

Open House for Overheating:

A Case Study of Overheating Policy Synergies in London

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Abstract

Overheating in buildings is a growing public health hazard becoming more prevalent with climate change. The research aimed to analyse how interactions between jurisdictional scales, urban stakeholders and policies promoting synergies affect adaptation processes in cities using overheating policies in London as an example. Understanding how these interactions affect policy implementation can ensure that cities are not promoting ineffective policies. To achieve this aim, a case study of London's two overheating policies was conducted using a multilevel governance framework encompassing scale analysis and the adaptation-mitigation dichotomy. First, a descriptive literature review was conducted to understand where synergies in buildings occur. A review of policy documents was then undertaken to establish the political framework London's policies operate in and how national and intergovernmental policies create synergies, trade-offs and conflicts with the London policies. Interviews with municipal stakeholders, building professionals and advisory groups were used to confirm interactions with the policy documents, as well as identified barriers and future drivers to policy implementation. The policy document analysis showed that national and intergovernmental support for overheating was lacking which had the effect of weakening London's enforcement capabilities for its local overheating policies. Multiple barriers were found relating to challenges of overheating being pushed into the future to address and stakeholders' inability to prioritize the issue given specific circumstances within their operating domain. Future drivers to improve implementation of London's policies related to preventing overheating from being seen as a future problem and incentivizing individuals to act sooner through more regulations, alternative financing mechanisms, and more. The thesis makes three unique theoretical contributions. While the adaptation-mitigation dichotomy can be used to explain barriers and drivers to integrated policies, overheating presents two unique challenges: i) overheating provides a significant adaptation challenge because of the perceived non-critical nature of the issue to the general public and apparent lack of immediate benefits; ii) large cities with devolved enforcement powers will face many of the same challenges as higher levels of governance. Finally, including informal institutions when conducting scale analyses is necessary so that these institutions can be mitigated with precautionary measures and tools. Policy recommendations are provided for London and other cities.

Keywords: adaptation, overheating, synergies, buildings, cities, policy analysis

Executive Summary

Problem

Climate change threatens to make cities less liveable by increasing the risk of environmental hazards. Adaptation—the process of adjusting social, environmental, and economic systems to actual and expected impacts of climate change—is thus necessary to make cities resilient and safe. One hazard becoming progressively impactful with rising global temperatures is overheating. Overheating can result in exhaustion, bodily distress, and in worst case scenarios, death. This risk can be exacerbated in buildings. In temperate climates with cold winters, many buildings increase overheating risk because they were built to withstand different climatic conditions. While active cooling—i.e. air conditioner—can mitigate heat risk, active cooling increases emissions if non-renewable sources are used and expels waste heat into the environment which further increases temperatures. Thus, a negative feedback loop occurs. Adaptation to overheating is necessary but constrained by factors such as limited resources, lack of concern, trade-offs with other policies, and difficulties measuring adaptation success.

Cities looking to address overheating can turn to synergies as a way to increase support for adaptation. Synergies occur when an adaptation action concurrently has a positive effect on mitigation and vice versa, such as when efficient cooling is required in low carbon buildings or passive design is promoted instead of active cooling. Conflicts occur if an adaptation action has a negative effect on mitigation or vice versa. Buildings designed today are expected to be used for 60+ years and thus represent infrastructural lock-in difficult to diverge from once in use. As temperatures increase, preventing or minimizing the uptake of active cooling is critical to mitigation efforts. This makes it imperative to ensure policies are successful before being locked into buildings that are not prepared to withstand higher temperatures and simultaneously counteract mitigation efforts.

London's 2018 Environment Strategy has two policies integrating adaptation and mitigation that aim to minimize overheating risk in buildings and reduce active cooling. While this demonstrates the potential of integration to result in synergies, there is a need to ensure overheating policies are leading to positive lock-ins within urban areas. Examining how overheating policies interact across jurisdictional scales—such as local, national, regional and inter-governmental scales—and what the underlying drivers and barriers are to achieving synergies remains a research gap (Grafakos et al., 2019; Walsh et al., 2011). As overheating becomes a serious hazard in many cities, it is imperative the right policies are promoted.

Research Questions and Methodology

The aim of this thesis is to analyse how interactions between jurisdictional scales, urban stakeholders, and policies promoting synergies affect adaptation processes in cities; London's overheating policies for buildings are used as an example. Understanding how these interactions impact overheating policies enables cities to better develop integrated policies that tackle mitigation and adaptation in buildings. This also ensures ineffective policies are not promoted. London is a promising case study because of the integrated nature of its two overheating policies that have been in place for over a year. There are key lessons that can be learnt from London's policy implementation. Thus, the following research questions were devised:

RQ1: *What actions can be implemented in the buildings sector in cities that address overheating and result in synergies?*

RQ2: *How do interactions across jurisdictional scales affect London's overheating policies for buildings?*

RQ3: *What are the barriers that affect the implementation of London's overheating policies for buildings?*

RQ4: *What are the possible drivers for increasing the implementation of London's overheating policies for buildings?*

To answer RQ1, an exploratory analysis of relevant literature was conducted to understand and summarize where synergies and conflicts in buildings can occur. 29 articles were identified according to pre-set criteria. The catch-all term used in this research when referring generally to these measures with synergies is 'passive measures'. A case study approach was chosen to answer RQ2-4 covering the two main units of analysis from the London Environment Strategy published by the GLA (Greater London Authority):

Policy 8.4.3: *Minimise the risk of new development overheating:* mandatory overheating assessments in all new buildings and consideration of the Cooling Hierarchy in domestic buildings;

Policy 8.4.4: *Minimise the risk of existing homes and non-domestic buildings building* incorporation of overheating assessment in the Energy for Londoners retrofitting programs.

Multilevel governance, scale analysis and adaptation-mitigation dichotomy theories guided the analysis. Policy documents and interviews were the main source of data, and relevant research documents from non-profits and buildings organizations were used for triangulation. Interviews were held with three groups: i) GLA/Local Authority employees; ii) building professionals; iii) climate advisory groups. To answer RQ2, the LES policies were assessed against relevant policy documents. Interviews were used to confirm instances where jurisdictional scales—i.e. local, national and intergovernmental—policies support synergies, trade-offs, or conflicts with the LES policies. To answer RQ3-4, interviewees were asked open-endedly about barriers and future drivers they see to implementing the LES policies.

Main Findings

RQ1: The identified technical measures and corresponding synergies and conflicts can be found in Table 4-1. While the promotion of any measures by city governments will depend on context, the breadth of passive measures available demonstrates the possibility of reducing active cooling use in both old and new builds.

RQ2: Locally, the GLA institutionalized consideration of overheating with energy efficiency in the Energy Assessment Guidance. The London Plan serves to prevent potential conflicts and trade-offs that emerge, such as poorly installed insulation leading to overheating in small flats. While there are policy documents at the national and intergovernmental levels that could support regulatory synergies with both policies, overheating assessments are either voluntary, not legally required, or the onus is placed on localities to consider adaptation and mitigation together. While this might seem irrelevant because London's standards are more stringent, lack of government support results in the city's weakened enforcement capabilities.

RQ3: Several barriers related to overheating being viewed as a far-off problem. **Trade-offs with building more housing** allow large sites to be approved with inadequate adaptation preparedness if they provide multiple affordable units. **Trade-offs with mitigation** emerge because prioritization of mitigation has led to emission targets that are more easily enforced than adaptation. **Lack of public concern** for overheating, combined with the aforementioned trade-offs and minimal government support, leads to a market failure where homes are not built for the future. Finally, **limited capacity** in terms of resources and time for multiple stakeholders involved means overheating falls lower on the priority list.

Barriers related to the characteristics and requirements of stakeholders involved in policy implementation include a **lack of regulations** on the national scale supporting LES policies.

There are *skill shortages* that prevent building professionals from implementing passive measures and prevent officials in boroughs from properly assessing planning proposals. *Informal institutions* like developers embellishing overheating assessments weaken the policies. *Culture and aesthetic preferences* result in some passive measures not being used to address overheating because they do not fit style ideals. Finally, **occupant behaviour** impacts policy implementation when some passive measures require resident action.

RQ4: Possible drivers that could help overcome some barriers include the *overheating problem getting worse* which would make the problem impossible to ignore. *Changing the narrative* to one highlighting overheating as a health issue could make the public aware of negative impacts. *Alternative financing models*, particularly for retrofits, could incentivize more holistic upgrades. *Stronger regulations* such as an overheating definition from the national government were unanimously favoured. The *reputation* of developers and architects was considered an increasingly important driver. Finally, increasing the *education* of the public to be aware of overheating dangers could stimulate demand for safe buildings.

Key Takeaways

Minimizing or eliminating active cooling needs with passive measures is possible. Even in hot climates, reducing reliance on active cooling helps increase energy resiliency, reduce costs, and reduce emissions. Identified instances where conflicts or trade-offs occur include: centralized heating pipes contributing to overheating in hallways; insulation applied in small flats with few ventilation options; an inability to open windows in polluted or noisy areas, preventing ventilation. Cities should be aware of these potential conflicts and work to minimize them.

Regulatory support institutionalizes the issue. While national governments mandating overheating assessments or definitions lends credence to the issue, this may not be realistic in all political climates. Requiring overheating assessments in planning proposals helped institutionalize the issue in London, even with the GLA's limited enforcement powers. Setting definitions or targets for overheating lends a quantifiable aspect to overheating which is a key challenge in determining if adaptation is successful.

Overheating impacts the most vulnerable. Short term trade-offs result in overheating adaptation being pushed to future occupants. Those in lower socioeconomic statuses may not be able to afford active cooling. In cities with high social inequalities like London, this problem is magnified. To avoid an overheating crisis and increased emissions from active cooling in the future, remedying the market failure of low-quality buildings through government foresight is needed given that overheating is a silent killer.

New value from addressing overheating must be derived for stakeholders to enable an overheating transition. Overheating does not have the same quantifiable benefits as emission reductions, but the unseen benefits—less stress, reduced hospital admissions, etc.—can strengthen the investment case. Passive measures do not require significantly more resources, but financial tools like property charges and low cost loans can incentive owners to act. Social housing or care homes represent areas where city investment can reduce the prices of overheating technology to create supply chain economies of scale and set an example.

Large cities will face additional enforcement challenges. Informal operating rules can affect policy implementation particularly when central or strategic bodies need to delegate authority to city subdivisions. While cities cannot control this entirely, providing additional resources and lobbying for higher level regulations to overcome these informal rules can help increase stringency. Challenges with setting overheating thresholds remain, but until targets are

quantified the institutionalization of policy integration is unlikely. Having targets for local authorities or the city to assess in planning applications ensures the issue is tackled.

Occupant behaviour and cultural preferences can result in weak uptake of measures.

Some passive measures require occupant action. Whether information is reaching the most vulnerable about what to do during heatwaves is critical to understand. Cities can address this confounding variable by undertaking research on occupant behaviour to determine the problem’s extent. Examples can be made of public buildings to begin a cultural aesthetic shift. Partnerships with care homes or social housing providers can demonstrate what is possible. Character homes or conservation areas are common in many cities. A broader conversation may need to occur about whether visual design should be prioritized over adaptation, or what policy changes can occur to ensure adaptation is not overlooked.

Policy Recommendations

The policy recommendations spurned by this research and London case study are below:

Policy Recommendations for Cities	
Mandatory overheating assessments	Legally requiring assessments against future temperatures institutionalizes overheating into planning practices. This gives the issue credibility and at least ensures the hazard is not entirely overlooked. London’s leadership with the mandatory CIBSE assessments is something other cities can look to replicate.
Consider implementing a Cooling Hierarchy	The Cooling Hierarchy lays out cooling measures building professionals can implement instead of automatically implementing active cooling. A hierarchy can be adapted to different cities given their unique geophysical circumstances and extent of overheating risk. Requiring building professionals to demonstrate consideration of passive measures and justify why they think active cooling is necessary can be critical to reducing automatic reliance on active cooling.
Alternative financing mechanisms to address overheating in new builds and retrofits and discouraging active cooling	Costs will always be a barrier to sustainable buildings. Energy efficiency retrofits suffer from a lack of financing and uptake, as do holistic retrofits. Incorporating overheating assessments into city run programs can ensure adaptation is being considered. Energy contracting models where the utility companies are responsible for meeting projected energy savings can encourage customer uptake. Allowing retrofit charges to be added to properties for future owners is another option. Banks valuing resilient homes more highly to reduce the risk premium is also critical to institutionalizing adaptation into the public discourse and financial systems. Experimenting with different models and lobbying for alternative schemes can be critical to city overheating prevention goals. For commercial/industrial buildings, subsidies can be explored for active cooling units that are top class for efficiency. While the EU has fairly high efficiency standards, this is not the case in North America or many Asian cities (IEA, 2018). Requiring on site energy generation for certain amounts of cooling energy usage can reduce the scale of the conflict.
Integrate overheating into wider public goals and sectors	There are multiple benefits to minimizing the use of active cooling. Building owners or renters can benefit from lower energy bills, stronger energy resiliency, and better comfort and sleep in domestic buildings. Emissions are lowered if active cooling is not used and a city still relies on non-renewable energy. Increased productivity benefits the economy, and fewer doctor and hospital admissions benefit the health sector. While these benefits may be difficult to quantify, investment calculations ought to take the benefits that go beyond synergies into account.
Policy Recommendations for London	
Mandatory white roofs if green roofs are not feasible	Green roofs are already required on buildings above a certain size. Due to the multiple benefits green roofs provide, interviewees said they are preferable to white roofs in London. However, if a building cannot feasibly incorporate green structures, reflexive or white paints can contribute to reducing the UHI and cooling demand. New York and Los Angeles are examples of cities with mandatory white roof policies. This option could be especially viable for industrial buildings. See section 4.1.2 for more on the viability of this solution.

Study occupant behaviour during heatwaves	Conducting ex-post evaluations of heatwave alerts can drive a better understanding of the effectiveness. Whether instructions are used by building occupants and if vulnerable populations are reached is also critical to understand. This could point to how to improve current alert systems, determine if information provision should be made mandatory in new homes or after retrofits, and increase awareness.
Lobby for the 201 Building Regulations update to include overheating	<p>Several stakeholders interviewed are already lobbying. Overheating updates to the regulations enables stronger vertical governance on the topic. The SAP appendix could be updated to include a mandatory assessment, provided the tool is improved. As the Building Regulations cover certain retrofit standards, this could support holistic retrofits by mandating overheating modelling for certain scales of retrofits.</p> <p>EU member states are flexible in how they meet ‘nearly zero energy’ construction standards, and the new regulations will likely introduce standards similar to what was eliminated from the Code for Sustainable Homes and Zero Carbon Homes; mitigating cooling demand increases should not be overlooked in this update either.</p>
Trial incorporating overheating preparedness into retrofit programs	This would strengthen local governance on the issue. Asking residents whether their home overheats or if this is something they would like their home prepared for could raise awareness. Basic insulation upgrades can protect residents from overheating when applied correctly; ensuring technical professionals are aware of risks can prevent conflicts and result in more comprehensive upgrades. Something like the recently produced Good Homes Alliance report provides an easy to use checklist that can be incorporated into new builds and retrofits to determine overheating risk.
Liability for future overheating upgrades	It does not make climate sense to implement active cooling in current temperatures. Yet this will change as the climate gets warmer. Assigning responsibility to building managers or owners for flats and other large developments can ensure the burden does not fall on tenants to prepare buildings for the future. This is done by some local authorities already. As it is difficult to get 2050 or 2080 assessments completed for a variety of reasons, regulating liability is likely to be a challenge. However, as awareness grows and more customers experience overheating, this is an important equity consideration.
Better enforcement mechanisms for local authorities	Many local authorities struggle to properly assess planning applications. There are a few ways this could be mitigated: investing in training to ensure assessments are done properly by providing common examples of information fraud by developers; investing in a neutral, 3rd party committee that crosschecks applications; investing in better technology to automate parts of the process; centralization of processing at the city level rather than the borough level; etc. The GLA and local authorities are limited in financial resources and the planning approval process is already slow. Making the process more efficient does require resources. Yet investment can ensure housing, mitigation, and adaptation targets are met, and fewer trade-offs occur in non-referable applications. Given that few buildings built today are equipped for future climates, money invested now means less reparative investments later on.
Make examples of municipality owned buildings:	As discussed, improving the supply chain for overheating measures is critical. If a city leverages its buying power to ensure low carbon overheating measures are in place, it brings attention to the overheating issue and creates demand for technical solutions and skill building. As many public buildings still require efficiency upgrades, these retrofits are a natural time to take on a more holistic approach. Brussels for instance, mandated that all social and public housing was expected to meet Passive House levels in 2013.

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Abbreviations

CCC	Committee on Climate Change
CIBSE	Chartered Institution of Building Services Engineers
EU	European Union
EWI	External wall insulation
IWI	Internal wall insulation
LES	London Environment Strategy
LP	London Plan
MHCL	Ministry of Housing, Communities and Local Government
NPPF	National Planning Policy Framework
PCMs	Phase change materials
PHE	Public Health England
SAP	Standard Assessment Procedure
UHI	Urban heat island
UK	United Kingdom

1 Introduction

1.1 Background

Climate change increasingly has negative effects across the globe. Cities in particular face attention for being major contributors to global emissions and for the high risks they face from climate change impacts and vulnerabilities (Field, Barros, & IPCC, 2014). Rising temperatures make cities less liveable by threatening human health, increasing the risk of hazards such as flooding, heat and water scarcity, and endangering our social, environmental and economic systems (Wamsler, 2014). Urban climate adaptation is thus necessary to avoid infrastructural damage in cities and the sequential negative effects on systems (IPCC, 2018; Wamsler, 2014). Adaptation refers to “the process of adjustment to actual or expected climate and its effects... In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities” (Field et al., 2014, p. 1758). While mitigation—which reduces emissions from human caused activities—is still necessary to reduce the threat and severity of climate change, it is increasingly recognized that adaptation must play a role in reducing hazards that already exist. That is why this thesis will focus on adaptation to overheating in buildings.

Overheating is becoming a progressively serious hazard as temperatures rise globally, rendering it necessary to use adaptation measures to protect city residents. When humans are exposed to extreme heat they are not acclimatized to, they can suffer from heat exhaustion and cardiovascular diseases that in worse-case scenarios can lead to death; older populations are more vulnerable, as are children and individuals with pre-existing medical conditions (Lomas & Porritt, 2017). Overheating can cause distress, trouble sleeping, and other emotional discomforts (Campbell & Marsh, 2018; Lomas & Porritt, 2017). Health-related effects stem from the length of time individuals are exposed to heat, meaning buildings that overheat are especially dangerous given inhabitants cannot always leave easily.

There is not one threshold for when humans overheat in buildings as this depends on inhabitants' acclimatization and vulnerability (Lomas & Porritt, 2017). Yet buildings can increase the risks urban populations face from overheating if not designed to withstand this hazard, which many are not given different temperatures today (Wamsler, 2014; Wilby, 2007). Buildings increase risk if heat builds up with inadequate ventilation or cooling options (Gupta and Gregg, 2012). The built environment also contributes significantly to the urban heat island (UHI) effect, the phenomenon where densely populated areas have higher average temperatures than surrounding rural areas; this increases overheating risk within cities as heat builds up and takes longer to cool off at night (Wilby, 2007). Buildings are major emission contributors, with buildings and construction estimated to emit 39% of energy related CO₂ emissions and make up 36% of global final energy use (Abergel, Dean, & Dulac, 2017). The majority of these emissions come from fossil fuel combustion to power electricity, heating/cooling, and appliances. Climate change results in higher demand for active cooling (i.e. air conditioner), which in turn increases emissions resulting in even higher temperatures. Thus, a negative feedback loop occurs when active cooling powered by non-renewable sources is installed.

At the same time, buildings act as a first defence against hazards and can increase urban resiliency by allowing cities and populations to withstand or recover from overheating. Adaptation measures for buildings that address overheating include: active cooling; passive building design; green roofs; and more (Gupta & Gregg, 2012; McLeod, Hopfe, & Kwan, 2013). Active cooling demand is expected to triple by 2050 and become the largest driver of electricity demand in buildings (IEA, 2018). Effective governance of buildings, overheating, and urban density is thus critical not only to lowering emissions, but for locking in capacity to adapt (The World Bank, 2010).

Addressing overheating is critical for cities to avoid infrastructural damages and sequential negative effects on social and economic systems (Wamsler, 2014). Yet overheating measures, like all adaptation measures, are constrained by several factors: availability of resources; trade-offs between policy goals (Field et al., 2014, p. 948); and complex interplays between physical, social and economic processes that make it difficult to predict how systems react to shocks (Wamsler, 2014). Mitigation strategies have also traditionally received more attention and resources. This is partly because successful mitigation would minimize adaptation needs, and many of the immediate impacts of climate change were not felt on wide scales (Biesbroek, Swart, & van der Knaap, 2009). Overheating has not been a priority concern in Northern Europe and cooler climates because overheating was not viewed as an endemic problem. However, countries with temperate climates like the United Kingdom (UK) now experience hotter average temperatures and heatwaves on an increasingly reoccurring basis.¹ UK summer heatwaves are 10-20% more likely than several decades ago (Committee on Climate Change, 2019a). How countries deal with this new challenge is less explored, and one reason why the UK was chosen as a case study.

To incentivize socially optimal outcomes for policy selection and funding decisions for addressing overheating, synergies can be integrated into political and economic decision-making (Field et al., 2014). Synergies occur when an adaptation action concurrently has a positive effect on mitigation (Field et al., 2014). Synergies often arise between adaptation and mitigation policies, such as when efficient cooling is required in low-carbon buildings or effective land management strengthens protection against hazards (IPCC, 2018). These policies can be described as integrated policies because of benefits for adaptation and mitigation; integrated strategies that combine mitigation and adaptation are thought to result in more synergies (Grafakos, Trigg, Landauer, Chelleri, & Dhakal, 2019). Cities have a vested interest in minimizing trade-offs between adaptation and mitigation and preventing conflicts that occur if an adaptation action has a negative effect on mitigation, or vice versa. Synergies can change the calculation when deciding whether to implement adaptation actions that address hazards, as they offer immediate benefits for mitigation. For example, passive building designs reducing overheating risk while eliminating the active cooling need. Active cooling would otherwise increase emissions if non-renewable sources are used, contribute to the UHI when expelling hot air, and increase vulnerability in power outages.

1.2 Problem

Cities beginning to experience overheating have started to implement policies addressing overheating in the built environment. Many of these policies promote measures with synergies as they emerge from integrated climate strategies that tackle mitigation and adaptation simultaneously (Grafakos et al., 2019). While there are regions in the world facing greater heating risk, existing building stocks in temperate climates were not built to withstand overheating; new developments are also not necessarily prepared for a vastly different climate in the future (Barbhuiya, Barbhuiya, & Nikraz, 2013; Gupta & Gregg, 2012). Buildings designed today are expected to be used for 60+ years and thus represent infrastructural lock-in difficult to diverge from once in use (Reyna & Chester, 2015). This makes it imperative to ensure policies are successful before being locked into buildings that are not prepared to withstand higher temperatures and simultaneously counteract mitigation efforts. As temperatures increase, minimizing the uptake of active cooling for as long as possible is critical to mitigation efforts.

¹ Temperate can refer to a variety of climates, but it generally encompasses countries with non-extreme temperature variation between the winter and summer i.e. mild winters and summer. This includes the UK, coastal areas of North America, much of Northwest Europe, New Zealand, Eastern Asia and Southern Chile [\[x\]](#)

Despite the promise of synergies in building policies supporting adaptive processes, there is still an incomplete evidence base related to how synergistic policies can best be supported by multilevel climate governance (Grafakos et al., 2019; IPCC, 2018; Landauer, Juhola, & Klein, 2018). City networks like the C40 cite an incomplete evidence base related to which actions result in urban synergies, which spurred this research project. While governments have started promoting synergies in policy-making, there is minimal knowledge underpinning these claims which can lead to a waste of economic and political resources if ineffective actions are promoted (IPCC, 2018). Understanding what actions or policies lead to positive lock-ins in urban areas is also a major knowledge gap (Ürge-Vorsatz et al., 2018). Given that 75% of infrastructure that will exist in 2050 has yet to be built (Global Infrastructure Basel, 2014), it is imperative that building policies do not result in negative lock-ins. Though the importance of complementary policies, institutions and regulations is recognized as necessary for adaptation and a successful climate change response, understanding how overheating policies interact across different jurisdictional scales—such as local, national, regional inter-governmental scales—and what the underlying drivers and barriers are to achieving synergies remains a research gap (Bulkeley, 2010; Grafakos et al., 2019; Walsh et al., 2011).

The aim of this thesis is to critically analyse how interactions between jurisdictional scales, urban stakeholders, and policies promoting synergies affect adaptation processes in cities. This is done by using overheating policies for buildings as an example. Understanding how these interactions impact overheating policies enables cities to better develop integrated policies that tackle mitigation and adaptation, and ensures ineffective policies are not promoted.

This thesis takes a multi-level approach as there are global implications for how localities design policies that interact with other scales and avoid barriers. Overheating policies in some countries are a new phenomenon only becoming necessary with a changing climate (Hewitt, Mackres, & Shickman, 2014). Building control traditionally receives higher public approval than explicit spatial planning which has been accused of being “excessive public interference” (Thornbush, Golubchikov, & Bouzarovski, 2013, p. 7). Thus, building control is a promising area for adaptation to receive institutional government support. While new developments are held to increasingly high standards for energy efficiency and adaptation, there are concerns this is not happening at the extent necessary to prevent negative lock-in (Brown, Kivimaa, Rosenow, & Martiskalnen, 2018). Retrofitting existing building stock continues to be a challenge for municipalities because it is costly to incentive private individuals to make upgrades (Makantasi & Mavrogianni, 2016; Brown et al., 2018). All infrastructure requires systemic change to limit warming to 1.5°C and ensure urban citizens are protected against hazards (IPCC, 2018).

As overheating policies are still a novel phenomenon in temperate climates, they warrant an especially critical analysis before ineffective policies are promoted. This research will address the aforementioned research gap in three ways: first, by identifying adaptation measures for buildings that reduce overheating risk and support synergies; secondly, using London as a case study to analyse how jurisdictional scales affect overheating policies for buildings supporting synergies; and finally, looking at additional barriers or possible drivers that can result in synergies, conflicts and trade-offs when implementing London’s overheating policies.

1.3 Research Questions

Based on the above, the following research questions are devised:

RQ1: What actions can be implemented in the buildings sector in cities that address overheating and result in synergies?

RQ2: How do interactions across jurisdictional scales affect London’s overheating policies for buildings?

RQ3: What are the barriers that affect the implementation of London’s overheating policies for buildings?

RQ4: What are the possible drivers for increasing the implementation of London’s overheating policies for buildings?

RQ1 will be answered through a descriptive analysis of the relevant literature, descriptive in this case meaning listing relevant actions that can result in synergies. The process of how literature was selected is expanded on in Section 2.3. A case study approach was selected for answering RQ2, RQ3, and RQ4 using London.

This research aims to help urban decision-makers maximize the synergies of urban adaptation actions for building. Cities in temperate climates are the main audience that can learn from the findings. Identifying how institutions at different levels of governance lead to synergies, trade-offs or conflicts will accelerate urban sustainable transitions by raising awareness about how governance affects buildings when designing new plans and strategies. As more cities seek to take an integrative approach to their climate strategies, climate governance will be critical to ‘get right’ if climate goals are to be achieved.

1.4 Disposition

The contents of this research work are as follows:

Section 2 justifies the methodology used in this research. An introduction to the external organisation and the case study is provided. Limitations and ethical considerations associated with the research are also discussed. Section 3 presents the analytical framework used to guide this research based on theories of multilevel governance, scale analysis and the adaptation-mitigation dichotomy.

Section 4 presents the findings from the literature review for RQ1. A comprehensive review of overheating measures for buildings that result in synergies is included. Section 5 addresses RQs 2-4, presenting the findings from the London case study. This includes the jurisdictional scale analysis and additional barriers and future drivers. Section 6 analyses the data from these findings.

Finally, a conclusion including policy recommendations and areas of future research is presented in Section 6.

2 Methodology

This section will (i) introduce the author's relationship with the partner organisation, (ii) present the research design including collection and analysis methods and (iii) discuss the scope, limitations, audience and ethical considerations affiliated with the research.

2.1 External advisor: C40 Cities Climate Leadership Group

The idea for this project emerged from the author's outreach to the C40 Cities Climate Leadership Group, an international city network, about potential thesis research advice. C40 connects cities across the world to facilitate peer-to-peer knowledge sharing, gain external support in implementing climate action and access funding opportunities. Several topics were discussed with C40 Adaptation Research before deciding on synergies and trade-offs within urban adaptation building policies to address overheating. C40 has supported the work on this topic by providing external input through an advisory role. Contacts for the London case study were identified through the author's own network.

2.1.1 Choice of Case Study Evaluation Approach

As the aim of this study is to understand what drives or impedes synergies in urban climate policy, a primarily qualitative, explanatory, holistic, paradigmatic case study approach was selected. Case studies allow researchers to develop better understandings of social phenomena through an in-depth look at how events are developing (Walliman, 2016). Analysing unique situations or exploring innovative theories comprehensively is possible within single case studies, and even encouraged when a phenomenon has not been properly established. Though it is difficult to make statistical generalizable statements, the strengths of this approach are that it can be used to test theories and "reveal concepts that are useful for theory building" (Walliman, 2016, p. 40). A case study approach also creates a framework for analysis that cities can use to assess their own adaptation policies for buildings.

New topics of research warrant qualitative investigation to better understand the phenomenon (Creswell, 2014). As integrated overheating policy effectiveness is poorly understood, implementation of these policies requires further consideration. Quantitative data for assessing synergies and trade-offs in urban climate policies is also not generally publicly available. This is due to privacy concerns, but also cities often not publicly acknowledging trade-offs that emerge within strategies or having the capacity to evaluate all policy impacts (Grafakos et al., 2019). While quantitative ex-post data cannot be captured, interviewees will be working with London's policies and can thus speak to their progression and limitations.

Case studies are classified as exploratory, descriptive or explanatory (Scholz & Tietje, 2002). Exploratory studies allow researchers to gain a deeper understanding of phenomena to further develop theories and models. Descriptive studies instead use a theory or model to guide data collection and can allow researchers to examine a case from a different perspective. Explanatory case studies allow cause and effect relationships to be tested; hypotheses should be formed before analysing the case to test the theory (Scholz & Tietje, 2002). In this case, whether integrated, urban overheating policies are supported or hindered by multilevel governance can be tested, making this an explanatory study.

Flyvbjerg proposes four types of cases that demonstrate how strategic selection can help increase their generalizability: extreme/deviant cases which provide information on unusual cases in a problematic or exemplary sense; maximum variation cases to highlight differences between dimensions; critical cases that allow one to make logical deductions about all, many or no cases; and paradigmatic cases which can operate as reference points within intellectual

domains relevant to the case (Flyvbjerg, 2006). In this research, the objective is to test multilevel governance within a new domain for cities: overheating.

London cannot be considered a critical case per Flyvbjerg's reasoning, as its political structure is unique to the rest of the UK. It is also impossible within the limited scope of this research to control for variables across international cities and make a judgement on whether the findings are likely to hold true. This is especially difficult with explanatory design (Scholz and Tietje, 2002). While London has some characteristics of an extreme case—overheating research funding from the government, inequity in society that brings unique challenges, buildings that are described by professional bodies as ill-prepared for heatwaves—these characteristics and others better support London's classification as a paradigmatic case.

A final key difference between case study designs is whether they have an embedded or holistic design i.e. whether they look at one unit of analysis or multiple units of analysis (Yin, 1994). The units of analysis are two policies that address overheating in buildings within the London Environment Strategy (LES), making this a holistic study. To analyse trade-offs, as well as barriers and drivers to synergies occurring, a case study approach captures the context within which the selected policies are being evaluated (Kemp & Pontoglio, 2011). It is hypothesized that the successful implementation of these policies is dependent on supportive levels of multilevel governance, concepts that can only be understood by analysing the broader context within specific cases.

2.1.2 Introduction to the Case Study

London in the UK is a city that faces increasingly hot temperatures in the summer. While the UK already experiences about 2000 heat-related deaths annually, this number is expected to more than triple by the 2050s to 7000 a year (Environmental Audit Committee, 2018). The risk is greatest in the south where London is located (Environmental Audit Committee, 2018). Housing in London has been identified as an area inadequately prepared to deal with current overheating risk and anticipated disruptive variations in climate (Committee on Climate Change, 2019b); buildings are also the most significant emission contributor in the city (Global Covenant of Mayors, 2016). A House of Commons Environmental Audit Report from July 2018 noted that minimal resources and auditing have resulted in local authorities allowing heatwave adaptation to “slip to the bottom of the pile” (Environmental Audit Committee, 2018, p. 3). The UK government is also “concerned that essential heatwave adaptation measures are not being delivered” at the local level (Environmental Audit Committee, 2018, p. 19). Buildings unprepared to deal with changing temperatures are thus being locked in. Overheating is a critical issue to address but one that should be addressed concurrently with mitigation when possible.

Overheating is a novel concern in temperate climates and synergy promotion is only now becoming commonplace within integrated climate strategies. London serves as a unique example where overheating and integrated policies promoting adaptation and mitigation are issues of high importance despite the UK government's concerns. The city is at high risk from extreme heat and buildings are its most significant emissions contributor, meaning London has an interest in ensuring its buildings are adapted to climate change while reducing emissions from this sector (Global Covenant of Mayors, 2016). London is a C40 ‘megacity’ meaning it has a population of at 3 million+ (Marinello, 2012). It is a prominent and active member of the C40, and other cities within the network often look to London's best practices for guidance. London is a wealthy city with high capacity to implement initiatives and policies but is still subject to inter-jurisdictional institutions and barriers that affect the functioning of policies. The city has high levels of socioeconomic inequality and a population that could increase to 9.37 million by 2021 from 8.2 million in 2011 (Greater London Authority, 2016). Thus, London grapples with

a range of issues that affect its capacity to deal with climate change, many which are shared by other major cities.

The Greater London Authority (GLA), the central elected strategic body in London, previously took a *Stand-alone parallel/combined* approach to mitigation and adaptation meaning plans were developed independently of one another and operated in parallel (Grafakos et al., 2018). However, London recently took an *integrated approach* by combining mitigation and adaptation in the LES, released in May 2018 (Greater London Authority, 2018b). This strategy stresses that synergies should be promoted while also addressing air quality, health, biodiversity, and more. This provides an interesting analytical lens as London is inherently taking a synergistic approach in combining various climate strategies. The strategy is based on previous climate strategies and acts in parallel with the London Plan, another strategy for the Greater London area (Greater London Authority, 2016). Besides strategies at policies at the urban level, London is also subject to regulations at national and EU scales.

Addressing overheating while reducing emissions is necessary for the safety of London residents and the climate, making it critical to understand how policies promising synergies can best be supported and implemented. While climate actions are ultimately dependent on local context, other cities can learn best practices from a global leader and see what might be lacking in their own institutional requirements to support their climate strategies.

2.2 Methods for Data Collection

2.2.1 Literature Review

The literature review is divided into two sections: Section 3: Background to Synergies and Section 4: Results from the Literature Review.

Background to Synergies

Section 3 presents the topics of synergies, conflicts and trade-offs in urban adaptation policies and addresses how multilevel governance affects adaptation policies. This is done to define and map the relationships between relevant concepts, demonstrate the implications of synergies for urban sustainability, and present the analytical framework guiding this research. The results for RQs 2-4 are derived from this analytical framework.

Results from Literature Review (Synergies in Buildings)

In order to analyse synergies in buildings policies in London, an exploratory analysis of relevant literature was conducted to understand and summarize where synergies and conflicts in buildings can occur; the C40 also requested this review. The review was scoped down to actions addressing overheating using three primary categories: passive cooling such as windows, orientation, brise soleil, awnings, shutters and reflexive surfaces, and etc.; insulation; green infrastructure. This categorization is adapted from a ClimateJust—a non-profit in the UK—typology establishing structural adaptation measures for overheating. Using this initial categorization ensures the actions looked at are relevant for the UK. Even though there is overlap—passive cooling can include green infrastructure and insulation because energy use is reduced—the categories provide structural organisation to the review. This selection of actions is further elaborated on in Section 4.1. The catch-all term used in this research when referring to measures with synergies generally is ‘passive measures.’

The literature review was conducted by asking what synergies and conflicts for adaptation measures in buildings have been identified within the aforementioned categories by academic researchers and practitioners, government agencies, and think tanks. A structured search for

relevant peer-reviewed and grey papers was done by a) conducting key word searches in the University of British Columbia Library, LUB Search, and Google Scholar and b) referring to the bibliographies of already identified relevant literature. The keyword searches included combinations of the following: overheating; buildings; structural adaptation; passive cooling; green infrastructure; cool roofs; insulation; synergies; conflicts; effectiveness; shading.

Literature was deemed relevant if:

- a) it was a peer-reviewed academic paper, or published report with an ISBN or ISSN;
- b) synergies or conflicts identified were for measures that addressed overheating and could be implemented in buildings (other ancillary benefits can occur);
- c) these measures could be implemented in the building design or retrofitting stage, both within residential homes and commercial buildings (this does not cover appliances, district cooling, etc.);
- d) the synergy or conflict had not already been identified at least three times in this review (to set a limit for literature reviewed);
- e) it was written in English.

This resulted in 29 articles identified. The findings of the literature review are presented in Section 4.1. As adaptation actions are highly localized, a note will be made about the context of the study where these synergies or conflicts have been identified. This review is not meant to be comprehensive but rather highlight critical areas in buildings where synergies and conflicts can occur to guide the policy analysis.

2.2.2 London Policy Selection

The main document under examination is the LES, an integrated climate action plan for London that encompasses mitigation, adaptation, and other sustainable development goals. The following policies were selected for analysis because both address overheating in buildings and promote the use of measures with synergies:

Table 2-1. Units of Analysis

Policy 8.4.3: Minimise the risk of new development overheating	Proposal 8.4.3a The London Plan includes policies to minimise the risk of new developments overheating, and reduce their impact on the UHI
Policy 8.4.4 Minimise the risk of existing homes and non-domestic buildings overheating	Proposal 8.4.4a The Mayor will work to minimise overheating in existing buildings through Energy for Londoners energy efficiency programmes

Source: Greater London Authority (2018)

The two policies are expanded on in Section 5.1. Full policies and accompanying text can be found in Appendix 1: Policy 8.4.3 , and Appendix 2: Policy 8.4.4 .While these policies and proposed actions overlap with other LES policies, 8.4.3 and 8.4.4 are the units of analysis in terms of interactions with other mitigation and adaptation goals and multilevel governance.

2.2.3 Other Relevant Policy Documents

A number of relevant policy documents were pre-screened against the LES policies, the initial selection of which was guided by the scale framework in Figure 3-1. Vertical Scale Governance for the London Context. The documents represent different vertical governance scales—local, national, and intergovernmental—affecting overheating in London. The pre-screening of these

documents provided context about the London governance framework and how it affects the units of analysis via the following: i) whether the documents affects the management of overheating in buildings; ii) whether the documents address mitigation and adaptation concurrently to achieve synergies and reduce or minimize conflicts and trade-offs with the LES policies. The pre-screening also helped guide the development of interview questions.

The interactions between the policy documents and two LES policies were confirmed through interviews and additional sources. Some interviewees provided one additional example of a policy document that affects the governance of the two LES policies: the UK Building Regulations. The final policy documents include:

- a) The London Plan;
- b) Energy Assessment Guidance;
- c) Energy for Londoners;
- d) The National Planning Policy Framework;
- e) SAP Building Assessment Tool;
- f) Building Regulations;
- g) EU Energy Performance of Buildings Directive (2010/31/EU);
- h) Planning (Listed Buildings and Conservation Areas) Act 1990.

2.2.4 Interview Process

The primary literature review was necessary to understand where common synergies and conflicts occur in buildings and thus understand how policies in cities tackle these synergies and conflicts. While the desk research and policy document analysis identified initial supportive or inhibitive policies, semi-structured interviews would allow for a deeper understanding of London's unique jurisdictional context. Drivers and barriers to the actual implementation of the policies could also be identified. It was also possible that due to the author's lack of technical knowledge about buildings, important documents or regulations might have been overlooked. Given that required information from interviewees would regard practical experiences with regulatory standards and practice as opposed to sensitive matters, semi-structured interviews were chosen for additional data collection.

Interviewees were selected based on their ability to provide relevant insights to the research (Creswell 2014), specifically the implementation phase of the LES policies. Key stakeholders were invited to participate that were split into three groups: i) GLA/Local Authorities, including those helping with developing and implementing the LES policies within programs and boroughs; ii) Building Professionals, including designers, developers, architects, and research experts; iii) Advisory Groups, including relevant policy advisors from climate groups. The advisory groups were important for understanding the context within the UK but were not involved with specific implementation of the two London policies. Thus, the data from advisory groups was used anecdotally within Sections 5 and 6, rather than relying on these advisories to confirm jurisdictional interactions, barriers, or possible drivers.

The initial interviewee sample was selected by internet searches for employees working with adaptation at the GLA. An email was sent introducing the project and seeking participation in an interview which can be found in Appendix 3: Email to Interviewees. The author attended a London Climate Week event where she met two individuals willing to chat about the project. Further contacts were recommended by interviewees and introduced to the author via email. As two interviewees wished to remain anonymous, the interviewees are categorized according to whether they represent the GLA/boroughs, their building profession, or advisor area instead of names, companies, or departments. The interviewees and their interview information is presented in Appendix 4: Overview of Interviewees.

Interview questions followed a semi-structured format and were categorized as introductory, policy, or drivers and barriers questions. This format allowed interviewees to provide detail on their answers; important themes could be expanded on if, for example, an interviewee held more knowledge about a relevant subject area. While there was one set of primary questions, additional questions specific to a person's role were added for each interview. As it was assumed synergies and trade-offs language is highly theoretical and some interviewees would be less familiar with the two LES policies, the questions were sent to interviewees two days beforehand. The list of primary questions, along with project information that was sent to interviewees, can be found in Appendix 5: Appendix 5: Interview Questions.

The interviews took place between June 25th and August 16th, both in person and through video conferencing tools. All interviews were recorded with explicit permission. The duration of the interviews was between 30-60 minutes. The author attempted to avoid asking leading questions which can lead to biased results that risk the reliability of the study (Walliman, 2016). Prompts were used if interviewees needed examples, particularly when asking the interviewees about the policy documents in 2.3.3. Occasionally, questions had to be omitted due to a lack of knowledge on an interviewees' part or limited time.

2.3 Methods for Data Analysis

2.3.1 Results from Literature Review Analysis

The analysis of selected papers was conducted through a matrix analysis approach as defined by Webster and Watson (2002). Sources were listed on the y-axis of the matrix while relevant concepts—synergies, trade-offs, context, drivers, barriers, limitations, and conclusions—were coded on the x-axis. The results of this review are in Section 4 Findings: Results from the Literature Review.

2.3.2 Analysis of Policy Documents

Policies 8.4.3 and 8.4.4 were assessed against the policy documents in 2.3.3. The documents were read to understand how the policies might impact the implementation of 8.4.3 and 8.4.4 according to the analytical framework in Section 3 and the following criteria: a) whether they address overheating; b) whether they could support policy synergies with the LES policies; c) whether they could support conflicts; d) whether they could support trade-offs. An example of a supportive policy synergy would be a national law requiring the consideration of overheating while implementing energy efficiency measures, as this further strengthens Policy 8.4.3. Trade-offs are supported if the policy document is prioritized over the LES policies. Conflicts occur if the document has a negative impact on adaptation or mitigation goals in the LES policies. Information from the literature review was used to identify initial synergies and conflicts. This information was captured in another matrix analysis, with the documents listed on the y-axis and the four questions on the x-axis.

2.3.3 Interview Analysis

Interviews were conducted to: a) support the policy document analysis; b) identify barriers and future drivers relevant to the selected policies and analyse whether they can be explained by the analytical framework. The recordings were listened to twice to ensure no important information was overlooked.

The interviewees were asked whether any policies—laws, regulations, formal/informal operating rules, or the interpretation of policies—had supported synergies, trade-offs, or conflicts with the LES policies. This was done to confirm instances of synergies, trade-offs, and conflicts emerging from vertical governance and gain a holistic understanding of how national

and intergovernmental policies affect the LES policies. Triangulation with sources besides the interviewees was carried out when possible. Answers were added to the policy document matrix. A short narrative was established explaining the content of the documents and their effect on mitigating overheating in buildings. These results are found in 5.1 Scale Analysis of Vertical Governance

The interviews were also used to identify additional barriers and future drivers outside of the policy scale analysis, e.g. stakeholder behaviours affecting policy implementation. Answers were coded in NVivo according to the analytical framework in Figure 3-2. Analytical Framework. When possible, triangulation with publicly available documents was employed to increase validity. Barriers and drivers were not pre-determined to allow the full scope to be captured. These results are found in 5.2 Temporal, Spatial and Stakeholder Analysis of Multilevel Governance

2.4 Scope and Limitations

The scope of this research is one case study of two integrated polices. Common limitations of single case studies are that they are bounded by time and reality and are not statistically generalizable (Creswell, 2014). While the findings may not be relevant several years down the line, the purpose of this work is to address the policies and actions cities are currently implementing. Suggestions other cities can implement immediately can be provided. Given urban strategies are revamped every few years, it is important to examine policy successes and challenges immediately (Grafakos et al. 2019). While the results cannot be directly applied to other cities, London as an urban climate leader helps set the standard for what cities emulate. While cities must adapt recommendations according to their own unique context, London's context is still valuable to learn from and can point out what supportive institutional practices are needed for successful urban climate policy. While there are additional integrated policies within the LES that could potentially address overheating in building (green space; UHI reduction; etc.), only Policies 8.4.3 and 8.4.4 explicitly recognized buildings and overheating. Thus, the scope is considered appropriate for the problem and aim this research seeks to address and for the context of integrated overheating policies.

As a relatively new plan, ex-post evaluation of the success or failure of the LES is premature. However, as this report is primarily concerned with the interaction of multilevel governance with the strategy, the assessment is largely observatory and practical. As the LES policies have been implemented for more than a year as of June 2019, interviewees can speak to how policies play out on the ground and what barriers have emerged.

Another limitation is the time constraint for the thesis. This particularly affected the number of building professionals interviewed. While some of the interviewees were able to recommend designers and architects to interview, no contacts had any developer suggestions. Eight cold emails went unanswered with the exception of one developer who agreed to an interview. Building professionals are represented as one group even though it is recognized that the individuals within this group—designers, architects, developers—might have different answers if more representatives were included for each field. While the author initially wanted to organise the drivers and barriers according to whether they affected city stakeholders or building professionals, the uneven representation of interviewees within the building professionals group reduced the validity of this approach. Finally, there could be additional relevant policy documents that the interviewees did not identify.

2.5 Audience

The research findings are relevant to urban policy-makers. Cities across the world, as well as officials in London, will be able to use this research to shape their own policies. The London focus inherently narrows the scope as cities have different governance frameworks and adaptation is highly localized. However, as more cities enter networks like the C40 where comprehensive climate goals are committed to, and as more cities develop integrated climate strategies, it is important that these strategies are designed with as much awareness about common pitfalls and successes as possible. While policies and regulations differ, the findings of this project will be somewhat generalizable as they will highlight areas that cities should be aware of when designing their climate strategies.

2.6 Ethical Considerations

Interviews inherently require relying on individuals' subjective experiences. Given the time constraint and the author's lack of technical knowledge, the veracity of some claims may be unassessed to a suitable degree.

All interviewees were informed of the scope of the project and interview questions in a document sent through email (see Appendix 3). Explicit consent for recordings was sought, and all interviews were kept anonymous. Interviewees' did not have to answer questions involuntarily. Informed consent was obtained for the evidence and quotes presented in the research; interviewees were sent the results section prior to September 20th with their corresponding citation (e.g. 13 GLA, 112 Local Authority, etc.) to ensure the data could be used. All of the recordings and additional data collected for this project are stored electronically on a password protected, encrypted computer.

This project was not commissioned or funded by the C40. While the academic institution supervisor and C40 project contact provided suggestions and input, the methodology, literature review, and analytical framework were not unduly influenced. The project was carried out for the completion of the author's MSc in Environmental Management and Policy at The International Institute for Industrial Environmental Economics.

3 Earlier Research and Analytical Framework

The following section presents the analytical framework guiding the research. Key terminology and concepts are first presented surrounding synergies, followed by an analysis of the rise of integrated urban climate strategies and policies. Multilevel governance and how it applies to the implementation of integrated policies is covered, including formal vertical governance within a jurisdictional scale analysis, and how vertical and horizontal governance interact to affect policies on the ground. Finally, the theory behind how the adaptation-mitigation dichotomy can support or inhibit integrated policies is presented to structure the multilevel governance analysis and the barriers and future drivers results section.

3.1 Background to Synergies in Climate Action

Synergies in climate action can potentially increase support for certain measures. Differences between mitigation and adaptation have resulted in contrasting approaches about how to tackle both issues, with adaptation in particular receiving less attention and funding than mitigation (Biesbroek et al., 2009; Fussler, 2007). Synergies can contribute to multiple local goals—including political feasibility—which is why they are the focus of this report.

Synergies can be defined as “the interaction of adaptation and mitigation so that their combined effect is greater than the sum of their effects if implemented separately” (Klein et al., 2007, p. 749). The C40 describes synergies as “actions that reduce both carbon emissions and climate risk” (WSP, 2018). Synergies can lead to the more effective implementation of climate actions by altering the cost-benefit analyses of measures through additional benefits incurred (Klein et al., 2007; Ürge-Vorsatz & Herrero, 2012). Policies that take into account interrelationships between mitigation and adaptation can result in more efficient outcomes for society by leading to ‘win-win’ solutions in policy implementation (Landauer, Juhola & Söderholm, 2015). While synergies are sometimes used interchangeably with co-benefits, most definitions for synergies focus exclusively on mitigation and adaptation impacts; co-benefits instead refer to societal, environmental and economic impacts (Field et al., 2014; Landauer et al., 2015). For instance, a synergy occurs when green roofs improve the thermal efficiency of buildings while at the same time reducing flood risk; a co-benefit occurs from the increased biodiversity on the roof. As this report is primarily occupied with the interplay between adaptation and mitigation, synergies will refer exclusively to this positive interplay.

Not all interactions between adaptation and mitigation are positive. The term trade-offs is used when competing priorities between adaptation and mitigation must be balanced in the policy-making process or implementation. Trade-offs thus refers to the choice between measures “when it is not possible to carry out both activities fully at the same time (e.g. due to financial or other constraints)” (Klein et al., 2007, p. 749). Others apply trade-offs broadly when analysing how climate policies must be balanced with other public goals such as development (Moser, 2012). These trade-offs exist because climate policies can have negative impacts on other goals—i.e. less deforestation means less economic output—and these other goals are prioritized. The C40 takes a different approach, defining trade-offs as “actions with contrary effect on mitigation and adaptation, i.e. mitigation actions that increase risk or adaptation actions that increase emissions”—this definition focuses on the effects of the action once implemented rather than the choice between measures (WSP, 2018, p. 1). This conceptualization can be referred to as a conflict (Barbhuiya et al., 2013; Landauer et al., 2015). As this report is interested in practical trade-offs and contrary effects of actions, the term conflicts will be used when a mitigation or adaptation measure has a negative effect on the other following Barbhuiya et al. and Landauer et al. (2013, 2015). The use of trade-offs in this report will be based on the Klein et al. and Moser definitions and refer to the balancing act that must occur between the choice of adaptation or mitigation measures and other actions, policies or goals (2007, 2012). Conflicts

and trade-offs can occur simultaneously, but a distinction is made here to separate the effects of actions and the intentions of actions.

Some trade-offs can be considered neutral, but attention has been given to the negative repercussions in academic research. Moser makes a distinction in the type of constraint leading to trade-offs discussed by Klein et al. to highlight these consequences (2007, 2012). The neutral barriers are a lack of supporting means and conditions such as a “lack of sufficient financial or human resources, lack of information, inadequate political leadership, legal incompatibility, institutional obstacles, physical feasibility limits, or lack of social acceptability” (Moser, 2012, p. 167). The negative barriers are the potential concern over unwanted outcomes, such as “negative environmental consequences, undesirable social implications, political repercussions, [and] equity concerns such as distributional or intergenerational impacts” (Moser, 2012, p. 167). Addressing these barriers demonstrates how trade-offs are not always a neutral choice between policies but can negatively impede other goals. This report will use the term trade-offs to encompass both negative and neutral interactions in policy implementation and make a distinction when appropriate.

Table 3-1. Definition of Synergies, Trade-offs and Conflicts

Synergies	Actions that reduce both carbon emissions and climate risk.
Trade-offs	The choice between adaptation or mitigation measures when it is not possible to carry out both at the same time, or the choice between adaptation/mitigation measures and other policies, actions and priorities. A distinction can be made between neutral and negative trade-offs.
Conflicts	An adaptation action has a negative or neutral effect on mitigation or vice versa.

Source: Adapted from: Klein et al. (2007) and Moser 2012

To date, research has focused on establishing the benefits of synergies in policy-making to encourage greater integration within climate strategies. Landauer et al. look at Copenhagen and Helsinki’s standalone mitigation and adaptation plans to analyse what synergies and trade-offs between the policies occur, as well as how interactions across jurisdictional scales support or impede these policies (2018). They conclude that there are multiple opportunities to integrate adaptation and mitigation, but this depends on supportive institutions across different scales. Beyond that, prior work has been more theoretical. Grafakos et al. develop a framework for assessing the integration of adaptation and mitigation in city plans but do not look at how integration works in practice (2019). Pasimeni, Valente, Zurlinii and Petrosillo assess climate plans in cities in Spain and Italy for synergies; they developed a framework for analysing which ‘best practices’ from the Global Covenant of Mayors are implemented and have synergies but do not look at whether these materialize (2019). As the research focus has been on establishing benefits of integrated policies and strategies, there has yet to be an assessment of how policy synergies play out in practice and none in relation to overheating. There has been no assessment of buildings specific policies within a city that is taking an integrated approach to climate change. While integrated plans and policies are meant to combat trade-offs and conflicts, they are still subject to barriers at various levels of multilevel governance that can prevent the success of these policies.

3.2 Integrated Climate Policies

Cities have positioned themselves as actors ready to tackle both mitigation and adaptation (Bulkeley and Newell, 2010). Cities are especially well-suited to take on adaptation challenges as climate hazards produce localized effects and thus require local responses; this is in contrast to mitigation which requires emission reductions across the globe to be successful (Wamsler,

2014). Both have a spatial component because the distributions and capacities of people and places affect the climate responses cities can implement (Biesbroek et al., 2009). Cities first define what their potential climate change risks and vulnerabilities are before addressing these risks with strategies and follow up evaluation (Bulkeley & Newell, 2010). European cities generally have standalone adaptation plans or incorporate adaptation into wider sustainability strategies. While standalone plans can highlight the importance of adaptation, this can prevent the mainstreaming of adaptation into all urban sectors (Bulkeley & Newell, 2010; Wamsler, Pauleit, Zölch, Schetke, & Mascarenhas, 2017). Scholars and practitioners are increasingly calling for integrated strategies for adaptation and mitigation to ensure policies do not counteract; policies implemented in siloes are unlikely to result in maximum synergistic potential (Dymén & Langlais, 2013; Field et al., 2014; Grafakos et al., 2019; IPCC, 2018; Landauer, Juhola, & Söderholm, 2015; Wamsler et al., 2017). For the purpose of this study, integrated strategies are strategies that combine mitigation and adaptation; integrated policies are policies with both mitigation and adaptation goals that ideally result in synergies.

The benefits and challenges of integrated plans and exploring whether synergies occur are research topics of high importance (Biesbroek et al., 2009; Dymén & Langlais, 2013; Göpfert, Wamsler, & Lang, 2019; Field et al., 2014). Facilitators and barriers to policy-making across departments and sectors relate not only to policy integration, but the cooperation and coordination needed to ensure integration happens. Stead and Meijers undertake a literature review classifying drivers and barriers to integrated spatial planning within political, institutional, economic, process and behavioural factors (2009). They argue that these factors manifest differently in practice based on perceptions and experiences of the actors involved, which do not always reflect reality (2014). They also caution against an overly optimistic approach to integration as trade-offs are inevitable and social, economic, and political circumstances will affect the coherence and consistency of policies. While this is not a reason to avoid pursuing integration, the additional efforts successful integration requires should be accounted for (Stead and Meijers 2014). One can argue that these challenges require better accounting of synergies to ensure easier implementation in urban policy-making, which RQ1 addresses.

3.3 Multilevel Governance of Urban Climate Policy

Despite the potential of integrated policies, there are obstacles to effective implementation. Cities do not exist in siloes. What is possible on the local scale is constrained by different jurisdictional scales as well as the actors involved in enacting policies (OECD 2010; Dymén & Langlais, 2013). Jurisdictional scales in this context refer to the local, regional, national, and inter-governmental regimes cities are subject to. While each jurisdictional scale also has levels within it, this report is primarily occupied with the interactions between individual jurisdictional scales. Additional challenges related to integration include: a lack of devolved power over critical areas such as buildings and transport (OECD 2010); political tensions due to different governmental priorities (Landauer et al., 2018); inability to fund incentives to persuade necessary stakeholders to act on climate change (Bulkeley & Kern, 2006); lack of coordination between municipalities (Dymén & Langlais, 2013); etc. These do not speak to whether cities face challenges greater than other tiers of governance but acknowledge the different baseline cities start from. For example, a city could not unilaterally implement a carbon tax as that power tends to lie with central governments. Even though cities are implementing integrated policies that address mitigation and adaptation, what remains a question is how successful this implementation is.

Cities are thus dynamic spaces where “multiple forms of rules and authorities can be found,” leading to competing needs city governments must accommodate (Bulkeley & Newell, 2010, p. 71). Both adaptation and mitigation policies are developed within the acceptable limits overlapping institutional factors create, such as operating rules and regulations. Adaptation is

often inherently more complicated given the greater number of actors and sectors involved, making institutional complexity critical to navigate correctly if adaptation policies are to succeed (McEvoy, Lindley, & Handley, 2006). Not only do local, regional, and national jurisdictions maintain different priorities that affect urban climate management, but cities are increasingly participating in governance through city networks and international agreements and by bringing in non-state actors to participate in climate change management (Andonova, Betsill, & Bulkeley, 2009; Bulkeley, 2010).

Multilevel governance represents the interactions between local and central governments in addition to other public and private actors when managing climate change (OECD, 2010). Broadly, it “involves processes through which collective goals are defined and pursued in which the state (or government) is not necessarily the only or most important actor” (Betsill & Bulkeley, 2007, p. 144). This provides a baseline for understanding how different levels of governance influence policy design and implementation. Academics have stressed the importance of effective multilevel governance in enabling a climate change response (Landauer et al., 2018). The “reliability, stability, and effectiveness of a city administration are enhanced by persistent, formal, rule-based structures comprising defined roles, positions, routines, and hierarchies,” making it critical to understand how multilevel governance affects synergies in practice (Göpfert et al., 2019, pp. 6–7). While governments have begun to promote synergies, there is minimal knowledge underpinning these claims which can lead to a waste of economic and political resources if ineffective policies are promoted (IPCC, 2018). Examining how multilevel governance supports or impedes policies is necessary to ensure integrated plans supporting synergies succeed.

3.4 Horizontal and Vertical Multilevel Governance

A distinction can be made between horizontal and vertical governance when analysing multilevel governance. Relationships between different scales of government within a are considered ‘vertical’ relationships, whereas non-traditional interactions with transboundary or non-state entities are classified as ‘horizontal’ (Bulkeley, 2010). This distinction between governance forms is also referred to as Hierarchical and Polycentric or Type 1 and Type 2 (Betsill & Bulkeley, 2007; Ostrom, 2005). Vertical relationships have traditionally supported or constrained municipal responses to climate change by:

“framing the roles and responsibilities of local actors; by determining the duties and powers that municipalities have in key sectors (such as transport, planning, energy); and by enabling or constraining policy integration across these sectors” (Bulkeley & Newell, 2010, p. 100).

In the last two decades, there has been a shift in urban climate governance to include new forms of authority. No longer are national authorities dominant in managing climate risk; instead, cities also rely on the inclusion of public and private actors (Bulkeley & Newell, 2010). Horizontal governance focuses on interactions between local governments and non-state entities such as networks, private actors, and public interest groups that do not fit into traditional authoritative domains (Betsill & Bulkeley, 2007; Bulkeley, 2010). These groups, therefore, have a significant role to play in the success of policies.

This analysis is not occupied with how international networks or groups govern climate change, but rather how local stakeholders and private actors implementing urban policies affect the success of these policies. The focus on private stakeholders is a departure from understandings of horizontal governance focusing on transnational entities (Bulkeley 2010). Local stakeholders and private actors can be understood as horizontal governance when viewing the local ecosystem as an arena for climate governance. As Gustavsson, Elander and Lundmark describe, “when it comes to initiating, formulating, coordinating, and implementing local climate policies

the potential list of relevant actors is much longer than local government as a unitary actor”—this includes private companies, non-profits, community groups, individuals, and more (2009, p. 63). This distinction between vertical and horizontal provides two lenses of analysis for this report; Table 3-2 presents the distinction between the two.

Table 3-2. Distinction Between Vertical and Horizontal Governance

Vertical Governance	Interactions between intergovernmental, national, provincial, regional and local jurisdictions that affect the implementation of policies.
Horizontal Governance	Interactions between local governments and non-state actors that affect the implementation of policies.

Source: Adapted from Betsill and Bulkeley (2007), Bulkeley (2010), and Gustavson et al. (2009)

3.4.1 Scale Analysis of Vertical Governance

Vertical governance occurs within intergovernmental, national, regional and local jurisdictions, each of which has unique administrative capacities and objectives (Landauer et al., 2018). These interactions are enabled or constrained via institutions. Competing scales of vertical governance make it challenging to navigate policy landscapes and develop urban strategies that overcome institutional barriers and avoid trade-offs (Bulkeley, 2010).

The institutional scale, as a singular concept, consists of the rules within each jurisdiction, including constitutions, laws, regulations, and operating rules (Landauer et al., 2018). This conceptualisation aligns with traditional definitions of institutions such as “humanly devised constraints that shape political, economic and social interactions,” incorporating this understanding into a multilevel governance framework (North, 1991). These rules define the formal capacity of each jurisdiction to contribute to developing and implementing climate policies. Institutional capacity is a crucial area affecting climate governance (Bulkeley & Newell, 2010; Patterson & Huitema, 2019). What shapes this capacity includes a city’s degree of autonomy within the aforementioned vertical relationships to implement policies, but also employees’ knowledge of climate problems, internal dynamics and resources available (financial and human) (Bulkeley, 2010; Göpfert et al., 2019). Formal rules and structures create roles, routines and hierarchies that help institutionalise climate action. In this context, institutionalisation refers to the integration of policy synergies into a city’s organisational culture (Göpfert et al., 2019). These formal institutions are thus necessary to examine given that “the institutional setting provides the frame for action” (Göpfert et al., 2019, p. 7).

While cities like London maintain integrated climate plans, formal institutions influence the actual outcomes of policies. Local policy-making faces difficulties at least partly because of the nested nature of the local jurisdiction, nested referring to the differing levels of rules contained within each other that shape climate action. Cities follow nested sets of rules according to the aforementioned vertical governance (Ostrom, 2005). While local policies shape urban planning and development, “the space for action and potential for change is usually limited by national development paths, national policies and technical standards, and national budgets and funding priorities” (OECD, 2010, p. 73). It is possible that institutions at other levels of governance can take precedence over integrated urban policies because of contradicting regulatory frameworks or expectations (Grafakos et al., 2018).

Assessing the governance of a specific issue area in cities (i.e. overheating in buildings) through its interactions with nested multilevel institutions can help us better understand how urban systems can effectively govern adaptation synergies (Patterson & Huitema, 2019). To capture

nested institutions within multilevel governance, the scale framework from Landauer et al., first adapted from Cash et al. is useful to present how formal vertical governance affects the implementation of policies on a local level (2018, 2005). While the scale framework was initially developed for analysing separate climate strategies alongside governance scales, integrated policies also interact with the same nested institutions. The different policies, laws, regulations and operating rules emerging from different scales of vertical governance affect the units of analysis, either through supporting synergies concurrently or not

This framework does not capture the “informal systems, codes and rules that guide social action” though these are necessary to consider (Bulkeley, 2010, p. 98). Informal institutions are more common in developing countries, but can still have a role in steering cities towards integrating climate change at all levels of governance (Patterson & Huitema, 2019). Informal institutions are difficult to capture as they become evident during the actual enactment of policy, making interviews critical to understand this component in the analysis of London. Particularly as more stakeholders are needed to help support integrated policies, their unique informal institutions can affect whether strategic policies are achieved. It is only through first understanding formal vertical governance that encompasses urban policies however, that we can make sense of how policies play out during implementation.



Figure 3-1. Vertical Scale Governance for the London Context

Source: Adapted from Landauer et al. (2018)

Analysing urban climate policies from a nested institutional perspective helps uncover policy conflicts and barriers stemming from multilevel governance and used to answer RQ2. However, the existence or non-existence of vertical support for an issue does not mean London’s integrated policies are inherently successful. There are additional barriers and future that emerge when analysing how vertical and horizontal governance affect the implementation of integrated policies.

3.4.2 Temporal, Spatial and Stakeholder Analysis of Multilevel Governance

The management of climate policies requires cities to be involved in vertical and horizontal governance. Drivers and barriers to successful integration of policies or specific adaptation/mitigation policies have been categorised several ways (Landauer et al., 2015; Stead & Meijers, 2009). Yet because analyses of integrated overheating policies promoting synergies are non-existent, this research requires a deeper understanding of what barriers and future drivers emerge. Multilevel governance can be used to understand practical implications of urban policies: why synergies, trade-offs and conflicts arise from vertical governance, and how non-state actors affect policy implementation.

Dymén and Langlais argue that the temporal, spatial and stakeholder dimensions of climate change affect municipalities’ success in implementing integrated policies (2013). This argument is based on analysis from Biesbroek, Swart and van der Knaap who argued that these three

factors created the initial dichotomy between mitigation and adaptation—known as the adaptation-mitigation dichotomy—that translated into a siloed management approach in academia and practice (2009). Their work was preoccupied with challenges in developing integrated policies. Dymén and Langlais make the case that these factors are not only critical for understanding the policy integration of mitigation and adaptation, but also how a climate change response on the ground will be impacted by the dichotomy (2013). Overheating is primarily an adaptation challenge. How the dichotomy applies specifically to integrated policies primarily focused on adaptation within multilevel governance can thus be analysed.

Barriers and drivers relate to the temporal dimension if they address the time horizons of competing interests at hand. These differences refer to how the perceived payback periods of mitigation and adaptation influence the approach taken. While adaptation and mitigation are both seen as short-term investments, adaptation provides immediate benefits by addressing impending climate hazards, whereas mitigation is a long-term solution to climate change (Biesbroek et al., 2009). While this is a highly simplistic way of thinking—restructuring economic systems to decrease consumption is not short term, nor are significant infrastructure investments—this distinction highlights how both adaptation and mitigation compete for the same investments (Biesbroek et al., 2009). Adaptation has also traditionally been dealt with reactively, whereas mitigation is meant to be anticipatory to prevent increasingly worse effects of climate change. In Europe, overheating was brought to the forefront after heatwaves killed thousands of people in 2003 and 2006. The short-term integration of adaptation and mitigation is needed to ensure synergies are maximized, and responses are more effective over the long term. This understanding is also predicated on the basis that addressing the adaptation hazard—in this case, overheating—is considered to provide immediate benefits because otherwise, synergies are unsuccessful.

Municipalities and the actors involved in implementing policies also have competing priorities in the short term that can act as barriers to integration (Dymén & Langlais, 2013). Drivers and barriers related to time can thus go beyond the adaptation and mitigation dichotomy and instead relate to competing priorities and perceptions of the issue at hand. For example, if overheating is not viewed as an adaptive priority, this can lead to a lack of policy enforcement when assessing building proposals, resulting in a trade-off.

As effective adaptation is not dependent on localities doing the same globally, as is the case for mitigation, spatial differences have led to different management approaches. These differ in country, regional and neighbourhood levels. Localities see the outcomes of their adaptation investments, whereas mitigation efforts are internationally orientated (Biesbroek et al., 2009). While this led to mitigation governance occurring largely at national or international scales and municipalities controlling adaptation, both still depend on interactions and circumstances within each scale. This is in line with vertical scale governance, of which the spatial dimension of who takes institutional responsibility is critical to the effectiveness of a climate response (Cash et al. 2006). Biesbroek et al. follow the argument that localities will want to implement more adaptation measures because of the immediate benefits that flow to local stakeholders. However, this does not acknowledge that adaptation has traditionally received less attention than mitigation across all scales and whether horizontal governance stakeholders care to address adaptation. While this is changing as municipalities take increasingly proactive approaches to adaptation, this proactive shift depends on the perceptions of actors incorporating adaptive measures.

Each scale of governance is subject to spatial strategic decisions, circumstances, geophysical landscapes, cultural values, norms and political discourse that can all constrain adaptation or mitigation efforts and are often outside a city's control (Biesbroek et al., 2009; Patterson &

Huitema, 2019; Young, King, & Schroeder, 2008). For instance, while there may be a policy at the municipal scale encouraging the use of white roofs on homes and a corresponding regulation that mandates developers to consider the application of such roofs, preferences for different aesthetics from consumers combined with a lack of incentives for developers may prevent the success of the policy. Considering spatial factors in light of their interactions is valuable as it takes the aforementioned scale analysis further to highlight underlying causes of differences in governance. Drivers and barriers relate to the spatial dimension if they address the unique characteristics and requirements of the different actors involved with the horizontal/vertical governance and implementation of London's policies.

The final factor affecting integration is stakeholders. While academic and policy circles formerly worked on their distinct agendas, the growing attention towards climate change has resulted in demands for involvement in climate governance from public and private organisations (Biesbroek et al. 2009). It is the stakeholder scale where one can analyse interactions between actors that have unique perspectives about how to handle conflicting priorities. As social networks and public interest groups have demanded action and the right to participate in the development of mitigation and adaptation strategies, climate governance is being steered towards a more integrated approach. Both adaptation and mitigation require different stakeholders with their own unique capabilities and desires for implementation of strategies to be effective (Biesbroek et al. 2009). It is only by bringing together stakeholders from across boundaries that effective, integrated approaches can be developed, and trade-offs avoided.

This analysis is primarily interested in analysing existing policies, as opposed to the process of developing integrated policies. The two primary stakeholder groups involved in the implementation of the policies are the city stakeholders and building professionals implementing measures with synergies. However, private individuals in cities also play a role in terms of preferences and creating norms and behaviours.

Overheating is primarily an adaptation issue, but London's approach has been to tackle the problem with mitigation simultaneously to achieve synergies in policy outcomes. Due to this approach, it is believed the spatial and temporal distinctions will arise from the perceptions of stakeholders involved in the policy implementation process. Actors involved in both vertical and horizontal governance are expected to abide by these policies. The temporal and spatial dimensions can thus be analysed in-depth to explain stakeholders' interactions with the two London policies. Both dimensions influence the perspectives of different stakeholders who gather to develop policies that are nested in formal and informal institutions, as well as implement policies on the ground. It is hypothesized that the mitigation-adaptation dichotomy can help answer why certain barriers and possible future drivers arise to the implementation of London's integrated overheating policies and the synergies expected to emerge.

Interviewees were asked open-endedly about what barriers and future drivers they see to the implementation of London's policies to determine whether temporal and spatial dimensions support or hinder the implementation of the policies in the form of synergies, trade-offs or conflicts. Drivers had a positive impact on the two policies in practice via addressing overheating or encouraging synergies; barriers prevented addressing overheating or the implementation of measures with synergies. This analysis takes a broad understanding of the temporal and spatial concepts to incorporate factors like institutional complexity. It is recognized overlap will occur when applying the dimensions to the barriers and drivers, but Table 3-3 demonstrates how the distinctions will be categorized.

Table 3-3. Distinction Between Temporal and Spatial Dimension with Stakeholder Integration

Temporal Dimension	Drivers and barriers relate to the temporal dimension if stakeholders have competing issues and priorities that counteract the policies under analysis.
Spatial Dimension	Drivers and barriers relate to the spatial dimension if they address the characteristics and requirements of different actors involved with implementing the policies under analysis; this includes geography, culture, behaviour, practices, norms.

Source: Adapted from Biesbroeck et al. (2009) and Dymén and Langlais (2013)

3.5 Analytical Framework

Drawing on the theory behind scale governance and the adaptation-mitigation dichotomy, the analytical framework in Figure 3-2 was developed to analyse the multilevel governance of London’s integrated overheating policies. The author hypothesizes that vertical governance affects the implementation of integrated policies in localities through jurisdictional scale interactions. These interactions result in concrete policy synergies, trade-offs and conflicts in the buildings sector when addressing overheating and affect opportunities to implement integrated strategies. Some cities may find it challenging to develop an integrated strategy because of jurisdictional and regulatory systems that act as barriers contradicting each other (Grafakos et al., 2018). The ineffective coordination of strategies and policies between jurisdictional scales can also lead to limited progress in achieving goals (Moser, 2012).

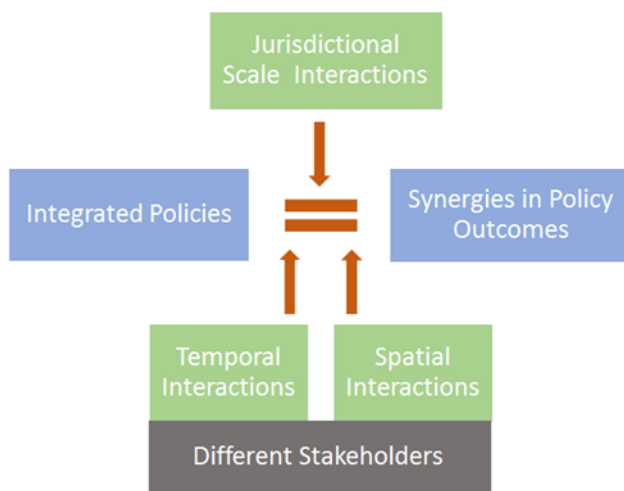


Figure 3-2. Analytical Framework

Source: Author’s own rendering. Adapted from Landauer et al. (2018); Biesbroeck et al. (2009); Dymén and Langlais (2013)

The author further hypothesizes that the temporal and spatial dimensions of overheating can explain additional vertical and horizontal interactions that may result in synergies, trade-offs and conflicts during policy implementation. These dimensions uncover additional barriers and future drivers that affect stakeholders’ implementation of measures with synergies; these may not be evident from only analysing formal jurisdictional scale interactions that constrain urban policies through institutions. The framework in Figure 3-2 represents the hypothesized relationship between integrated climate policies and synergies in policy outcomes. The barriers and future drivers that emerge from scale governance and spatial and temporal dimensions are also captured.

There are a number of factors that Biesbroeck et al. identify as being distinct from the spatial, temporal, and stakeholder dimensions. For example, difficulties in quantifying the effectiveness of adaptation as opposed to having intuitive mitigation targets like emission reductions or liability regarding who pays for adaptation. Yet for this thesis’ analysis, having emission targets at the national level that take priority over the LES policies would emerge from the temporal dimension. With the temporal dimension understood here as being why trade-offs or conflicts may emerge, stakeholders at different levels of governance view overheating as either critical to address or not. Without clear targets it is difficult to perceive how time-critical an aspect is. This results in trade-offs in how the issue is dealt with because the temporal scale that the issue is

being analysed from differs. There is a spatial element to the response as local actors can take specific actions to overcome this barrier in the future.

3.6 Summary of Conceptual Literature Review

This section provided the main concepts and theories guiding the research and justified the research methodology. Integrated policies offer promise with the synergies they can create. A robust evidence base for the actions that result in synergies while addressing overheating in buildings enables cities to encourage these measures while minimizing conflicts. Thus, a literature review establishing these possible measures is provided in the following section to demonstrate the measures cities can support and what conflicts cities should be aware of. This literature review also highlights conflicts that London must minimize within its policies, given that Policies 8.4.3 and 8.4.4 support many of the measures discussed.

To analyse the actual implementation of urban policies, one must first understand how different scales of vertical governance interact to support or impede urban policies. Only by first understanding the formal institutional structure in place can we analyse additional barriers to policy implementation and what drivers can address shortfalls in implementation. The adaptation-mitigation dichotomy addresses both vertical and horizontal governance in terms of how the stakeholders involved with implementation must accommodate temporal and spatial constraints of adaptation. Both the scale analysis and adaptation-dichotomy are thus applied to London to analyse what similar or novel challenges overheating policies provide as a necessary adaptive response.

The framework in Figure 2, with the nested understanding of institutions discussed in the preceding section, forms the conceptual basis of this report and the answers for RQ2, RQ3 and RQ4. However, to be able to understand why synergies, trade-offs, and conflicts in buildings can occur, one must also understand where these occur; what measures with synergies can cities support? What are the measures the London policies aim to support? Section 4 will be used to answer RQ1 and provide a clear understanding of which measures address overheating in buildings and provide synergies as well as which conflicts can emerge.

4 Findings: Results from the Literature Review

To address overheating, one must understand when overheating occurs. The point where individuals exceed thermal comfort differs; age, gender, underlying medical conditions, acclimatization, and other factors affect this. The point where individuals feel uncomfortable in the same rooms can differ by up to 6°C (Lomas & Porritt, 2017). This does not mean thresholds cannot be set. Most studies use TM criteria which states that a threshold of 2°C should not be passed for bedrooms (given weakened ability to control heat at night) or 28°C for non-sleeping rooms; thresholds generally underestimate temperatures for safety.

As this research is primarily interested in structural adaptation measures that address overheating in buildings, a typology from ClimateJust in the UK was used to establish which measures could be studied as a starting point. This typology lays out measures for heatwave resilience that can be implemented in buildings within temperate climates such as the UK. While not exhaustive, this typology allowed the author to ensure measures looked at would be appropriate for the scope of the case. The categories included: technical solutions to adapt buildings, such as building standards; low cost measures such as shutters, reflective surfaces, etc.; insulation; passive cooling techniques such as shading; and green space interventions (ClimateJust, n.d.). With the exception of technical solutions, which are expected to be implemented by builders regardless, the other four categories are used as a starting point for exploring what actions in these categories can contribute to synergies.

For this analysis, low cost measures and passive cooling techniques were combined together. Many of the low-cost measures described are passive in the sense that they do not require power sources for cooling, though some of the measures—shutters, blinds—do require human intervention compared to design features. While insulation is also passive, explicit concerns about insulation contributing to buildings overheating in London warranted a closer look. Green interventions remain a separate category because they require different technical skills for implementation and offer many co-benefits. ‘Passive measures’ will be the catch-all term used in this report when addressing measures with synergies generally.

When discussing synergies, it can be difficult to distinguish actions with adaptation as a primary objective versus mitigation. For example, while drainage systems primarily manage flooding hazards, passive house design reduces emissions and heat risk. The primary objective is difficult to distinguish and can even be dependent on the developer or residents. This report will look at measures that affect overheating as a primary focus or synergistically to account for both. These measures can all result in synergies, and some conflicts, e.g. active cooling increasing thermal comfort while increasing emissions through increased energy demand. The list of identified measures where synergies could occur follows (adaptation benefits are marked with an A, while mitigation benefits are marked with an M):

4.1 Passive design to address overheating (A), reduce UHI (A) reduce energy demand (M)

4.1.1 Design Measures

Passive technical design results in synergies because overheating risk and the need for active cooling are reduced. There are a variety of passive design measures, such as building orientation, glazing, ventilation corridors, and more. Building orientation is a key determinant of the solar gain (heat) a building receives (Barbhuiya et al., 2013). Though changing orientation is only applicable to renovations and new houses, the direction a room is facing (i.e. south-facing where the sun comes in) will affect the degree of overheating experienced and should guide strategy implementation (Porritt, Cropper, Shao, & Goodier, 2012).

As passive cooling measures are often implemented in packages rather than as individual components, many studies examine the effects of combining various measures together. Gupta and Gregg conducted a modelling study that assessed the effectiveness of different passive strategies for existing residential homes in the UK according to future climate projections (2012). The performance of a variety of measures—reflexive surfaces, insulation, louvered shadings (blinds/shutters with horizontal panels that limit direct sunshine), materials with high thermal mass (materials that absorb and release heat slowly)—were analysed for effectiveness in limiting overheating against different external temperatures. Louver devices that shaded glazed windows were often the most effective tool for reducing overheating; high albedo surfaces followed closely afterwards (Gupta & Gregg, 2012). The measures were also tested in different packages i.e. wall retrofits, roof retrofits, all adaptation options, all adaptation exceptions except thermal mass. It was found that the package with thermal mass could contribute to increased need for space-heating in cold climates if used in old, poorly insulated, leaky homes with minimal benefits for reducing overheating. This presents a conflict if the right design strategy is not chosen. Ultimately, the effectiveness of measures depends on the type of building—flat, detached, semi-detached, etc.—and the selected combination of actions (Gupta & Gregg, 2012).

Certain cooling measures need to be combined with night ventilation which requires awareness on the part of owners. Thermal mass, for instance, can contribute to overheating if in a suboptimal location (i.e. close to the ground) and heat is not released from the building in a timely manner (Gupta & Gregg, 2012). Ren, Wang & Chen also found that “excessive striving for building energy efficiency, which does not explore cooling load reduction, could result in greater exposure to health risks during heatwaves” (2014, p. 235). Designers should consider whether vulnerable populations will be willing and able to engage in additional measures (Gupta & Gregg, 2012). Lomas and Porritt (2017) in their literature review of overheating in buildings stress that occupant behaviour can matter more than design, particularly in senior homes and hospitals where individuals at risk cannot necessarily engage in cooling actions. In other situations, it may be difficult to open windows such as in heavily polluted areas or if occupants have security concerns. It cannot be assumed that residents will always be aware, willing or able to incorporate active ventilation, making education critical to the use of some passive strategies.

Passivhaus’ are becoming increasingly prevalent in cities that aim to achieve carbon neutrality in buildings. Passivhaus design aims to achieve maximum thermal comfort for occupants without relying on energy. There are concerns that Passivhaus’, or homes designed along similar principles, can lead to overheating in unexpectedly high temperatures (Barbhuiya et al., 2013; McLeod et al., 2013). McLeod et al. find in a study of UK Passivhaus’ that buildings must be designed for their entire 60+ year lifetime to address future heat and prevent active cooling (2013). The fixes McLeod et al. suggest for optimizing design for longer term well-being and comfort are simple, such as higher window glazing ratios and external shade devices (2013). Other authors also find these measures to be most effective, with Porritt et al. also finding shutters to be important to reducing heat risk (2012; Gupta and Gregg, 2012). These fixes and tools will only be implemented to a sufficient degree if future climates are considered, helping to avoid the uptake of active cooling for as long as possible.

4.1.2 White Roofs and Reflexive Paints

The high albedos of cool roofs and cool walls are credited for their ability to reduce internal temperatures, associated cooling demand, and the UHI (Akbari & Matthews, 2012; Barbhuiya et al., 2013). While their uptake is common in places with mandatory regulations (e.g. California), they have not received political priority in countries with milder climates such as the UK. As a fairly low-cost solution with well-established benefits, their potential for reducing overheating in buildings and the UHI is significant.

Macintyre and Heaviside examined the 2003 and 2006 summer heatwaves to find that the UHI contributed to up to 40% of heat-related mortality (2019). They found that if cool roofs were implemented in the West Midlands, average daytime air temperatures could be reduced by 0.5-3°; the intensity of the UHI during heatwaves could be reduced by approximately 23% and associated mortality by 25% (Macintyre & Heaviside, 2019). Their findings point to the significance of targeting industrial and commercial buildings. Retrofitting half of the industrial buildings in the West Midlands with cool roofs would have the same effect as retrofitting all residential buildings (Macintyre & Heaviside, 2019). However, the study does not acknowledge any conflicts with increasing energy demand in the winter.

In a study comparing cool and green roofs in Crete, Rome and London, Kolokotsa, Santamouris and Zerefos find both to be viable options (2013). In London, roofs with albedos of 0.8 and 0.9 were most effective in reducing the UHI. The cool roofs in London resulted in higher reductions in heat release from the roof because of the cooler climate (112 kW h/m² for cool roofs vs 70 kW h/m² for green roofs). The authors acknowledge that green roofs in hot climates require irrigation which may not be available, cool roofs do age overtime resulting in a lower albedo, and the contribution of green roofs to insulation is thought to be greater than cool roofs contribution to insulation (Kolokotsa, Santamouris, & Zerefos, 2013). This has important implications for the choice of roof in different climates, as it indicates that green roofs may be better suited for temperate climates.

In temperate climates that require winter heating, cool roofs can lead to a conflict by requiring more energy in the winter months. In one study of a UK office building, summer thermal comfort was improved by 2.5 °C with a cool roof, though this corresponded with an almost 10% increase in heating demand during the winter (Kolokotroni, Gowreesunker, & Giridharan, 2013). When heating and cooling demand were factored in, overall energy demand still fell by about 1-8.5% depending on the albedo ratio (Kolokotroni et al., 2013). Cool roofs do not need to be eliminated as a UHI reduction and thermal comfort option, especially as temperatures rise and heating demand in the winter is inevitably lowered. Kolokotroni et al.'s analysis showed that overall, reducing cooling needs will have a greater environmental impact for both rural and urban areas than reducing heating demand in the long term (Kolokotroni et al., 2013). While their study was only based on one simulation of office buildings in rural and central areas, this finding replicates additional studies that show increased cooling needs in temperate climates are a significant environmental concern (Baniassadi & Sailor, 2018; Gupta & Gregg, 2011). This potential conflict must be weighed carefully in climates where energy demand in the winter is significant and energy poverty is a concern, like the UK. It is also difficult to say with certain that lower indoor temperatures will necessarily result in fewer air conditioners installed because this is based on predictions for the future.

Another conflict to be aware of is the potential of white/reflexive paints to contribute to the UHI if external walls are painted. In a street canyon, solar reflections can cause heating in other buildings and contribute to the UHI (Theeuwes et al., 2014). While retro-reflective coatings can be incorporated, these tend to be expensive and not widely available (Theeuwes et al., 2014).

At present, the majority of buildings in temperate climates do not have active cooling (Gupta & Gregg, 2012). Various studies point to the importance of equipping and retrofitting homes now to address heat risk before the demand for air conditioning grows (Kolokotroni et al., 2013; McLeod et al., 2013). Air conditioners are often used in glass buildings that absorb a large amount of heat; windows in these buildings often lack sufficient glazing, are difficult to open for ventilation, and are not orientated to reduce solar gains (Lomas & Porritt, 2017). While this may seem like an adequate strategy if low carbon energy sources are used, researchers caution that passive strategies are still critical to reduce heat demand; even if low carbon energy becomes

the norm, it is likely to be more expensive and scarcer in the future (Barbhuiya et al., 2013). Furthermore, apartments or homes that rely on active cooling can risk extreme overheating in the event of power failure (Baniassadi, Heusinger, & Sailor, 2018; Baniassadi & Sailor, 2018).

4.2 Insulation to reduce overheating (A), reduce energy demand (M)

Insulation is generally included within passive design but is considered separately here regarding its relationship to energy efficiency. Insulation and its relationship to overheating has been a priority research topic in recent years. There is a question of whether insulation and other efficiency measures actually contribute to overheating in buildings due to increased thermal load (Barbhuiya et al., 2013; McLeod et al., 2013; Ren et al., 2014). For instance, McLeod et al., find increased overheating risk in Passivhaus' in temperate climates due to insulation and increased air tightness (2013). However, this can be mitigated with the right glazing ratios and external shading devices (McLeod et al., 2013). Strategically placed windows or extra caution for South facing units can be critical to preventing overheating.

Baniassadi and Sailor find the opposite in hot American cities (2018). As an explanation, they suggest that in hot climates—Mediterranean, tropical—insulation prevents heat from entering buildings. In temperate climates with mild summers, i.e. UK, outdoor temperatures stay fairly low during hot peaks. The main drivers of overheating are solar and internal gains; insulation can therefore prevent heat from escaping outdoors because of low temperature differences (Baniassadi & Sailor, 2018). With cities' increasingly stringent efficiency standards for buildings, the importance of design choices for specific climates cannot be overlooked.

Overheating risk can be higher for internal wall insulation (IWI) added inside walls, compared to external wall insulation (EWI) inserted beneath external facades. IWI is considered more flexible because it can be installed in specific rooms and maintain a building's appearance, though installation temporarily disrupts residents; while EWI is not as disruptive as IWI, it is often more expensive and can require special permission in conservation areas (Tink, Porritt, Allinson, & Loveday, 2018). Tink et al. found in a study of UK houses that IWI increased indoor temperatures compared to non-insulated buildings, particularly in west facing rooms that receive more solar gains at night (2018). The bedroom with IWI experienced overheating for 12.3% of occupied hours while the non-insulated control house only experienced overheating for 4.6% of occupied hours during a simulated heatwave. However, they stress that this overheating is a rare scenario and efficiency gains from insulation should not be overlooked. Keeping temperatures comfortable would need to be combined with night ventilation and closed curtains during the day, measures that residents may be incapable or unwilling to take on as discussed (Tink et al., 2018). This is a similar finding to Gupta and Gregg, and Makantasi and Mvroggianni, who found that compared to uninsulated houses IWI increases overheating risk and EWI decreases the risk (2012, 2016).

The insulation type can affect heat storage as well. Building materials such as phase change materials (PCMs) are promoted for their synergistic potential. PCMs are materials that release heat at certain melting temperatures. They are used as insulators to reduce energy demand and can also improve thermal comfort, especially in hotter climates. In one study of extreme scenarios where AC fails, the ultimate gain in internal temperatures depended on the melting temperature of the PCMs and the heatwave temperatures (Baniassadi, Sailor, & Bryan, 2019). As PCM melting temperature is usually optimised for energy efficiency rather than resiliency, a trade-off occurs if residents or developers choose not to take resiliency into consideration at the expense of some efficiency loss. Given that cost-savings through efficiency will often be prioritized by homeowners, particularly in climates where overheating is not a major concern, the potential for these materials to provide synergies may not be leveraged (Baniassadi, Sailor, & Bryan, 2019). The authors suggest that the use of PCMs can be valuable in social housing

where individuals might be less able to take on cooling strategies and passive cooling can instead be relied on.

PCMs have been analysed for effectiveness as a roofing solution. When enclosed in roofs, PCMs reduce heating demand through regulating indoor temperatures, compared to traditional high albedo surfaces. In comparison with green roofs and other standard insulation materials in a Mediterranean climate, the PCM roof had the most favourable reduction in active cooling during hot peaks (Lassandro & Cosola, 2018). Despite being more expensive initially, the projected cost-savings during hot periods made it the most cost-effective solution. It was also the solution that retained the least heat at night, an important consideration in residences. Green roofs retained more heat at night but managed to keep the indoor temperatures the lowest during the day compared to the other solutions, making them a viable option for schools and industrial buildings (Lassandro & Cosola, 2018). While green roofs were not examined, Roman, O'Brien, Alvey and Woo tested the performance of PCM roofs with other high albedo surfaces across a range of temperatures in the United States (2016). The performance of the PCM roof was superior in energy saving and UHI reduction due to keeping the surface temperature of the roof lower (Roman et al, 2016).

4.3 Green structures to reduce overheating (A), prevent flooding (A), reduce UHI (A), reduce energy demand (M), capture carbon (M)

4.3.1 Green Roofs and Walls

Green roofs and walls are solutions with synergies commonly implemented in cities. Toronto, Basel and other cities have green roof bylaws that require new developments or renovations to include green roofs. Not only does this infrastructure promise co-benefits of cleaner air and aesthetic pleasure, they can capture carbon and reduce the need for air conditioning; however, green roofs and walls are usually the most expensive solution when it comes to heat and UHI reduction (Lassandro & Cosola, 2018; Tam, Wang, & Le, 2016).

The insulation green roofs provide can help reduce indoor temperatures. A study in Hong Kong demonstrated that green roofs could reduce indoor temperatures by 3.4% (Tam et al., 2016). While this is a sub-tropical warm climate, this replicates the findings from additional studies across a wide range of climates (Alexandri & Jones, 2008; Lassandro & Cosola, 2018). In some temperate climates, green walls have been found to reduce the need for active cooling almost entirely (Alexandri & Jones, 2008), though the hotter and drier the climate, the more the potential for green roofs to contribute to energy savings given the wider spread of air conditioning. As Kolokotsa et al. demonstrated, green roofs can still significantly contribute to reducing the UHI by reducing surface temperatures through absorbing heat (2013). For green roofs to have an effect beyond the individual scale however, they must be applied alongside other green infrastructure in a city (Alexandri & Jones, 2008).

Charoenkit and Yiemwattana analysed the contribution of living walls to thermal comfort and carbon sequestration in 19 studies (2016). In temperate climates, a 5-5°C reduction in outdoor temperature compared to the temperature around the bare wall was found (slightly lower than Mediterranean or tropical climates). In all climates, indoor temperatures reduced by 2-6°C. Due to the higher thermal mass, rooms with living walls may have higher temperatures at night due to the slowed heat release (Charoenkit & Yiemwattana, 2016). However, no studies were found analysing whether this could contribute to overheating at night. While energy-savings are highest for hotter climates, green walls should not be overlooked for their potential in reducing cooling needs in temperate climates given their insulation properties. Particularly in commercial

buildings where air conditioners are prevalent, green walls, green walls may contribute significantly to energy savings.

Carbon sequestration for green walls was lower than for green roofs (0.14e0.98 kg C m² annually vs 0.375e30.12 kg C m²) (Charoenkit & Yiemwattana, 2016). While this is dependent on the sebum level (soil depth) and plants used in the structure, green walls generally have a shallower substrate depth leading to lower sequestration. However, the authors also acknowledge the lack of experimental studies for carbon sequestration from green walls. Other literature reviews and studies have pointed to the carbon sequestration of green roofs as one of the less significant benefits compared to flood capture (Alves, Gersonius, Kapelan, Vojinovic, & Sanchez, 2019; Demuzere et al., 2014). The value of green walls in directly sequestering carbon may be considered inconsequential in cities. Given the costs and the large-scale carbon reduction needed at the city level, green walls are unlikely to be the most effective option for capturing emissions. This makes the integration of green roofs synergies or co-benefits necessary in any cost-benefit scenarios to be seen as a viable option.

4.3.2 Trees

Strategic tree planting for shading can reduce indoor air temperatures and cooling demand and improve energy efficiency. Trees tend to be implemented at the neighbourhood scale, but exposed houses without any shading from trees or other sources are more vulnerable (Gupta & Gregg, 2012). The ability of strategically placed trees to reduce electricity consumption and improve thermal comfort is well-documented (Laband, 2009; Nikoofard, Ugursal, & Beausoleil-Morrison, 2011; Szkordilisz & Kiss, 2016).

A study by Pandit and Laband developed a model to assess electricity savings from shading trees (2010). In the summer, a house with 50% shading led to an energy demand decrease of 14%; in the winter, a home with 20% shading increased energy demand by 6% (Pandit & Laband, 2010). Nikoofard et al. had similar results with increases in heating demand of up to 10% in winter for various Canadian cities (2011). As trees also have the added benefit of sequestering carbon, the conflict with the slight increase in heating demand may prove to be inconsequential for cities. However, the payback period for trees to become carbon neutral has been found to take 3-10 years due to the embedded carbon within production (Cameron et al., 2012). Dense cities are also limited by where they can place trees.

A Shashua-Bar et al. demonstrated that courtyards lined with trees and grass could provide temperature reductions of up to 2.5°C in Israel (arid climate) (2009). When the trees shaded the grass, there was a 50% reduction in water use compared to the courtyard with only grass; this courtyard also had an insignificant temperature reduction. An interesting trade-off emerged with the use of mesh nets for shading, as these actually resulted in greater temperature increases likely because of the heat retention (Shashua-Bar et al., 2009). While wind speeds and climate affect ultimate temperature reductions, the ability of trees to provide cooling relief externally is well documented (Cameron et al., 2012).

4.3.3 Green Gardens

Green gardens can address heat risk, though their flood capture abilities have been more extensively studied than their ability to address overheating or sequester carbon (Cameron et al., 2012; Demuzere et al., 2014). In one study of the Leicester in the UK, domestic gardens stored about 0.76kg C m² out of a total of 3.6 kg C m² in urban areas (Davies, Edmondson, Heinemeyer, Leake, & Gaston, 2011). Of this total, trees still made up 97% of the total carbon captured (Davies et al., 2011). Underground soil sequestration can result in even greater carbon storage, with the top 100mm of soil possibly capturing as much as the overground vegetation

due to organic matter in the soil (Cameron et al., 2012). However, when urban gardens are disrupted, carbon is released due to organic matter oxidizing (Bolinder et al., 2007). While studies have calculated green infrastructure's contribution to reducing the UHI, the exact contribution of urban gardens is generally unclear (Cameron et al., 2012).

Even if a garden sequesters carbon, the use of pesticides, lawn mowers, heavy water use and other mechanical tools can result in less carbon capture than expected and lead to a potential conflict (Cameron et al., 2012). While embedded carbon is important to consider with all described measures, green gardens stood out as the one measure where this was acknowledged. Private gardens require maintenance and willing participation and investments on the part of residents. The space for gardens is limited in cities and usually only available to individuals who own houses. As a city has little power over residents' behaviour, the promotion of urban gardens as a tool for addressing overheating is likely to require many resources and not be a significant contributor to different climate goals.

4.4 Summary: Results from Literature Review

Table 4-1 presents the identified measures. Capturing the exact synergies from passive cooling measures is difficult as synergies depend on climate, strategies, and what the alternatives are. Houses do not generally face as much risk compared to flats because they are larger with more windows and doors. Flats are more likely to be single aspect, have low ceilings, and lack ventilation options which make them difficult to cool down (Lomas & Porritt, 2017). Thresholds for when individuals overheat differ which makes it difficult to set target baselines. Occupant behaviour can also be critical to overheating. The type of clothing people wear, whether shutters and blinds are used properly, refusal to change patterns, and so on can all affect whether a building overheats. Whether decreases in indoor temperature actually result in occupant behaviour change is also unclear. Hypothetically, a decrease in indoor temperature should result in concurrent decreases in cooling demand. This may not always be the case, particularly with incremental changes in temperature that residents may acclimatize to. This is known as the energy performance gap. Synergies in buildings are possible, but all of these factors and a changing climate must be kept in mind.

Table 4-1. Overheating Measures with Synergies and Conflicts

Measures	Synergies	Possible Conflicts	Sources
Building design: orientation, ventilation, thermal mass, etc.	- Address overheating (A) - Reduce energy demand (M)	- Thermal mass can contribute to increased heating demand in cold homes (M)	<i>Barbhuiya et al., 2013; Gupta & Gregg 2012; Ren et al. 2014; McLeod et al. 2013; Porritt et al., 2012</i>
White/ reflexive paints	- Address overheating (A) - Reduce UHI on roofs (A) - Reduce energy demand (M)	- Can contribute to UHI if applied on sides of buildings (A) - Can increase energy demand in winter (M)	<i>Akbari & Matthews, 2012; Barbhuiya et al., 2013; Macintyre & Heaviside, 2019; Kolokotsa, Santamouris, & Zerefos, 2013; Kolokotroni et al., 2013; Baniassadi & Sailor, 2018; Gupta & Gregg, 2011, Roman et al. 2016</i>
Shading devices: louvers, shutters, etc.	- Address overheating (A) - Reduce energy demand (M)	- Less efficient if used indoors (M) - Occupant behaviour is critical to success	<i>Gupta & Gregg, 2012; Porritt et al. 2012, McLeod et al. 2013</i>

Insulation (external vs internal)	- Address overheating (A) - Reduce energy demand (M)	- Can contribute to overheating if done incorrectly (A) - IWI can heighten risk compared to EWI (A)	<i>Barbhuiya et al., 2013; McLeod et al., 2013; Ren et al., 2014; Baniassadi & Sailor, 2018; Tink et al., 2018; Makantasi & Mvrogianni 2016</i>
Phase change materials	- Address overheating (A) - Reduce energy demand (M)	- Lacking sufficient evidence	<i>Baniassadi, Sailor, & Bryan, 2019; Lassandro & Cosola, 2018; Roman et al. 2016</i>
Green roofs	- Address overheating (A) - Reduce UHI (A) - Reduce energy demand (M) - Sequester carbon (M)	- Embedded carbon in implementation (M)	<i>Kolokotsa, et al., 2013; Lassandro & Cosola, 2018; Tam et al., 2016; Alexandri & Jones, 2008; Charoenkit & Yiemvattana, 2016, Alves et al. 2019</i>
Green walls	- Address overheating (A) - Reduce UHI (A) - Reduce energy demand (M) - Sequester carbon (M)	- Embedded carbon in implementation (M) - Low carbon sequestration	<i>Lassandro & Cosola, 2018; Tam et al., 2016; Charoenkit & Yiemvattana, 2016</i>
Trees for shading	- Address overheating (A) - Reduce UHI (A) - Reduce energy demand (M) - Sequester carbon (M)	- Hazard in storms (A)	<i>Laband, 2009; Nikoofard, Ugursal, & Beausoleil-Morrison, 2011; Szekordilis & Kiss, 2016; Pandit & Laband, 2010; Cameron et al., 2012; Shashua-Bar et al., 2009</i>
Urban gardens	- Address overheating (A), reduce UHI (A), sequester carbon (M)	- Embedded carbon in maintenance (M)	<i>Cameron et al., 2012; Demuzere et al., 2014; Davies et al., 2011</i>

Source: Adapted from multiple sources

5 London Case Study Findings

The London case study results are divided into two sections: 5.1) the jurisdictional scale analysis to establish the institutional framework in London for overheating policy synergies, using policy documents and; 5.2) the analysis of how the two policies are implemented on the ground by stakeholders such as city and building professionals. The context analysed is the relationship between policies addressing heat risk (adaptation) and synergies, trade-offs, and conflicts with the management of the built environment (mitigation). The units of analysis are the two LES policies and their practical implementation, i.e. enforcement on the ground.

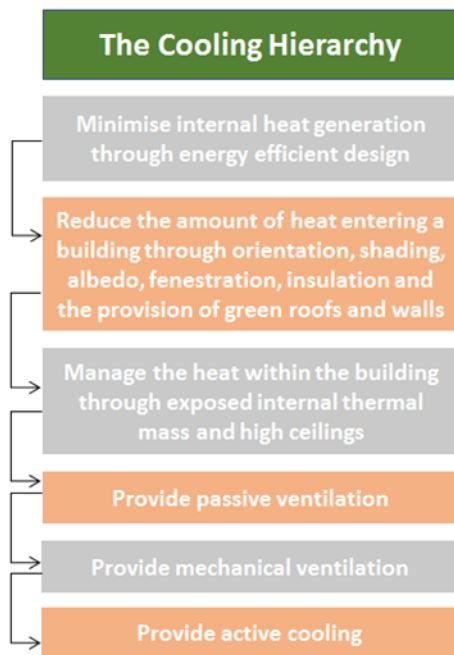


Figure 5-1. The Cooling Hierarchy

Source: Adapted from Greater London Authority (2016)

Policy 8.4.3—minimise the risk of new development overheating—aims to reduce heat risk and conflicts with mitigation through use of the cooling hierarchy in Figure 3-2. Policy 8.4.4—minimise the risk of existing homes and non-domestic buildings overheating—aims to do the same for existing building stock by promoting overheating assessments via the Energy for Londoners retrofitting programmes.

5.1 looks at policy documents related to the LES policies within the jurisdictional scale to answer RQ2. A document-level of analysis is necessary because policies are what is available given overheating is a new policy arena, and there have not been ex-post evaluations of the success of the policies. 5.2 looks at the governance of both policies within London and some of the underlying barriers and potential drivers to policy implementation facing stakeholders. The analysis of both sections is led by the framework in Figure 3-2 and

is structured accordingly. Interviews were used anecdotally in Section 5.1 to confirm instances of synergies, trade-offs or conflicts identified in the text of documents. Section 5.2 relies on interview data, as well as a BRE survey and UKGBC report to triangulate results when appropriate.

5.1 Scale Analysis of Vertical Governance

As the first point of analysis, the vertical scale governance framework in Figure 3-1 was used to assess policy documents at jurisdictional scales of vertical governance and their interactions with the LES policies. The interviews, alongside the document analysis, were employed to confirm specific institutions—laws, regulations, rules, informal institutions, or the interpretation of these institutions—had supported synergies, trade-offs, conflicts with the LES policies. Four questions were asked in analysing each jurisdictional scale: a) are there any specific policy documents addressing overheating in buildings that affect the implementation of the LES policies? b) has the document supported synergies? c) has the document supported conflicts? d) has the document led to trade-offs? These questions were selected to allow interviewees to select relevant documents and confirm instances of synergies, trade-offs and conflicts.

It is recognized that the same synergy, trade-off or conflict will not emerge for every interviewee or stakeholder. What is important for this analysis is that the documents have at some point affected the implementation of the policies under analysis via formal vertical governance. A summary of the document analysis is presented in Table 5-1. Jurisdictional Scale Analysis, on the following page.

5.1.1 The London Plan

London is divided into 32 boroughs, each with a borough council responsible for governing within that district. Boroughs are also known as local authorities. The GLA guides strategic development in London and is composed of an elected Mayor and Assembly. The different borough councils are composed of elected representatives (London Councils, n.d.). While local authorities can set bylaws, it is the national government that sets regulations and laws.

The Greater London Authority Act requires that the Mayor produce a spatial development strategy known as the London Plan (LP) (Greater London Authority, 2016). The Mayor is legally required to deliver the LP, rendering the LP a local scale strategy with a legal basis; any policies or plans within the LP are expected to be achievable and realistic to meet the mayor's obligation (I2 GLA; Greater London Authority, 2016). Each borough is responsible for its own management, but they are legally obligated to implement LP policies and ensure it is applied in good faith (Greater London Authority, 2016). Thus, the GLA and boroughs share responsibility for managing education, environmental health, waste collection, planning applications, and more (Greater London Authority, 2016). The most recent version of the LP was released in 2016, two years before the LES, though a draft for the next iteration is currently available. To achieve sustainable development, a variety of areas are covered within the LP such as housing, economy, environment and more. The LES is closely aligned with the LP and refers to the policies and requirements in the LP multiple times, but ultimately does not hold the same legal basis within local authorities and is instead a guiding strategy.

Policy 8.4.3 Impacts

The LP is a legal requirement at the local jurisdictional scale supporting synergies within the LES. A synergy was identified in Policy 5.9 of the LP which requires consideration of the cooling hierarchy in new developments. Policy 8.4.3 in the LES refers to Policy 5.9 when addressing overheating in new developments. Policy 5.9 requires developers to conduct overheating modelling scenarios and follow the Cooling Hierarchy to avoid overheating and reduce the UHI (Figure 5-1. The Cooling Hierarchy). Only strategic schemes or developments with more than 150 homes or commercial developments higher than 30m are required to go to the Mayor for approval (Greater London Authority 2018b; I2 GLA). These are known as referable applications. It is up to the boroughs to implement Policy 5.9 for smaller developments and ensure proposals show sufficient evidence the hierarchy has been considered (I2 GLA; I4 GLA; I5 GLA). If active cooling is deemed necessary, representing a conflict with mitigation, sufficient evidence must be provided to demonstrate the hierarchy's lower levels cannot feasibly be used.

Policies in the LP around building more housing, energy efficiency and sunlight requirements can lead to 8.4.3 trade-offs (I3 GLA; I4 GLA; I5 GLA). The current LP asks for 25,600 units of affordable housing a year, while the draft LP asks for 65,000 units of housing a year with 50% of units classified as affordable. The boroughs have specific housing targets to meet. As of October 2016, the LP requires new domestic developments to be zero-carbon, while non-residential buildings are expected to meet this target by 2019. The LES notes careful design is necessary to prevent potential conflicts between insulation and overheating, which the LP specifies in the supplementary Sustainable Design and Construction document for new developments and retrofits (Greater London Authority, 2014). This conflict is described as

Table 5-1. Jurisdictional Scale Analysis

POLICY 8.4.3 JURISDICTIONAL INTERACTIONS				
Policy Document	Does it address overheating?	Can it result in synergies?	Can it result in trade-offs?	Can it result in conflicts?
The LP	Yes	Mandatory assessment of cooling hierarchy; minimize risk of insulation contributing to overheating, minimize UHI while building more	Building more homes and affordable units, energy efficiency, sunlight	Push for centralized heating results in overheated corridors
Energy Assessment Guidance	Yes	Legal consideration of mitigation and overheating together, demonstrate consideration of passive measures to reduce UHI and provide cooling	Meeting mitigation and efficiency targets	None identified
NPPF	Yes	Supports consideration of mitigation and adaptation together in municipalities	Building more homes and affordable units; daylight and sunlight requirements	Spatial density contributing to UHI, small compact buildings overheating
SAP Building Tool	Yes	Voluntary overheating assessment while calculating emission rates, synergies with LES policies not supported	Mitigation prioritized if SAP followed instead of Energy Assessment Guidance targets	Promotion of active cooling without adequate risk assessment
Building Regulations	No	None identified, refer to SAP	Meeting efficiency, mitigation requirements	Poorly designed flats can lead to overheating
EU Directive	Yes	Energy efficiency requirement for active cooling	Meeting efficiency targets	Promotion of active cooling
Planning Act 1990	No	None identified	Difficulties in planning approval, minimal exterior changes	None identified
POLICY 8.4.4 JURISDICTIONAL INTERACTIONS				
The LP	Yes	Efficiency standards should be applied while considering overheating risk	None identified	None identified
Energy for Londoners	No	Required consideration has not happened yet	Meeting mitigation and efficiency targets	None identified
Building Regulations	No	None identified	Mitigation and efficiency targets for retrofit upgrades	Poorly designed flats can lead to overheating
EU Directive	Yes	Energy efficiency requirement for active cooling	Meeting efficiency targets for A/C upgrades	Promotion of active cooling
Planning Act 1990	No	None identified	Difficulties in planning approval, minimal exterior changes	None identified

Source: Author's Own Analysis

something to be aware of that requires management. One conflict was identified, however; the focus on centralized heating systems for mitigation benefits in new developments has resulted in hallways and corridors overheating due to waste heat emitted from pipes (12 GLA; I13 Developer).

Policy 8.4.4 Impacts

Another synergy can be found in the LP'S requirement to assess retrofits for overheating risk. The LP supports Policy 8.4.4 via Policy 5.4 which highlights the importance of reducing emissions and improving resource efficiency in retrofits; it refers to Policy 5.3 on Sustainable Design and Construction and notes the same principles should be applied for retrofits. These principles include avoiding excessive internal heating while increasing insulation, thus addressing overheating with solutions reducing emissions. However, Policy 8.4.4 does not refer to the LP for guidance, and instead only refers to the Energy for Londoners Program to address overheating risk in existing buildings (see Section 5.1.3 Energy for Londoners). The current draft LP also does not mention the programs. While this does not reduce the impact of the synergy, it means 8.4.4 enforcement responsibility lies with the GLA and not on the boroughs. No specific policies within the LP were confirmed as trade-offs or conflicts for policy 8.4.4.

5.1.2 Energy Assessment Guidance

The Energy Assessment Guidance is a document that developers are legally required to submit when seeking approval for large developments. It was created as a supplement to the LP to guide energy requirements when seeking development approval in local authorities. The GLA requires submission of this document for referable applications; boroughs are encouraged to adopt the guidance for non-referable projects and modify requirements as needed (Greater London Authority, 2018a; I3 GLA). Policy 8.4.4 is not relevant as this Guidance only covers new developments.

CIBSE TM49, TM 52 and TM59 are calculations that predict overheating risk in buildings through dynamic thermal modelling. TM59 covers domestic household assessments, whereas TM52 is for non-domestic buildings. In both situations, developers must demonstrate that specific thresholds of thermal comfort will be achieved under overheating scenarios in conjunction with TM49. TM49 provides guidance for developers and retrofitters to assess the expected performance of their buildings against 2020, 2050 and 2080 simulations of future weather in London. This is to ensure buildings are prepared for future climates. Assessing internal heating against 2050 or 2080 predictions is not required by the GLA (Greater London Authority, 2018a). The Guidance does not mention the potential conflict with insulation measures, which could be problematic as the Guidance is the legal document used by developers rather than the broader policy within the LES.

Non-residential developments are subject to fewer overheating requirements. Exceptions from following the Cooling Hierarchy are made for a variety of buildings—supermarkets, cinemas, warehouses, etc.—whereas domestic households are expected to demonstrate consideration of passive strategies using the Domestic Overheating Checklist (see next paragraph). Households heighten overheating risk is because residents are exposed to heat for longer periods; however, commercial buildings still consume copious amounts of energy for active cooling. While many commercial buildings will require active cooling because of the size and function of the building, passive strategies could still be utilized.

A Domestic Overheating Checklist is included in Appendix 5 of the guidance for domestic developments to submit in planning proposals (Greater London Authority, 2018a). This checklist assesses site features that make a location vulnerable to overheating such as proximity to loud industrial sites which prevents window opening. This is followed by passive measure

suggestions that can address the risk. Developers check off and describe which features have been included. There are suggestions not to rely on occupant behaviour (i.e. not relying on blinds to reduce overheating). The checklist is not prescriptive and left to the interpretation of auditors assessing applications in the GLA and boroughs to verify if passive measures have been integrated to a sufficient degree.

Policy 8.4.3 Impacts

The Energy Assessment Guidance acts as an operating rule at the local scale supporting synergies in Policy 8.4.3. To demonstrate adherence to Policy 8.4.3, the guidance requires assessment of overheating risk (adaptation), and incorporation of passive strategies to mitigate the risk while assessing energy use in new developments (mitigation). The risk assessment baseline determines the scale of overheating precautions required. Thus, the assessment supports policy synergies by considering overheating and mitigation together and in determining the scope of passive cooling measures necessary.

As the checklist mandates consideration of passive strategies like white roofs that reduce UHI, policy synergies in domestic buildings are further supported. Some applicants cite trade-offs with requirements such as energy efficiency as the reason passive measures are not incorporated; sometimes this is accepted in support of mitigation (I2 GLA; I4 GLA). However, one interviewee previously involved with assessing planning applications at the GLA did say eliminating the need for active cooling is a huge priority; planning applications have been sent back to incorporate shading, glazing or other minor adjustments (I5, GLA).

5.1.3 Energy for Londoners

Energy for Londoners is an umbrella name for London's retrofitting programs, each with different objectives including tackling fuel poverty and retrofitting public buildings. The programs range from granting and funding schemes to pilots testing innovative energy solutions. As these programs only deal with retrofits, they are not relevant for Policy 8.4.3. While not a policy document in the sense it stipulates behaviours or rules, Energy for Londoners is included in the jurisdictional scale analysis because these programs represent the management jurisdiction where the governing of Policy 8.4.4 takes place.

Energy Leap: The Energy Leap program pilot is based on the EU Energie Sprong retrofitting model. This model relies on an energy performance contract that guarantees a specific percent of carbon and energy savings from a retrofit (Greater London Authority, n.d.a). If the retrofit does not result in the promised savings, the supplier is liable to pay back the owner. While the program is only being trialled in London for private homes and the social sector, it has been tested in the social sector outside of London with positive results (I10 GLA). This model is used in London's RE:FIT program which provides suppliers for retrofitting workplaces. The London pilot will include provisions that internal heating should not go above 26°C throughout the year (Transition Zero, 2018). In pilots outside of London, passive cooling measures like shutters and blinds have been implemented in lieu of active cooling. As contractors are on the hook for savings lost, it has been in their best interest to install these measures rather than risk increasing cooling demand through HVAC systems (I10 GLA). However, it is yet to be seen how this will play out in London.

RE:FIT and RE:NEW: The RE:FIT program is a supplier for non-residential public buildings. Energy service companies are procured to provide retrofitting measures under an energy contracting model to guarantee savings (Greater London Authority, n.d.b). Overheating is not generally considered within the tools offered. The RE:NEW program retrofits existing homes to reduce energy bills and carbon emissions (Mayor of London, 2017). The program is currently inactive. The successor program will include an energy contracting model as the gold standard

to achieve which will include overheating assessments (I10 GLA). However, the program previously did not promote overheating preparedness.

Warmer Homes and Fuel Poverty Support Fund: Finally, Warmer Homes and the Fuel Poverty Support Fund aim to reduce fuel poverty—when households cannot afford to keep homes at satisfactory temperatures—by helping vulnerable populations retrofit their homes. The Fuel Poverty Support fund will be integrated with Warmer Homes, which is currently closed for applications as the program is revamped (Greater London Authority, n.d.c; I10 GLA). The primary measures implemented through Warmer Homes are generally efficient boilers, heating control and features addressing ancillary issues like damp walls and mould (I10 GLA). The program is currently set up as a purchasing scheme which does not put the auditors in a position to address overheating. However, as Warmer Homes is revamped, assessing overheating risk may be included (I10 GLA).

Policy 8.4.4 Impacts

Policy 8.4.4 aims to incorporate overheating considerations into these different programs (Greater London Authority, 2018b). Overheating has not yet been mandated in the programs though one program intends to include holistic assessments, contradicting Policy 8.4.4. It was not confirmed whether conflicts emerged as a result of the programs, though the trade-off with prioritizing mitigation focus was captured (I4 GLA; I5 GLA; I10 GLA). However, two GLA interviewees did note that at some point in the future, overheating and other adaptation hazards like flooding would be addressed (I4 GLA; I10 GLA).

5.1.4 The National Planning Policy Framework

The National Planning Policy Framework (NPPF) in the UK sets legal planning requirements for municipalities' development strategies (Great Britain & Ministry of Housing, 2019). The framework promotes sustainable development across the country and sets minimum requirements, though municipalities can go beyond listed requirements. The most recently updated version of the NPPF, from February 2019, advises local authorities to take proactive adaptation planning approaches which includes preparing for overheating risk (Great Britain & Ministry of Housing, 2019). As the NPPF deals with new buildings, it was not found to have an effect on Policy 8.4.4.

Policy 8.4.3 Impacts

Policy synergies are theoretically supported on the national scale via the NPPF. The NPPF is a strategy with a legal basis, like the LP, that mandates consideration of overheating with mitigation in local development processes. However, the NPPF has been cited as a reason for inability to address overheating and mitigation concurrently due to the focus on building more housing and more affordable housing. There is nothing currently provided by the national government to minimize conflicts or trade-offs, leaving this up to cities to enforce.

The NPPF contains a strong focus on increasing housing stock, increasing density, and providing affordable housing. Municipalities are expected to assess development proposals on the basis of efficient land use and reject applications if they promote low density development (NPPF, Para 123). While density helps reduce emissions and should be encouraged, this comes with intensification of the UHI and less available land for green infrastructure (Barbhuiya et al., 2013; McEvoy et al., 2006). Neither of these conflicts are addressed in the framework, though the focus on building more housing creates a conflict by contributing to the UHI (I4 GLA; I6 Climate Change Advisor).

While developers must prove efficient use of space, requirements for managing adaptation measures are subject to interpretation. In some referable applications, applicants cite the emphasis on creating more housing as a reason for not implementing passive measures; the costs would prohibit new development (I5 GLA; I4 GLA). Creating affordable housing is also a significant priority of the Mayor within the LP, which does mean concessions for mitigation and adaptation are situationally sought if developments can provide large amounts of homes (I5 GLA; I14 Architect). The NPPF also removed requirements for municipalities to provide “active” support for energy efficiency improvements to buildings (i.e. funding, programs), though local municipalities can set higher standards for construction and design as London has done (Committee on Climate Change, 2019b).

Local planning authorities are invited to take a “flexible approach in applying policies or guidance related to daylight and sunlight” if there is a chance this could prevent efficient use of a site (NPPF, para 123). This clause is subject to interpretation. Ensuring buildings are compact with little consideration of sunlight could result in smaller single aspect dwellings that risk overheating from solar gains, especially if there are minimal ventilation options (I5 GLA). While the Energy Assessment Guidance discourages single aspect dwellings, solar gains have been cited as a reason to incorporate floor to ceiling windows, an alarming trend in London and across the UK (I1 Research Expert; I2 GLA; I5 GLA). Industry standards for solar gains make it easier to incorporate this requirement alongside energy efficiency targets, meaning overheating falls to the bottom of priorities (I4 GLA).

5.1.5 Standard Assessment Procedure (SAP)

There is a legal requirement for new developments in the UK to use SAP 2012, the national building energy assessment tool for energy performance. The 2012 version is the most recent iteration though SAP 2016 is in consultation stages (BRE Group, n.d.). In the 2012 iteration, assessing overheating is in the appendix as a voluntary assessment. Using the procedure will not affect the overall SAP rating or estimated CO2 emissions (BRE, 2012). Unless the overheating performance of dwellings is made a specific characteristic to look out for, it is unlikely regulatory bodies consider it within proposals.

Policy 8.4.3 Impacts

SAP 2012 supports voluntary overheating assessments, but the assessment procedure was described as being subjective, basic and crude (I1 Research Expert; I2 GLA; I8 Designer). These sentiments were echoed by the UK Committee on Climate Change (CCC) in their 2019 report on the UK’s housing preparedness for climate change (2019b). The appendix is seen as “simplistic in its approach and assumptions and...not sufficient to identify either current or future levels of overheating risk in dwellings” (Committee on Climate Change, 2019b, p. 72). The criterion is considered difficult to fail and relies on unrealistic assumptions such as windows being open at all times (I2 GLA). Without the promotion of passive strategies, a conflict could occur with the uptake of active cooling.

SAP 2012 represents operating rules at the national level possibly resulting in a conflict or trade-off between mitigation and Policy 8.4.3; overheating risk could be underestimated, and mitigation prioritized. London has the Energy Assessment Guidance which includes more robust criteria and holds higher regulatory standing within London. SAP 2012 is still used however; the risk arises if the Guidance is not followed. SAP 2012 further highlights the lack of stringent overheating support at the national scale. As this is not legally required on a national scale, one cannot conclude synergies in London are supported through this tool.

5.1.6 Buildings Regulations

Building Regulations are an integral area for addressing synergies in the UK as they set the minimum baselines for design and construction (House of Parliament, 2010). Some refurbishments are included such as active cooling installations and window replacement. Developers must obtain Buildings Regulations approval from local authorities or approved inspectors (Planning Portal, 2019). This is in addition to planning approval from the local authorities. The regulations were last updated in 2010 though there are periodic updates. A review of the Building Regulations by the national governments and consultation with experts has started; the Ministry of Housing, Communities and Local Government (MHCLG) is reviewing energy and ventilation requirements in 2019 (Committee on Climate Change, 2019a).

Policy 8.4.3 and 8.4.4 Impacts

The Building Regulations do not support 8.4.3 or 8.4.4 because neither regulates mandatory overheating assessment. Overheating is not required to assess beyond the voluntary SAP assessment, something brought up by several GLA interviewees as an oversight (I3 GLA; I4 GLA; I5, GLA). The Regulations are currently being reworked though it remains unclear whether overheating will be included (I5 GLA; I8 Designer). As opposed to the NPPF which requires municipalities to consider synergies, the Building Regulations along with SAP are where enforcement of assessing overheating with mitigation would occur nationally. Overheating would be considered from the onset of a project and verified on-site, compared to the final stages as it can be now (I14 Architect). Retrofit measures that require adherence to the Building Regulations include glazing on windows, boilers, active cooling efficiency, and more, all which can impact overheating risk. Synergies between overheating and mitigation are not regulated at the national scale if the Building Regulations do not contain this requirement.

Part L of the Building Regulations lays out the target CO₂ emission rate buildings must meet. Overheating regulations would likely be inserted here (I6 Climate Change Advisor; I14 Architect). The Building Regulations as they exist today promote a trade-off between addressing energy efficiency and heat risk in London because adaptation preparedness is not an immediate requirement like target CO₂ rates; the London policy requirements come afterwards, often after blueprints are created (I4 GLA; I5 GLA; I8 Designer).

5.1.7 EU Energy Performance of Buildings Directive (2010/31/EU)

As an EU member, the UK is responsible for translating EU Directives into national law. The EU Energy Performance of Buildings Directive (2010/31/EU) has been in place since 2010. The directive aims to reduce energy demand by 20% and for 20% of energy to come from renewables in member states, who are expected to set energy performance standards for buildings amongst other requirements with the intent of meeting these two goals (European Union 2010).

Policy 8.4.3 and 8.4.4 Impacts

Overheating is addressed through an analysis of the rising use of active cooling in new and old buildings. This use must be reduced to meet environmental targets. Paragraph 25 lists measures that reduce overheating such as shading, using sufficient thermal capacity in construction, and passive cooling; these measures can reduce temperatures not only within buildings, but in surrounding areas as well (2010/31/EU (Para) 25). To incentivize their uptake, these measures are to be given preferential treatment by governments. Since this clause does not contain a quantitative target, its requirements are open to interpretation. EU emission targets guide UK 2050 net zero carbon targets for new developments and retrofits (I10 GLA). However, the UK has not implemented preferential treatment of non-active measures in the NPPF, SAP 2012, or Buildings Regulations, only stipulating that overheating must be considered. One interviewee

mentioned there is no evidence of the UK government being concerned about air conditioning as a maladaptive measure (I7 Adaptation Advisor).

The Directive supports synergies in that it ensures air conditioners meet efficiency standards; without this, the conflict with mitigation would likely be higher given air conditioner use is rising in the UK. While in theory the Directive could further support synergies in policies 8.4.3 and 8.4.4 via intergovernmental requirements for passive measures, this has not occurred. Conflicts or trade-offs were not identified in the interviews.

5.1.8 Planning (Listed Buildings and Conservation Areas) Act 1990

The Planning (Listed Buildings and Conservation Areas) Act 1990 classifies UK character buildings as listed buildings (1990). Listed buildings require special planning permission to alter the interior or exterior to ensure the architectural and historic interest of individual homes or areas is maintained (House of Parliament, 1990). The rules can be subjective as Listed Building Consent is needed not only for structural changes, but anything altering the character of the buildings. This clause has no specific definition (House of Parliament, 1990).

Policy 8.4.3 and 8.4.4 Impacts

As the Act is not intended to deal with adaptation, the omission of overheating does not have any significant effect on policies or synergies. The Act instead represents a trade-off between aesthetics and adaptation for 8.4.3 and 8.4.4.

Some passive measures are difficult to implement because national regulations prevent residents from changing the appearance of their homes if it affects area character. Homes with listed building status or in conservation zones are likely to face difficulties with insulation and exterior changes (I8 Designer; I1 Research Expert; I10 GLA). Developments in character areas also have limited structural options given aesthetic requirements (I14 Architect). Even non-listed buildings can require refurbishment permission from local authorities. Structural adjustments such as shutters, replacing windows or changes to thermal elements for walls, roofs and floors, require Building Regulations approval. Any thermal upgrading must also meet a certain standard of insulation (House of Parliament, 2010). One research expert mentioned that the perceived difficulty or misunderstanding of legal requirements can affect whether someone implements measures that affect exterior appearances (I1 Research Expert). The difficulties in changing the appearance of homes in conservation areas results in delayed approval for retrofits, acting as a barrier to exterior changes (I10 GLA).

5.1.9 Summary of Jurisdictional Scale Analysis

A full table of the synergies, trade-offs and conflicts identified can be found in Table 5-1. Overheating is acknowledged as a problem on local and national scales. However, London is doing significantly more to address overheating with mitigation and implement synergies in building design within the local jurisdictional scale. As the following analysis will show, limited support on a jurisdictional scale can be exacerbated by temporal and spatial barriers to stakeholders' implementation of the policies. These dimensions can explain additional barriers affecting the two policies and some trade-offs discussed above.

5.2 Temporal, Spatial and Stakeholder Analysis of Multilevel Governance

Based on the results of the jurisdictional scale analysis and interviews, additional barriers and future drivers to the implementation of Policies 8.4.3 and 8.4.4 were identified. Many of the challenges and opportunities can be related to the adaptation-mitigation dichotomy. A full

summary of the identified barriers and future drivers is in Table 5-2 presents the barriers and possible drivers according to which policy they affect. While these barriers and drivers manifest in different ways, their ultimate effect on the policies comes down to two factors for stakeholders involved: the perceived lack of criticalness of overheating; the inaction within different governance arenas stemming from traits inherent to the actors within those arenas.

Table 5-2 on Page 53.

5.2.1 Temporal Dimension Barriers

Barriers relate primarily to the temporal dimension if stakeholders within vertical and horizontal governance have competing priorities that counteract the implementation of the policies under analysis. These temporal barriers are identified as: trade-offs with building more homes and more affordable homes; prioritizing mitigation over adaptation; lack of concern for overheating; limited financial resources to address the policies.

Trade-off with Building More Homes

The national and local government's prioritization of building homes was described by all interviewees as a significant barrier to achieving synergies for residential buildings with Policy 8.4.3. This factor takes priority in assessments for many city stakeholders working with the policies. Building professionals responsible for design and development have explicit requirements for affordable housing units which can inhibit passive measures due to cut profits. A short-term increase in construction leads to decreases in long-term disaster preparedness, relating this barrier to the temporal dimension.

On the national scale, the NPPF and Building Regulations promote this barrier because of the emphasis placed on creating more homes at the expense of quality; the MHCLG was identified as a critical force in the national government (I7 Adaptation Advisor). On a local level, the LP was identified as a critical force behind the push for more housing within the local jurisdictional scale (I5, GLA). London suffers from high social inequality making affordable housing an important election issue (I9 Public Health Advisor). This trade-off highlights vertical governance on national and local scales affecting policy implementation.

Interviewees from the GLA described how stakeholders behind new development proposals had cited demands for affordable housing as why they cannot address sustainability (I3 GLA; I4 GLA; I5 GLA). One architect described how proposals providing substantial amounts of housing will never be rejected on the basis of inadequate adaptation preparedness; even if some units are expected to overheat, this will be overlooked if multiple benefits accrue from the project (I14 Architect). Implementing passive cooling measures or addressing overheating without air conditioning is seen as a second priority and not feasible given the resources available to address different issues (I2 GLA; I5 GLA). While the Domestic Overheating Checklist results in major proposals demonstrating that they have considered the hierarchy, the focus on building housing quickly and affordably can result in adaptation falling down the priority list for the GLA and local authorities. The conflict with more housing contributing to the UHI is not something currently being assessed, despite the focus on reducing the UHI in the LES (I3, GLA; I4, GLA; Greater London Authority 2018).

The removal of two national housing policies highlights the prioritization of building more homes. The Code for Sustainable Homes was revoked as a mandatory assessment certifying sustainable design and construction of homes. While London still has high sustainability standards, the Code was previously held as a standard for which buildings received funding in some departments, such as the Housing and Land Directorate. Alternative benchmarks now need to be used, or sustainable design does not factor into decision-making (I2 GLA). One

interviewee pointed to the federal government deregulating the sector as the reason for revoking the mandatory standards. They expressed that “cynically you can argue they stopped focusing on design [as] they want to build more” (I2 GLA).

Zero Carbon Homes was removed concurrently with the same justification. This policy aimed for all new homes to achieve carbon neutrality by 2016 through mandating on-site generation of renewable energy equivalent to a home’s energy demand. This would be complemented with increasingly stringent energy efficiency requirements. The official reason for the removal of both policies was to “reduce net regulations on housebuilders” (Oldfield, 2015). While the carbon neutrality goal remains, the national government has removed means to do so. Even if London has zero carbon standards to achieve carbon neutrality in homes, lacking national support highlights the lack of long-term concern and support.

Building more housing is a negative trade-off because there are social consequences of not having enough homes. Yet this prioritization also results in buildings unequipped for the future, and thus acts as a barrier to the implementation of 8.4.3.

Trade-off with Mitigation

Trade-offs with mitigation prevent synergies in Policies 8.4.3 and 8.4.4. Mitigation has historically been focused on, making it easier for city stakeholders to assess proposals on this basis; building professionals have improved at creating energy efficient homes, compared to addressing heating risk. The historical evolution of prioritizing mitigation, as well as immediate concerns over fuel poverty in retrofits, place this barrier in the temporal dimension. The relevant policies include the SAP Assessment, the Building Regulations and other local and national level emission targets that guide mitigation.

While building more homes has also resulted in quality trade-offs for mitigation, mitigation is still a higher priority for the local and national government (I2, GLA; I4, GLA; I5, GLA). There is a stronger jurisdictional framework supporting mitigation via SAP, Building Regulations and the EU Directive. Several interviewees noted this is not inherently problematic. Fuel poverty is still a danger, and energy efficiency is critical to the solution (I4 GLA; I10 GLA). Despite the health dangers of overheating, more people in London die from cold-related deaths each year. Temporally, the more immediate danger of cold homes leads to strategic spatial decisions by actors about where efforts are directed; mitigation can also hypothetically offer immediate benefits by mitigating the need for adaptation measures.

A focus on mitigation, however, has resulted in conflicts where poorly designed buildings—both old and new—suffer from overheating. A short-term solution for mitigation is creating long term problems for adaptation. Developers and designers have improved at designing efficient homes, but insulation in retrofits of poorly designed flats and developments has led to buildings overheating in recent decades (I2 GLA; I4, GLA; I5, GLA; I8 Designer; I10, GLA). Building professionals emphasized that this was because of poor design; well-insulated buildings should keep heat out, but lacking adequate ventilation keeps heat in (I8, Designer; I14 Architect; I1 Research Expert). For instance, buildings with IWI risk reducing ventilation options (I1, Research Expert). Mitigation benefits can be achieved while reducing overheating risk so long as the insulation is applied while considering these aspects, something that the LP stipulates (I8 Designer).

The GLA now actively discourages single aspect homes and encourages ventilation through the use of the cooling hierarchy. While mitigation may be the main focus of applications, suggested changes are often simple for developers to implement, such as adding shading or reducing glazing (15 GLA). However, it was noted that suggested changes are limited at the assessment

stage of the proposal because the design is largely completed and cannot be changed significantly (I14 Architect).

5.2.1.1.1 Additional Policy Trade-offs

Building more homes and mitigation were the two primary policy trade-offs identified. There were additional trade-offs and conflicts noted in the scale analysis and discussed by interviewees that come at odds with Policies 8.4.3 and 8.4.4. These include: sunlight requirements or combining on-site energy generation with adaptation measures like green roofs (I4 GLA; I5, GLA); prioritization of the size or scale of a site (I3 GLA; I5 GLA); centralized heating resulting in overheating due to waste heat emitting from pipes (I13 Developer); air pollution and noise reduction (I8 Designer; I14 Architect).

Some trade-offs are “an exercise in myth-busting” where knowledge shared between GLA departments comes in use (I5 GLA). London is trying to take an integrated approach to assessing housing applications to determine whether trade-offs must materialize. One interviewee noted that while affordable housing and addressing energy efficiency with overheating are seen as trade-offs, the GLA stresses the need for a holistic approach:

“There may be a few applicants that come forward using the viability argument, as an opportunity to avoid implementing additional energy efficiency measures, so passive measures, but what we’re trying to do in those cases is try and make it very clear that we’re talking about two different elements of the policy. Affordability and housing is there, it’s a very important part of the policy, but it’s different from energy, it’s two very different areas. And when an applicant comes forward, they need to be aware that they have to test viability across all policies in the London plan (I5 GLA).”

Lack of concern for overheating

In conjunction with policy trade-offs, the general public is not concerned about addressing overheating in new developments or retrofits (I6 Climate Change Advisor; I10 GLA). Building professionals do not face demand for overheating measures or do not view overheating as a pressing issue which burdens policy implementation. These perceptions relate to the temporal dimension because the problem is pushed to the future. The limited national scale support for minimizing overheating risk likewise highlights this perception.

GLA interviewees described the sentiment in the UK of overheating not being seen as a problem (I3 GLA, I4 GLA, I5 GLA). Warmer temperatures are viewed as “barbecue weather” which represents a temporal perception of overheating as a non-existent hazard, or at worst, a positive thing (I1 Research Expert; I7 Adaptation Advisor; I14 Architect).

Many homes at risk from overheating were built in the last couple of decades. Motivating building managers to view overheating as a problem is challenging because these buildings are considered new and not up for refurbishment. This is problematic because flats built in the last few decades with little ventilation tend to overheat; it is unlikely for a single residential home to overheat if it has a front and back yard (I8 Designer; I12 Local Authority). Lack of client demand was also noted in a BRE survey of buildings professionals as a barrier to addressing overheating (BRE, 2017). Without strong demand from customers or regulations, policies addressing synergies are overlooked by developers.

Limited capacity (financial resources and time)

Temporal trade-offs emerge partially because of limited resources to accommodate measures with synergies. Limited resources are a barrier for city stakeholders because they have limited capacity to support the policies and retrofit programs. Costs were also identified unanimously

as a reason building professionals claim the inability to implement passive measures for new builds and retrofits. Limited financial resources warrant analysis as a category because of affecting aspects beyond previously identified barriers. Limited capacity represents a temporal trade-off regarding when and where money is invested, inhibiting Policies 8.4.3 and 8.4.4.

A lack of funding from national governments for retrofit programs was viewed as a barrier to synergies for city stakeholders. It is difficult to secure money to address fuel poverty, let alone ensure overheating synergies are considered (I4 GLA; I10 GLA). The perceived costs for retrofits are generally high to residents, with building managers also not prioritizing overheating (I7 Adaptation Advisor; BRE 2017). Funding cuts to national programs like ECO have reduced the number of homes being retrofitted for energy efficiency in London and beyond (I10, GLA; Emden, Murphy, & Hywel, 2018). Resource-stretched care homes are fearful of audits which may uncover problems they lack means to address (I4 GLA). One interviewee viewed funding as the most critical thing the national government could provide to address overheating in retrofits (I10 GLA). When it comes to supporting measures like urban greening to address overheating, new developments are prioritized because this is where the mayor has more power compared to retrofits (I4 GLA).

The GLA has limited financial capacity to enforce overheating policies. Multiple competing priorities—mitigation, social housing—mean there are limited resources to expend to overheating support and programs (I3 GLA; I4 GLA). This can lead to overheating falling lower on the priority list given other concerns (I3 GLA). Overheating also falls lower on the priority list in local authorities who have limited time and capacity to ensure overheating is enforced in development proposals (I8 Designer; I12 Local Authority; I14 Architect). Although summer heatwaves are more frequent, perceptions of overheating as a distant problem still affects the GLA’s capacity to prioritize the issue.

Closely related to limited financial capacity are siloed teams at the GLA. While teams communicate and work together to develop integrated strategies, teams do ultimately work on their own for strategy implementation (I4 GLA). Multiple GLA interviewees noted that employees are aware of each other’s work and attempt to balance adaptation and mitigation together (I4, I10, I5). Yet individuals still have their own targets and objectives to meet:

“Of course people want to work on these synergies and unintended consequences, But they're so under pressure to deliver to their kind of purist targets. And that means that sometimes these synergies and consequences get dropped off.” (I3)

The spatial dimension of who is in charge of ensuring synergies are promoted in programs—i.e. energy efficiency, green infrastructure, air quality, etc.—can be unclear.

Whether costs are prohibitive for building professionals is debatable, with different realities for new builds versus retrofits. The pressure not to add costs for new developments links back to building more housing (I1 Research Expert; I4 GLA). Developers cite insufficient funds for why overheating is not addressed via passive measures (I4 GLA; I5 GLA; I13 Developer). Passive measures will often be the first design features eliminated if efficiency and sunlight trade-offs emerge (I4 GLA). A BRE survey of building professionals also found that when suggestions for passive measures are proposed by designers to address overheating, these suggestions are eliminated if costs need to be saved (2017). However, one interviewee noted that design fixes like shutters or well-positioned windows are low-cost and significantly cheaper to implement in early design stages compared to retrofits (I8 Designer). Even if costs today prevent policies from being entirely successful, someone will be responsible for shouldering costs in the future if overheating risk is not mitigated now.

The BRE survey noted a similar number of respondents thought costs could be significant for new builds and retrofits (47.5% and 48.2%). However, 47.5% of building industry professionals thought there were little to no costs for addressing overheating in new builds compared to 17.2% for retrofits; 34.5% thought costs would be very high for retrofits compared to 4.9% for new builds. The survey findings echo the interview results that overheating retrofits require more financing than new builds (I4 GLA; I7 Adaptation Advisor; I10 GLA). It is difficult to conclude whether costs are prohibitive for the implementation of 8.4.3 and 8.4.4, or if the temporal aspects of not viewing overheating as a pressing problem contribute to adaptation being dropped as a priority.

When limited financial resources are combined with minimal vertical governance around new developments or retrofits, there are few incentives to go above and beyond what is required. As one Public Health Advisor noted:

“Part of [the problem] as well is a lack of government policy. They [developers] want a level playing field with their competitors and in the absence of government policy they don’t want to be the ones going above and beyond and spending time and money if no one else is. They don’t see the benefits of doing that, so there’s a need to educate around this and help them see the value they can get (I9).”

Whether it is trade-offs with other political priorities or the costs of implementing synergies, these barriers stem from temporal mismatch. While it is easy to say there are more pressing priorities than overheating or implementing measures with synergies, these barriers do not eliminate the problem but instead shift it forwards temporally.

5.2.2 Spatial Dimension Barriers

Barriers are related to the spatial dimension if they address the characteristics and requirements of different actors involved with implementing the policies under analysis. This includes geography, culture, behaviour, practices, and norms within vertical and horizontal governance. Lacking regulatory support from the national scale, skill shortages for building professionals and local authorities, informal institutions, cultural and aesthetic preferences, and occupant behaviour are identified as barriers within this dimension.

Lack of regulatory support

Trade-offs and minimal concern for overheating in the temporal dimension relates to spatial aspects regarding who takes responsibility for overheating as neighbouring geographic areas have different regulatory regimes. The absence of national thresholds—i.e. when overheating occurs—or a mandatory assessment is currently a barrier for the GLA as they have limited enforcement power for Policies 8.4.3 and 8.4.4 within the boroughs. London’s institutional framework for policy enforcement is expected to be replicated within local authorities for non-referable applications, yet the nested nature of enforcement and regulatory powers implies the baseline for achieving synergies is not consistent across all builds. SAP 2012 and the Building Regulations currently lack any mandatory assessments for overheating, and the Energy Assessment Guidance is not used to a sufficient degree.

Compared to mitigation, there are no quantitative targets to meet with overheating assessments within jurisdictional interactions. Mitigation targets and strategies such as energy efficiency requirements provide numeric targets easily assessed in applications (I3 GLA; I4 GLA). Lacking targets for overheating on a national scale translates into a trade-off and weak enforcement in some boroughs; this is not from lack of caring, but instead, limited resources and skills to properly assess proposals to ensure synergies are considered, and conflicts or trade-offs minimized (I3 GLA, I4 GLA, I5 GLA).

While there are Energy Assessment Guidance thresholds at the local scale, many non-referable applications do not use the CIBSE criteria properly, if at all. Some interviewees thought the majority of non-referable applications do not use the criteria (I8 Designer; I12 GLA; I14 Architect). While it is recommended overheating risk be assessed against future weather patterns (2050 and 2080), this is not required nor requested on a wide scale by developers or boroughs (I8 Designer, I12 Local Authority). Passing 2050 and 2080 criteria is technically more difficult than 2020 criteria and given that 2020 assessments are not completed widely, pushing future weather file assessments may be misguided (I8 Designer). Ignoring CIBSE requirements entirely again demonstrates developers prioritizing short term gains over building resilient homes and demonstrates the importance of national regulations in ensuring stricter compliance.

The temporal perceptions of overheating do not reflect future reality, and the spatial dimension of who should be responsible for mitigating overheating in the future thus remains a grey area. For example, preparing developments to implement measures like brise soleil, or even active cooling when passive measures are no longer enough, requires fewer resources in the long term (I12 Local Authority). Appointing someone responsible for equipping buildings for future temperatures—adding more awnings, active cooling, etc.—also removes the burden from tenants (I12 Local Authority). While there has not yet been a quantitative survey or assessment, interviewees believed that even with the London policies, the majority of new buildings in London are not equipped to address overheating. Designs implemented today are unlikely to be enough several decades into the future.

It was acknowledged it is not easy to come up with thresholds or targets and assess the success of overheating measures. Defining a threshold for overheating that determines when overheating risk has been mitigated to a sufficient extent was also highlighted in the literature review as a conceptual challenge. London faces unique challenges with its UHI compared to smaller towns. These challenges partly explain why setting a threshold or determining whether overheating risk is being successfully mitigated is more difficult than for risks like flooding or other hazards (I4 GLA; I6 Climate Change Advisor).

An interviewee working on adaptation with the national government noted that insufficient evidence is cited by national departments as the reason they do not support thresholds (I7 Adaptation Advisor). However, the interviewee did not agree with this reasoning and stressed that given available information, even higher thresholds would be better than no mandatory regulations at this time (I7 Adaptation Advisor). Despite the challenges, lacking national regulations only weaken London's policies.

Skills Shortage

The skills shortage manifests in two manners: a lack of knowledge by local authorities assessing development proposals; limited knowledge from building professionals about using the CIBSE criteria and implementing passive measures in new developments and retrofits. This barrier is related to the lack of regulatory support in that it prevents the GLA from ensuring Policies 8.4.3 and 8.4.4 are implemented in local authorities. Lack of knowledge and skill on the part of building professionals in assessing overheating risk and implementing measures with synergies also acts as a barrier to implementation within the building sector. Lack of skill is inherent to stakeholders involved, making this barrier relate to the spatial dimension. This participation is further restricted by geographic reach within boroughs. The relevant policy document for 8.4.3 is the Energy Assessment Guidance which requires a certain level of knowledge to use and assess.

Overheating workshops and discussions are held with boroughs to train local authorities in assessing non-referable applications with the Energy Assessment Guidance (I3 GLA). However,

the local authorities differ in capacity and ability to prioritize Policies 8.4.3 and 8.4.4 (I3 GLA, I5 GLA). As one interviewee states:

“Boroughs may be limited in capacity, in terms of knowledge and time and budget, maybe this is not implemented throughout all applications that they see, and the smaller ones, so having a national requirement would definitely strengthen this area of the policy and make applicants consider it from scratch regardless of whether they’re submitting in London or any other council in the UK (I5 GLA).”

This perspective is replicated within some local authorities. One interviewee responsible for assessing flat proposals stated the majority of London is not looking at overheating (I12 Local Authority). This reflects findings from the CCC in an assessment of UK housing (Committee on Climate Change, 2019b). Assessments require time and understanding of the complexity of the issue and with short-term strained financial resources and capacity, applications are not always likely to be cross-referenced. The interviewee described a trade-off with air quality and noise reduction strategies and how numbers are altered:

“I think designs are altered slightly and there’s a fair amount of fudging that goes on. So often I will see an overheating assessment for a development but I might not always have a chance to cross reference it with noise strategy and air quality strategy. But it’s very likely that the noise strategy and air quality strategy will say the windows must be kept shut because of noise pollution or air quality is bad, but that’s often in complete contradiction to what’s in the overheating strategy which says we need to open the windows to ensure the units don’t overheat. So, the question often back to them is, well, which one of you is right? It’s a trade-off really (I12 Local Authority).”

These trade-offs were noted by building professionals as well (I8 Designer; I14 Architect). The CIBSE criteria are complex to understand, as is assessing proper implementation of the cooling hierarchy. Planners in local authorities have hundreds of other requirements they need to ensure are met for developments. When combined with the limited time and resources, some interviewees did not think it was fair to leave the overheating assessments for the local authorities and planners to do (I8 Designer, I12 Local Authority).

For building professionals, a lack of knowledge on the part of designers and developers was cited for limited implementation of passive strategies addressing overheating (I1 Research Expert, I8 Designer, I12 Local Authority). A skill shortage exists because many designers and architects currently working on developments are not specialists in overheating or passive measures. Interviewees with the GLA noted that policy evolves quickly, and it can be challenging to catch up (I3 GLA; I4 GLA). There were similar findings in the BRE survey that point to a systemic problem: adaptation and resiliency are not embedded within experts’ education (2017). If designers are not trained in preparing buildings for future climates, the measures possible today are not being implemented in the middle of a housing push.

A skill shortage was identified by the UKGBC as a barrier in an analysis of energy efficiency in UK buildings, both for new builds and retrofits (Aldersgate Group, 2017). While this analysis focused on efficiency, the report noted retrofits are not currently being completed for warmer temperatures. Retrofitting buildings for efficiency is critical but this cannot come at the expense of buildings overheating in the summer. Within some efficiency programs, generic recommendations are made for addressing overheating in retrofits. However, these are often not taken up because comprehensive changes like altering window designs or including thermal mass require expertise knowledge (I4 GLA).

A lack of knowledge on the part of local authorities constrains the GLA in enforcing its policies via its Energy Assessment Guidance and cooling hierarchy requirement. Local authorities and

planners cannot always assess proposals properly given their knowledge base and minimal resources. Overheating is still a novel concern within the building community and designers and developers are ill-equipped to implement measures with synergies sufficiently.

Informal Institutions

The UK's push for more housing and weak regulatory framework created the circumstances for informal institutions. These informal operating rules are a barrier to the GLA implementing Policy 8.4.3 because they operate outside of jurisdictional scales to affect how new buildings are governed. Informal institutions impact the ability of stakeholders to enforce policies by altering available information. These informal operating rules manifest in three ways: 'shopping' for regulatory approval; intentional deception on assessments; and settling overheating cases outside of court to avoid setting litigation precedents.

As regulation is privatized, developers select building control companies to certify projects with regulatory compliance. Developers can shop around and choose companies with the "best answer" for how projects will address requirements in the Building Regulations or the Energy Assessment Guidance (I4 GLA). There is no neutral third-party verification for meeting engineering and design standards as building control companies are paid to sign off on projects (I14 Architect). While building proposals may show that targets will be met, the way of meeting these targets is flexible (I4 GLA). In some cases, this can lead to innovation, but if there is a lack of skills for assessing proposals—as can be the case in local authorities—proposals inadequate in low-priority areas like overheating risk preparedness can easily be approved despite weak compliance. The pressure to build more homes quickly on local authorities and buildings professionals heightens this problem.

Overheating numbers in planning proposals are embellished to seek approval faster (I8 Designer, I12 Local Authority; I14 Architect; I9 Public Health Advisor). Numbers like occupancy patterns or hours overheating are falsified to minimize the problem (I8 Designer; I12 Local Authority). Measures with synergies do not need to be implemented because the scale of the problem is minimized, though it is difficult to ascertain whether this is done on purpose or because of a lack of skill. The enforcement challenge comes back to boroughs assessing proposals lacking the skills or time to detect these embellishments. One interviewee noted that this is a problem on a UK wide scale:

"There's evidence that you don't necessarily have to, there's evidence that builders are basically paying lip service to these assessments and not doing them properly. So even though a design may pass on whatever assessment they're doing, there's a whole bunch of other factors that aren't taken into account (I9 Public Health Advisor)."

Another informal institution relates to settling overheating cases outside of court. There are cases where residents who live in flats experiencing overheating have sued developers; all cases have been settled privately to avoid setting precedents (I8 Designer, I12 Local Authority; I14 Architect). Residents are not being sold the homes they are promised, instead living in buildings endangering their health or, at a minimum, creating uncomfortable living conditions. While one may think these court cases would serve to further prioritize overheating, there remains a spatial disconnect between those living in homes and the ones designing or building the home (I6 Climate Change Advisor; I10 GLA). A socioeconomic aspect is likely at play because only certain groups will have the resources or expertise to take developers to court; the real scale of the problem could be larger. Those suffering from building overheating are not necessarily prepared or equipped to mitigate risks on their own.

Building Professionals Culture and Aesthetic Preferences

Developers and building managers reluctance to change their practices relates to the spatial dimension because this is a characteristic unique to building professionals that inhibits adaptation practices in design norms. This barrier is not linked to any documents.

Many passive strategies recommended by London were not considered to be complicated or costly, particularly in the early stages of the design (I8 Designer; I12 Local Authority, BRE 2017). However, because they are perceived as an additional burden, there is little willingness on the part of building professionals to implement beyond the bare minimum. One interviewee described the built environment as an old industry reluctant to change, while another described developers as old-school and accustomed to building a certain way (I9 Public Health Advisor; I12 Local Authority). The cooling hierarchy and overheating assessments were considered to be largely paid 'lip service to,' with trends and bottom-line profits winning out over passive strategies (I14 Architect); developers were also described as having the city "over the barrel" in terms of what developers are willing or not willing to do (I6 Climate Change Advisor). If the changes are perceived as costly, as discussed previously, there are no incentives to go beyond what is required (I11 Buildings Non-profit; I12 Local Authority; I9 Public Health Advisor).

Culture is closely tied with aesthetic preference, both on the part of the designers and customers. Two GLA interviewees noted that designers and architects are not fans of shading measures like shutters and louvers, but that there has been a rise in balconies to act as external overhangs; however, balconies do not tend to be implemented in low-income housing (I4 GLA; I5 GLA). The trend in recent years towards floor to ceiling, un-openable windows with high glazing leaves residences prone to overheating (I5 GLA; I12 Local Authority). A barrier brought up in the BRE survey was that if overheating solutions were not aesthetically acceptable to customers, they would not be implemented within the actual design (BRE, 2017). This reluctance to change has contributed to overheating becoming a market failure within the weak regulatory framework in London and the UK.

Occupant Behaviour

Occupant behaviour was identified as negatively affecting the implementation of the policies. Even if the policies are implemented, some measures may not be used properly by occupants to mitigate heating risk. This relates to the spatial dimension because even though measures are implemented by one actor, the realisation of the benefits may not emerge without another stakeholder group being engaged. Policies 8.4.3 and 8.4.4 are both affected because this is something that emerges only after the implementation of overheating measures.

Some passive measures do require precautions to be taken by residents. Many studies looking at shutters or blinds assume perfect behaviour by residents. In reality, there are common misconceptions about how precautions ought to be taken (I3 GLA; I12 Local Authority). For instance, keeping windows and shutters closed during the day to minimize overheating can be counterintuitive and the opposite of what people do (I1 Research Expert). This results in a conflict with mitigation by increase cooling demand, or the reverse in winter.

The GLA has started to ask large developments to include instructions about what to do in heatwaves. However, effectively communicating with residents about risks in their homes is a significant challenge, in addition to communicating precautions that must be taken in the outdoors (I2 GLA; I3 GLA; I6 Climate Change Advisor). Identifying whether heatwave alert advice is actually taken up is a research gap. Contradictory behavioural effects can occur, such as individuals in cool homes still wanting air conditioning because they come to expect a higher cooling threshold (I9 Public Health Advisor; I2 GLA).

The degree to which residents should be expected to take precautions for their own safety is debated. The point where individuals overheat differs and relying on human behaviour can be dangerous. As one interviewee pointed out, it is possible that the two most vulnerable groups—older individuals and young children—can be resistant to change or reliant on others having perfect information to help them (I12 Local Authority). None of this may be a definitive barrier to implementing measures like shutters and blinds but does highlight that a variety of cooling techniques should be used to reinforce each other.

5.2.3 Current Drivers

There were few existing forces driving policy synergies in the LES. One was having an ambitious Mayor highly focused on sustainability (I5 GLA). The Energy Assessment Guidance was also described as a driver because it requires consideration of an issue that otherwise is not looked at, even if the numbers are altered (I3 GLA; I8 Designer; I3 GLA). The CCC was identified as bringing overheating to the forefront with different reports highlighting the UK's unpreparedness for overheating (I9 Public Health Advisor). Heatwaves also helped create awareness for governments and research institutions (I1 Research Expert).

However, because new developments were seen to be falling drastically short with overheating preparedness, this research focused on discussing what future drivers could help promote the implementation of the policies.

5.2.4 Temporal Dimension Future Drivers

Future drivers relate primarily to the temporal dimension if they can help minimize the competing priorities facing stakeholders within horizontal and vertical governance. The drivers identified here were the overheating problem intensifying, changing the overheating narrative, stronger regulations and difference financing models for retrofits.

The Overheating Problem Intensifying

Overheating resulting in more significant human impact was one possible policy driver. This would drastically shorten the time horizon of overheating being seen as a far-off problem and potentially result in strengthened vertical governance within some policy documents in 6.1.

Some GLA representatives and building professionals did not think the temporal perceptions of overheating as a far-off hazard would change significantly. A national emergency was a potential trigger for systemic change (I1 Research Expert; I4 GLA; I12 Local Authority). Public and media attention to climate change has spiked due to the Mayor's declaration of a climate emergency and movements like the Extinction Rebellion (I4 GLA). There is currently an abundance of construction happening in London, making it a critical time to get adaptation and mitigation "right" for new developments (I5). However, as the discussion on barriers highlighted, mitigation and other concerns are prioritized.

While the average person in the UK may not view overheating as a challenge now, it is residents of poorly designed homes that have to live with the ill effects of hotter weather (I4 GLA). Even if overheating is not a priority of building managers or developers, one interviewee from the GLA believed that as the problem worsens there would be a massive outcry from the public that would drive change in buildings (I4 GLA). One interviewee from the boroughs thought there would be no other drivers:

"What I think will happen is probably someone in the future, there will be a heatwave in the UK, it will cause a couple thousand deaths, it will cause a national outcry and then solar shading will be what everyone wants. And the planning system won't be able to say no (I12 Local Authority)."

Waiting for the problem to get worse before implementing the solutions is one way to mitigate the temporal mismatch between adaptation and other priorities for current weather, though this comes with the negative health effects of overheating.

Changing the Overheating Narrative

A shift in the temporal perception to view overheating adaptation as having immediate benefits could be a critical strategic shift for successful policy implementation for Policies 8.4.3 and 8.4.4. Similarly to the overheating problem intensifying, this would result in more effective policy implementation by city stakeholders and building through creating more demand for addressing the hazard. How a change in narrative would be achieved is less clear.

While hot summers and heatwaves receive the bulk of attention, overheating does not only occur in the summer. Exposure to higher temperatures throughout the year negatively impacts individuals' health and causes overheating in poorly designed buildings (I3 GLA). As the UK is temperate, it is difficult for people to contextualise heat as a problem (I3 GLA; I4 GLA). One interviewee noted a complete change in overheating narrative would be critical to bringing the issue to the forefront and made a comparison between overheating and air quality; it was only when the city consciously shifted to talking about pollutant exposure danger that it was seen as a public health issue (I3 GLA). While reducing emissions and changing transportation habits is critical for long term air pollution reduction, the short-term dangers created awareness (I3 GLA). Changing the narrative to make overheating a safety issue, like fire safety or structural durability in buildings, could change the perception of overheating as a box to check off and minimize informal institutions (I14 Architect).

Another interviewee suggested that overheating would not be prevented sufficiently with the current heatwave alerts (I6 Climate Change Advisor). The alerts are currently triggered three days into a heatwave, but research has found that health-related impacts occur before prolonged exposure (Lomas & Porritt, 2017). Changing the narrative to one of heat risk as a year-round problem enables preparation beforehand (I4 GLA). While risk will never be entirely removed due to underlying health problems, it can be mitigated.

Another element that could change the narrative would be incorporating overheating into other public issues like green infrastructure (I4 GLA). While green infrastructure is not the only solution, there has been a movement towards valuing ecosystem services given all of the benefits they provide throughout London (I4 GLA). The GLA tries to push developers towards green roofs because green infrastructure is a significant priority (I4 GLA; I5 GLA). The cooling properties of green infrastructure for reducing internal temperatures and the UHI have been captured within the literature review; the specific application for reducing overheating is something that could be promoted.

Changing narratives is not easy, and there were few explicit suggestions about how to do this. However, given dealing with overheating pre-emptively is continuously ignored, active attempts to alter this perception could become a driver.

Different financing models

Zero existing drivers for addressing overheating in retrofits through Policy 8.4.4 were noted (I4 GLA; I5 GLA; I8 Designer; I11 Buildings Non-profit). Different financing models could reduce the temporal mismatch between adaptation and current priorities by incentivizing building professionals—property owners, building managers—to take on retrofit projects. This would be incorporated into the Energy for Londoners programs.

Insufficient funding and incentives are significant obstacles for homeowners and building managers. Financing for retrofits was described as the most significant future driver for addressing overheating through synergies in homes (I4 GLA; I10 GLA; 17 Adaptation Advisor; I11 Buildings Non-profit). A selection of innovative funding models for retrofits was highlighted as potential drivers for accelerating change in Energy for Londoners.

While the success of the Energy Leap is to be seen, the energy contracting model has been successful in other European countries. An interviewee involved with the development and implementation of Energy Leap is optimistic about the pilots working effectively and transferring the model to other programs (I10 GLA). Banks providing green finance loans with low-interest rates for efficiency would also be helpful (I10 GA). Another model involves adding retrofit charges to a property, allowing owners to recoup their investments when selling their property while delivering benefits for adaptation and mitigation now and in the future (I10 GLA). The Mayor's energy efficiency funds could provide low-cost financing to local authorities to test attaching charges to properties at scale (I10 GLA). Passive measures contributing to higher financial valuing of the home can also be seen as reducing the risk premium (I11 Buildings Non-profit). Adaptation would avoid postponement via a financing model that allows costs to be pushed into the future rather than the safety and health of inhabitants. One interviewee involved with energy efficiency programs summarized the current predicament:

“Finance is always one of those things that crops up. We got the technical solutions for thermal efficiency and cooling in the market, I would argue we need to go on a cost reduction journey and make projects financeable at scale. There are 3.2 million homes that need retrofits in London (I10 GLA).”

5.2.5 Spatial Dimension Future Drivers

Future drivers relate primarily to the spatial dimension if they alter the unique characteristics, norms, values, and geophysical barriers facing stakeholders within horizontal and vertical governance. The drivers identified here were stronger regulations, reputation and education.

Stronger regulations

The lack of a national threshold or mandatory assessment was highlighted as a spatial barrier to synergies in both LES policies. Concurrently, having both was identified as a driver that could strengthen London's policies at the local scale by creating short-term importance. This would support local authorities in the enforcement of the policies by ensuring building professionals were considering these issues from scratch. It would strengthen the vertical governance of the issue by making overheating assessment mandatory at the national scale.

All interviewees thought additional regulatory support would be useful for policy enforcement. This could take the form of updates to the Building Regulations or other mechanisms. There are practical challenges with developing a threshold but lacking any definition or assessment shifts the burden of responsibility. National regulatory support creates a baseline that ensures building professionals consider overheating from scratch. This is promising given the current subjective interpretations of the Energy Assessment Guidance in local authorities has aggravated the market failure of low-quality buildings.

National regulations would ideally reduce the burden on local authorities to assess falsified overheating criteria and whether the cooling hierarchy has been adequately considered and overheating addressed. Two building professionals noted that it would have to be a more straightforward criteria or methodology on the national scale than what is expected in London at the moment (I12 Local Authority; I14 Architect). Designing regulations that are too complicated or that do not function well together results in difficulties regardless due to a skills shortage (see Section: Skills Shortage). However, a baseline would mandate a higher standard

from the beginning for all developers and local authorities (I3 GLA; I4 GLA; I5 GLA). Making a pass/fail criterion within Building Regulation or another tool would help to simplify the issue as well, whether on a national or London level (I6 Climate Change Advisor; I12 Local Authority). An assessment or threshold from the national governments could strengthen the London policies and help minimize the burden on local authorities. Until then, there is a risk for adaptation synergies to continue to slip to the bottom of local priorities.

There is debate about whether CIBSE 2050 and 2080 assessments should be necessary (I8 Designer; I12 Local Authority). One value-add of using the assessments is that developers can incorporate features that will be included in the future within plans, including who will be responsible. For example, it is preferable to have built-in active cooling vs stand-alone units which are more energy-intensive and inefficient. Thus, if active cooling is required in 2080, designing the building with the capacity to incorporate this in the future is helpful. The responsibility can also be delegated to the building company or manager in the future rather than the tenants (I12 Local Authority).

Education

Increasing the education and awareness of occupants, city stakeholders and building professionals can do two things: address the skills shortage identified as a barrier and increase consumer demand for addressing overheating through synergies. Education could positively influence both policies. By altering the knowledge base and priorities of stakeholders, calculations for implementing overheating measures are altered. This could increase demand for programs in Energy for Londoners, as well as shift market demand to create more stringent adherence to overheating vertical governance by building professionals.

Education on how to properly use and assess CIBSE criteria was another suggestion. Having national assessments or thresholds does not guarantee that local authorities and planners accurately assess applications. Not everyone thought the obligation should be on planners in the boroughs to assess applications properly given limited resources and education (I8 Designer; I14 Architect). The boroughs have suffered from budget cuts in recent years which further stretch their resources (I4 GLA). One building professional brought up the consideration of an accreditation scheme for building professionals using CIBSE criteria when assessing overheating in the design stage. Because there is no training in the modelling CIBSE requires, it is difficult to determine whether someone is reliably using the assessment (I8 Designer). Accreditation could reduce the expectation on the boroughs because it would be easier to verify the modelling was done sufficiently, but the idea is in the early stages.

Several interviewees viewed overheating awareness-raising as critical to implementing policies 8.4.3 and 8.4.4 (I3 GLA, I5 GLA, I11 Buildings Non-profit). The temporal dimension of not viewing overheating as a problem correlates with evidence that awareness of overheating risk is low (I7 Adaptation Advisor). Lack of consumer awareness contributes to the market failure of overheated buildings. Changing this could help the problem; the critical question that appears to remain is how. A knowledge gap about the efficacy of heatwave alerts and occupant behaviour generally was cited several times as something the GLA is working on to increase awareness (I3 GLA; I6 Climate Change Advisor).

Access to resources about using passive measures correctly is something residents and occupants require for adequate education (I3 GLA; I4 GLA). Mere access to resources, however, does not guarantee people change their practices. Difficulties reaching particular segments of the population can mean the most vulnerable will not be reached, pointing once again to needing to raise awareness prior to heatwaves and change the narrative (I6). Automated

systems were suggested, but these systems are more expensive and those most at risk will generally not be able to afford them (I3 GLA).

Increasing knowledge about assessing overheating accurately and implementing different cooling techniques without air conditioning is essential. Increasing education about techniques was not considered as critical as making developers see the value in what the project can achieve (I11 Buildings Non-profit; I3 Developer; I14 Architect). Financial value stems from creating high-quality buildings with lower energy needs for customers if air conditioner is avoided (I13 Developer). Since most building managers and homeowners view buildings as assets, future-proofing should be a valuable quality (I3 GLA). The lifespan of most of these assets is 60+ years and given the drastically different climate expected, education and promotion of valuable aspects is critical (I11 Buildings Non-profit).

Reputation

One possible driver was architecture and development firms' reputation (I7 Adaptation Advisor; I13 Developer; I14 Architect; BRE, 2017). This could potentially drive better implementation of Policy 8.4.3. Reputation belongs to the spatial dimension because it incentivizes buildings stakeholders to work on adaptation in the implementation stage of policy. While overheating may not be a pressing concern, private actors inherently rely on good public opinion. This can bring adaptation into the design stages to deliver a quality product before becoming known as the firm that creates heat trap buildings. While this acts as a current driver for some firms, it is likely to become a bigger driver as overheating awareness grows. This addresses an issue outside of vertical governance, by instead influencing attributes belonging to horizontal stakeholders.

As one developer discussed, passing off high energy costs to consumers—i.e. through active cooling or poor energy efficiency—or developing a reputation for weak environmental practices or constructing overheated buildings would be detrimental to their brand (I13). The BRE survey also found that avoiding customer complaints was a driver for implementing these measures (2017). This finding suggests reputation is something that makes buildings professionals accountable to customers. Yet as cases regarding overheating are still being settled privately, the concept of naming and shaming does not appear to be working for all situations related to overheating risk. At least one building professional pointed out that it is not the developers or housing associations currently pushing this issue; until it affects bottom line profits, there will not be a change (I14 Architect). In firms that have made explicit environmental commitments however, this can be an effective driver.

5.2.6 Summary of Barriers and Future Drivers

Table 5-2 presents the barriers and possible drivers according to which policy they affect. While these barriers and drivers manifest in different ways, their ultimate effect on the policies comes down to two factors for stakeholders involved: the perceived lack of criticalness of overheating; the inaction within different governance arenas stemming from traits inherent to the actors within those arenas.

Table 5-2. Barriers and Future Drivers

Barriers	Policy Affected		Relevant Policy Documents
(I) Focus on building more housing	8.4.3	X	NPPF, Building Regulations, Energy Assessment Guidance, London Plan
	8.4.4		
(I) Focus on mitigation	8.4.3	X	

	8.4.4	X	SAP, Building Regulations, EU Directive, various emission targets, LP
(T) Lack of concern for overheating	8.4.3	X	
	8.4.4	X	
(T) Limited capacity (financial, time) for policy/program enforcement in boroughs	8.4.3	X	Energy for Londoners
	8.4.4	X	
(T) Limited capacity (financial) for building professionals	8.4.3	X	Energy Assessment Guidance
	8.4.4	X	
(S) Lack of regulations	8.4.3	X	SAP 2012, Building Regulations, Energy Assessment Guidance
	8.4.4	X	
(S) Skills shortage in local authorities for assessment	8.4.3	X	Energy Assessment Guidance
	8.4.4		
(S) Skill shortage for buildings professionals to implement measures	8.4.3	X	
	8.4.4	X	
(S) Informal institutions	8.4.3	X	Building Regulations, Energy Assessment Guidance
	8.4.4		
(S) Building professionals culture and aesthetic preferences	8.4.3	X	
	8.4.4	X	
(S) Occupant behaviour	8.4.3	X	
	8.4.4	X	
Future Drivers	Policy Affected		Relevant Policy Documents
(T) Problem getting worse	8.4.3	X	
	8.4.4	X	
(T) Changing the narrative	8.4.3	X	
	8.4.4	X	
(T) Different financing models for retrofits	8.4.3		Energy for Londoners
	8.4.4	X	
(S) Stronger regulations	8.4.3	X	Building Regulations, SAP
	8.4.4	X	
(S) Education	8.4.3	X	
	8.4.4	X	
(S) Reputation	8.4.3	X	
	8.4.4		

6 Discussion

While jurisdictional scale interactions affect how adaptation is vertically governed, assessment of integrated policies across these scales and the underlying barriers and drivers to achieving synergies was identified as a research gap (Grafakos et al., 2019; Walsh et al., 2011). Prior literature discussed how the adaptation-mitigation dichotomy supports or prevents policy integration, but there are few empirical assessments of whether this can explain barriers or drive implementation synergies (Biesbroek et al., 2009; Dymén & Langlais, 2013; Landauer et al., 2018). Addressing these gaps allows us to identify where policy implementation falls short and whether these barriers can be addressed in future policy.

Section 6 discusses the key findings of the thesis and how the RQs align. 6.1 briefly addresses how the identified measures in RQ1 must be considered in light of trade-offs and conflicts with climate goals; effective policy will take these systematic impacts into consideration. 6.2 analyses how weak vertical governance in the UK prevents synergies from being realised, though there are places within jurisdictional scales where this can be strengthened. 6.3 brings together key findings from RQ3 and RQ4. To avoid repetition, a few key points related to adaptation are relevant to bring up rather than discuss all barriers and future drivers: i) the temporal barriers all have a socioeconomic element that affects who is impacted by overheating in the future; ii) closing this temporal gap requires deriving new value from addressing overheating for key stakeholders; iii) in addition to value, the weak vertical governance as discussed in RQ2 must be adjusted in light of London's spatial circumstances; iv) cultural-aesthetic and occupant behaviour barriers are behavioural aspects more difficult to manage by cities but critical to address for policy implementation nonetheless.

6.1 Achieving synergies through building design is possible

There are dozens of measures that can achieve synergies by providing mitigation benefits while cooling homes. The promotion of these measures in integrated policies thus has a place in cities given they contribute to mitigation and adaptation goals.

The literature review showed that combining multiple measures results in the most effective responses. Some strategies result in incremental improvements in reduced cooling demand compared to others, but the difference is marginal if confounding factors such as building orientation, thermal mass placement, and ventilation are controlled. These factors increase implementation challenges because exact levels of cooling are not guaranteed as with active cooling. While many experts will be aware of how technical choices are affected by such factors, this may not hold true for all stakeholders making or approving technical decisions. Cities must be careful when promoting measures that risk trade-offs or conflicts when implemented.

The review also highlighted the importance of systems thinking. Window opening for ventilation may not be possible in places with bad air or noise pollution; occupant behaviour impacts both. White roofs may marginally increase heating demand in winter, but in densely populated areas like London with large UHIs, reducing the UHI may outweigh the risks. Buildings with active cooling expel waste heat, further contributing to the UHI; reflexive paints in street canyons can do the same. Green roofs can be low-maintenance in places like London with heavy rainfall, but white roofs are also viable options. It is important to design with future climate optimization as buildings designed today may not be equipped for vastly different temperatures down the line, particularly if not tested against future scenarios.

Effective policies will take these factors into consideration to minimize conflicts and maximize synergies, which London attempts to do with its cooling hierarchy. To analyse if integrated policies are being implemented successfully and resulting in expected synergies, the formal

vertical governance framework within multilevel governance must first be established: how do institutional rules across different jurisdictional scales support synergies, trade-offs or conflicts with the LES policies?

6.2 Institutionalizing synergies within jurisdictional interactions

To add to Grafakos et al.'s and Bulkeley and Newell's suggestion that jurisdictional scales can constrain policy integration, this research proposes that unresponsive jurisdictional scales act as barriers to implementing integrated overheating policies (2019, 2010). Vertical governance through jurisdictional interactions has not hindered London from creating Policies 8.4.3 and 8.4.4, but it does affect implementation on the ground. Without national regulatory support for strong policy synergies, it is more difficult for actors to cooperate and implement local objectives (Landauer et al., 2018; McEvoy et al., 2006). In London's case, boroughs struggle with enforcement given the lack of national regulations. The finding that a country's limited institutional framework inhibits synergies in integrated policies reflects results from Landauer et al. who look at climate strategies in Copenhagen and Helsinki (2018). The theory that cohesive vertical governance is important to synergies is supported.

The LP and Energy Assessment Guidance do institutionally support synergies. Göpfert et al. suggest that for institutionalization of integration into municipal practices, planning instruments need to go beyond informal strategies and policies to also include formal tools embedded in standard operating procedures (2019). On the local level, the LP and Energy Assessment Guidance tie together energy efficiency targets and overheating assessments which would otherwise be unrelated, creating synergies. This can help achieve mitigation goals within London's building sector while preventing overheating in domestic and commercial buildings. While other cities have similar guidance—Toronto has a resiliency checklist for developers to use, Melbourne and Vancouver have passive measure best practices—they are not mandatory, highlighting London's regulatory stringency. This formalization results in better policy outcomes under the Göpfert et al. framework.

However, the LES policies are governed by national jurisdictional institutions that lead to conflicts and trade-offs given additional priorities and lacking regulatory support for synergies. The national jurisdiction has been a strong force behind increasing housing stock via the NPPF, at the expense of sustainability, despite the NPPF theoretically supporting overheating synergies. Neither the Building Regulations or SAP provide means to achieve synergies; instead, municipalities are expected to create synergies with local tools and strategies. Boroughs have individual housing targets set by the LP and energy efficiency standards to assess in applications. Thus, the institutionalization of energy and mitigation policies through the Building Regulations, SAP, and LP can take precedence in the GLA and boroughs. In London specifically, boroughs can more easily ensure new developments meet these requirements compared to the GLA's.

Enactment of policies in local boroughs thus represents the lower level of nested institutions within vertical governance. This confirms assertions that enactment of urban policies follows national regulations and policies (Bulkeley, 2010; Patterson and Huitema, 2019). London can set higher building standards and apply these standards to referable applications, but devolved power to local authorities results in mixed enforcement success. A similar trend has been identified as a barrier in cities with minimal control over building codes; their lack of devolved power limits what they can achieve (Bulkeley, 2010; OECD, 2010). Because of London's size, this predicament flips and they face challenges with devolved enforcement powers to the boroughs. The GLA operates at the jurisdictional scale above the boroughs and needs to manage the multi-scale relationship, just as it does with the national level.

Weak vertical governance results in a tension between London's discouragements of active cooling through the Cooling Hierarchy and national lack of action. There was little influence from the intergovernmental scale on LES policy synergies. While the EU Directive efficiency requirements for active cooling reduce the scale of the conflict, there was little to suggest in the scale analysis that the UK views or governs active cooling as a maladaptive measure. Despite the Directive's encouragement of passive measures, the national scale in the UK has not made meaningful strides to incorporate low-carbon solutions in buildings. In fact, it has even gone so far as to remove sustainable home standards. Jurisdictional support for avoiding this conflict at levels other than the local is lacking despite now being the time to incorporate preparedness for overheating before the active cooling trend continues.

There is little vertical support for incorporating overheating into retrofits, on both a local and national level. While the LP supports synergies in theory, these have not materialized in the Energy for Londoners programs. The Building Regulations do not support synergies in the same way as they do not address overheating for new developments. A knowledge gap exists surrounding the best way to optimize retrofitting programs for mitigation and adaptation and avoid unforeseen consequences (Makantasi & Mavrogianni, 2016). With London exploring unique policy interventions and financing mechanisms as it revises current programs, it is important this is done concurrently with adaptation. Currently, there is a lack of jurisdictional interactions that affect Policy 8.4.4 despite its integrated approach.

This analysis demonstrates there are places where synergies can be strengthened. Buildings are a natural place for the integration of adaptation and mitigation and forward thinking can improve building resiliency. The upcoming revision of the Building Regulations presents an opportunity to integrate overheating into planning and refurbishment norms on a national scale. Until mitigation and adaptation are seen on equal footing, it will be difficult to harmonize them given their economically and legally disparate standings (Moser, 2012). Regulations lead to positive institutional lock-in and thus positive infrastructural lock-in, with the potential to impact both existing buildings and new construction.

London's integrated approach allows it to have goals that cross departments and meet multiple objectives. The national government's two separate approaches to adaptation and mitigation may explain some of the discrepancies that arise, similarly to Copenhagen and Helsinki (Landauer et al., 2018). It is common for local governments to have more comprehensive approaches and stricter climate standards than higher levels of government (Bulkeley, 2010). However, it is evident from the London case that policy enforcement will benefit from additional support within the nested policy framework. At the practical level, there is value in understanding how jurisdictional scale interactions affect London's policies. Only with this analysis can specific conclusions about London's circumstances be drawn. Those recommendations can be found in Section 7.3.

6.3 How the adaptation-mitigation dichotomy affects policy implementation

Even with a weak jurisdictional framework for synergies, a multilevel governance framework requires looking beyond theoretical policies to assess how vertical and horizontal governance affects policy implementation in cities. Adaptation policies are particularly complicated because they involve a myriad of stakeholders implementing measures from the bottom-up (Biesbroek et al., 2009). Looking at the intersection of explicit vertical scale interactions and governance derived from interactions with key stakeholders leads to better policy integration down the line by uncovering barriers and possible drivers. Particularly since overheating policies are a new area of study, both levels of analysis provide insights into how to better create or update

overheating policies. Within the Figure 3-2 Analytical Framework this, lens of analysis is represented by the temporal and spatial interactions between stakeholders.

It was hypothesized that the adaptation-mitigation dichotomy could further explain some of the implementation challenges London's overheating policies face, as well as identify what future drivers could help the policies succeed. The full list of barriers and future drivers can be found in Table 5-2 Barriers and Future Drivers, but there are four points worth highlighting.

i) The temporal trade-offs identified—trade-offs with mitigation and housing, lack of concern, and financial resources—combined with weak vertical governance have resulted in a market failure where the most vulnerable are impacted

Multiple short-term trade-offs take priority over adapting to overheating. In their original discussion of the adaptation-mitigation dichotomy, Biesbroeck et al. argued that adaptation provides immediate benefits and thus localities will want to invest in solutions (2009). This is likely true for hazards like flooding which have explicit visual and monetary consequences impacting affected individuals. In Copenhagen, flash floods have led to adaptation being a higher priority than mitigation (Landauer et al., 2018). London remains mitigation focused despite increasing heatwaves, as the vertical governance analysis showed, and prioritizes building housing. Both provide immediate benefits for addressing energy poverty and the housing crisis, if not directly for emission reduction, and were identified as priorities over implementation of 8.4.3 and 8.4.4. However, overheating remains a silent killer.

Adaptation to overheating also suffers from extremely mixed perceptions of the hazard by multiple stakeholders. Hotter temperatures are viewed in London as positive, i.e. 'barbeque weather', infrequent, or a future problem. Consumers and building professionals do not demand or assess overheating risk reduction partly because of these perceptions. While city stakeholders can promote policies, they struggle with triggering public concern.

Energy poverty and socioeconomic concerns are extremely important and policy trade-offs will always be necessary. This analysis does not attempt to capture the extent to which trade-offs materialize with the LES policies. However, if the balance between building more housing or energy efficiency comes at the expense of safe and sustainable homes, overheating will only emerge as a bigger challenge as time goes on. Trade-offs cannot be considered neutral if overheated buildings are dangerous now and in the future. The Grenfell Fire highlighted shortcomings in the UK's regulatory framework and resulted in public uproar and demands for change. While overheating disasters might not have the same impact within one space, many people are instead at risk throughout the city. An affordable housing push is happening where quantity is being prioritized over quality. The socioeconomic aspects of who is living in affordable housing and thus affected by overheating mean that, regardless, it is vulnerable communities who will be paying costs in the future. Combined with limited vertical governance, this had led to a market failure where buildings are not equipped for future weather patterns and vulnerable people needing protection do not receive protection.

Limited concern for overheating as a current issue and building owners' limited financial commitments make adaptation retrofits challenging. Retrofit barriers have been captured in numerous studies (Brown et al., 2018; Makantasi & Mavrogianni). While adaptation retrofits are studied less extensively, one can assume the same barriers exist with added challenges of ensuring the most vulnerable are protected. The mayor and GLA have more power over new developments compared to retrofits, and that is where most efforts are focused. Yet it is flats built in the last few decades that have the highest overheating risks. Overheating measures can lack the same energy utility bill savings as mitigation, particularly in areas where active cooling

is not the norm. Private owners are unlikely to make these changes without additional incentives, requirements or financing support, all of which are currently lacking from Energy for Londoners (Makantasi & Mavrogianni, 2016). How to best incorporate heat stress resiliency benefits of insulation and other passive strategies for synergies with mitigation could be a promising area of further research.

Socioeconomically, the ones who can make changes without incentives are the wealthy. The upfront costs of investing in overheating protection can be seen as a short-term financial trade-off. Resource-stretched care homes, hospitals and schools are also at risk (Committee on Climate Change, 2019a); as recently as 2018, multiple London hospitals were buying bulk air conditioners and fans in the midst of a heatwave to comfort patients (Campbell, 2018). Spatially, vulnerable individuals may lack knowledge or be unable to protect themselves. The costs of preventing overheating now and who is affected spatially can result in unintended consequences.

This analysis furthers the adaptation-mitigation dichotomy theory by expanding on overheating's place within effective integrated strategies. Landauer et al. discuss how perceptions of how policy implementation and priorities should play out within governance scales influences trade-offs (2018). The results of RQ2 highlight how mitigation and housing requirements are easier to enforce within London's existing jurisdictional framework. These priorities are strongly driven by perceptions of different actors involved. A specialised approach is needed to close the adaptation-mitigation dichotomy for overheating given it faces additional adaptation barriers; it is not perceived as providing many immediate benefits and thus synergies are harder to achieve. Using integrated policies to mitigate overheating risk must be driven by government foresights rather than public concern given that overheating is a silent killer; this can further be driven by alternative financing mechanisms.

ii) New value from addressing overheating must be derived for stakeholders to enable an overheating transition that overcomes temporal impediments

Overheating suffers from temporal mismatches regarding the scale of the problem, in addition to weak regulations and spatial characteristics preventing passive measure implementation. As long as this is the case, a lack of resources will continue to be a limiting factor for policy implementation. Rather than waiting for the problem to get worse, different financing mechanisms can be explored to change the overheating narrative and create value for stakeholders.

The results showed that costs were not a feasible excuse for reducing building quality. This is especially relevant for overheating measures that come down to simple design changes. Current regulatory processes are set up so designs are created by the time they come to the local authorities or GLA for approval. This makes it difficult to implement changes suggested at this stage, even if they are low-cost. Combined with spatial aesthetic preferences of various stakeholders, simple changes like shutters and louvres are further deterred. The energy costs of inefficient buildings are instead pushed to consumers in the future, as is overheating risk. During a push for affordable housing, the likelihood of vulnerable people being impacted in the future is heightened. Regulatory oversight earlier in the process may help prevent this.

A link was not generally identified between short-term economic development and long-term preparedness for climate change in London. Dymén and Langlais highlighted how in the Augustenborg project in Sweden, long-term climate synergy goals could be realised because of the project's inclusion of short-term economic development (2013). This closed the adaptation-mitigation dichotomy because it brought both issues to the forefront. While building developments and retrofits are not directly comparable to a massive social regeneration project

like Augustenborg, there is untapped potential in future-proofing assets. Instead of seeing financing as a barrier, opportunities may lie in effectively valuing long-term heat resistant and resilient property. This creates positive institutional lock-in with longer term payback periods for investments (Ürge-Vorsatz et al., 2018). Combined with low interest financing for retrofits or the ability to pass on fees to future owners, the long payback period can be minimized. However, it is unclear if this is fully compatible in a city with severe economic inequality and a lack of affordable housing.

To increase synergies in new developments and retrofits, co-benefits can be incorporated into urban investment calculations. The benefits of passive measures are currently financially undervalued though they make up to 30% of efficiency co-benefits (Field et al., 2014). Residents benefit from less stress, lower energy bills, increased productivity and improved mental health; health departments benefit from reduced hospital and doctor admissions. Overheating does not have the same quantifiable benefits as emission reductions, but the unseen benefits can strengthen the investment case. Overheating is unlikely to be incorporated voluntarily without some mandatory mechanism because of the lack of benefits for landlords. This is known as the ‘split incentive’ problem within retrofits. Several possible financing mechanisms were discussed in the results. It is difficult to see adaptation getting more attention in retrofit programs or new construction unless financing, programs and policy explicitly mandate adaptation to make it viable for private building owners.

Social housing represents one area where overheating retrofits can be exemplified on a city level. Social housing is generally comprised of flats that are difficult to retrofit given the need to get inhabitants permissions in multi-owner complexes and incentive building owners to take on holistic retrofits (Committee on Climate Change, 2019b). The overall supply chain for overheating measures was described as lacking. With city investment, revitalizing the social housing stock can reduce the prices of overheating technology to create supply chain economies of scale (Makantasi & Mavrogianni, 2016). This also stimulates demand for skills-building for building professionals, another spatial barrier identified. Currently, deep retrofits for overheating are more expensive than standard insulation measures.² However, by building those economies of scale, the city could take the lead in changing those costs.

It is complicated to ensure efficiency measures are holistic; sole efficiency retrofits suffer from financing challenges. Yet it becomes less financially viable to pursue systemic changes after implementing minor improvements, leading to lock-in preventing further retrofits. For example, boiler replacement results in 10-30% efficiency gains compared to the 80% gains whole building retrofits can garner (Ürge-Vorsatz et al., 2018). There is yet to be a solution for closing this temporal gap, but making systemic changes and incorporating overheating resiliency in retrofits requires a fundamental shift in how retrofits are viewed.

iii) Spatial difficulties in enforcement and informal institutions lead to additional challenges of effective vertical governance in the jurisdictional scale

While government foresight is needed, difficulties in spatial enforcement come down to minimal institutional requirements and local authorities and building professionals lacking skills. Combined with informal institutions that dictate norms and practice, regulations face more challenges. However, this does not mean higher regulatory stringency is not needed.

² One estimate by the London Climate Change Partnership valued a 200 unit flat overheating retrofit at £1,400,000 in 2014. This involved Triple glazing, external shading, EWI, mechanical extract ventilation, heat reflective exterior.

The adaptation-mitigation dichotomy helps explain how challenges in integrated policy enforcement come down to the detailed level within cities, as Dymén and Langlais proposed (2013). Lacking national regulations makes it harder for the GLA to enforce responsibility within local authorities. Each borough has unique interests and priorities when it comes to planning applications, much like competing municipalities in states (Dymén & Langlais, 2013). Combined with minimal resources to devote to adaptation and limited time to assess development proposals properly, overheating slips down the priority list.

It is when considering this enforcement that one uncovers a shortcoming in the Landauer et al. framework, adapted for Figure 3-1. Vertical Scale Governance for the London Context (2018). Temporal trade-offs prioritizing housing and mitigation contribute to spatial difficulties in enforcement. Yet these spatial difficulties also emerge from informal institutions that govern many building professionals' actions: developers taking advantage of regulation privatization to get approval faster; reporting fraud on planning applications; and settling overheating cases out of court. The privatization of building control and developers' power highlight power imbalances in London, but other cities also experience power disparities with developers (Dymén & Langlais, 2013). These informal rules are a form of horizontal governance closely entwined with vertical governance that emerges in a spatial analysis. Without including informal institutions when considering interactions between jurisdictional scales, policies are less likely to be successful.

One can debate whether it is fair to expect under-resourced authorities involved in assessing proposals to do this properly. Many will lack expertise on the subject and face competing responsibilities within their roles. Stronger regulations do not automatically result in local authorities improving at assessing proposals and enforcement, nor will informal institutions be overcome. Yet studies show that developers do not tend to go above minimum regulatory requirements, making it critical to ensure regulations are promoting resilient standards (Lazoroska & Palm, 2019). Customers from lower socioeconomic brackets may not have the ability to ask for changes or lack knowledge to ask for overheating preparedness.

Addressing the identified regulatory shortfalls can help overcome informal rules. Ensuring overheating considerations are integrated through Building Regulations, SAP or other policy tools will accredit the issue and drive positive institutional lock-in. This would need to be backed up with education resources, a resource already identified as lacking. Ultimately, the involvement of national authorities creates an even starting ground in spatial enforcement, as proposed by Dymén and Langlais (2013). Municipalities cannot solely coordinate diverse interactions between scales and stakeholders (Dymén & Langlais, 2013).

Another reason the dichotomy has impeded policy implementation is difficulties in measuring the success of adaptation compared to mitigation (Biesbroek et al., 2009; Dymén and Langlais, 2013). Having specific, achievable goals—in addition to visions—has been identified as critical to the institutionalization of urban policy integration (Göpfert et al., 2019). While London has concrete policies, there is nothing specifically targeting the number of buildings meeting overheating thresholds in future climates, avoiding active cooling entirely, or other numeric goals unlike with housing or emissions. The success criteria for Policies 8.4.3 and 8.4.4 has been raising overheating awareness and suggesting passive measures for applications. The challenges with overheating thresholds remain, but until targets are quantified either on national or local levels, institutionalization of policy integration is unlikely. When a voluntary approach faces opposition from scale mismatches and temporal and spatial barriers, other methods of accountability must be explored.

London is exploring the use of an interactive tool that allows developers to see how much their property will contribute to the UHI, as well as an Urban Greening Factor that requires minimum levels of green infrastructure in new developments. There is a risk these tools may go down the same route as the Guidance: minimal follow up in many local authorities. Nevertheless, they are examples of tools that can provide important quantifiable targets related to adaptation.

Achieving synergies through policies has only been considered in spatial planning in the last two decades (Biesbroek et al., 2009). Building professionals are only beginning to learn how to accommodate overheating. Both factors likely contribute to building professionals' lack of skills, one of the spatial barriers identified. While cities may not be able to influence what schools teach, it is clear adaptation needs to be made a larger priority in the education of building professionals. Professionals are influenced by what they learn in their early academic careers and there has been minimal adaptation attention to date (Hoffman & Henn, 2008). Building professional culture and aesthetic preferences for non-passive measures heighten the challenge, as the next section shows.

iv) Spatial norms and behaviours of different stakeholders translate into weak uptake of measures and uncertainty about effectiveness

Several barriers relate to the spatial characteristics of stakeholders involved with implementing overheating measures in buildings. Simple, cost-effective fixes like shutters and louvres have a role to play, yet do not fit building professional or consumer aesthetic preferences. This is an example of negative behavioural lock-in emerging from the spatial characteristics of those implementing measures or asking for designs (Ürge-Vorsatz et al., 2018).

While overcoming cultural inertia is a knowledge gap, cultural paradigms and preferences can change quickly. A concentrated effort to incorporate passive measures through the Cooling Hierarchy, retrofits of public buildings or other cases can help create a cultural shift. An example could be made of the Planning Act; while not meant to deal with adaptation, the document has an indirect effect of creating a trade-off within vertical governance. Changing requirements for shutters and EWI in conservation areas is one step to creating a conducive environment for shifting aesthetic preferences. This is unlikely to help overcome all barriers, but could demonstrate the prioritization of adaptation over visual design

The impact of occupant behaviour on the success of overheating measures both indoors and outdoors was identified as a barrier and research gap. Shading, shutters and other devices are effective but require residents' to take action, which is not guaranteed to happen or be effective (Makantasi & Mavrogianni, 2016). Whether information is reaching the most vulnerable about what to do during heatwaves is critical to understand, especially for those who may not have the capacity to help themselves. Simply providing information does not guarantee behaviour changes (Abrahamse, Steg, Vlek, & Rothengatter, 2005). It is recommended best practice in London to provide guides on what to do during heatwaves in new buildings, but it is unclear to what extent this is successful; the same applies to the city heatwave alerts. Thus, looking at occupant behaviour during heatwaves and developing strategies to accommodate this can help the success of overheating policies.

Behaviour and culture are difficult to capture in a jurisdictional scale analysis and thus demonstrate the value of the dichotomy in analysing policy implementation. A spatial analysis establishes cultural and behavioural challenges stakeholders may present. Evaluating whether stakeholders are effectively targeted and if behavioural lock-ins may prevent successful integrated policies is important to address.

7 Conclusion

This section summarises the answers to the RQs, reflects on the analytical framework, provides recommendations for policies and future research, and addresses the study's generalizability. The aim of this thesis was twofold: i) to analyse how interactions between jurisdictional scales and policies promoting synergies affect adaptation processes in cities using overheating policies for buildings as an example, and; ii) to discover barriers and possible drivers to implementing integrated policies addressing overheating.

A baseline was first established for determining what measures can be implemented in buildings with synergies. This answered RQ1:

RQ1: What actions can be implemented in the buildings sector in cities that address overheating and result in synergies?

The literature review uncovered a variety of features: passive design features including building and room orientation, ventilation corridors, thermal mass, window placement, glazing; white reflexive paints; shading devices (louvres, shutters); insulation; phase change materials; green roofs and walls; trees for shading; and urban gardens. These measures all had the ability to minimize overheating risk while reducing energy demand and/or sequestering carbon. Some measures were also able to reduce the UHI.

Some conflicts to be aware of were highlighted: insulation in single aspects flats or poorly ventilated buildings can lead to overheating; white paints on external walls can increase dense cities' UHIs; poorly placed thermal mass leads to greater energy demand; shading trees can be a hazard in storms; and sequestered carbon within some measures can outweigh adaptation or mitigation benefits received. There are trade-offs to keep in mind when applying some measures, such as relying on window ventilation for cooling in polluted areas. These various conflicts highlight the importance of applying systems thinking to built environment policies.

Secondly, this research established a framework based on multilevel governance, scale theory and the adaptation-mitigation dichotomy to analyse the implementation of integrated policies, using overheating policies in London as an example. The aim was to assess how interactions between jurisdictional scales affect integrated urban policies promoting synergies, as well as additional implementation challenges and possible drivers. This enables cities to better develop integrated policies that tackle mitigation and adaptation in buildings.

RQ2: How do interactions across jurisdictional scales affect London's overheating policies for buildings?

Currently, few institutions within the national jurisdiction strengthen synergies with Policies 8.4.3 and 8.4.4. London represents the nested lower level of jurisdictional governance, resulting in London's limited capacity to enforce the LES policies within boroughs. The quantified nature of goals surrounding energy efficiency, housing and mitigation are prioritized by the national government because they are easier to enforce; the same applies to local authorities. Documents like the Building Regulations and SAP have not regulated overheating synergies. There is also little in the intergovernmental scale governing synergies.

This analysis showed that jurisdictional scale interactions have resulted in trade-offs and conflicts with the LES policies. For example, the strong focus on building housing in the NPPF results in a trade-off and conflict by increasing the UHI. London would benefit from stronger vertical governance of overheating, reflecting findings from Landauer et al., Biesbroek et al.,

and Dymén and Langlais (2018, 2009, 2013). The analysis also highlighted places where synergies can be strengthened within the institutional scales, such as in the Building Regulations.

RQ3: What are the barriers that affect the implementation of London's overheating policies for buildings?

The main barriers to implementing both Policy 8.4.3 and 8.4.4 were: trade-offs with mitigation, lack of concern for overheating, skill shortages, limited capacity, building professionals' culture and aesthetic preferences; occupant behaviour. Policy 8.4.3 was also hindered by trade-offs with building more homes, insufficient regulations, and informal institutions. Some of the barriers manifested in different ways for different stakeholders, such as limited capacity. City stakeholders lack financial resources and time to support overheating projects and assess proposals properly. Building professionals face pressure to add more units to meet housing targets; fewer profits means fewer resources to spend on passive measures. Ultimately, the barriers affect vertical and horizontal actors in policy implementation by pushing the management of overheating into the future and making spatial responsibilities unclear.

RQ4: What are the possible drivers for increasing the implementation of London's overheating policies for buildings?

The possible future drivers that would help stakeholders implement Policies 8.4.3 and 8.4.4 include: the overheating problem getting worse; changing the overheating narrative; updating regulations to address overheating; increasing the education of the public and building professionals. Another driver for Policy 8.4.3 was firm reputation. Different financing models for retrofits were found to be a possible driver for Policy 8.4.4. What these drivers had in common was that they closed temporal and spatial gaps to help solve the market failure that leads to buildings that are un-equipped for warmer weather. While some drivers had more suggestions for how to ensure the driver is actually realised, all drivers served to push overheating higher on agendas before the risk too great to mitigate.

7.1 Reflections on the Usefulness of the Analytical Framework

It was hypothesized that the adaptation-mitigation dichotomy combined with jurisdictional scale governance could explain why some barriers emerge and what future drivers may help overcome the dichotomy. The dichotomy has hindered integrated policies before, and the same appears to apply for overheating policies.

Short-term prioritization of other goals dominates the implementation of overheating. Yet dealing with this challenge later on will be more expensive, increase emissions, and cause untold ill-health impacts along the way. Within new residential developments, the costs will be on future inhabitants. In the middle of an affordable housing push, those residents are likelier to be vulnerable. In commercial buildings, many exceptions to restrictions on active cooling exist and the issue is not prioritized. Much of the existing building stock in London overheats even in average summer temperatures because buildings are low-quality and residents lack the funds, capacity, or awareness to mitigate this. Overheating adaptation is even more challenging to address than other adaptation measures because the effects are silent. The causal connection between overheating and negative impacts is not well known.

Closing the temporal and spatial gaps is something stakeholders are aware of; however, it is worrying that some think disaster needs to strike in order to change perceptions. The fact that several interviewees expressed that almost no new buildings today are prepared for overheating is a shocking reflection on London's building stock. Addressing overheating can, and should, be done at the same time as mitigation efforts in new builds and retrofits. Changing the narrative

and incorporating solutions to other social challenges when addressing the issue can be critical to a paradigm shift.

It is understandable why 2050 and 2080 overheating assessments are not made mandatory by the GLA. They are more difficult to pass, require modelling skills by building professionals, and require effective spatial enforcement in local authorities. If proposals are not including 2020 modelling, this would simply add another level of complexity that would likely go unenforced. However, these thresholds are there for a reason: 2050 and 2080 temperatures will be reached eventually. It was highlighted that retrofits are more challenging and costly as time goes on, once again pushing the problem into the future. One can argue that this is short-term thinking that must be overcome as it represents an oversight in current adaptation policies. At the very least, it may be in London's interest to mandate that flat and social housing owners be responsible for implementing overheating measures in the future, given flats are at the highest risk of overheating. This can ensure the onus is not put on residents.

7.2 Reflections on Contributions to the Analytical Framework

This analysis supports the work by Dymén and Langlais, and Biebroeck et al., in establishing that the adaptation-mitigation dichotomy can be used to explain barriers and possible drivers to integrated policy implementation (2013, 2009). However, there are two important add-ons: i) overheating provides a greater adaptation challenge because of the perceived non-critical nature of the issue to the general public and apparent lack of immediate benefits; ii) large cities that must devolve enforcement powers will face many of the same challenges as higher levels of governance.

Including informal institutions is an important add-on to the scale framework by Landauer et al. (2018). Informal operating rules and practices can significantly dictate policy implementation. These institutions are known for being notoriously difficult to change and this analysis does not propose how to change this. However, it is critical to consider these institutions when developing policies and to try to overcome them through precautionary measures and tools.

There is little information on the most appropriate strategies for integration at different scales (Biebroeck et al., 2009). Integrated policies do not automatically equate to successful implementation on the ground. Successful integration requires closing the adaptation-mitigation dichotomy in practice; strong vertical governance can help. Only through better understanding the drivers, barriers and implications of adaptation measures across different sectors, regions, and scales can we make informed choices about effectively incorporating adaptation within mitigation strategies (Moser, 2012). This analysis is a useful first step for addressing heat risk in other cities because it points to where synergies can be strengthened between building and zoning requirements, retrofit programs and adaptation to overheating.

7.3 Policy recommendations

In terms of strengthening London's overheating policies moving forwards, it is difficult to come up with a strategy tackling all barriers or future drivers identified. However, a few promising areas emerged in the prior discussion. A number of these are policies directed towards building professionals that would need to be implemented at the GLA level. The technology is available and building professionals know what needs to be done, but many choose not to for short-term profits. In order to change that, the playing field building professionals operate on, as defined by various levels of governance, needs to shift.

While the recommendations in Table 7-1 were developed for London, many can be applied to other cities as well.

Table 7-1. Policy Recommendations for London

Relevant Policies for London	
Mandatory white roofs if green roofs are not feasible	Green roofs are already required on buildings above a certain size. Due to the multiple benefits green roofs provide, interviewees said they are preferable to white roofs in London. However, if a building cannot feasibly incorporate green structures, reflexive or white paints can contribute to reducing the UHI and cooling demand. New York and Los Angeles are examples of cities with mandatory white roof policies. This option is could be especially viable for industrial buildings. See section 4.1.2 for more on the viability of this solution.
Study occupant behaviour during heatwaves	Conducting ex-post evaluations of heatwave alerts can drive a better understanding of the effectiveness. Whether instructions are used by building occupants and if vulnerable populations are reached is also critical to understand. This could point to how to improve current alert systems, determine if information provision should be made mandatory in new homes or after retrofits, and increase awareness.
Lobby for the 2019 Building Regulations update to include overheating	Several stakeholders interviewed are already lobbying. Overheating updates to the regulations enables stronger vertical governance on the topic. The SAP appendix could be updated to include a mandatory assessment, provided the tool is improved. As the Building Regulations cover certain retrofit standards, this could support holistic retrofits by mandating overheating modelling for certain scales of retrofits. EU member states are flexible in how they meet ‘nearly zero energy’ construction standards, and the new regulations will likely introduce standards similar to what was eliminated from the Code for Sustainable Homes and Zero Carbon Homes; mitigating cooling demand increases should not be overlooked in this update either.
Trial incorporating overheating preparedness into retrofit programs	This would strengthen local governance on the issue. Asking residents whether their home overheats or if this is something they would like their home prepared for could raise awareness. Basic insulation upgrades can protect residents from overheating when applied correctly; ensuring technical professionals are aware of risks can prevent conflicts and result in more comprehensive upgrades. Something like the recently produced Good Homes Alliance report provides an easy to use checklist that can be incorporated into new builds and retrofits to determine overheating risk.
Liability for future overheating upgrades	It does not make climate sense to implement active cooling in current temperatures. Yet this will change as the climate gets warmer. Assigning responsibility to building managers or owners for flats and other large developments can ensure the burden does not fall on tenants to prepare buildings for the future. This is done by some local authorities already. As it is difficult to get 2050 or 2080 assessments completed for a variety of reasons, regulating liability is likely to be a challenge. However, as awareness grows and more customers experience overheating, this is an important equity consideration.
Better enforcement mechanisms for local authorities	Many local authorities struggle to properly assess planning applications. There are a few ways this could be mitigated: investing in training to ensure assessments are done properly by providing common examples of information fraud by developers; investing in a neutral, 3rd party committee that crosschecks applications; investing in better technology to automate parts of the process; centralization of processing at the city level rather than the borough level; etc. The GLA and local authorities are limited in financial resources and the planning approval process is already slow. Making the process more efficient does require resources. Yet investment can ensure housing, mitigation, and adaptation targets are met, and fewer trade-offs occur in non-referable applications. Given that few buildings built today are equipped for future climates, money invested now means less reparative investments later on.
Make examples of municipality owned buildings:	As discussed, improving the supply chain for overheating measures is critical. If a city leverages its buying power to ensure low carbon overheating measures are in place, it brings attention to the overheating issue and creates demand for technical solutions and skill building. As many public buildings still require efficiency upgrades, these retrofits are a natural time to take on a more holistic approach.

	Brussels for instance, mandated that all social and public housing was expected to meet Passive House levels in 2013.
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Source: By Author

For all cities, the importance of reducing active cooling should not be overlooked. Active cooling is warranted in places like hospitals. Yet there are meaningful temporal and spatial dimensions to active cooling. As trends in hotter climates demonstrate, socioeconomic status is associated with increased risk of heat mortality given active cooling's inaccessibility for poorer population segments. As time goes on, the most vulnerable are increasingly be at risk. Active cooling units expel waste heat into the air which exacerbates the UHI and negatively impacts those not causing the problem. While at some point in the future passive measures will not be adequate to mitigate overheating risk, there is a strong need to reduce the scale of the conflict. This research highlight policy areas where cities may find inspiration, as presented in Table 7-2:

Table 7-2. Policy Recommendations for Cities

Policy Recommendations for Cities	
Mandatory overheating assessments	Legally requiring assessments against future temperatures institutionalizes overheating into planning practices. This gives the issue credibility and at least ensures the hazard is not entirely overlooked. London's leadership with the mandatory CIBSE assessments is something other cities can look to replicate.
Consider implementing a Cooling Hierarchy	The Cooling Hierarchy lays out cooling measures building professionals can implement instead of automatically implementing active cooling. A hierarchy can be adapted to different cities given their unique geophysical circumstances and extent of overheating risk. Requiring building professionals to demonstrate consideration of passive measures and justify why they think active cooling is necessary can be critical to reducing automatic reliance on active cooling.
Alternative financing mechanisms to address overheating in new builds and retrofits and discouraging active cooling	Costs will always be a barrier to sustainable buildings. Energy efficiency retrofits suffer from a lack of financing and uptake, let alone holistic retrofits. Incorporating overheating assessments into city run programs can ensure adaptation is being considered. Energy contracting models where the utility companies are responsible for meeting projected energy savings can encourage customer uptake. Allowing retrofit charges to be added to properties for future owners is another option. Banks valuing resilient homes more highly to reduce the risk premium is also critical to institutionalizing adaptation into the public discourse and financial systems. Experimenting with different models and lobbying for alternative schemes can be critical to city overheating prevention goals. For commercial/industrial buildings, subsidies can be explored for active cooling units that are top class for efficiency. While the EU has fairly high efficiency standards, this is not the case in North America or many Asian cities (IEA, 2018). Requiring on site energy generation for certain amounts of cooling energy usage can reduce the scale of the conflict.
Integrate overheating into wider public goals and sectors	There are multiple benefits to minimizing the use of active cooling. Building owners or renters can benefit from lower energy bills, stronger energy resiliency, and better comfort and sleep in domestic buildings. Emissions are lowered if active cooling is not used and a city still relies on non-renewable energy. Increased productivity benefits the economy, and fewer doctor and hospital admissions benefit the health sector. While these benefits may be difficult to quantify, investment calculations ought to take the benefits that go beyond synergies into account.

Source: By Author

7.4 Generalisability

7.4.1 Methodology

Multilevel governance, the adaptation-mitigation dichotomy, and scale theory were combined in the analytical framework to guide this research. The theoretical contributions this analysis made are relevant to other cities. Including informal institutions when conducting scale analyses can uncover weak spots within jurisdictional frameworks. These institutions are not easy to uncover from a document analysis; even in this research, it was only through interviews that they were uncovered. Informal operating rules need to be considered because they fundamentally alter urban governance structures. The adaptation-mitigation dichotomy has hindered integrated policies from succeeding in the past; this analysis highlighted that integrated overheating policies also face these challenges, in addition to unique challenges and opportunities related to stakeholder, spatial and temporal dimensions.

Nevertheless, there are limitations. It is unlikely all policy documents were captured where synergies or trade-offs could emerge. The methodological approach does not allow for a guided selection of documents instead relies on interviewees' contributions to confirm instances of synergies, trade-offs and conflicts; these are subject to biases and recollection challenges. Triangulation was employed when possible, but there were limited additional sources for the topic.

The small sample size of interviewees given the scale of stakeholders involved in the policies' implementation meant barriers and drivers affecting only two general groups were looked at: city stakeholders and building professionals. The building professionals represented a range of professions and it is possible that this sampling was too diverse. Actors within each stakeholder group will have unique experiences that affect their interpretation of events. However, it was impossible in the time period and with cold outreach to get a robust sampling of the specific professions within the building professionals group. Barriers and drivers were also not quantified according to the number of times they were brought up due to the variety of individuals interviewed and uneven representation from different stakeholders.

Upon reflection, the author does believe the research questions were answered sufficiently. However, examining two policies instead of one meant the results were general rather than customized to new developments or retrofits. The two subjects require slightly different approaches; additional analytical concepts and delineations could have been applied that were impossible otherwise with the limited research time and space.

7.4.2 Other Cities and Future Research Areas

Case studies result in specific findings within delineated boundaries. Particularly with policy analyses, cities have unique jurisdictional frameworks they abide by that influence policy outcomes. Yet as discussed in the case study justification, there has been little critical analysis of integrated policies. Overheating is a new policy arena for temperature climate, rendering a qualitative case study approach necessary. Testing theories in this new arena helps academics and cities in further their work in the area.

Adaptation requires localized responses because hazards have different impacts according to spatial distribution, climate, geophysical landscapes and more. However, overheating policies are still a novel policy area and any contributions regarding their efficacy are warranted. Other cities can use the hot spots where synergies were identified in the London case to try to create synergies within their own jurisdictional frameworks and practices and concurrently avoid conflicts. For example, heritage building renovation restrictions or information provision are

not unique to London, nor are retrofitting challenges. While the LP is a unique legal tool to introduce requirements like the Energy Assessment Guidance, other cities have regulatory tools and processes they can leverage for mandatory overheating assessments.

This analysis provides a framework for future research on overheating policies. Case studies in smaller cities or places with different climates can highlight additional areas where synergies can be strengthened within jurisdictional frameworks and what barriers different cities face. Analysing how retrofitting policies can better be designed to accommodate adaptation is also a promising research area, as is whether heat-resilient homes are valued more highly. Occupant behaviour within buildings is another research gap, particularly as heatwave alerts and information campaigns become more common. Whether the energy performance gap exists for active cooling is something that can be explored as well.

Some cities may feel their scale of overheating is beyond what passive measures can address. In many cities overheating is already the norm, or synergies promised by measures are not adequate to meet the scale of mitigation or adaptation challenges. For instance, New York does not view cool roofs to be adequate for the emission problem the city faces, and thus finds the synergies argument to be uninspiring (WSP 2018). With current available technologies, there will be a point in the future where active cooling is likely to be necessary; some cities may view it as a necessary evil to avoid any risks, particularly regarding people's safety. Yet research organisations like the IEA warn that rising air conditioner use is the next energy crisis and cities must play their part in reducing this crisis (IEA, 2018). The arguments against reliance on active cooling are there and it should not be viewed as the default given there are ways of mitigating cooling demand through building design.

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Appendix 1: Policy 8.4.3

Source: *London Environment Strategy (Greater London Authority, 2018)*.

Policy 8.4.3 Minimise the risk of new development overheating

Proposal 8.4.3.a The London Plan includes policies to minimise the risk of new developments overheating, and reduce their impact on the UHI

The London Plan encourages developers to carry out overheating modelling against extreme weather scenarios, which will provide the necessary detail for developers to design developments with appropriate mitigation measures. The London Plan requires developers to follow the cooling hierarchy (see Box 41) to reduce the risk of developments overheating and reduce the impact on the UHI effect through avoiding mechanical cooling where possible and promoting passive cooling measures. Where mechanical cooling is proposed, developers will need to consider the use of low global warming potential refrigerants to reduce harmful emissions.

BOX 41: COOLING HIERARCHY

The cooling hierarchy is:

- minimise internal heat generation through energy efficient design
- reduce the amount of heat entering a building through orientation, shading, albedo, fenestration, insulation and the provision of green roofs and walls
- manage the heat within the building through exposed internal thermal mass and high ceilings
- provide passive ventilation
- provide mechanical ventilation
- provide active cooling systems

The Mayor will also consider the impacts of further densification of London on the UHI, and develop guidance on how new developments can be designed to minimise the amount of heat absorbed by the development, which is then released at night, warming the surrounding area.

It is vital that when existing buildings are retrofitted for energy efficiency purposes that this does not lead to the unintended consequence of overheating. More information on how this will be achieved is available in Chapter 6. Green infrastructure plays a key role in providing cooling and shading. More information on how green infrastructure will be embedded across the city to provide a safer, easier, cleaner and more appealing environment for everyone to enjoy is available in Chapter 5, the London Plan, and Transport for London's Healthy

Streets Approach.

Appendix 2: Policy 8.4.4

Source: London Environment Strategy (Greater London Authority, 2018).

Policy 8.4.4 Minimise the risk of existing homes and non-domestic buildings overheating

Proposal 8.4.4.a The Mayor will work to minimise overheating in existing buildings through Energy for Londoners energy efficiency programmes

The Mayor will include wider promotion of heat mitigation measures, such as solar shading, cool and green roofs, and tree shading in and around existing homes through the Energy for Londoners programme (Box 26). Whenever technical assistance and advice is provided to homes on improving energy efficiency, this will include an assessment of the overheating risk for the dwelling to avoid unintended consequences once the energy efficiency work has been completed. This will include promoting the Chartered Institution of Building Services Engineers (CIBSE) guidance on assessing and mitigating overheating risk in new developments (TM59 and TM52).

The Mayor will also consider the impacts of overheating in existing homes and non-domestic buildings. This will lead to evidence and guidance to show how existing buildings (older and newer stock) can be retrofitted to improve thermal comfort, minimise the reliance on mechanical cooling, and reduce the amount of heat absorbed by poor design, which is then released at night, warming the surrounding area.

Appendix 3: Base Email to Interviewees

[Subject]: Invitation to participate in C40 master's thesis project on climate policy synergies and trade-offs

[Email body]: Hi [first name],

I hope this email finds you well! My name is Alexandra Jonca and I am a Master's student in the Environmental Management and Policy program at the International Institute for Industrial Environmental Economics at Lund University. I spoke with your colleague Abby last week regarding my thesis project with the C40 about energy efficiency and green infrastructure measures that can address overheating. While our interview was highly insightful, I still have a few questions about the planning application process and energy efficiency that I think you are well-suited to answer.

As your knowledge and experience would be extremely useful, would you be willing to do a virtual 60 minute interview before July 31st? I know you are extremely busy as Abby had mentioned you just came back from leave, so I would be happy to chat in early August if necessary as well.

I have included more details about my project below and if you have any additional questions, I am more than happy to answer them.

Thanks, and I look forward to hearing from you.

Alexandra Jonca

Project Information

Using London as a case study, I am researching how policies that support synergies (ie. actions with adaptation and mitigation benefits) related to Energy Efficiency and Mitigation and Green Infrastructure interact with different institutions. I am seeking to answer how institutions at different levels of governance (federal/regional rules and regulations, informal beliefs and ways of doing things, etc.) interact with these policies to either promote or prevent synergies, looking at both retrofits and new developments. Your input would be useful for identifying the relevance of London's integrated policies for other C40 cities, to enrich the knowledge base of how institutions affect urban climate policy, and to identify successes and barriers to addressing overheating in buildings.

The C40 and I decided on this topic because synergies and trade-offs between climate policies are still quite poorly understood. Though buildings are a hotspot for addressing both mitigation and adaptation, we are not seeing the emergence of these synergies at the pace we need. As London is a leader in climate policy, you help set best practices for other cities to ensure climate goals are met.

I am hoping to speak to individuals who:

- Participated in developing and/or implementing the London Environment Strategy or the London Plan or;

- Can speak to the municipality's experience with encouraging retrofitting, energy efficiency measures, supporting new developments, and implementing green roofs and walls, or;
- Are responsible for ensuring the policies in London strategies align with other regulations, rules and policies, or;
- Work with developers in the city, work as a planner, or;
- Can speak to the process of implementing buildings policies in different boroughs, or;
- Anyone else you think might be relevant.

I would greatly appreciate the opportunity to discuss this topic with you during a 30 to 60 min interview. If you are interested in participating, please send me an email at al0308jons@student.lu.se with your preferred dates and times.

Many thanks for your time, and I hope to hear from you!

Appendix 4: List of Interviewees

Interview #	Role	Categorization	Date	Duration	In-text Citation
1	Research Expert	Buildings professionals	June 25 th , 2019	43 min.	I1 Research Expert
2	GLA Employee	GLA/Local Authorities	June 25 th , 2019	52 min	I2 GLA
3	GLA Employee	GLA/Local Authorities	July 4 th , 2019	28 min	I3 GLA
4	GLA Employee	GLA/Local Authorities	July 11 th , 2019	60 min	I4 GLA
5	GLA Employee	GLA/Local Authorities	July 22 nd , 2019	60 min.	I5 GLA
6	Climate Change Advisor	Advisory Groups	July 23 rd , 2019	35 min.	I6 Climate Advisor
7	Adaptation Advisor	Advisory Groups	July 23 rd , 2019	30 min	I7 Adaptation Advisor
8	Designer	Building Professionals	July 25 th , 2019	59 min	I8 Designer
9	Public Health Researcher	Advisory Groups	July 29 th , 2019	43 min	I9 Public Health Advisor
10	GLA	GLA/Local Authorities	July 30 th , 2019	60 min.	I10 GLA
11	Buildings non-profit	Building Professionals	July 31 st , 2019	28 min.	I11 Buildings Non-profit
12	Local Authority	GLA/Local Authorities	August 8 th , 2019	60 min.	I10 Local Authority
13	Developer	Building Professionals	August 15 th , 2019	32 min.	I13 Developer
14	Architect	Building Professionals	August 16 th , 2019	57 min.	I14, Architect

Appendix 5: Interview Questions

The Project

Thank you for agreeing to this interview. My research with the C40 is looking at synergies within overheating measures in buildings, specifically what institutions support or impede policies promoting these measures in London.

Synergies occur when a measure or action has positive benefits for both adaptation and mitigation. Examples of measures with synergies include:

- Passive cooling of buildings combined with night ventilation to avoid air conditioning;
- Building orientation, window performance, super insulation of fabric to improve cooling and energy efficiency;
- Green roofs and gardens to reduce UHI and sequester carbon;
- Shading houses with trees to cool them in summer to improve energy efficiency and avoid air conditioning etc.

The main policies from the London Environment Strategy under analysis are:

Policy 8.4.3 Minimise the risk of new development overheating (aligned with the London Plan Policy 5.9 - see Appendix 1)

Policy 8.4.4 Minimise the risk of existing homes and non-domestic buildings overheating (through the Energy for Londoners efficiency programmes - See Appendix 2)

These policies interact with other programs and strategies in London, but my focus is specifically on how these policies interact with other institutions and what you perceive as the drivers and barriers to these policies being successful.

Your responses can be anonymous if you wish. If you consent to being recorded, please state so for the recorder with your name.

Introductory Questions

- 1) Can you tell me a bit about how your work relates specifically to buildings?
- 2) Who are the key stakeholders you work with?
 - a) Are adaptation and mitigation seen as equally important by the stakeholders you work with?
- 3) How much do you consider balancing mitigation and adaptation in your work?
- 4) Do these ever come at odds with each other? i.e. energy efficiency pursued at the expense of thermal comfort/resilience?

Institutional Analysis

- 5) Are you familiar with current policies, regulations, housing standards, etc. that can address overheating in the UK?
 - a) Do these ever support synergies?
 - b) Do these ever support trade-offs?
 - c) Do these ever support conflicts?

- 6) Do you work with London policies regarding the Cooling Hierarchy and overheating in retrofits?
- 7) Do you think there are sufficient policies and regulations in place to support synergies in buildings?
- 8) Are there any policies or regulations you would like to see to address overheating?
- 9) Are there any informal institutions that support or prevent the uptake of measures with synergies?

Drivers and Barriers

- 10) Do planners/developers/designers view these measures with synergies as important?
- 11) What are the main challenges a) address overheating and b) implement passive measures in new developments and retrofits?
- 12) Is there anything you can point to that has encouraged the implementation of measures with synergies? Or considering overheating alongside mitigation?
- 13) Even if London has policies in place to promote measures with synergies, are there any additional barriers that we have not discussed already that prevent measures from being implemented?
- 14) Do you think occupant behaviour within homes is sufficiently addressed in terms of reducing overheating?

Appendix 1: London Plan Policy 5.9 Overheating and Cooling (from the 2016 London Plan)

Source: The London Plan, Greater London Authority 2016

The London Plan - Policy 5.9 Overheating and Cooling

- A. The Mayor seeks to reduce the impact of the UHI effect in London and encourages the design of places and spaces to avoid overheating and excessive heat generation, and to reduce overheating due to the impacts of climate change and the UHI effect on an area wide basis.
- B. Major development proposals should reduce potential overheating and reliance on air conditioning systems and demonstrate this in accordance with the following cooling hierarchy:
 1. minimise internal heat generation through energy efficient design
 2. reduce the amount of heat entering a building through orientation, shading, albedo, fenestration, insulation and the provision of green roofs and walls
 3. manage the heat within the building through exposed internal thermal mass and high ceilings
 4. provide passive ventilation
 5. provide mechanical ventilation
 6. provide active cooling systems
- C. Major development proposals should demonstrate how the design, materials, construction and operation of the development would minimise overheating and also meet its cooling needs. New development in London should also be designed to avoid the need for energy intensive air conditioning systems as much as possible. Further details and guidance regarding overheating and cooling are outlined in the London Climate Change Adaptation Strategy.

9.4.4

The increased use of air conditioning systems is not desirable as these have significant energy requirements and, under conventional operation, expel hot air, thereby adding to the UHI effect. Therefore, passive ventilation should be prioritised. If active cooling systems, such as air conditioning systems, are unavoidable, these should be designed to reuse the waste heat they produce. Future district heating networks are expected to be supplied with heat from waste heat sources such as building cooling systems.

9.4.5:

The Chartered Institution of Building Services Engineers (CIBSE) has produced guidance on assessing and mitigating overheating risk in new developments, which can also be applied to refurbishment projects. TM 59 should be used for domestic developments and TM 52 should be used for non-domestic developments. In addition, TM 49 guidance and datasets should also be used to ensure that all new development is designed for the climate it will experience over its design life. The GLA's Energy Planning Guidance provides further information on how these guidance documents and datasets should be used.

Appendix 2: Energy for Londoners Efficiency Programmes (from the Greater London Authority official website)

Projects included:

Warmer Homes – £2.5m grant funding for heating and insulation measures that will warm the homes of fuel-poor Londoners. The scheme will target homeowners with disabilities or long-term sickness, and older people claiming eligible benefits, with up to £4,000 available per household.

Fuel Poverty Support Fund – £250,000 grant funding to the boroughs of Islington, Croydon, Kingston and Lewisham to offer advice and refer fuel-poor households to support services including income maximisation, health, and energy efficiency schemes.

RE:NEW – the Mayor's award-winning programme to help make London's homes more energy efficient, reducing both energy bills and carbon emissions.

Energy Leap – testing innovative ways to reduce grid energy consumption to near zero through whole-house 'eco-refurbishments'. The pilot scheme will give up to ten homes a radical makeover involving off-site manufactured insulation panel, solar panels, heat pumps and other measures from 2018.

Switching suppliers – the Mayor is encouraging people to switch to a better energy supplier. It could potentially save Londoners hundreds on their bills or help them to buy energy from cleaner sources.

Fuel Poverty Partnership – working together with experts across the health, social and environment sectors to guide London's work on fuel poverty.