The fuse rating is for guidance only. Please refer to the relevant databook for detailed specification. It is the responsibility of a qualified electrician/electrical engineer to select the correct cable size and fuse rating based on current regulation and site specific conditions. Mitsubishi Electric’s air conditioning equipment and heat pump systems contain a fluorinated greenhouse gas, R410A (GWP:2088), R32 (GWP:675), R407C (GWP:1774), R134a (GWP:1430), R513A (GWP:631), R454B (GWP:466), R1234ze (GWP:7) or R1234yf (GWP:4). *These GWP values are based on Regulation (EU) No 517/2014 from IPCC 4th edition. In case of Regulation (EU) No.626/2011 from IPCC 3rd edition, these are as follows. R410A (GWP:1975), R32 (GWP:550), R407C (GWP:1650) or R134a (GWP:1300).

Effective as of May 2022

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