Health in the green economy

Co-benefits to health of climate change mitigation

HOUSING SECTOR *Executive summary*

Key messages

Health co-benefits

- **The right mix of mitigation policies** could lead to very large health co-benefits, including reductions in noncommunicable and infectious diseases.
- **Noncommunicable diseases: heart disease, strokes, injuries, asthma and other respiratory diseases** can be reduced through mitigation measures that: reduce exposure to extreme heat and cold; reduce mould and dampness; improve natural ventilation and provide for safer, more energy-efficient home heating and appliances. There is also evidence that housing improvements increase well-being and mental health.
- **Infectious diseases: vector-borne diseases such as malaria, waterborne diseases (diarrhoea), and airborne diseases, including tuberculosis,** can be prevented through low-energy and climate-friendly designs to: improve natural ventilation; limit vector and pest infestations (e.g. sealing of cracks, window screening); and improve access to safe drinking water and sanitation as part of planning and siting.
- **Good ventilation is critical to ensure health gains from energy-efficient and weather-tight housing.** Insufficient natural ventilation is associated with higher risk of airborne disease transmission, dampness and accumulation of indoor pollutants that are risk factors for allergies and asthma. Unless outdoor air is heavily polluted, natural ventilation also reduces buildup and exposure to toxic indoor air pollutants from interior design materials, furnaces (e.g. carbon monoxide) and naturally-occurring radiation (radon).
- **Energy-efficient biomass and gas cookstoves can help avert a large proportion** of chronic obstructive pulmonary disease (COPD) in poor countries. Over 1 million COPD deaths every year are due to indoor cookstove smoke exposure, mostly among poor women.[i] Coal smoke from cookstoves kills another 36 000 people annually from lung cancer; poor women are at greater risk.
- **Cleaner home energy also can help avert nearly 1 million deaths annually from pneumonia among children under 5.** Half of all childhood pneumonia deaths (2004) were due to indoor smoke from biomass and coal cookstoves.

The climate footprint of housing

According to the International Energy Agency, residential buildings were responsible for close to 18% of direct CO_2 emissions in 2008, with 11% due to home use of grid-electricity and district heating, and the remainder from household-level heating and cooking with fossil fuels (biomass was not included).

Despite its large contribution to climate change, the residential and commercial building sector was described by the IPCC *Fourth Assessment Report* as having the greatest potential for reducing greenhouse gas (GHG) emissions cost-effectively within a short time frame, using available and mature technologies. This is in comparison to other sectors subject to IPCC assessment, including transport, agriculture, industry, forestry, energy supply and waste generation.

About Health in the Green Economy

Many strategies to reduce climate change have large, immediate health benefits. Others may pose health risks or tradeoffs. Examined systematically, a powerful new dimension of measures to address climate change emerges.

WHO's *Health in the Green Economy* series is reviewing the evidence about expected health impacts of greenhouse gas mitigation strategies in light of mitigation options for key economic sectors, considered in the *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007* (IPCC).[ii] The aim is to propose important health co-benefits for sector and health policy-makers, and for consideration in the next round of IPCC mitigation reviews *(Fifth Assessment Report* [AR5]). Opportunities for potential health and environment synergies are identified here for housing.

World Health Organization

- **Health risks from insulation and construction materials can be avoided by using healthier substitutes.** The health risks of asbestos and lead paint use are well documented. Other hazardous materials include arsenic-impregnated timber and formaldehyde binders in insulation foams and pressed-wood products. Construction workers are most at risk.
- **"Smart growth" strategies that integrate land use with climate-friendly housing can yield health gains for populations in rapidly growing cities.** Most of the world's growth in the next four decades will be in cities of poor countries, and by 2050, most of the world's urban population will live in Asia and Africa. Better land use planning and planned housing development can avoid risks and create synergies. For instance, clustering homes around green areas and providing pedestrian/cycle ways and clean rapid transit/ public transport promote healthy air quality and physical activity, and reduce traffic injury risks as well as the urban "heat island" effect.
- **Health co-benefits of housing-related climate change mitigation strategies require more systematic assessment** by the Intergovernmental Panel on Climate Change (IPCC). The IPCC's *Fourth Assessment Report*, the focus of this review, does not systematically consider health. That constitutes a "missed opportunity" for identifying strategies that benefit society.

"Win-win" strategies for health and housing mitigation

- **Health can be a driver** of cost-effective housing climate change mitigation strategies. Particularly in low-income settings, health savings from improved housing are immediate and tangible. For instance, improved insulation has been shown to reduce illness from cold and dampness. In economic terms, these savings may be far larger than energy savings; thus health may provide a good economic argument for mitigation measures. This requires the involvement of many actors, from construction and funding agencies to public health institutions and health insurers.
- **Better thermal insulation, with adequate management of energy sources and ventilation,** reduces exposure to extreme temperatures and risk of respiratory and infectious diseases, as well as reducing exposure to damp mould and pests. Thermal comfort is also associated with better mental health.
- **More energy-efficient heating** and more energy-efficient biomass and biogas cookstoves in developing countries can significantly reduce health-damaging indoor air pollution exposures and improve thermal comfort, reducing asthma and respiratory illnesses as well as home injuries (e.g. from burns).
- **Climate-friendly housing designs** that make more effective use of active and passive natural ventilation for cooling can help decrease heat stress. Adequate fresh air exchanges can help reduce risks of airborne infectious diseases as well as exposure to toxic chemicals and other indoor air pollutants, e.g. radon. Screens, bednets and/ or air duct filters are needed, however, to reduce transmission of vector-borne diseases.
- **Access to safe drinking-water and improved sanitation can save lives and reduce the climate footprint** associated with poor wastewater management, water resource degradation and water resource extraction. In addition to the 880 million people lacking access to safe drinking-water, some 2.6 billion people had no access to improved sanitation facilities and 1.1 billion were defecating in the open in 2008. Unsafe drinking water, sanitation and hygiene were estimated to cause 1.9 million deaths in 2004.

[i] See the companion *Health and Green Economy* report*: Co-benefits to Health of Climate Change Mitigation: The Household Energy Sector in Developing Countries* (Adair-Rohani H, Bruce N, 2011).

SCOPE AND METHODS

This report looks first at the climate and environmental impact of housing and then at how housing impacts health with respect to building siting and land use, choices of construction materials, design features, ventilation and energy, and also inhabitant behaviour. Summaries of key evidence are presented in two categories, which often overlap:

- **Housing-related risks to health, such as:** poor indoor air quality – e.g. indoor smoke from heating and cooking, moulds and moisture, exposure to carcinogenic or otherwise harmful chemical pollutants from building materials such as asbestos, lead and formaldehyde, as well as radon underground; thermal conditions – exposure to extremes of heat and cold; pests and infestations; noise and urban design – which may facilitate or deter healthy physical exercise and childhood mobility.
- **Housing-related diseases and injuries, where significant evidence exists, including:** tuberculosis and other air-borne infectious diseases, asthma, water-borne diseases impacted by lack of clean drinking-water and sanitation access, vector-borne diseases, home injuries, and mental health.

The report then focuses on an examination of specific mitigation measures considered by IPCC[ii] alongside the body of evidence about the health impacts of housing. Identified health studies of specific intervention measures are given special attention, e.g. studies of health impacts of insulation and energy efficiency programmes. This brings the broad knowledge about housing and health into focus on measures proposed for climate mitigation.

While the IPCC assessment covers both residential and commercial buildings, this analysis was limited to residential buildings.

IPCC-reviewed measures that were considered included strategies for: improving the "thermal envelope"[iii] of buildings; use of more energy-efficient heating systems; use of passive solar systems for heating and domestic hot water production; reduction of building cooling requirements ("cooling load") [iv]; design and landscaping; and ventilation measures. Also considered are measures for heating, ventilation and air conditioning (HVAC) systems; daylighting and lighting, including photovoltaic solar panels for electricity generation; and certain efficiencies in household appliances.

Improving health equity

- **About 40% of urban growth is in slums.** Climatefriendly housing initiatives should focus more on slum areas, where simple innovations such as insulated roofs, low-energy/ solar lighting and water heating could improve health equity and reduce the health impact of heat waves and extreme weather. These should be coupled with access to safe drinking water, sanitation and healthy transport.
- **Many low-income cities are experimenting with costeffective, healthy climate change mitigation** strategies for housing; these should be studied, expanded and evaluated. Examples include inexpensive passively cooled homes and apartments using underground earth-pipe cooling, passive solar water heating that improves access to hot water and hygiene, and improved building design for natural ventilation to offer relief from heat stress along with better control of tuberculosis and other infections.
- **Air conditioning is associated with certain health risks,** although it may also be the only way to rapidly reduce heat load in some structures. Large heating, ventilation and air conditioning (HVAC) systems may increase risks of bacterial proliferation and infectious disease transmission if not well maintained, and in the absence of sufficient air exchanges.
- **Air conditioning can reinforce health inequities** by adding to overall urban noise and urban heat generation, which negatively affect the health of others, particularly those who cannot afford air conditioners. Also, since air conditioners typically have a larger carbon footprint than passive or other mechanical modes of natural ventilation, they add to long-term climate change.
- **Replacing kerosene lamps with LED lanterns powered by small solar photovoltaic panels** can potentially reduce risk of injuries and eye diseases as well as indoor pollution exposures in poor countries. Expanding access of poor households to DC (direct-current) household appliances (e.g. refrigerators, phones, computers) that can be powered directly by photovoltaic solar panels may offer health equity as well as climate benefits.
- **Stronger building codes and housing finance measures can support investment** in healthier and more energy-efficient housing while avoiding excessive fuel costs or "energy poverty."
- **Improved international and national climate finance mechanisms** are needed to help fund and implement climate change mitigation interventions in housing, particularly among the poor.

BACKGROUND AND RATIONALE

This analysis reviews and evaluates the potential health impacts of mitigation strategies and technologies for the residential building sector, with a focus on strategies reviewed in the: *Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* also referred to here as the *IPCC mitigation review.*[ii]

Residential buildings are responsible for nearly 18% of direct carbon dioxide emissions (International Energy Agency, 2008), with 11% due to household grid consumption of electricity and district heating, and the remainder from household-level cooking and heating (e.g. with natural gas, LPG or biomass/coal). The residential and commercial building sector was described by the IPCC mitigation review as having the greatest potential for reducing greenhouse gas (GHG) emissions cost-effectively, within a short time using available and mature technologies. This is in comparison to other IPCCassessed sectors including transport, agriculture, industry, forestry, energy supply and waste generation. Housing is therefore a significant factor in greenhouse gas emissions and climate change.

At the same time, housing and the built environment have a profound impact on human health. Healthy housing conditions can significantly decrease risk of communicable and noncommunicable diseases. Demographic and migration trends mean that the world's urban population will double by 2050, with most urban growth occurring in low- and middle-income cities. That, in turn, translates into an explosion of urban housing construction and/or informal settlement and slum expansion. Clearly, then, the way in which new housing is developed will have far-reaching impacts on urban health risks – as well as on urban safety, energy efficiency, heat wave resilience, access and mobility, and other urban health determinants.

Not all mitigation measures, however, have identical health impacts. Some measures may be highly positive for health, while others may generate new and unforeseen health risks if simple preventive measures are not incorporated. For instance, insulation improvements in temperate climates need to include measures to ensure adequate ventilation so as to avoid transmission of airborne infections, such as tuberculosis, or accumulation of indoor air pollutants, including toxic chemicals and radon. At the same time, lowenergy buildings in warm climates and malaria-endemic regions that include design features to promote cooling with natural ventilation need to consider screening or other measures to protect from vector-borne diseases. Health-informed choices between mitigation measures in housing and construction can thus significantly impact strategies, but also ensure the best benefit-to-cost ratio for investments made by reducing concrete costs of disease and injury and also improving public health.

[ii] Levine M, Urge-Vorsatz D. Residential and commercial buildings In: Metz, B et al. eds. *Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge and New York, 2007.

SUMMARY OF INITIAL FINDINGS

Climate change mitigation strategies in the housing sector can yield both immediate health gains and long-term mitigation objectives, as long as the choice of measures to be adopted explicitly considers potential health benefits and risks. Health inequalities can be addressed by deploying low-carbon climate change mitigation measures adapted to slums and other poor communities. Implementation of climate change mitigation measures should consider occupational health risks and relevant exposures of workers engaged in construction or retrofits of homes. Home occupant behaviour should also be considered, as it influences the effectiveness of certain mitigation measures and impacts on health (e.g. regulation of indoor temperature and ventilation). Findings reflect an urgent need for including health into housing policies, for example in improved building standards and in the enforcement of housing codes. Climate-related finance and other housing finance mechanisms should consider the health benefits and risks of climatefriendly construction or retrofits alongside carbon savings. More careful evaluation of potential health benefits and risks from all strategies, as well as monitoring and follow-up of their impacts, can ensure "win-win" outcomes for health and environment in accordance with the following principles:

- **Consider health co-benefits and risks at the planning stage.** Health impact assessment (HIA) of proposed housing climate change mitigation strategies can be applied to a specific intervention or package of measures. This can provide information about the expected health impacts of alternative scenarios as well as practical recommendations to improve the health performance of climate change mitigation strategies.
- **Ensure that housing strategies include land use and transport planning for walking, cycling and rapid transit/public transport, as well as access to green areas** to enhance health and climate benefits and reduce risks (e.g. urban heat island effect).
- **Ensure that appropriate standards and codes are in place, particularly to safeguard basic structural features** such as access to electricity, safe drinking water, proper sanitation, natural ventilation and lighting, and to avoid use of materials with health hazards.
- **Develop/use healthy housing criteria, checklists and good practice guidance,** to select strategies and investments and to monitor healthy housing indicators.
- **Document reductions in risks to health, benefits to health and savings in health care costs** related to housing interventions; this information is useful in communicating health gains and related savings.
- **Build capacity of health and non-health professionals** regarding mitigation measures and their potential health impacts using a systems approach that considers GHG impacts at all stages of building construction and use.

The main findings of this review are summarized in Table 1. The potential for mitigation strategies to provide health co-benefits or generate health risks are classified as: -- (strongly negative health impact); – (negative health impact); + (positive health impact); ++ (strongly positive health impact). These are weighted classifications relating to two factors: 1) qualitative evaluation of the evidence based upon expert opinion, as well as 2) number and quality of scientific studies available (e.g. study design, sample size, and consideration of potential confounding factors, etc.). These classifications should be regarded as indicative, rather than definitive.

[iii] Thermal envelope refers to the shell of the building as a barrier to unwanted heat or mass transfer between the building interior and outside conditions. (Source: IPCC *Working Group III – Fourth Assessment Report*).

[iv] The hourly amount of heat that must be removed from a building to maintain indoor comfort, measured in British thermal units (BTUs). (Source: US EPA, *Terms of Environment: Glossary, Abbreviations and Acronyms*; http://www.epa.gov/OCEPATERMS/bterms.html)

Table 1. Appraisal of health implications of selected mitigation strategies

Mitigation strategy	Likely health co-benefits	Impact of health co-benefit	Health risks to be avoided	Impact of health risk
Improved thermal performance of building envelope (IPCC 6.4.2)	**Environmental exposure**		Risk of inadequate ventilation:	
	Thermal comfort	++	a) Reduced indoor air quality leading to potentially increased concentrations of indoor air pollutants (e.g. radon, mould and moisture) as a cause of asthma, bronchial obstruction and other illnesses	- -
	Noise exposure reduction	+		
	Disease risk reduction		b) Increased airborne infections transmissions (e.g. TB); risk of exposure to health damaging insulation materials and fibres that cause cancer and other illnesses	- -
	Reduced cardiovascular diseases, bronchial obstruction, asthma and other respiratory conditions	++		
	Reduced vector-borne disease due to infestations and pests	++		
	Better mental health through thermal comfort	+		
	Equity impacts			
	Depends on access of poor to improvements	+		
Low-carbon-emissions heating systems and passive solar design (IPCC 6.4.3, 6.4.6–7)	**Environmental exposure**		Field studies have found that more cost- and energy-efficient heating do not always reduce net household energy use (and thus energy-related greenhouse gasses and air pollutants) by an equivalent amount. This is because some households may allocate a portion of their cost savings to *increase* their energy (electricity or heat) consumption, a phenomenon described as the "take-back effect"	0
	Thermal comfort	++		
	Hygiene	+		
	Disease risk reduction			
	Reduced asthma and respiratory symptoms related to cold exposure, damp and mould	++		
	Reduced pneumonia and COPD (in case of reduced biomass use)	++		
	Better mental health due to better thermal comfort	+		
	Equity impacts			
	Depends on access of poor to improvements	+		
Reduced cooling loads on buildings through design features and improved natural ventilation (IPCC 6.4.4)	**Environmental exposure**		May not work when night temperatures remain high; need to be adapted to regional humidity	0
	Thermal comfort	++		
	Disease risk reduction		Design must take account of winter as well as summer risks	0
	Reduced asthma/respiratory illness from particulates, radon, mould, etc.	++	Natural ventilation without house screening may increase vulnerability to vector-borne diseases	- -
	Reduced TB and other airborne infection transmission risk	++		
	Less airborne disease transmission via air-conditioning systems	+	May increase exposure to high outdoor air pollution concentrations, causing respiratory symptoms, unless filters are used	- -
	Equity impacts			
	High equity co-benefit from broader access to effective cooling and ventilation, particularly when design measures are adopted in low-income settings	+	Avoid use of lead in paint (e.g. white paint for albedo effect)	-

Strongly positive health impact ++; Positive health impact +; Strongly negative health impact: - - ; Negative health impact: -

Mitigation strategy	Likely health co-benefits	Impact of health co-benefit	Health risks to be avoided	Impact of health risk
More energy-efficient and better-maintained heating, ventilation and air conditioning systems (HVAC) **Greater reliance on building design and natural ventilation** **(IPCC 6.4.4–5)**	**Environmental exposure**		Greater risk of airborne infectious diseases (e.g. tuberculosis) and upper and lower respiratory symptoms in AC rooms/spaces lacking sufficient fresh air exchanges	- -
	Thermal comfort	++		
	Reduced noise exposure	+		
	Disease risk reduction		Increased urban dependence on AC stimulates vicious cycle of exacerbated urban heat island effect	-
	In settings with significant outdoor air pollution, reduced respiratory symptoms and asthma	++		
	Less risk of cardiovascular disease due to heat exposure	++	More noise and pollution exposure for those not using air conditioning	-
	Less risk of vector-borne disease due to closed windows	+	Bacterial proliferation/legionellosis in very large HVAC tanks/cooling towers	- -
	Equity impacts		Delayed climate-related health impacts from added greenhouse gas emissions of air conditioners	-
	Those least able to afford AC suffer the most from its noise and heat island impacts.	-		
Passive solar hot water and photovoltaic solar electricity **(IPCC 6.4.7–8)**	**Environmental exposure**		Greater initial cost outlays pose barriers for poor families if not offset by subsidies	-
	Hygiene and sanitation	+		
	Disease risk reduction		New technology risks require more assessment, including of occupational and environmental risks of production and exposure to waste byproducts, e.g. respiratory irritations and impacts of exposures to toxics or heavy metals	0
	Less asthma and respiratory disease due to decreased use of kerosene lighting in developing countries	+		
	Fewer burns from kerosene appliances	+		
	Equity impacts			
	More access to electricity among poor and rural populations	++		
	Lower long-term electricity cost once initial investment is made	+		
Lighting and day lighting: window positioning to reduce heat/cold impacts; highly energy-efficient indoor lighting **(IPCC 6.4.9–10)**	**Environmental exposure**		Household injury from inadequate indoor/proximity lighting	-
	Thermal comfort	++		
	Disease risk reduction			
	Less asthma and respiratory disease due to natural ventilation through windows	+		
	Fewer home injuries (falls)	++		
	Positive effect of light on metabolic function and mental health	+		
Household appliances and electronics: more low-energy and direct-current appliances, including improved biomass cookstoves **(IPCC 6.4.11; 6.6.2)**	**Environmental exposure**		Equity gains dependent on increased access of poor to new low-energy cookstove technologies and other appliances	-
	Reduced indoor air pollution	++		
	Improved food safety, kitchen hygiene	+		
	Disease risk reduction		In developed countries, more efficient appliances may not decrease GHG and air pollution emissions if there is not a equivalent decrease in overall energy use	-
	Reduced asthma and respiratory disease	+		
	Fewer injuries from burns due to inadequate cooking and heating appliances	++		
	Less COPD, cancer and cardiovascular disease	+		
	Equity impacts			
	Access to cleaner biomass and biogas cookstoves	++		

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Photo:
An urban garden in a Caracas, Venezuela, residential neighborhood provides multiple health benefits: local fresh produce, physical activity and green spaces around housing to offset the urban "heat island" effect. (©FAO/Giuseppe Bizzarri)