GBPN
Global Buildings Performance Network

MONASH University
MONASH SUSTAINABLE DEVELOPMENT INSTITUTE

MONASH University
MONASH ART DESIGN & ARCHITECTURE

Co-benefits of sustainable building and implications for Southeast Asia

A rapid evidence review, practice review and interviews with community members

Authors

Peter Bragge, Nita Lauren, Loyal Pattuwage, Alexandra Waddell, Alyse Lennox
(Monash Sustainable Development Institute)

Declarations of Conflict of Interest
The authors have no conflicts to declare.

Citation
Bragge, P., Lauren, N., Pattuwage, L., Waddell, A. & Lennox, A. Co-benefits of sustainable building and implications for Southeast Asia. Review Document. Melbourne, Australia: MSDI Evidence Review Service, Monash University and Global Buildings Performance Network. June 2021.

Funding declaration
This project was commissioned by the Monash Faculty of Art, Design and Architecture (MADA) in partnership with the Global Buildings Performance Network (GBPN), with funding provided by the CRUX Alliance.

Copyright

Social Systems Evidence, Monash Sustainable Development Institute
Monash University, Victoria 3800, Australia
+61 3 9905 9656
peter.bragge@monash.edu

Table of Contents

Executive summary

There is increasing urgency to limit global warming by reducing carbon pollution. The building sector, as a large contributor to carbon pollution, is increasingly focused on sustainable building – the practice of designing and engineering to reduce carbon emissions and improve energy performance through the whole of the building cycle. Sustainable building carries benefits beyond reduction in greenhouse gas emissions.To examine these benefits, Monash University Faculty of Art, Design and Architecture (MADA) funded Monash Sustainable Development Institute's Evidence Review Service to undertake a review of published research and a series of six one-on-one interviews with practice professionals from Australia, India, China and Indonesia.

The research review identified 37 review-level studies, 23 of which were moderate or high quality. Most research was from Europe and the USA and focused on building modifications and design rather than cultural, social or behavioural aspects. Key findings were:

1. In addition to reducing greenhouse gas emissions, what co-benefits of sustainable building are relevant to the SE Asia, India, China, US, and EU regions?

- Sustainable building benefits general / mental health and health equity, principally due to improvements in air quality and light. For example, a high-quality review reported that low-emission biomass cook stoves would result in an estimated 570,000 fewer premature deaths in India due to improved air quality
- Other reported co-benefits of sustainable building are job creation / economic stimulus, household cost savings, increased energy security and 'flow-on' effects such as educational benefits due to enhanced lighting

2. How can co-benefits of sustainable building drive sustainable building in SE Asia?

- Financial incentives (rebates, grants, tax breaks) and low-interest loans are key drivers; however, consideration of marketplace dynamics is required
- Policy interventions (rating / certification, urban development schemes) can drive sustainable building, especially when real-world impacts such as resource efficiency gains are realised
- Communication and capacity-building campaigns to increase knowledge of sustainable building benefits may be especially relevant where local municipalities have agency and power to influence their building sector
- Economic considerations, rather than demonstrated health benefits, have been the primary driver of sustainable building in SE Asia

3. What trade-offs and synergies are associated with pursuing sustainable building in SE Asia and what are the associated transition processes?

- Energy improvements should pay attention to adequate ventilation owing to the potential for adverse health effects (for example due to mould growth)
- Accessibility of sustainable building to low-income households should be considered
- 'Rebound effects' are not necessarily adverse outcomes – they may reflect desirable welfare gains stemming from reduced energy poverty;
- Although estimates exist, benefits of sustainable building such as lives saved through better air quality and jobs created should be better quantified, especially given the
- importance of financial incentives in driving sustainable building. This will provide a more objective and tractable picture of synergies.

Practice implications based on the review are:

- Elevating the profile and benefits of sustainable building will aid policymakers and other leaders in understanding value and promoting relevant policies and other strategies;
- Enhancing policy and practical coherence between municipalities can address current limitations that are hampering effective uptake and development of sustainable building;
- Corruption and lack of access to materials and technologies are further barriers to sustainable building in SE Asia that need to be addressed;
- Other potential drivers of sustainable building in SE Asia include
    - greater emphasis on health and other benefits that repay initial investments in sustainable building;
    - focusing on women as key decision-makers in Indonesian households; and
    - focusing on the macro / system-level to optimise impact – for example by connecting the building sector with other sectors vested in the challenge including transport, energy, health, business / real-estate and consumers
- Greater focus on habits, norms, cultural, social and other behavioural factors that can highly influence the success of sustainable building could supplement understanding of the positive impacts of sustainable building design and construction;
- Ultimately, enhancing knowledge and awareness of the non-climate change benefits of sustainable building could create a 'virtuous cycle': consumer demand for sustainable building → government / sector response to demand → more consideration and quantification of sustainable building co-benefits → stimulation of further interest and investment in sustainable building.

Lived experience of community members who reside in low carbon buildings

Families who live in low carbon buildings in Asia, as well as the people working behind the scenes to make these quality homes affordable and accessible to the lower- and middle-income markets, speak to the health benefits and personal cost savings. Hear their stories here.

Co-benefits of Sustainable Building and Implications for Southeast Asia

A RAPID EVIDENCE AND PRACTICE REVIEW

KEY FINDINGS

Key drivers of sustainable building identified in the review included:

- Financial incentives (e.g. rebates, grants, tax breaks and low-interest loans);
- Policy interventions (e.g. rating / certification, urban development schemes);
- Communication and capacity-building campaigns to increase knowledge of the benefits of sustainable building - this may be especially relevant to Indonesia, where local municipalities have agency and power to influence their building sector.

Although estimates of lives saved through better air quality and jobs created have been made, many co-benefits of sustainable building are inadequately quantified. This should be addressed to provide a more objective and tractable picture of synergies.

Sustainable building interventions (such as energy efficiency and design measures) result in benefits to **general/mental health and health equity,** principally stemming from improvements in **air quality and light**.

OPPORTUNITY

Despite these findings, there is no evidence that the health benefits of sustainable building have been used to incentivise low-carbon building in Southeast Asia.

A transition to sustainable building involves a number of key considerations including:

- Elevating the profile and benefits (especially health co-benefits) of sustainable building to encourage policymakers and other leaders to promote relevant policies and other strategies;
- Enhancing policy and practical coherence between municipalities, as lack of such coherence is currently hampering effective uptake and development of sustainable building;
- Addressing corruption and lack of access to materials and technologies, which are further barriers to sustainable building in Southeast Asia.

SOURCES

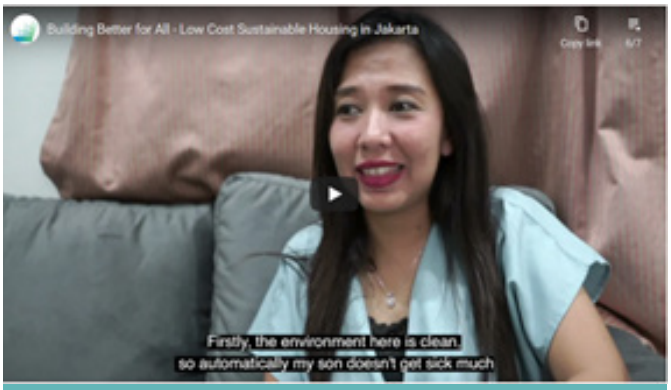
37 reviews were identified from a rapid review of the literature.

6 interviews were conducted with practice professionals from Australia, India, China and Indonesia.

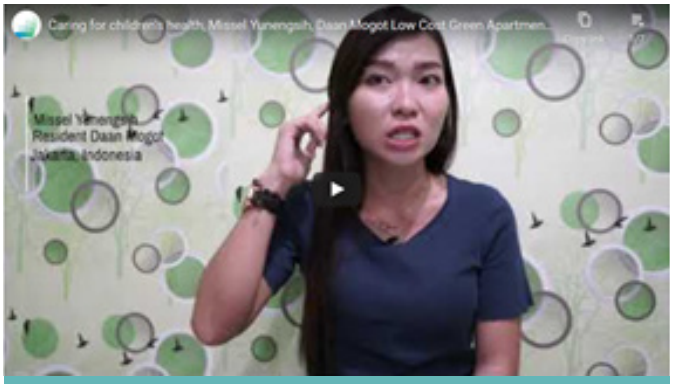
Interviews with community members

To elevate the voices of community members who are ultimately impacted by climate change and to add the lived experience to the research, GBPN engaged its network to identify and speak to community members in Asia who have recently moved into Sustainable buildings. GBPN also spoke to experts from across Asia who are advocating for affordable low carbon buildings because of all the benefits they provide. Hear Yuli, Missel, Pak Piet's stories…

Building Better for All – Low Cost Sustainable Housing in Jakarta
Building Better for All - Low Cost Sustainable Housing in Jakarta



Bangunan Hijau untuk Semua – Manfaat Bangunan Berkelanjutan
Bangunan Hijau untuk Semua - Manfaat Bangunan Berkelanjutan



Caring for children's health
Caring for children's health, Missel Yunengsih, Daan Mogot Low Cost Green Apartments, Jakarta

Healthy Buildings, Healthy Lives
Healthy Buildings, Healthy Lives, Yodi Danusastro, Sustainability Consultant

Children Can Play Freely
Children Can Play Freely, Yuli Armadianti, Daan Mogot Low Cost Green Apartments, Jakarta

Benefits of Living in Green Buildings
Benefits of Living in Green Buildings, Pooja Shukla, Senior Director, Green Business Certification

Sustainable Buildings Save Money
Sustainable Buildings Save Money, Yuli Armadianti, Daan Mogot Low Cost Green Apartments, Jakarta

Rapid review findings

A rapid review of evidence was undertaken to answer the following question: **In addition to reducing greenhouse gas emissions, what co-benefits of sustainable building are relevant to the SE Asia, India, China, US, and EU regions?**

Rapid reviews are an emerging method of efficiently synthesising research evidence where a broad overview of research evidence is required in a short timeframe. Caution must be applied when interpreting rapid review findings, since more comprehensive review methods may reveal further information and insights and could influence review interpretation and conclusions. Systematic reviews remain the definition method of literature review and we recommend systematic reviews be undertaken whenever possible. Further details of the review and other methods employed in producing this briefing document can be found in Appendix 1.

The literature search yielded a total of 2425 citations after the removal of 192 duplicates. Following screening, 37 reviews were eligible for inclusion. These comprised:

- 14 systematic reviews, including one review of reviews (Bird 2018); and
- 23 narrative reviews, including three bibliographic analyses (Camarasa 2019; Li 2019; Zhao 2019).

The majority of the systematic reviews were of poor methodological quality, satisfying less than half of applicable items from the validated AMSTAR tool (Appendix 3). Only three of the 14 systematic reviews satisfied more than half of the applicable AMSTAR items (Bird 2018; Gao 2018; Graham 2019).

Conversely, most of the narrative reviews scored well on the SANRA quality appraisal tool for narrative reviews, with only three (Gatea 2020; Ryan 2012; Urge-Vorsatz 2007) scoring half or less against applicable items in this tool (Appendix 4).

Tables 1a and 1b present key findings from systematic reviews and narrative reviews with an emphasis on higher-quality reviews. A reference list of included studies is provided in Appendix 5.

Table 1a: Included systematic reviews by methodological quality (n=14)

Citation	N studies	Quality	Key finding
Higher quality (meets more than half of applicable quality criteria)			
Bird 2018	117	6/10	Increase in energy efficient homes associated with improved general & mental health outcomes.
Gao 2018b	36	8/10	GHG mitigation strategies in 5 industries including household (e.g. low-emission stoves) can yield substantial & possibly cost-effective public health co-benefits.
Graham 2019	8	7/10	Low-carbon retrofit / renovation policy should be tailored to decision-makers & context; target up-front costs; implemented early; and use a systems approach.
Lower quality (meets less than half of applicable quality criteria)			
Carratt 2020	108	1/10	A review of assessment approaches for thermal retrofits recommends systematic approaches focusing on key parameters including temperature, CO2 & heat flux.
Carvajal-Arango 2019	117	4/10	Lean & sustainable construction approaches share some common aims including waste reduction, efficiency, productivity, environmental & social benefits.
Du 2021	n/r	3/10	Energy efficient buildings improve thermal environment but may result in mould growth due to lack of ventilation. Building standards should reflect this balance.
Fisk 2020	36	4/10	Residential energy efficiency retrofits increase thermal comfort & subjective health outcomes & decrease indoor dampness & mould (most studies Europe and USA).
Ghisellini 2018	70	2/10	Reuse / recycling construction & demolition waste yields environmental & waste benefits; local factors heavily influence underlying circular economy frameworks.
Gouldson 2018	>700	3/10	Solar lighting, clean stoves, improving heating & ventilation deliver monetised benefits > energy savings; green building can create 2 – 16 million jobs p.a. to 2050.
Houghton 2019	39	3/10	LEED-based green building can reduce negative health outcomes from extreme heat & are influenced by vegetation & exposure to high temperatures.
Kamal 2019	38	1/9	Presents a cost-benefit energy efficiency framework of 22 categories across 4 levels with only 6 / 22 benefit categories (mainly economic) estimated in literature on average.
Kozusznik 2019	34	3/10	Green building solutions generally do not jeopardise, and may improve, employee well-being & performance; however, results are mixed & influenced by moderators.
Naldzhiev 2020	132	4/10	Insulation reduces energy bills & CO2 footprint & enhances comfort; however, insulation contains volatile compounds that may cause adverse health effects.
Tham 2020	82	3/10	Building energy efficiency measures create health benefits; ventilation mitigates against unintended health outcomes; strategies need tailoring to location & climate.

Table 1b: Included narrative reviews by methodological quality (n=23; bibliographic analyses italicised)

Citation	N studies	Quality	Key finding
Higher quality (meets more than half of applicable quality criteria)			
Brambilla 2020	94	10/12	Energy efficient houses have reduced indoor air change rates. This can create conditions for mould growth which can impact human health.
Brown 2020	183	12/12	USA-based household energy efficiency schemes are inaccessible to low-income households. Policy & other responses are identified.
Camarasa 2019 (BA)	*954*	*10/12*	*Energy efficiency in European residential buildings results in job creation, less air pollution, improved air quality & reduced energy poverty.*
Collins 2019	n/r	8/12	Without adequate ventilation, residential energy efficiency retrofits in the EU can increase indoor pollutants & mould & cause signal attenuation and overheating.
Creutzig 2016	n/r	8/12	Demand-side strategies are critical to reducing GHG; these include urban planning to shape demand and behaviour change strategies aimed at norms & practices.
Gao 2018	n/r	8/12	In low-income countries there is high burden of disease due to indoor air pollution. Interventions aimed at reducing GHG can result in cost-beneficial health gains.
Lemaire 2018	98	8/12	Solar lighting saves costs compared to kerosene lamps; can benefit childhood education; & enables more home activities; however long-term studies are lacking.
Li 2019 (BA)	*3060*	*12/12*	*Research is growing in volume & multidisciplinary focus; 12 research 'hotspots' include certification in developing countries; barriers to GB promotion were identified.*
Lima 2020	15	11/12	Energy efficiency measures such as insulation, heating and improving windows / doors result in positive cardiovascular, respiratory and mental health impacts.
Omrany 2020	68	10/12	Well-designed atriums can reduce building energy use, enhance visual comfort and support social & psychological well-being; poor design has the opposite effect.
Ortiz 2020	n/r	8/12	Energy-efficiency retrofitting can create airway, skin & eye health problems through humidity, pollutants & overheating; however, comfort and health are under-reported.
Sakiyama 2020	n/r	8/12	Natural ventilation in buildings enhances thermal comfort, energy efficiency & indoor air quality. Research in these areas & their measurement has grown since 2015.
Sharifi 2021	56	11/12	Green building co-benefits include water efficiency, energy resilience & thermal comfort; with health & economic flow-on. Research in the Global South is lacking.
Shnapp 2020	>100	10/12	Building energy efficiency co-benefits, including macro (environmental, economic, social) and micro levels (building quality, user wellbeing) should be monetised.

Citation	N studies	Quality	Key finding
Thoday 2018	n/r	11/12	Conversion from kerosene to LPG for cooking in Indonesia has reduced mortality and morbidity, however these benefits have not been well-measured.
UN Env. Program 2019	120	10/12	Co-benefits of low-carbon building include impacts on energy costs, employment / economic, health & wellbeing, energy poverty productivity & energy security.
Urge-Vorsat 2009	n/r	8/12	Co-benefits - health (3), ecological (4), economic (11), service provision (3) & social / political (6) - should be part of energy efficiency cost-benefit analysis.
Urge-Vorsatz 2014	80	9/12	Co-impact taxonomy: health impacts (6); affordability (2); comfort (3); ecosystem services; building damage; productivity (2); energy security; macroeconomic.
Willand 2020	73	9/12	Energy-efficiency retrofits target low-income, children & elderly; program-delivery & contextual factors influence benefits & therefore should be carefully considered.
Zhao 2019 (BA)	2980	11/12	'Hot' topics (2000–2016) include green & cool roof, vertical greening & financial benefits; research gaps are corporate social responsibility & performance validation.
Lower quality (meets less than half of applicable quality criteria)			
Gatea 2020	n/r	5/12	Hospitals are heavy energy-users; efficiencies in heating, ventilation, air-conditioning and lighting can reduce energy consumption by an estimated 20%
Ryan 2012	n/r	6/12	Co-benefits of energy are presented at individual (6); national (4); and international (4) levels; the 'rebound' effect is a trade-off between welfare gains & energy savings.
Urge-Vorsatz 2007	80	6/12	Green building positively impacts social welfare, poverty, air quality, health, quality of life, comfort, the economy & energy security; barriers & policies also discussed.

*BA: Bibliographic Analysis; nr: not reported

Commentary on included evidence

Overall, the relevant studies primarily reported on European and US-based studies compared to Asia; Sharifi (2021) reported a lack of research in this field in the Global South. The literature also more frequently reported on residential, rather than commercial-scale building energy efficiency measures. The reviews predominantly focused on building modifications and design. Few reviews reported on other considerations such as culture, social norms and building occupant behaviour, which can exert considerable influence on energy use and emissions reduction.

The higher quality systematic reviews report a range of co-benefits of sustainable building and energy efficiency including improved general and mental health outcomes. For example, enhancing warmth and energy efficiency was found to reduce health inequalities by Bird (2018). The high-quality review by Gau (2018b) reported that low-emission biomass cook stoves would result in an estimated 570,000 fewer premature deaths in India due to improved air quality. Graham's 2019 review focused on how to best tailor and implement sustainable retrofit / renovation policy. Similar findings were reported in the higher quality narrative reviews, many of which reported health and health equity co-benefits of sustainable building measures. Principally these were reported to relate to improvements in air quality (e.g. Camarasa 2019, Gao 2018, Lima 2020, Sakiyama 2020, Sharifi 2021, Thoday 2018).

A number of non-health impacts were also reported in higher-quality systematic and narrative reviews. These include job creation / economic benefits (Camarasa 2019, Sharifi 2021, Urge-Vorsatz 2009, Schnapp 2020, Urge-Vorsatz 2014; and a low-quality review (Gouldson 2018) estimated that green building could create 2 – 16 million jobs per annum to the year 2050. Other non-health benefits reported included cost savings to households (Lemaire 2018); increased energy security (UN Environment Program 2019, Urge-Vorsatz 2014) and educational benefits of enhanced lighting (Lemaire 2018).

However, some reviews reported adverse outcomes. For example, without adequate ventilation, energy improvements can also result in adverse outcomes such as mould growth (Brambilla 2020, Collins 2019). Furthermore, Brown (2020) found that USA-based household energy efficiency schemes are inaccessible to low-income households. The 'rebound' effect – where benefits of energy efficiency measures are undermined by increased consumption – was another reported adverse outcome. However, Ryan (2012) pointed out that although this can be viewed negatively, the rebound effect may actually represent desirable welfare gains – for example, reductions in energy poverty enabling people who previously could not afford to heat their homes to do so.

Broadly, the lower-quality systematic reviews reported similar findings, although less confidence can be placed in these reviews due to methodological shortcomings. These reviews were mixed in relation to the problem of mould, with one review reporting that this is a possible outcome of energy efficiency (Du 2021) and one other review reporting a decrease in dampness and mould (Fisk 2020). Additionally, Naldzhiev (2020) reported that insulation containing volatile compounds may adversely affect human health. Kozusznik (2019) reported mixed effects of green building on employee well-being.

Various techniques for quantifying benefits of sustainable building exist including social cost-benefit analysis, integrated assessment modelling and multicriteria analysis. However, the complexity and relative lack of quantification of co-benefits of sustainable building (presumably stemming from this complexity) was a key theme throughout included studies, with several reporting that more attention to this was required (Kamal 2019, Ryan 2012, Shnapp 2020).

Finally, a number of taxonomies exist for categorising co-benefits of sustainable building. For example, Kamal (2019) presents a cost-benefit energy efficiency framework of 22 categories across 4 levels – microeconomic (e.g. asset values, energy savings); macroeconomic (productivity, energy security); environmental (air and water quality) and social (health, energy affordability). Similarly, Urge-Vorsatz (2007) represents co-benefits across various domains including social welfare, air quality, health, productivity, employment creation and energy security domains. Ryan (2012) considered outcomes at individual (e.g. health), sectoral (asset values), national (job creation) and international (energy prices) levels. These may form the basis of an evidence map or other organising framework for representing research and practice findings and identifying gaps in knowledge.

Practice review findings

Interviews were conducted with six practice professionals from policy, building, and research sectors with experience in sustainable buildings in SE Asia, China or India:

- one research/policy professional was based in Australia who had experience broadly related to SE Asia;
- two policy/construction professionals were based in India with experience relevant to India;
- one policy/research professional was based in China with experience relevant to China;
- one research professional was based in Indonesia with experience relevant to Indonesia; and
- one policy/research professional was based in Indonesia with experience relevant to Indonesia.

The interviews focused on sustainable buildings in SE Asia or India, with opportunities to discuss the types of co-benefits that have been achieved through these projects, the motivations of relevant stakeholders, and the requirements for generating greater interest in sustainable buildings in SE Asia or India. The interview schedule can be found in Appendix 2.

Key themes of these interviews are outlined below, with quotes in italics:

What incentivises sustainable buildings in SE Asia or India?

Financial incentives encourage development

Most participants noted the influence that financial incentives have on the development of sustainable buildings. A range of incentives were described (e.g. funding from international organisations or governments, government-offered rebates or reducing taxes, or banks providing lower interest rates on loans), highlighting that financial incentives are clearly needed to drive the development of sustainable buildings.

One participant noted that externally-provided funding allowed for the development of 'demonstration projects', which allow local organisations to learn about green buildings and foster local interest in developing sustainable buildings for themselves.

"A result of having a number of demonstration projects and capacity building programmes and so on funded by international organisations over time, that sort of got us to appoint where cities and regions are now saying we want help to do it ourselves."
SE Asian participant

Across India and Indonesia, the economy was mentioned as a key priority for governments. In India, construction influences a large proportion of GDP, and in Indonesia, governments (federal and local) are focused on securing short-term outcomes that drive the economy. In summary, based on the influence of tax reductions, reduced interest rates, and high support of rebates, "money talks" - to government officials as well as construction stakeholders and consumers.

In China, government-led financial incentives were described as critical to the promotion and uptake of sustainable buildings. For example, tax incentives based on building energy ratings were used by both local and state governments. In contrast, another participant in India felt that the government-led financial incentives were not enough alone to drive demand for sustainable buildings. They felt any government-led incentive must be in line with business' needs to encourage innovation and development to increase consumer confidence and demand:

"This whole business of trying to see if we can get sustainability to be moved by giving somebody a drop in price, or a lower cost fund as an incentive, makes no sense at all. It has to work in the marketplace. It has to be viable for the business creating it, and the customer appeal should drive the market." Indian participant

This quote is consistent with the review by Creutzig 2016, which emphasizes the need to consider demand-side factors such as habits, norms and behaviour change and their influence on reducing energy demand.

Mainstream policy issues drive government mechanisms that foster development

All participants mentioned government mechanisms that drive development of sustainable buildings. These mechanisms include building policy or sustainable building rating/ certification schemes, as well as tax incentives and rebates (specific to China and India).

Two participants noted that governments developed interest in sustainable development after realising the impacts of urbanisation. Issues such as air quality, energy grid demand, and water efficiency drive development of greener buildings, particularly in India and Singapore.

Furthermore, the cost-effectiveness of resource efficiency was noted as a driver of development, but in India, this was only realised once governments had witnessed the real effects of sustainable buildings.

"In the initial phase, they did not understand the benefit of green building, but later, they started to understand that, all right, if people or the builders are constructing green buildings, then, me as the chairman of, or I should say the director of a local government, my jurisdiction is saving certain percentage of water. My jurisdiction is saving certain percentage of electricity. My jurisdiction is getting cleaner. My jurisdiction is seeing a lot of greenery around it. Then, they realise the importance of what green building is."
Indian participant

The effects of climate change have been noted as concerns but not central drivers of policy by two participants (SE Asian and Indonesian). There may be several reasons for the lack of relevance that climate change outcomes have on the development of sustainable buildings, which are discussed below.

"I think from time to time climate does drive the agenda, in my experience that depends a little bit on the availability of climate finance and funding projects from development banks and multilateral donors."
SE Asian participant

What factors prevent development of sustainable buildings in SE Asia?

Mindsets prevent perceiving a need for development

All participants commented that 'mindsets' get in the way of sustainable development. This includes a limited / lack of awareness about sustainable buildings and sustainability more generally, overestimating the costs of sustainable buildings, as well as underestimating the benefits or demand of sustainable buildings.

"Builders who have that visibility and who are well-exposed, they know that, all right, this is the future, but builders who are only focusing on making money, they are not trying to move towards this, because they are not concerned about the environment."
Indian participant

"It's still also very difficult to convince people in Indonesia to implement this green building, because it doesn't give them any [benefit]."
Indonesian participant

An Indonesia participant pointed out that within Bandung, sustainable building was implemented due to the local official adopting a mindset to see the value of sustainable buildings. Given that only four cities in Indonesia have adopted sustainable building policy, this suggests that mindsets are influential in driving development of sustainable buildings in Indonesia.

"Why [region] is chosen, the second city in Indonesia to have a green building? Because the mayor … he knows that the green building is important. So he does as fast as possible to make a green building regulations."
Indonesian participant

There were mixed opinions between participants about the actual costs of sustainable buildings, which may depict financial differences between geographic regions. One of the Indonesian participants noted that sustainable buildings are expensive, with one reporting that fossil-fuel energy is still subsidised by the Indonesian government, making renewable energy more expensive to purchase. This could prevent a demand in buildings utilising renewable energy sources, thus driving down sustainable building development. The Chinese participant noted the importance of acknowledging a long payback period to reach the break-even point from sustainable buildings.

Lack of focus on long-term initiatives in Indonesia

In Indonesia, it was reported that those who are influential hold short-term mindsets and rarely look towards the future.

"Waiting for seven years is something very long in a country with a lot of uncertainty."
Indonesian participant

Although one participant noted that green buildings reduce costs over time, both Indonesian participants noted that green buildings carry expensive initial costs and so are less appealing to those who want to save money.

Competing interests at all levels of government means there are issues with governance
Two participants commented on governance issues preventing sustainable policy. This highlights the need for greater alignment and integration across all levels of the government.

"But sometimes they're not coordinated one to others. So everybody in our local cities sometimes difficult to understand what's one regulation, sometimes conflict to other regulations."
Indonesian participant

Indonesian government wields power differently between regions
Within both India and Indonesia, government incentives are highly influential; however, there are differences in where the power to intervene lies. In India, one participant noted that the government and financial institutions held the power to be able to issue incentives, either through reduced tax, rebates, or reduced interest rates. Within Indonesia, power is more devolved, with local Mayors responsible for implementing regulation within a city. This means that regulations vary across Indonesia; only four cities have green building regulation.

One of these cities is Bandung, Indonesia's third-largest city. The mayor of Bandung was reported as understanding the importance of sustainable buildings and their influence on society. As such, Bandung have implemented regulations that led to a steep increase in new green buildings between 2018-2019 (from 3,000 to over 5,500 buildings). However, the regulation with Bandung stipulates only 3 requirements to be considered a 'green building' - dual flush toilet systems, LED lighting, and waste systems that separate organic and non-organic waste. Within Jakarta, the regulation for green buildings is more extensive, for example accounting for influences on thermal conditions (which could affect co-benefit of thermal comfort and health impacts of air quality). The participant also suggested that the policies in Bandung make it 'too easy' for a building to be considered green in Bandung.

Corruption is a deterrent
Two participants commented on stories that depict elements of corruption that actively prevent development of sustainable buildings. Within India, builders are incentivised to build sustainable buildings, but there is the sentiment that some take advantage of the incentives but fail to deliver sustainable buildings. While the government has put penalties in place to deter this type of behaviour, they have not been as effective as intended.

"Look, penalising will never help. It has never helped in any sector. One thing that motivated all the sectors is the incentive mechanisms, some more innovative incentive mechanism needs to come in place because builder community is such, or the building sector is such an India that it's a money making sector."
Indian expert

Within Indonesia, one participant noted that hotels are deterred from implementing efficiency measures as hotel managers would want to keep the profits for themselves instead of passing onto the owner.

"Every year they have to, how do you say it? The management side will give the profit, the management profit to the owner. And if they got an energy efficient running, then it means they can have more profit, but then they do not want to share the profit to the owner. They want to keep it to themselves."
Indonesian expert

Lack of access to materials or technology
Indian and Indonesian participants noted the debilitative effects that reduced access to materials or technology can have on sustainable development. Within India, the country is very large and many rural parts are restricted to the types of materials that are within affordable reach. Within Indonesia, the technology available is not advanced enough to facilitate a transition to net-zero and may only get them to nearly zero. Furthermore, the country lacks appropriate reference buildings that demonstrate the real effects sustainable buildings can produce. The SE Asian participant noted that within Indonesia, international funding has led to the development of 'demonstration projects' that allow local regions to see the possibilities that come from sustainable buildings, prompting them to request help to build them themselves.

Some themes pertaining to barriers align with the report of the United Nations Environment Program (2019), which identified the following barriers to building and decarbonization policies:

- Perceived or actual increases in up-front building costs;
- Political reluctance to long-term commitment to develop required policy coherence within jurisdictions and between levels of government;
- Social and behavioural barriers to change in building occupants; and
- Knowledge and information barriers, including insufficient building performance and other data.

Potential levers for change – Can co-benefits drive change?

Not all interview participants considered the notion of co-benefits / social / health implications of sustainable buildings. The regional participants did not focus on the potential for sustainable developments to generate a multitude of co-benefits, rather the emphasis was generally on cost. The importance of economic value and jobs was a key focus point for most, with only one participant raising the potential value that health co-benefits brought by encouraging a hospital to adopt sustainable retrofitting. Both Indian participants did mention the potential for sustainable developments to improve air quality, which suggests that the Indian government is interested in buildings with health co-benefits. However, the participant did not recognise health as a driver of development.

Reduced cost was seen to be the most important co-benefit. Sustainable buildings need to be cheaper in the long-term, provide value in other ways (such as improved health or air quality) that also reduce cost, or generate revenue or jobs.

Other strategies were noted as potentially influential for driving development of sustainable buildings in SE Asia:

Shift mindsets using communication or capacity building campaigns
Within India, there is a lack of awareness about the significance and impact of sustainable buildings. Within Indonesia, government officials lack awareness about sustainable buildings and the benefits they can produce for society and the government, while in China, developers and real estate

professionals are slow to recognise the benefits of sustainable buildings. In India, officials have realised the benefits that come from adopting methods for resource efficiency, such as reduced costs, reduced pressure on energy grids, and improving air quality. Awareness or educational campaigns could be implemented to encourage stakeholders to learn about the benefits of sustainable buildings, especially when considering the long-term effects of such developments.

The SE Asian participant noted that greater support is needed for building the capacities of municipalities. Within Indonesia, there appears to be opportunity for educating local officials about the benefits of sustainable buildings. These officials have the potential to create fast-paced change if they desire to do so, and as such, combining an educational campaign with capacity building efforts could be one approach to help them recognise the real benefits of supporting sustainable developments and prompt action.

Emphasise the potential for saving money and making money

Most participants noted the savings that can be achieved through sustainable buildings, as well as a desire for countries to prosper and focus on economic efforts that maximise jobs for their populations. Within India, incentive mechanisms are particularly effective for driving development. One Indian participant called for more innovative incentive mechanisms to be implemented to drive further development. As such, financial incentives may be particularly motivating and could act as an important lever in emphasising the low-cost of sustainable developments. While the other Indian expert called for research and development to increase consumer demand, thus lowering prices.

Where an emphasis on low cost is not feasible (such as in Indonesia), the costs of sustainable buildings need to be balanced with the benefits in a way that is appealing to stakeholders. For example, one participant noted that a cost-benefit analysis contributed to a hospital 'going green'. It is in the best interests of hospital developers to ensure that the building actually improves health, rather than worsens it. As such, there is potential for stakeholders to be swayed when there is motivation for them to bear initial upfront costs. The SE Asian participant noted that stakeholders have misperceptions about the demand for sustainable buildings. Campaign efforts could centre on changing this misperception and allowing real estate developers in particular to learn about the potential for profit with developing sustainable buildings.

Target women with a new narrative

Two participants noted the potential for women to be influential decision makers when it comes to sustainable development. Within Indonesia, women rule the household and also like to save money. As such, efforts have been made to encourage them to support sustainable developments as a means for saving money by living more efficiently.

See sustainable futures as a whole of system change

The Chinese participant noted that for the successful implementation of sustainable buildings, changes would need to be made at the system level rather than within individual businesses or sectors – that is, focusing on individual buildings would take too long and be ineffective.

"I really think it's really important to cooperate with each other. For example, the building sector with transportation and also industries and even the great utilities combined together to find that a system solution."
China Expert

Appendix 1: Rapid review methods

Objective

The purpose of this review is to systematically review the effectiveness of sustainable building initiatives in Southeast Asia, India, China, USA, and the EU in creating co-benefits that go beyond reducing greenhouse gas emissions.

Search strategy

A comprehensive search of peer-reviewed journal publications was undertaken on 21 January 2021 using Web of Science and Compendex. A simplified search was undertaken using Google Scholar and the first 100 results were screened. Grey literature was identified through expert consultation. Search strategies are provided below:

Table 1. Web of Science and Compendex search strategy

	Keywords
1.Study type: Review	review OR overview OR synopsis OR "literature review" OR "concept synthesis" OR "conceptual framework synthesis model" OR "conceptual review" OR "critical interpretive synthesis" OR "critical literature review" OR "evidence synthesis" OR "integrative review" OR "integrative literature review" OR "interpretive synthesis" OR "knowledge synthesis" OR "meta-aggregation" OR "meta aggregation" OR "meta-analysis" OR "meta analysis" OR "meta-ethnography" OR "meta ethnography" OR meta-interpretation" OR "meta interpretation" OR "meta- interpretive" OR "meta interpretive" OR "meta-narrative" OR "meta narrative" OR "meta-review" OR "meta review" OR "meta-narrative" OR "meta narrative" OR "meta study" OR "meta-synthesis" OR "meta synthesis" OR "mixed-methods review" OR "mixed methods review" OR "mixed-methods synthesis" OR "mixed methods synthesis" OR "mixed-methods systematic review" OR "mixed methods systematic review" OR "mixed studies review" OR "mixed-studies review" OR "narrative review" OR "narrative synthesis" OR "rapid review" OR "realist review" OR "realist synthesis" OR "research synthesis" OR "review of qualitative studies" OR "scoping review" OR "systematic literature review" OR "systematic review" OR "systematic synthesis" OR "thematic review" OR "thematic synthesis" OR "qualitative meta-synthesis" OR "qualitative meta synthesis" OR "qualitative review" OR "qualitative synthesis" OR "horizon scan" OR "bibliometric analysis" OR "evidence search"
2. Population: Buildings	building* OR office OR hous* OR home* OR envelop* OR refurbish* OR renovat* OR retrofit* OR indoor* OR room* OR hospital* OR school* OR kitchen OR construction
3. Intervention: Low-carbon initiatives	"climate change mitigation" OR "emission* mitigation" OR "emission* reduction" OR "GHG mitigation" OR "greenhouse gas mitigation" OR "demand side intervention" OR "demand side management" OR "carbon emission technolog*" OR "energy transition" OR "net zero" OR "net-zero" OR "near zero" OR "near-zero" OR "green" OR sustainab* OR "low-carbon" OR "low-carbon" OR "thermal comfort" OR "energy efficien*" OR "energy efficiency technolog*" OR "decarboni*" OR "energy intervention" OR "low-emission" OR "energy security" OR solar OR "renewable energy" OR "integrated building design" OR "circular economy" OR "passive building design"
4. Outcome: Co-benefit	"wider impact*" OR "wider benefit*" OR "co-benefit*" OR "co-impact*" OR "multiple impact*" OR "multiple benefit*" OR "multiple effect*" OR "ancillary impact*" OR "ancillary benefit*" OR "ancillary effect*" OR "indirect impact*" OR "indirect benefit*" OR "indirect effect*" OR "secondary impact*" OR "secondary benefit*" OR "secondary effect*" OR "side-effect" OR "synerg*" OR "well-being" OR wellbeing OR health OR employment OR GDP OR "clean* cooking"

Google Scholar
Review+building|school|hospital|construction+climate change mitigation|demand side intervention|energy efficiency|low-carbon|net zero|low emission+co benefit|wider impact|multiple benefits|multiple impacts|health|well being|clean cooking|employment

Screening and selection

Two reviewers screened the citations against the inclusion and exclusion criteria listed in Table 2.

Table 2. Inclusion and exclusion criteria

	Include	Exclude
Study type	• Systematic or narrative reviews (reviews of quantitative or qualitative studies	• Primary studies • Conference abstracts, book chapters, theses
Population	• Buildings and renovations	• Unrelated to buildings or building occupants
Study design	• Reviews of effectiveness ('what works') studies, including simulation/modelled scenarios	• Correlational • Theoretical without simulated scenarios
Study setting	• Southeast Asia • Indonesia • India • China • USA • EU	• All other regions
Intervention	Low-carbon building strategies, including but not limited to: • Optimised building designs • Energy efficient building envelopes • Energy efficient appliances and lighting • Electrification of cooking. • Energy behaviour change campaigns with building occupants • Roof-top photovoltaic and solar thermal installations. • Decarbonised electricity supply • Demand-side management • Refurbished buildings • Application of principles of life-cycle design to buildings • Use of sustainable timber - certified sustainably managed forests. • Circular economy supply chain. • Prefabrication of buildings structures and envelopes • Integrated building design with life-cycle analysis. • Space provided for urban food production and composting.	Low-carbon strategies that are not related to buildings, including but not limited to: • Green space projects • Waste strategies not related to buildings • Transport strategies

	Include	Exclude
Outcome	Non-climate change mitigation benefits, including but not limited to: • Social: health & wellbeing; fuel poverty; improved productivity • Economic: employment; GDP; public budget; energy security; innovation & competitiveness	Climate change mitigation benefits, including but not limited to: • GHG impacts • Reduced air pollution • Resource management
Publication status	• English-language • Peer-reviewed journal publications • Grey literature • Published from 2018 – current (no date restriction on Google Scholar first 100 citations)	

Data extraction

For each included review, data was extracted (where available) as follows:

- Citation
- Aim
- Type of review
- Inclusion criteria (N/A for narrative reviews)
- Number and type of studies included (N/A for narrative reviews)
- Date of most recent search (N/A for narrative reviews)
- Key findings / conclusions re: co-benefits of low-carbon buildings in relevant regions (Southeast Asia, India, China, US, EU)

Extracted data can be found here.

Quality appraisal

One reviewer conducted quality appraisal of the included reviews. The AMSTAR tool[1] was used to appraise the quality of systematic reviews and the SANRA tool[2] was used to appraise the quality of the narrative reviews. See Appendices 3 and 4 for quality appraisal results.

[1] Shea, Beverley J., et al. "Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews." **BMC medical research methodology 7.1** (2007): 1-7.
[2] Baethge, Christopher, Sandra Goldbeck-Wood, and Stephan Mertens. "SANRA—a scale for the quality assessment of narrative review articles." **Research integrity and peer review 4.1** (2019): 1-7.

Appendix 2: Practice interview methods

Interview framework

The interviews were semi-structured, allowing the interviewer to explore emerging themes as well as salient issues. The interview framework was as follows:

Introductory statement: "We are undertaking a project funded by the Global Buildings Performance Network. A key aim of this project is to ascertain how **the co-benefits of low-carbon buildings can drive low-carbon building in Southeast Asia.**

For the purpose of this interview, there are some important definitions I'd like to outline:

- **"Low-carbon building"** refers to any strategy that reduces a buildings greenhouse gas emissions
- **"Southeast Asia"** refers to ASEAN countries, including India and China.
- **"Co-benefits"** refers to any benefit created by a low-carbon building strategy that is not related to a reduction in greenhouse gas emissions.

Your participation in this interview is confidential and voluntary. Do you consent to participating in a recorded interview? Do you have any questions before we begin?

1. Can you please briefly describe your experience or expertise in the area of low-carbon building in Southeast Asia?

2. From your perspective:

    a. What incentivises low-carbon building over other types of building in Southeast Asia? *(if necessary, could prompt with 'for example, policies, regulations, price, level of knowledge of benefits, consumer demand, tax or business incentives')*
    b. What makes low-carbon building more difficult compared to other types of building in Southeast Asia? *(if necessary, same prompts as above)*

3. Based on your experience, what types of co-benefits have been achieved by low-carbon building in Southeast Asia?

4. Based on your experience, what co-benefits of low-carbon buildings have influenced development of low-carbon buildings in Southeast Asia? *(if necessary, prompt with 'for example, the health co-benefits have been used to drive interest or the perceived costs of low-carbon investments have deterred interest)*

5. Thinking of the types of co-benefits of low-carbon buildings:
    a. Are there any that are more appealing to Southeast Asian stakeholders? Please explain.
    b. Are there any that are less appealing to Southeast Asian stakeholders? Please explain.

6. From your perspective, how could co-benefits of low-carbon building be used to incentivise low-carbon developments in Southeast Asia?

7. Based on your experience, what do you think would be required to encourage investment/interest in low-carbon projects in Southeast Asia?
8. Is there anything else you would like to say about the benefits of low-carbon buildings in Southeast Asia?
9. Are you able to connect me with any individuals that may be relevant to this research?

Participants

Participants were purposely selected based on their experience and/or expertise in the area of low-carbon buildings.

Procedure

Participants were contacted by the researchers and invited to take part. Research aims and procedures were outlined in an Explanatory Statement given to all participants prior to the interview and participants gave written consent. All interviews were conducted via teleconference. Interviews lasted between 26 and 60 minutes and were conducted by NL and AW between January and March 2021. Interviews were digitally audio-recorded, transcribed verbatim, anonymised and stored securely.

Analysis

Interview transcripts were coded and analysed thematically using a computer-assisted data analysis software program (Nvivo 12 Plus, QSR International Pty Ltd 2014, Doncaster). nterview transcripts were coded according to emergent themes relevant to the topic. Direct quotations from interview transcripts were used to illustrate key themes, participant characteristics (i.e. roles and responsibilities) have been de-identified.

Appendix 3: Systematic review quality appraisal results (AMSTAR)

Criterion (AMSTAR)	Bird 2018	Carratt 2020	Carvajal - Arango 2019	Du 2020	Fisk 2020	Gao (Public) 2018	Ghisellini 2018	Gouldson 2018	Graham 2019
1. Was an 'a priori' design provided?	No	No	No	No	No	Yes	No	No	Yes
2. Was there duplicate study selection and data extraction?	No	No	No	No	No	Yes	No	No	No
3. Was a comprehensive literature search performed?	Yes	No	Yes	Yes	No	Yes	No	Yes	No
4. Was the status of publication (i.e. grey literature) used as an inclusion criterion?	Yes	No	Yes	Yes	No	Yes	No	Yes	No
5. Was a list of studies (included and excluded) provided?	No	No	No	No	Yes	No	No	No	Yes
6. Were the characteristics of the included studies provided?	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes
7. Was the scientific quality of the included studies assessed and documented?	Yes	No	No	No	No	Yes	No	No	Yes
8. Was the systematic quality of the included studies used appropriately in formulating conclusions?	Yes	No	No	No	No	No	No	No	Yes
9. Were the methods used to combine the findings of studies appropriate?	No	No	No	No	Yes	Yes	No	Yes	Yes
10. Was the likelihood of publication bias assessed?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11. Was the conflict of interest included?	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes
TOTAL yes/applicable items	6/10	1/10	4/10	3/10	4/10	8/10	2/10	3/10	7/10

Criterion (AMSTAR)	Houghton 2019	Kamal 2019	Kozusznik 2019	Naldzhiev 2020	Tham 2020
1. Was an 'a priori' design provided?	No	No	No	No	No
2. Was there duplicate study selection and data extraction?	No	No	No	No	No
3. Was a comprehensive literature search performed?	No	No	Yes	Yes	Yes
4. Was the status of publication (i.e. grey literature) used as an inclusion criterion?	No	No	No	Yes	No
5. Was a list of studies (included and excluded) provided?	No	No	No	No	No
6. Were the characteristics of the included studies provided?	Yes	Yes	Yes	Yes	Yes
7. Was the scientific quality of the included studies assessed and documented?	No	No	No	No	No
8. Was the systematic quality of the included studies used appropriately in formulating conclusions?	No	No	No	No	No
9. Were the methods used to combine the findings of studies appropriate?	Yes	N/A	No	No	No
10. Was the likelihood of publication bias assessed?	N/A	N/A	N/A	N/A	N/A
11. Was the conflict of interest included?	Yes	No	Yes	Yes	Yes
TOTAL yes/applicable items	3/10	1/9	3/10	4/10	3/10

Appendix 4: Narrative review quality appraisal results (SANRA)

Criterion (SANRA)	Brambila 2020	Brown 2020	Camarasa 2019	Collins 2019	Creutzig 2016	Gao (Green house gas) 2018	Gatea 2020	Lemaire 2018	Li 2020	Lima 2020
1. Justification of the article's important for the readership	2	2	2	2	2	2	1	2	2	2
2. Statement of concrete aims or formulation of questions	2	2	2	1	1	2	1	1	2	2
3. Description of the literature search	2	2	2	0	0	0	0	0	2	2
4. Referencing	2	2	2	2	2	2	2	2	2	2
5. Scientific reasoning	0	2	0	1	1	0	1	1	2	1
6. Appropriate presentation of data	2	2	2	2	2	2	1	2	2	2
TOTAL /12	10/12	12/12	10/12	8/12	8/12	8/12	5/12	8/12	12/12	11/12

Criterion (SANRA)	Omrany 2020	Ortiz 2020	Ryan 2012	Sakiyama 2020	Sharifi 2021	Shnap 2020	Thoday 2018	UN Environment Programme 2019	Urge - Vorsatz 2007	Urge-Vorsatz 2009
1. Justification of the article's important for the readership	2	2	2	2	2	2	2	2	1	2
2. Statement of concrete aims or formulation of questions	2	1	2	1	2	2	2	2	2	2
3. Description of the literature search	2	1	0	0	2	1	2	1	0	0
4. Referencing	2	2	1	2	2	2	2	2	1	2
5. Scientific reasoning	0	1	0	1	1	1	1	1	1	0
6. Appropriate presentation of data	2	1	1	2	2	2	2	2	1	2
TOTAL /12	10/12	8/12	6/12	8/12	11/12	10/12	11/12	10/12	6/12	8/12

Criterion (SANRA)	Urge - Vorsatz 2014	Willand 2020	Zhao 2019
1. Justification of the article's important for the readership	2	2	2
2. Statement of concrete aims or formulation of questions	2	2	2
3. Description of the literature search	0	2	2
4. Referencing	2	2	2
5. Scientific reasoning	1	0	1
6. Appropriate presentation of data	2	1	2
TOTAL /12	9/12	9/12	11/12

Appendix 5: Included studies

1. Bird EL, Ige JO, Pilkington P, Pinto A, Petrokofsky C, Burgess-Allen J. Built and natural environment planning principles for promoting health: an umbrella review. *Bmc Public Health.* 2018;18:13.
2. Brambilla A, Sangiorgio A. Mould growth in energy efficient buildings: Causes, health implications and strategies to mitigate the risk. *Renewable & Sustainable Energy Reviews.* 2020;132:14.
3. Brown MA, Soni A, Lapsa MV, Southworth K, Cox M. High energy burden and low-income energy affordability: conclusions from a literature review. *Progress in Energy.* 2020;2(4).
4. Camarasa C, Nageli C, Ostermeyer Y, Klippel M, Botzler S. Diffusion of energy efficiency technologies in European residential buildings: A bibliometric analysis. *Energy and Buildings.* 2019;202:10.
5. Carratt A, Kokogiannakis G, Daly D. A critical review of methods for the performance evaluation of passive thermal retrofits in residential buildings. *Journal of Cleaner Production.* 2020;263:27.
6. Carvajal-Arango D, Bahamon-Jaramillo S, Aristizabal-Monsalve P, Vasquez-Hernandez A, Botero LFB. Relationships between lean and sustainable construction: Positive impacts of lean practices over sustainability during construction phase. *Journal of Cleaner Production.* 2019;234:1322-1337.
7. Collins M, Dempsey S. Residential energy efficiency retrofits: potential unintended consequences. *Journal of Environmental Planning and Management.* 2019;62(12):2010-2025.
8. Creutzig F, Fernandez B, Haberl H, Khosla R, Mulugetta Y, Seto KC. Beyond technology: demand-side solutions for climate change mitigation. *Annual Review of Environment and Resources.* 2016;41:173-198.
9. Du C, Li B, Yu W. Indoor mould exposure: Characteristics, influences and corresponding associations with built environmentA review. 2020.
10. Fisk WJ, Singer BC, Chan WR. Association of residential energy efficiency retrofits with indoor environmental quality, comfort, and health: A review of empirical data. *Building and Environment.* 2020;180:12.
11. Gao J, Hou H, Zhai Y, et al. Greenhouse gas emissions reduction in different economic sectors: Mitigation measures, health co-benefits, knowledge gaps, and policy implications. *Environmental Pollution.* 2018;240:683-698.
12. Gao J, Kovats S, Vardoulakis S, et al. Public health co-benefits of greenhouse gas emissions reduction: A systematic review. *Science of the Total Environment.* 2018;627:388-402.
13. Gatea AA, Batcha MFM, Taweekun J. Energy Efficiency and Thermal Comfort in Hospital Buildings: A Review. *International Journal of Integrated Engineering.* 2020;12(3):33-41.
14. Ghisellini P, Ripa M, Ulgiati S. Exploring environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector. A literature review. *Journal of Cleaner Production.* 2018;178:618-643.
15. Gouldson A, Sudmant A, Khreis H, Papargyropoulou E. The economic and social benefits of low-carbon cities: A systematic review of the evidence. *London and Washington DC.* 2018.
16. Graham P, Bok B, Jinlong L, Zwagerman M, Burton C. *Policy for low-carbon (energy efficiency) retrofit/renovation of residential buildings: Rapid review (report).* Sydney, Australia: CRC LCL;2019.
17. Houghton A, Castillo-Salgado C. Associations between Green Building Design Strategies and Community Health Resilience to Extreme Heat Events: A Systematic Review of the Evidence. *International Journal of Environmental Research and Public Health.* 2019;16(4):37.
18. Kamal A, Al-Ghamdi SG, Koc M. Revaluing the costs and benefits of energy efficiency: A systematic review. *Energy Research & Social Science.* 2019;54:68-84.
19. Kozusznik MW, Maricutoiu LP, Peiro JM, Virga DM, Soriano A, Mateo-Cecilia C. Decoupling Office Energy Efficiency From Employees 'Well-Being and Performance: A Systematic Review. *Frontiers in Psychology.* 2019;10:24.
20. Lemaire X. Solar home systems and solar lanterns in rural areas of the Global South: What impact? *Wiley Interdisciplinary Reviews-Energy and Environment.* 2018;7(5):22.

21. Li QW, Long RY, Chen H, Chen FY, Wang JQ. Visualized analysis of global green buildings: Development, barriers and future directions. *Journal of Cleaner Production.* 2020;245:15
22. Lima F, Ferreira P, Leal V. A Review of the Relation between Household Indoor Temperature and Health Outcomes. *Energies.* 2020;13(11):24.
23. Naldzhiev D, Mumovic D, Strlic M. Polyurethane insulation and household products - A systematic review of their impact on indoor environmental quality. *Building and Environment.* 2020;169:18.
24. Omrany H, Ghaffarianhoseini A, Berardi U, Ghaffarianhoseini A, Li DHW. Is atrium an ideal form for daylight in buildings? *Architectural Science Review.* 2020;63(1):47-62.
25. Ortiz M, Itard L, Bluyssen PM. Indoor environmental quality related risk factors with energy-efficient retrofitting of housing: A literature review. *Energy and Buildings.* 2020;221.
26. Ryan L, Campbell N. Spreading the net: the multiple benefits of energy efficiency improvements. 2012.
27. Sakiyama NRM, Carlo JC, Frick J, Garrecht H. Perspectives of naturally ventilated buildings: A review. *Renewable & Sustainable Energy Reviews.* 2020;130:18.
28. Sharifi A. Co-benefits and synergies between urban climate change mitigation and adaptation meas ures: A literature review. *Science of The Total Environment.* 2020:141642.
29. Shnapp S, Paci D, Bertoldi P. Untapping multiple benefits: hidden values in environmental and building policies. 2020.
30. Tham R, Morgan G, Dharmage S, Marks G, Cowie C. Scoping review to understand the potential for public health impacts of transitioning to lower carbon emission technologies and policies. *Environmental Research Communications.* 2020;2(6):35.
31. Thoday K, Benjamin P, Gan M, Puzzolo E. The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion. *Energy for Sustainable Development.* 2018;46:71-81.
32. United Nations Environment Programme. Adopting decarbonization *policies in the buildings & construction sector: Costs and Benefits.* 2019.
33. Ürge-Vorsatz D, Danny Harvey L, Mirasgedis S, Levine MD. Mitigating CO2 emissions from energy use in the world's buildings. Building Research & Information. 2007;35(4):379-398.
34. Ürge-Vorsatz D, Herrero ST, Dubash NK, Lecocq F. Measuring the co-benefits of climate change mitigation. *Annual Review of Environment and Resources.* 2014;39:549-582.
35. Ürge-Vorsatz D, Novikova A, Sharmina M. Counting good: quantifying the co-benefits of improved efficiency in buildings. Paper presented at: European Council for an Energy Efficient Economy2009.
36. Willand N, Maller C, Ridley I. Understanding the contextual influences of the health outcomes of residential energy efficiency interventions: realist review. *Housing Studies.* 2020;35(1):1-28.
37. Zhao X, Zuo J, Wu G, Huang C. A bibliometric review of green building research 20002016. *Architectural Science Review.* 2019;62(1):74-88..

GBPN
Global Buildings Performance Network

24, avenue Hoche
75008 Paris, France
@GBPN_org
www.gbpn.org
info@gbpn.org