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Aim:

The aim of the presentation is to highlight the increased risks when retrofitting buildings to meet sustainability targets and the mitigation measures to take to reduce these risks.

Learning Objectives:

By the end of this presentation, you should;

- Understand the concept around sustainable construction.
- Describe how design strategies regarding refurbishments increase risk.
- Know the concerns around green roofs and how they can aid fire spread.
- Understand the risks with regards to Photovoltaic , Electric Vehicles and Battery Energy Storage Systems.
- Know the concerns around retrofitting fire protection systems.
- State the mitigation measures to reduce risk.
- Understand the concept around building telematics to achieve safer, smarter and sustainable buildings.

Sustainable Construction

Building Retrofits and Refurbishments

For future developments and major refurbishments there will be strong emphasis on creating buildings which are energy efficient, promote user health and wellbeing, improve local biodiversity and are resilient to future climate change.

Trend	Overview
 **Building retrofits and refurbs**	For the UK to meet its legally-mandated net zero carbon ambitions, there will have to be an accelerated national retrofitting program to reduce the energy demand of existing homes. For residential properties, these refurbs could include the installation of additional insulation, replacement of single glazing, draught proofing and replacement of inefficient electrical equipment and lighting[2]. The push for building retrofits will be supported by regulations and increasingly stringent energy performance certificate (EPC) standards for any rental properties in the UK. With the growing awareness of the upfront carbon emissions associated with new construction, many councils are now prioritising building retrofits and refurbs over new construction as a way of maximising the value of their existing assets and aligning with built environment embodied carbon targets.

Sustainable Construction

Low Carbon Building Materials

Reducing carbon emissions and achieving net zero is a key part of the UK's strategy to reduce the impact of the buildings on the environment.

Trend	Overview
 **Low carbon building materials**	The UK's built environment sector is currently responsible for 25% of total UK greenhouse gas (GHG) emissions with common building materials (e.g. steel and concrete) significantly contributing to global GHG emissions. The embodied carbon emissions associated with concrete alone account for 25% of the embodied carbon of a typical construction process[1]. For the UK to meets its net zero carbon targets, construction will have to consider new materials and construction techniques which minimise the embodied carbon associated with construction.

For future developments and major refurbishments there will be strong emphasis on creating buildings which are energy efficient, promote user health and wellbeing, improve local biodiversity and are resilient to future climate change.

Sustainable Construction

Air Quality & Climate Risk Analysis

There will also be a strong emphasis on air quality, climate risk analysis, renewable energy and biodiversity

Trend	Overview
 **Air quality**	Coming out of Covid and with more people working from home, there is an increasing emphasis on indoor air quality and overall health and wellbeing of people and the spaces they occupy. For buildings, the indoor air quality can be improved in two ways, either actively through mechanical ventilation or passively through openable windows and air gaps. Wherever possible, passive ventilation is the preferable option as it reduces the energy demand of the property.
 **Climate risk analysis**	Although reaching net zero is critical it is also important to recognise that the climate is changing, and we will continue to experience climate-related impacts for the coming century. Both new and existing buildings will have to be designed, built and retrofitted to be resilient to these emerging risks. For the UK, the main climate risks relate to flooding and overheating. Recently released Part O building regulations have been developed to protect occupants from overheating in newly constructed residential homes. Part O covers overheating in domestic dwellings and residential properties such as care homes and student accommodation.

Sustainable Construction

Renewable Energy & Biodiversity

Trend	Overview
 **Renewable energy**	For UK homes to reach their net zero carbon ambitions, the large-scale adoption of on-site renewables will be required. For the residential sector this will involve the installation of on-site solar. Decarbonising residential heating is a challenge for UK properties and a major part of the UK being able to reach its commitments relies on the installation of heat pumps in all new properties and mass replacement of existing gas heating systems in existing housing.
 **Biodiversity**	Alongside climate change, the loss of biodiversity is projected to be one of the greatest challenges the global community will face over the coming century. It's recognised that high-quality greenspaces benefit nature, communities and the health and wellbeing of individuals. This is why councils are increasingly mandating the incorporation of greenspaces and biodiversity-enhancing features as part of the planning process. Upcoming legislation around Biodiversity Net Gains has been designed to contribute to the recovery of nature while developing land and will make sure that the habitat for wildlife is better because of the development.

There are considered to be tremendous opportunities in this space and already many examples of solutions providing multiple benefits. For example, sustainable drainage can not only reduce the risk of flooding, but it can include additional benefits of improving biodiversity and wellbeing too.

Design Strategies – Refurbishments

Internal layouts

With increasing pressures on budget allocations and funding streams, the concept of building refurbishment/retrofitting and reinstatement may be considered more viable and achievable if of affordable building provision.

Sustainability targets faced by building providers, designers and end users can present real challenges, and the concept of remodelling existing building provision, upgrade of existing facilities, services, building envelope and the overall environment may in some cases offer the only viable and affordable solution.

Photo source: ZRS

Design Strategies – Refurbishments

Internal layouts and circulation:

The existing building fabric may place constraints on internal layouts, with caution needed to ensure buildings can operate effectively and routinely

In respect of fire, appropriate separation and compartmentation should be facilitated to limit potential fire losses, for the benefit of both life safety and property protection.

Refurbishment schemes can involve the opening internal spaces, the creation of more flexible environments or the removal of part of an upper floor to create an atria type feature.

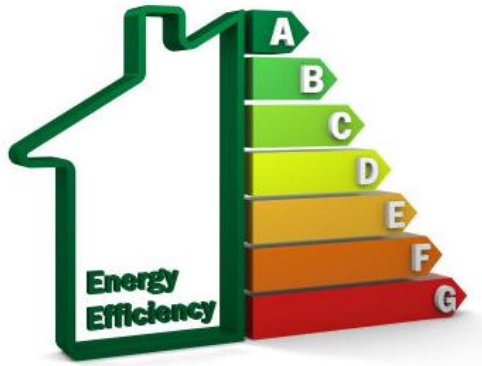
Thermal Performance:

Where improvements are proposed in the energy performance of existing buildings, the provision of additional and/or replacement thermal insulation is likely, with this taking a variety of forms.

Where externally applied insulation systems are to be incorporated, or new cladding systems proposed on walls and roof, the fire performance of such materials can have a significant impact on the overall behaviour of the building in a fire condition.

Extreme caution is required to ensure that any existing fire cavity barriers and fire stopping provision are not adversely affected.

Source: Geoff Tompkinson/GTImage.com (A Britannica Publishing Partner



Source: https://www.molygran.com/our-advice/improving-thermal-efficiency/

Design Strategies – Refurbishments

Asbestos Removal:

Where refurbishment works involves the removal, treatment or encapsulation of asbestos within the fabric of the building, reference should be made to the building's fire strategy to determine the function of any asbestos linings, cavity barriers or ducting.

It may be necessary to re-introduce barriers or linings to maintain the fire performance of a building, which could have an impact on not only property protection, but also life safety measures within the building.

Building Structure:

Existing passive and active fire protection afforded to a structure must be maintained, and in the case of major refurbishment programmes, enhancement of such protections may be considered appropriate.

A relatively small-scale fire can result in disproportionate damage and in many cases, total loss of buildings.

The overall behaviour of the structure in relation to windstorm can be dramatically altered following refurbishment programmes, with choices of external wall treatments, curtain walling systems and rainscreen cladding potentially affecting the likely performance of the building.

Photo source: Asbestos.com

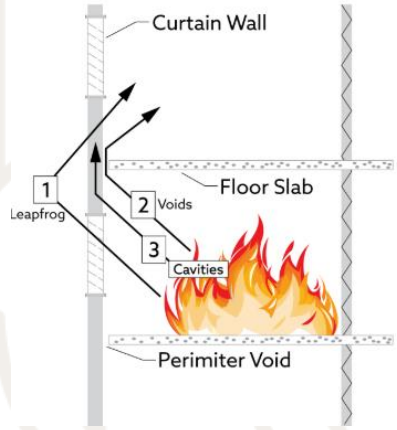


Photo source: Schuettmetals.com

Design Strategies – Construction Risks

The construction/retrofitting of a building can influence the extent of any property-related loss to a dramatic degree.

Key areas to assist designers and end users include;

Buildings should also be designed to adequately resist the range of hazards and perils they are exposed to such as fire, storm, flood and escape of water. Often, this will require designers and architects to go beyond compliance with minimum regulatory guidelines.

Project phasing is an extremely important concept to prevent major fire spread between multiple buildings or blocks or flats which are being constructed at the same time. When constructing/retrofitting multiple blocks, ensure fire spread between blocks is minimised by enclosing combustible elements before starting the next block.

If the site space is restricted, daily waste collections and just-in-time deliveries may need to be factored into the contract

2018 Battersea Art Centre Glasgow (second time) Cost: £100m

Photo source: https://www.newcivilengineer.com/

Design Strategies

Understanding how products will perform in a fire is a challenge due to the complexity of fire testing options and what these mean in practice. So, it is important that all parties involved tackle these issues head on at an early stage of the project.

Key questions for property fire resilience strategy:

1. Are combustible materials included in the structural frame?
2. Are combustible materials included on the external face or elements of the wall?

If yes:

3. What is the likely impact a fire will have on the building in the worst-case scenario?
4. How are combustible structural elements being protected from fire?
5. Can alternative non-combustible wall and insulation materials be used instead?

Photo source: https://internationaltimber.com/resources/how-does-timber-handle-fire-compared-to-steel-and-concrete/

Design Strategies – Refurbishments

External Envelope:

Refurbishment projects of a large scale can often involve upgrade works to the external envelope of the building with external cladding systems being applied, including rainscreen and external insulated finishing systems, for example.

Caution should be exercised when specifying such systems to ensure that these to do not adversely contribute to the fire load of the building, increase the vulnerability in terms of external fire spread, or introduce substantial combustible elements to the building fabric.

Re-Roofing:

Re-roofing is often required as part of refurbishment works to manage and control the lifecycle risks of the building and improve overall aesthetics of the facility.

Such works can however introduce the potential for reduced fire performance, in that fires within the building may not be so readily vented and heat building up within the ‘new’ roof void can assist in rapid fire spread. Hot work is considered the main risk from re-roofing.

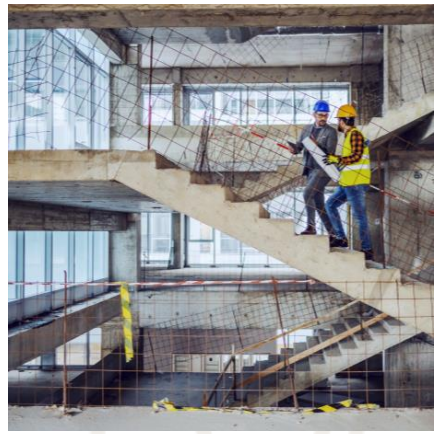


Photo source: ZRS

Photo source: ZRS

Design Strategies – Composite Panels

Composite panels with combustible components have contributed to some significant fire losses. In these cases, the combustible components have supported fire spread, and in some cases rapid fire spread. Not all composite panels used in projects/retrofits containing combustible components presents adverse fire behaviour.

Expanded polystyrene (EPS) - Highly combustible

Fire retardant EPS - Highly combustible

Polyurethane (PUR) – Combustible

Polyisocyanurate (PIR) (Standard) – Combustible

Polyisocyanurate (PIR) (Approved) - Withstands fire for longer but ultimately combustible

Modified phenolic (K15) - Combustible but good degree of Fire Resistant.

Glass fibre- Regarded as Non-Combustible.

Mineral wool - Regarded as Non-Combustible.

Photo source: ZRS

Design Strategies - Green Walls

Green or Living Walls are becoming a familiar feature of the built environment. Often incorporated as components of major retrofitting and more sustainable projects,

- Combustibility of the planted biomass and its dependency on irrigation and maintenance to keep ignition and fire spread potential to a minimum
- The extensive use of plastics in some Living Wall designs in the potting, irrigation, and drainage systems.
- The potential complexity of creating a fire-safe design when incorporated into a rainscreen type cladding system.
- A lack of guidance on the management of penetrations (windows and vents) to prevent fire ingress or egress between the building's internal compartments, wall voids, and the Living Wall.
- A lack of relevance of some certification tests to address the fire challenges.
- The potential for the aforementioned factors to allow mass fire spread over the building, both via the planted surface, and within wall cavities behind the potting system
- An overall inadequacy in Building Regulations to address property protection.

Photo source: ZRS

Photo source: FPA

Design Strategies - Green Walls

A concern with green walls is the use of combustible plastic frames and containers for the growing medium especially during the installation phase.

Further concerns are:

- A lack of maintenance can also increase the fire risk with the green wall.
- Hot work must be avoided during the installation of green walls.
- Once installed, hot work should still not take place above green walls or within 10 metres (35 feet) unless suitably protected.
- Green walls should not be placed where there is an arson risk e.g. waste bins should not be placed within 10 metres.
- Green walls contain combustible materials and are therefore not suitable for use on medium to high rise residential buildings.
- Green walls and balconies on existing buildings are also considered an increased fire risk from the inappropriate use of BBQs and carelessly discarded cigarettes.

Photo source: TTG Travel industry news

Photovoltaic (PV) Systems

Solar energy has established itself as a sustainable energy source in recent years. The installation of PV systems on rooftops continues to increase. *However, rooftop PV systems present perceived challenges including;*

The increased risks:

- PV fires on exterior building surfaces that are beyond the reach of fire protection systems.
- Inadequately defined inspection and maintenance programmes.
- Introduction of additional combustibles that increase the burn rate of roof decks.
- Unexpected structural loads that exceed design codes and standards, such as snow or ice loads.

Main caused of losses: Panels and system components

- Overheating connectors are a particular issue, these connect the panel to the DC cabling.
- Fire in components either poorly installed, poor quality or incompatible components.
- Damaged panels either from mechanical damage or hot spots.

Photo source: ZRS

Photo source: Plexus Energy Limited

Electric Vehicle (EV) Charging

As Electric Vehicles continue to become more popular in the UK, and as private companies and local authorities strive to reduce their carbon footprints, the demand for a charging infrastructure and dedicated parking areas has exponentially increased.

If the Electric Vehicles are operated according to manufacturer's specifications, operation is safe. However, the hazards increase if normal operating conditions are deviated from such as:

- *Age and usage*
- *Modification of the Lithium batteries and/or configuration of the vehicle*
- *External damage or impact to Lithium batteries (e.g. accident/impact, mechanical and thermal stress, extreme vibrations, etc.)*
- *Electrical malfunction during charging and discharging*

Photo source: ZRS

In the worst-case scenario, the above-mentioned conditions can cause a thermal runaway of the battery cells, which is a highly exothermic reaction creating toxic, flammable, and/or explosive chemical components.

The gaseous components generated such as hydrogen, carbon monoxide by the fire and those created for cooling and extinguishing activities such as hydrogen fluoride and other toxins present an increased risk to firefighters, building occupants and the environment.

Electric Vehicle (EV) Charging

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Type of fire: thermal runaway:

- Lithium-ion batteries used in EV vehicles (fully electric, hybrids, E-bikes, E-scooters) are subject to mechanical or thermal failure. Electro-chemical abuse from overcharging the cell can also initiate thermal runaway.
- Have higher energy density to extend lifetimes.
- These batteries are subject to mechanical or thermal failure. Additionally, electro-chemical abuse from overcharging the cell can initiate thermal runaway
- Thermal runaway is caused by initially high temperatures that leads to the rapid decomposition of the battery materials.
- The higher the temperature, the more rapid the battery materials decompose, so the fire increases in ferocity. It's a self-feeding process

Photo source: ZRS

Electric Vehicle (EV) Charging Underground Car Parks

Underground car parks :

- EV charging and electric vehicles are high voltage electrical appliances that are subject to mechanical and electrical failure and a potential source of ignition.
- Any conventional vehicle is a source of ignition, with several high-profile car park fires causes by electrical faults in combustion engine vehicles.

Increased fire loads: plastics:

- Modern vehicles are constructed of 70% expandable plastics. So modern car parks have tonnes of highly combustible plastics stored together.
- The higher the fire load, the more rapidly a fire can spread, the higher the temperature may be and the longer it will burn for.
- Structures such as car parks can be prone to partial collapse.

Car park design: lack of compartmentation

- Car parks are often wide, large open floor spaces with open connections to other floors via ramps, staircases and elevator shafts.
- Based on design and lack of compartmentation, most traditional car parks are essentially one single fire area that supports horizontal and vertical spread.

Photo source: ZRS

Battery Energy Storage Systems (BESS)

A Battery Energy Storage System is a device that converts chemical energy contained within its active materials directly into electric energy by means of an electrochemical oxidation-reduction (Redox) reaction.

Direct Current (DC) electric energy storage - We can't store Alternating Current (AC) yet!

Pretty much every modern technology at some stage uses BESS technology.

Power bank - Portable device charging

Cordless tool battery - Construction / DIY work

Mobile powerhouse - Portable Grid backup supply / PV harvesting

Fixed battery storage (up to 50kw) - Grid backup supply / PV harvesting / off-grid capabilities (self sufficient – energy source/sources dependent!)

Battery Energy Storage Systems (BESS)

Grid / Power Market Scale

Modular design is 85-90% of the market - More space = More power!

Photo source: WEG Supplies Colorado

Fire is a major risk, with several Li-ion battery-related incidents hitting the headlines in recent years, from exploding Samsung smartphones (2016) to electric car fires and even a Dreamliner catching fire at Heathrow (2013), along with a Hawaiian BESS facility fire (2012)

One of the most concerning features of battery fires is that they can seemingly ignite or reignite days or weeks after they were thought to be extinguished.

The increased risks include;
Thermal runaway
Difficulty of fighting battery fires
Failure of control systems (BMS)
Sensitivity of Li-ion batteries to mechanical damage and electrical transients

Fixed Fire Protection

Retrofitting Fixed Fire Protection

All elements of service provision within a building require consideration at an early stage in the design process, to minimise the impact of these services on the construction process and in the operation of the completed building.

Problems faced include;

Installation of residential sprinkler system i.e. BS9251 rather than LPC Rules for Automatic Sprinkler Installations incorporating BS EN 12845. This also includes installing water mist systems for life safety only.

Access back into ceiling voids and existing areas. I.e. production lines.

Conventionally, building design must meet the prescriptive requirements of the current building regulations together with their approved technical standards. However, such requirements have often dictated to designers the way a facility can be built, which in many cases limits the internal layout (design freedoms)

Photo source: ZRS

Mitigation Measures to Reduce Risk

Following on from the previous slides for retrofitting existing assets and the associated risks, the following mitigation measures could reduce the overall risk;

Challenge	Solution
A mass timber building where all the timber elements are exposed	• Place wet services in a concrete core and extend the concrete into wet areas such as kitchens and bathrooms • Our research shows that encapsulating key parts of the mass timber only increases the carbon footprint between 1% to 3% • Install sprinkler protection
Solar panels placed on a Building Regulation compliant roof	• Place solar panels on either pebble ballast, concrete pavers, or on non-combustible board installed below the roof membrane
A school external wall is provided with 60 minutes fire resistance but externally clad in timber or combustible High Pressure Laminate panel	• Reduce the arson risk by selecting a timber-effect cement board cladding or other Euroclass A1/A2 panel to BS EN 13501-1
Basement car park that extends below one or more high rise blocks above	• Provide sprinkler protection in accordance with BS EN 12845 and the LPC Rules • Avoid combustible ceiling linings • Have four hours fire resistance to separate the car park from the floors above

To support a resilient design, we need to manage the key property risks such as fire, weather-related losses and escape of water.

From a property resilience perspective, we would argue that the current regulatory regime falls short for property protection.

Our experience of losses highlights the opportunity to raise the level of property resilience for the benefit of end users, their wellbeing and financial security.

Mitigation Measures to Reduce Risk

Internal Layouts

Effective fire protection provisions in buildings are reliant on competent design, construction and management. To facilitate the appropriate development and implementation of fire protection provisions, clear communication on the division of these roles and responsibilities is essential between parties in a construction/refurbishment project.

Thermal Performance

The use of non-combustible insulation/products and the opportunity to introduce or improve the existing fire stopping provision should be considered within such works with appropriate reference to the Fire Risk Assessment or Building's Fire Strategy.

Asbestos Removal

Where panels are removed as part of a refurbishment programme, appropriate replacement materials should be used, and ideally be non-combustible. Refurbishment schemes may also need to remove pipe/service lagging that may contain asbestos. The removal of such products is considered best practice, however, appropriate alternative protection systems must be introduced, to avoid the freezing of pipes and subsequent escape of water losses and associated damage.

Mitigation Measures to Reduce Risk

Building Structure

Effective fire protection provisions in buildings are reliant on competent design, construction and management. To facilitate the appropriate development and implementation of fire protection provisions, clear communication on the division of these roles and responsibilities is essential between parties in a construction/refurbishment project.

External Envelope:

Current design standards and regulations must be observed to ensure appropriate fire compartmentation and separation is introduced.

Re-Roofing:

Non combustible insulation and close liaison with Insurer to ensure the make up of the roof is acceptable.

Green Walls:

Placing over concrete is preferred. For smaller exposures, a non-combustible board can be used to separate the green roof from the construction below. For areas with solar panels, only use gravel ballast or concrete pavers below and ensure easy access is provided for maintenance or repair.

Ensure fire breaks around openings such as roof lights, vents and flues.

Mitigation Measures to Reduce Risk

PV Systems:

Always install PV panels over non-combustible roofing materials or install a non-combustible barrier between the PV panels and roofing materials. Ensure designers and installers are competent for AC/DC systems and follow industry best practice. Clearly define inspection and maintenance requirements at the design stage to ensure the costs are accounted for in the overall system costs.

EV Systems:

Install chargers externally 10 metres from buildings, or 7.5m from openings in non-combustible walls. For internal car park areas, sprinkler protection to be designed to 12.5mm/min design density over 260m2, in accordance with BS EN 12845 and the LPC Rules. Try to achieve 120 minutes fire resistance (integrity and insulation) for internal charging areas.

BESS:

Spacings from each other and local housing/infrastructure. Monitoring systems which identifies the characteristics of thermal runaway and prototypical nature of technology. Comprehensive risk management process which identifies hazards and risks and having a robust emergency response plan.

Sustainable Construction

Smart Buildings

Monitoring and measuring a buildings performance.

Trend	Overview
 **Smart buildings**	Monitoring and measuring a building's performance through an integrated system of sensors and monitors can result in many benefits for building occupiers and managers. These can include reducing energy costs, personalising control of your immediate environment, measuring air quality and monitoring building efficiencies. Over the coming decade it is anticipated that more systems within a building will become integrated and customisable by the building user. This switch to smart buildings will require assets to have adequate capacity and connectivity to accommodate increasing data requirements.

Unlocking the power of data is the key to achieving safer, smarter and sustainable buildings.

Transforming data to knowledge and action is a big challenge in the digital world. Building Management Systems provide a wealth of data but how effectively can it be used to improve the performance of a building.

Sustainable Construction

Zurich Insite

A small self-installed device that listens to a Building Management System data. Additional sensors can also be added to increase data intelligence.

Boiler and pump activity, temperature, temperature pressure, filter operation, heating systems, ventilation, cooling, frost protection, power metering, CO2, presence detection and fire suppression data can all be monitored for maximum impact.

Advantages of using the device are;

Cost Reduction - Identifies where current energy use is unnecessary or does not align to current needs.

Reduces Carbon Emissions - Identify energy saving opportunities to manage carbon usage.

Risk Management – Risk identification, assessment, insight and improvements.

Proactive Preventative Maintenance – Prolong the lifetime and efficiency of assets by using data to take a risk-based approach to maintenance.

Workplace Safety - Monitor the operational status of safety equipment and the workplace environment including air quality.

Data Analysis - Report baselining building performance and highlighting improvement areas identified by use of a dashboard.

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- Understand the risks with regards to Photovoltaic , Electric Vehicles and Battery Energy Storage Systems.
- Know the concerns around retrofitting fire protection systems.
- State the mitigation measures to reduce risk.
- Understand the concept around building telematics to achieve safer, smarter and sustainable buildings.

Q&A

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