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Healthy, safe and sustainable buildings: Maximising benefits in building retrofit

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Introduction

Building retrofit is imperative, not only as a critical step towards the UK achieving its net zero objectives, but also as a timely opportunity to deliver healthier, safer indoor environments. Improving indoor environments will have health benefits that can contribute to improved quality of life, productivity and boost economic activity.

The UK has set ambitious legal targets for reducing greenhouse gas emissions and achieving net zero by 2050 to mitigate the threat of climate change. Heating and cooling of buildings are estimated to contribute to 17% of national emissions.[1] Given that approximately 80% of our existing buildings will still be in use by 2050, there is a clear role for improving their energy efficiency as part of the transition to net zero. To meet these challenges, there is a need to reduce energy demand, including improving energy efficiency, as well as rolling out low carbon heating technologies and scaling up renewable energy production. Delivering these ambitions requires retrofitting a significant proportion of our existing building stock.

The Department for Energy Security and Net Zero (DESNZ) has set out its commitments to transform homes by making them cleaner and cheaper to run through the delivery of the Warm Homes Plan. Across the Devolved Administrations there are similar retrofitting initiatives and funding schemes that support rollout of insulation and low carbon technologies for heating and energy, particularly in domestic settings and for low-income households.

Alongside decarbonisation, retrofit presents an opportunity to improve the quality of our indoor environments. Whether through heat, light, noise or air quality, the built environment can impact the health and wellbeing of its occupants. While there are estimates on the costs to the NHS from exposure to cold, damp, and overheating, there is limited data and information to attribute the cause of illnesses. However, improvements in air quality have been associated with improved health outcomes, including reductions in asthma, coronary heart disease, stroke and lung cancer.[2] As respiratory conditions are the fourth most common reason for sickness absence in the labour market, healthier buildings can contribute to productivity.[3] As the Department for Health and Social Care (DHSC) aims to shift the focus of the NHS from sickness to a preventative approach to tackling ill health, improving the health of our indoor environments is a vital consideration.

Extreme weather and heatwaves, which are predicted to become more common and severe because of climate change, increase risks to occupant health, especially for elderly or vulnerable populations. Regulations for new

1 CCC (2020), The Sixth Carbon Budget: Buildings

2 DHSC (2022), Chief Medical Officer's annual report 2022: Air Pollution

3 ONS (2022), Sickness absence in the UK labour market

homes consider risks from overheating. However, with millions of homes in the UK susceptible to overheating during hot weather, and an estimated 55% failing criterion for overheating in bedrooms,[4] we need to reduce risks in our existing buildings. Retrofit policies typically aim to protect against exposure to severe cold conditions, but there is an opportunity to ensure our indoor environments are resilient to extreme weather – both hot and cold.

Ensuring retrofit policy, plans and delivery achieve the greatest overall benefits requires a joined-up strategy, considering the whole-system effect of changes to a building's fabric or services.

This paper sets out key considerations for managing interdependencies in planning for building retrofit and use of new measures or technologies over time, with a focus on the opportunity arising from net zero ambitions for buildings. Five policy recommendations are presented to support the delivery of safe, healthy, sustainable buildings. This work builds on previous publications from the National Engineering Policy Centre (NEPC) which explored opportunities to embed infection resilience across the built environment,[5] outlining opportunities for changes to regulations, standards and commissioning for new buildings that are out of scope of this paper.

Image: Shutterstock

4 Arup (2022), Addressing overheating risk in existing UK homes

5 National Engineering Policy Centre (2022) Infection Resilient Environments: time for a major upgrade

Understanding health impacts of retrofit

There is a growing body of evidence that the indoor environments of buildings have a significant impact on the health and wellbeing of occupants.[6] These health impacts are not distributed equally, with those living and working in more disadvantaged locations associated with higher risks of indoor exposures to pollutants or airborne pathogens and greater negative health impacts.[7,8] Retrofitting therefore has an important role to play in reducing health inequalities.

Building retrofit is the process of upgrading buildings; key aspects of retrofit may often include:

- **interventions in a building's fabric, such as installing insulation, upgrading windows, improving airtightness to reduce heat loss and overall energy demand, and provision of appropriate ventilation**
- **introduction or changes to building services such as low carbon heating**
- **installation of monitoring and control tools for energy use and comfort to provide information to support and empower users to adopt energy-saving behaviours.**

Retrofitting may negatively impact the indoor environment if design strategies only consider energy use rather than building performance more holistically. For example, retrofit measures may reduce the overall air quality and provision of natural light, increase exposure to noise pollution, or introduce risks of damp, mould, and overheating. All these challenges could have unintended consequences for the wellbeing of the occupants including a known association with an increase in mental health conditions.[9,10,11]

Though these tensions exist, these effects are avoidable, and retrofits are an opportunity to deliver improvements beyond energy use. This can be achieved if the existing building is appraised as part of the pre-works planning phase, and the potential impacts of the works, both positive and negative, are identified and addressed. Occupiers would also need to have effective support on how to maintain healthy environments over long-term building use.

6 British Safety Council (2024), Why good indoor environmental quality can enhance wellbeing

7 The Health Foundation (2020) Build Back Fairer: The COVID-19 Marmot Review

8 Ferguson et al. Exposure to indoor air pollution across socio-economic groups in high-income countries: A scoping review of the literature and a modelling methodology, Environment International, 143, 105748 (2020)

9 Howieson S et al. Building tight – ventilating right? How are new air tightness standards affecting indoor air quality in dwellings? Building Services Engineering Research and Technology. 2014;35(5):475-487

10 Shrubsole C et al. 100 Unintended consequences of policies to improve the energy efficiency of the UK housing stock. Indoor Built Environment. 23, 340–352; 2014

11 Allen et al (2017), 'The 9 Foundations of a Healthy Building'

The table below outlines key interdependencies that may need to be considered for common retrofit measures, though any impacts will depend on the current state and characteristics of the building, and how well the retrofit elements are installed.

Table 1: Overview of key interdependencies to be managed in retrofit planning, installation, and building management:

Envelope: insulation, airtightness, fabric build-up, shading	
Risks: • Sources of pollutants • Overheating in hot weather • Moisture damage and mould spread • Encourage fire spread	**Opportunities:** • Improving indoor comfort • Better management of heat and thermal comfort in extreme weather • External noise and air pollution reduction • Energy demand, cost, and operational emissions reduction
Ventilation and air cleaning	
Risks: • Energy demand and operational emissions increase • Internal noise pollution increase	**Opportunities:** • Improving indoor comfort • Better management of indoor air quality • Reduced infection transmission • Better management of heat and thermal comfort
Low carbon heating	
Risks: • Localised noise pollution	**Opportunities:** • Operational emissions reduction

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Insulation and airtightness

Improving insulation and airtightness of a building envelope aims to prevent draughts and heat loss, making it easier to manage comfort and heating. These interventions are necessary both to mitigate health risks from cold conditions such as hypothermia or respiratory conditions, and to reduce energy demands for heating, plus associated operational costs and emissions. They can also reduce the risk of fabric degradation and mould growth on surfaces or inside the fabric. However, increasing airtightness and insulation can have direct and indirect health impacts, especially when improperly installed.

Moisture generated indoors can accumulate without an adequate ventilation strategy. High humidity environments pose risks for microbial or mould growth. Such conditions have been shown to be harmful to occupants, and in extreme cases, where left unmanaged, can even be fatal to vulnerable populations.[12] If insulation is not installed properly, moisture can also build up in interstitial spaces and lead to rot and corrosion in the building fabric, creating a potential structural safety risk. Moisture can be controlled with effective ventilation. Retrofit works must plan insulation, airtightness and ventilation together to ensure these needs are balanced and deliver a healthier indoor environment. Standards and best practice guidance are available for supporting a 'whole building approach' for retrofit.

Beyond moisture, airtight environments can allow accumulation of airborne pollutants from indoor sources, degrading the overall air quality. Exposure to pollutants such as carbon monoxide, radon, asbestos fibres, cigarette smoke and airborne microorganisms can cause short- and long-term respiratory conditions. Where insulation is added, this can potentially introduce an additional source of volatile organic compounds (VOC) which may continue low-level emissions over long periods, varying between different materials and locations within a building. Health impacts from cumulative pollutants and long-term exposure to airborne pollutants are poorly understood and require further research to support evolving guidance. However, when planned alongside dedicated ventilation, good airtightness protects from the ingress of outdoor pollutants.

Increasing airtightness can prevent heat transfer into buildings during hot summer weather, but could exacerbate existing risks of overheating, if for example, there is excessive glazing, lack of shading, or under-ventilation. This could have implications for the long-term resilience of our building stock. To suitably dissipate heat, summer ventilation requires higher air flow rates than for background ventilation. Ventilating during the nighttime when outdoor air is cooler can also be beneficial, where it is safe to do so.

Ventilation and air cleaning

When people gather in poorly ventilated indoor spaces pollutants can build up; unless action is taken, buildings become susceptible to stagnant air where carbon dioxide and infectious diseases can make the indoor air more polluted, and infections, such as flu and COVID-19, can be passed from person to person more easily. Many daily tasks such as cooking and laundry can generate moisture that should be managed. Moisture and indoor pollution sources can be controlled through effective ventilation. Different buildings, depending on their characteristics and how they are used, will have specific requirements for ventilation and this will determine whether natural, mechanical, or hybrid strategies can be applied.

Emerging research suggests that exposure to particles and chemicals including ozone, formaldehyde and nitrous oxides are linked to health effects including asthma, COPD, heart disease and dementia.[13] These particles are

12 CIBSE (2023), Ventilation: A matter of life and death

13 Royal College of Physicians (2016) Every breath we take: the lifelong impact of air pollution

associated with common indoor sources including cooking, fossil fuel heating, cleaning products and furnishings as well as ingress of outdoor pollutants. In some high-risk environments or where outdoor air is highly polluted, methods for air cleaning (such as filters) may also need to be incorporated into the design.

External factors such as the surrounding noise pollution should also be considered. Though there are regulations to protect people from exposure to excessive noise at work, managing noise from mechanical ventilation systems is mostly covered in voluntary guidance, including in Approved Document F [14] and industry best practice, for example residential design guidance from the Institute of Acoustics.[15] Standards exist for some specific environments, such as the BB93 standard for acoustic design of schools,[16] but for many buildings, ventilation noise levels are not strictly regulated. Managing acoustic pollution, from external and internal sources, is an integral part of a healthy indoor environment and should be considered in design and installation, especially if there are multiple systems being used in proximity.[17]

Low-carbon heating

Reducing or even ending the use of fossil-fuel powered heating offers benefits in addition to reducing carbon emissions. Electrification of heating, hot water and services for cooking in buildings can help to improve air quality through lower levels of pollution from gas, oil or solid fuel systems. Moving away from combustion sources also reduces wider safety challenges associated with fire and risks such as carbon monoxide poisoning.

Heat pumps may introduce sources of noise pollution that need to be factored into design. To reduce the harms of noise pollution there are limits for noise that can be emitted close to a neighbouring property. It is important heat pumps systems operate within these limits throughout their lifetimes to avoid negative health impacts.

Image: © thisisjude.uk

14 Ventilation: Approved Document F, 2010, Ministry of Housing, Communities & Local Government, GOV.UK

15 Institute of Acoustics (2020), Acoustics ventilation and overheating residential design guide

16 BB93: acoustic design of schools - performance standards, 2003, Department for Education, GOV.UK

17 House of Lords Science and Technology Committee (2023), The neglected pollutants: the effects of artificial light and noise on human health

Opportunities in building retrofit

The urgency to address carbon emissions and enhance energy efficiency in UK buildings is clear. With a growing policy focus on making UK homes warmer, greener, and safer, we now have a real opportunity to improve the health and wellbeing of building occupants, so that everyone can live and work in healthy, safe, and sustainable buildings.

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Embedding health in domestic retrofit initiatives

Various policies and funding support schemes have focused on improving heating performance and reducing energy costs in domestic settings. For example, the Great British Insulation Scheme [18] and Warmer Homes Scotland [19] offer homeowners advice and financial support for energy efficiency measures. There are also requirements for rental properties to have a minimum EPC certificate of C or above by 2030, setting a responsibility for landlords to introduce measures to improve energy efficiency. While these initiatives are vital to meet our net zero ambitions and prevent extreme cold conditions, they often focus solely on energy efficiency. With the development and delivery of the Warm Homes Plan, there is an opportunity to embed a systems approach in domestic retrofit. The PAS2035 standard, developed to assess dwellings and holistically consider building performance, provides resources to support delivering this in practice.[20]

Currently, there are no agreed measures for health outcomes relating to the built environment. The development of the Warm Homes Plan offers the opportunity to develop a clear understanding of the health outcomes we should expect from the built environment. This will require a collaborative approach between DESNZ, DHSC, and the Ministry for Housing Communities and Local Government (MHCLG), supported by experts in engineering, design and health, to set out what good looks like. These outcomes should be embedded in policies for domestic buildings and existing grant schemes could be extended to improve the health of our indoor environments. This should include eligibility for measures for managing ventilation and temperature control, such as pressure-sensitive trickle vents, fans, shading, and hot water pipe insulation.

Following retrofit, it is essential that homeowners and tenants understand how to use and maintain systems properly so that the intended health benefits can be achieved in practice.[21] As part of the delivery of the Warm Homes Plan, a public campaign should be delivered to raise awareness of the role indoor air and environmental quality in homes can play in maintaining good health and the steps people can take to support this.

Recommendation 1

Department for Energy Security and Net Zero should use the Warm Homes Plan to set out a clear definition and targets for expected health-based outcomes from retrofit programmes, ensuring these are co-created to allow alignment across wider policies for managing homes and public health. This policy, supported by a public information campaign, should encourage consideration of measures for ventilation, heating and cooling from retrofit design to building use, to improve indoor environmental quality and overall climate resilience of our domestic building stock.

18 DESNZ, Summary of the Great British Insulation Scheme: January 2024

19 Scottish Government, Warmer Homes Scotland Scheme

20 BSI (2023), PAS2035: Retrofitting dwellings for improved energy efficiency – Specification and guidance

21 National Engineering Policy Centre (2023), Ventilation Matters

Understanding needs in our public and non-domestic buildings

Commercial rented properties must meet minimum energy performance ratings, with targets for landlords to ensure properties have a rating of at least EPC B by 2030. While this is an important and challenging target for retrofit,[22] EPC ratings are limited as they only consider energy efficiency and are based on the construction, rather than actual performance. Targets beyond EPC ratings are needed for public buildings to deliver greater health benefits for local communities and maximise cost-benefits from retrofit. Health-based outcomes should be embedded into all programmes for net zero and retrofit. Existing standards for improving indoor environmental quality, such as BS 40102,[23] should be encouraged as a baseline for best practice performance requirements in retrofit in public buildings. Employers and public building owners need to understand building performance and where there may be health risks such as overheating and poor air quality, or excessive energy use, to inform and enable prioritisation for building works and retrofit. Dedicated support and guidance for post-installation monitoring and evaluation should also be available.

The NEPC post-COVID-19 analysis of infection resilient environments estimated total economic costs of £23 billion (discounted 2020) over a 60-year period for an influenza-like infection, with seasonal influenza costing £8.2 billion and pandemic influenza £14.7 billion. The analysis considered costs including those on the healthcare system, lost education and unemployment, and identified healthcare to be the main cost for seasonal illnesses. The work highlighted an opportunity for significant health and economic benefits from improving ventilation in local community buildings. To better understand where benefits could be achieved in retrofitting public spaces, a large-scale assessment of potential risks in existing buildings would be valuable, including overheating criteria, presence of damp, and indoor air quality. This could draw upon health and wellbeing criteria used in approaches such as the WELL building standard,[24] and add to existing building condition surveys with a more explicit focus on health impacts.

There will be some environments that have a higher risk for public health – particularly the NHS estate, where concerns have been raised about the impact on patients and workers of falling building quality, poor levels of maintenance, and lack of investment in healthcare infrastructure.[25]

Recommendation 2

Owners of public buildings, including local authorities and government departments, should lead a large-scale assessment of health risks in public buildings to inform needs for retrofit. Organisational net zero action plans should also promote the need for retrofit programmes to focus on improving health as well as energy efficiency.

22 UKGBC (2024), Retrofitting office buildings: the case for net zero

23 BSI (2023), BS 40102-1:2023, Health and well-being and indoor environmental quality in buildings

24 WELL Building standard (2020)

25 DHSC (2024), Independent Investigation of the National Health Service in England

Supporting an outcomes-based approach and understanding needs in long-term building use

Building regulations set out functional requirements for building performance parameters, which are specific criteria a building must meet to ensure it is fit for purpose. Regulatory compliance is enforced for new builds and any major retrofit works. Statutory Guidance (in the Approved Documents) gives guidance on how to meet the functional requirements, but alternative solutions may be adopted. While work should comply with all relevant requirements, there is often emphasis on one requirement, such as energy efficiency, at the expense of another, such as ventilation or fire safety.

There is also currently a lack of in-use performance targets, which risks the benefits of new interventions and the intended level of building performance declining over time because they are not used or properly maintained.[26] To achieve the overall goal of healthy, safe, sustainable buildings, it will be important to support building operators to implement management strategies – particularly over time and between different owners and operators. Effective delivery requires collaboration to be incentivised between experts in health, safety and sustainability and barriers like data sharing to be overcome.

When retrofit is undertaken, a clear record should be kept including details of building characteristics, performance requirements, health outcomes, and maintenance schedules. This information should be accessible and easily searchable so that future works can be planned based on the condition of a given building. For fire and structural safety, there is now a legal requirement for those operating higher risk apartment blocks to deliver the golden thread of information.[27] A similar approach should be adopted for public buildings, with an added focus on health and indoor environmental quality. New tools could also offer support for managers and occupiers to access information about the building in a simple format, essentially creating a 'digital passport' of the building where relevant information can be securely shared for iterative works. Guidance should be included so that managers and occupiers can use the building as it was designed to be used.

New technologies introduced must consider the needs and behaviours of building users. This could also be addressed in the building information for owners and occupants. Risks can stem from incorrect use of new systems, especially if mechanical systems are inadequately maintained and not operating effectively; this can inadvertently lead to poorer quality indoor environments. For example, poor maintenance of mechanical ventilation and air conditioning systems can lead to reduced air flow rates, higher fan energy consumption and emissions, fire risks from excessively dirty filters or ductwork, and specific health risks such as exposure to microorganisms. Where feasible, there should be a dedicated professional individual or group responsible for the operation and maintenance of public buildings. Additionally, creating simple user guides could be a helpful resource for occupiers in both domestic and non-domestic settings, especially to highlight maintenance needs. This will support improved building performance over time as there is rarely any contact with the building professionals after installation of retrofit measures.

Recommendation 3

Ministry of Housing, Communities & Local Government should work with a select group of owners of public buildings or housing associations to trial digital passports for buildings based on the golden thread guidance. If successful, this could be adopted more widely so that building records are more accessible and support better management and maintenance of building systems and indoor environments over time.

26 CIBSE (2024) Retrofit revisit

27 Construction Leadership Council (2024), Delivering the golden thread: Guidance for duty holders and accountable persons

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Shaping skills to ensure competent installation

Delivering safe, healthy, sustainable buildings through retrofit hinges on the competency of professionals and installation trades involved in its delivery. However, there are concerns that construction and retrofit sectors lack sufficient capacity to deliver at a national scale.[28] Recognising the need for recruitment and upskilling to deliver retrofit to meet net zero targets, this also provides an opportunity to review any knowledge and skills gaps and ensure that designers, builders, and installers have a good understanding of the needs for health, safety, and sustainability.

Training programmes for installers and accredited 'competent person' schemes that allow a builder to self-certify compliance with building regulations play an important role in ensuring that measures are installed properly, and where relevant, the wider interdependencies are considered in planning. For government initiatives there are requirements for installers. Standards such as PAS 2030 provide clear competence specifications and overall requirements for quality, which installers must be certified to. Content developers for specific training courses and standard setters should actively engage with experts and professional bodies, including in health and building management, to build up knowledge of potential impacts in training programmes. Peer review of training programmes can also help to ensure consistency in available content and alignment with evolving sustainability standards.

Building control is a crucial element in planning and process for retrofit works. Enforcing compliance with the building regulations is essential, building control professionals need to be supported to assess compliance and to understand potential health risks. The outcomes of the Grenfell Tower Inquiry have highlighted that

Image: Shutterstock

28 Gatsby Foundation (2024), Ready for retrofit: An analysis of local skill improvement plans

building control processes lacked rigour and officers often lacked relevant knowledge.[29] While the Inquiry focused on structural and safety risks, it is important that building control professionals also have skills relating to building resilience and understand the importance of buildings' impacts to health. The inquiry outcomes also recommended appointing a chief construction advisor and this role could also highlight health risks and embed these considerations into policies for construction and retrofit. With the reforms to the building control profession introduced through the Building Safety Act 2022,[30] there is now a clear basis on which to build this knowledge among building control professionals.

The wider industry will need clear guidance on how to demonstrate compliance in all three aspects of health, safety and sustainability against the functional requirements. This is another area in which the building regulations may need to be reviewed and updated.

There is a broader opportunity for professional membership organisations to support installers, building professionals and building operators by offering continuing professional development (CPD) programmes to mitigate risks to health and wellbeing in the built environment. This can help to address the limitations of one-off training programmes; ongoing support and mentorship, facilitated through a collaborative network with policy and industry partners, further ensures that professionals remain up to date with emerging technologies and regulations. This knowledge should also be integrated into the curriculum for apprenticeships and degrees that are accredited with these organisations.

Recommendation 4

Training providers should incorporate dedicated training on the importance of buildings for health, how to deliver good health outcomes in retrofitting, and the opportunities for co-benefits in the built environment. Accredited competent person schemes should ensure that competencies are promoted for managing health risks.

Image: Shutterstock

29 Grenfell Tower Inquiry (2024) Phase 2 report

30 Building Safety Act 2022, legislation.gov.uk

Image: Shutterstock

Encouraging R&D

Urgent action is needed to improve the quality of our building stock. However, approaches also need to be reviewed over time to ensure that measures are fit for purpose as evidence emerges. Evolution of robust guidance and standards relies on continuous development of new evidence and understanding of risks. There is a growing evidence base on health impacts of buildings, however, there are key knowledge gaps around the impacts of long-term, low-level exposure to noise pollution and poor indoor air quality. There is also insufficient data on scale up of technologies from experimental to real-world performance, including human interfaces, health impacts and economic factors. Research programmes, and lessons from international best practice, should explore interventions and health-based studies at scale, including domestic, public, and commercial buildings, to close these knowledge gaps. Building up a robust evidence base can be used to ensure the regulatory framework and available guidance are fit for purpose.

Integration of monitoring tools and controls for indoor environments is a clear opportunity for retrofit schemes to provide insights that can support research and innovation. The potential to collate data at a local authority level could also help to inform the need for targeted preventative health measures. The use of CO_2, temperature and humidity sensors could provide information for ventilation effectiveness and inform new guidance for longer term building performance. While there are recent standards for sensors and monitoring indoor environmental performance, this is not currently regulated or necessarily well-known or carried out nationally.

Recommendation 5

Research organisations should build on existing programmes to address knowledge gaps relating to indoor environments and health, especially for long term impacts. Research should integrate into policy and practice to continually iterate and improve guidance and standards, as well as support collaborative development of user-friendly tools and technologies to deliver healthier and more sustainable indoor environments.

Conclusion

Building retrofit programmes are an essential step in improving the quality of homes and building stock as well as meeting our national net zero goals. The benefits of measures to improve energy efficiency, however, extend far beyond reducing energy demand; when applied well, these measures can address health inequalities as well as building safety and sustainability. Uptake of retrofitting needs to be encouraged with support for ensuring high-quality practices and products. It will be important that a systems-based approach is used to develop the underlying regulation, standards, and accreditation processes that will underpin retrofit programmes. Policymakers and industry partners should explore what this process will look like in practice to help building owners plan for specific building needs as part of ongoing efforts to drive these programmes forward.

Various government departments and organisations have overlapping interests and responsibilities regarding retrofit and aims are often addressed in siloed programmes. Where there is only voluntary guidance available, this may also result in retrofit schemes delivering the minimum requirements rather than the widest benefits. The opportunities afforded by retrofit necessitate an outcomes-based approach to ensure building operational performance delivers for health, safety and sustainability, throughout its lifespan. This requires collaboration between policymakers, guidance providers, installers and building operators, to integrate health and wellbeing into central and local retrofit strategies and their delivery.

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