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Plan B for rapid adaptation, GHG reductions and resilience in the built environment

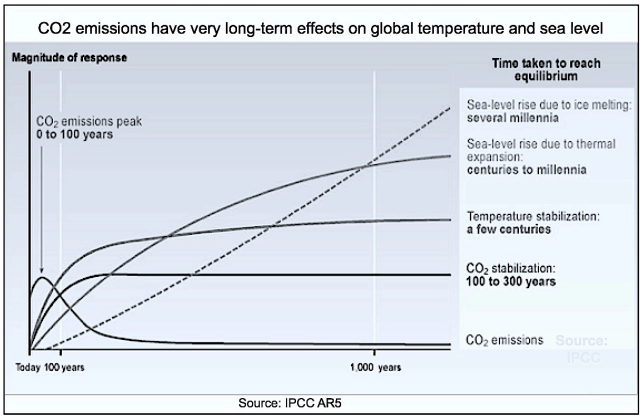
Key industry and government leaders have hesitated too long to implement adequate long-term mitigation measures. Measures that have been implemented tend to be of the no-regrets and painless variety, so these will not be sufficient to make the major and rapid reductions that are needed.

In addition, we must do more to adapt to the major climate change impacts that now appear inevitable. In view of these factors, we believe that a Plan B for more rapid action on both the adaptation and mitigation fronts is needed, and this short paper presents a number of proposals along these lines.

Considering the long lag times in the climate system, a "business as usual" approach to mitigation means that GHG reductions will probably *not* come rapidly enough to avoid severe climate change impacts and we therefore face a high probability that global temperature increases will be considerably more than the target 2ºC adopted in the 2015 Paris Agreement. A recent study[1] states that ... *only three countries in Europe push in the right direction to deliver on the Paris climate agreement. Sweden tops the list, followed by Germany and France*. Considering that European countries are considered to be leaders in GHG reduction, this poor performance by major polluting countries indicate the likelihood of massive long-term disruption of agriculture, industry, living and working conditions, as outlined by IPCC AR5 and others.

Specific direct effects will vary by region, but are generally expected to include the following, as detailed in the IPCC Fifth Assessment Report:[2]

- Higher annual ambient temperatures, with high-latitude regions seeing the most change and, during summers, hotter summer days and warmer nights;
- A gradual but relentless sea level rise,
- An increased probability and intensity of windstorms, cyclones and hurricanes;
- Highly variable rates of precipitation resulting in droughts and/or periods of intense rain or snow.



Secondary effects resulting from increasing global temperatures will include higher death rates during heat waves, a greater use of electricity for mechanical cooling systems, aggravated water shortages due to increased evaporation, more forest fires and migration of harmful insects with associated diseases towards higher latitudes. Sea level rise combined with more and stronger storms will lead to severe coastal flooding from storm surges in many areas. Greater riverine flooding and landslide events may also be expected from intense precipitation events.

The combination of these problems, especially in coastal regions, will result in high levels of mortality and injury as well as property damage in vulnerable areas and some disruption of essential services. In developed countries, the financial costs will be very high.

According to a recent paper in Nature Climate Change[3], *... a leading integrated assessment model can be used to estimate the impact of twenty-first-century climate change on the present market value of global financial assets. We find that the expected 'climate value at risk' (climate VaR) of global financial assets today is 1.8% along a business-as-usual emissions path. Taking a representative estimate of global financial assets, this amounts to US$2.5 trillion... Limiting warming to no more than 2 °C makes financial sense to risk-neutral investors—and even more so to the risk averse.*

[1] http://carbonmarketwatch.org/wp-content/uploads/2017/03/EU-Climate-Leader-Board-Where-countries-stand-on-the-Effort-Sharing-Regulation-–-Europe's-largest-climate-tool_final.pdf
[2] https://www.ipcc.ch/report/ar5/syr
[3] *'Climate value at risk' of global financial assets*, in Nature Climate Change 6, 676-679, 04 April 2016

These factors may in turn result in disruption of economies, social instability and influxes of climate refugees, leading to a need for large-scale and rapid re-housing in both originating and recipient locations.

We have already seen examples of some of these phenomena. The impact of the 2005 hurricane Katrina on New Orleans resulted in total damages estimated at $108 billion, with insurance payouts totaling $41.1 billion[4]. Hurricane Sandy in 2012 caused nearly $50 billion in property damage and required $4.8 billion in payouts through the U.S. National Flood Insurance Program[5]. To these must be added the recent major flooding event caused by Hurricane Harvey in Houston, not yet fully accounted for. The staggering physical damage in the Caribbean caused by hurricanes Irma, José and Maria show the vulnerability of such island states, but probably the most serious impacts will be social or long-term economic effects in this region. Based on these factors, we can expect sudden and extreme weather events to produce the following effects:

- We can expect a surge in demand for labor and materials to carry out urgent repairs, re-building and re-location needs. Manufacturers of building materials will be faced with urgent production requests but will face increased power costs and disrupted labor and plant conditions; and supply chains may be disrupted by transportation problems.
- These factors will, within weeks, deplete the supply of skilled workers and firms in the affected region and cause prices for materials and services to reach very high levels.
- Owners or managers of existing commercial buildings in urban areas will have to reduce operating hours to meet GHG reduction targets, and residential occupants will face mandatory energy cuts and reduced levels of living standards.
- Standards for good design and operations, such as adequate lighting levels, indoor comfort conditions, and work to preserve heritage buildings will fall by the wayside, at least temporarily.
- Social tensions will rise to very high levels when those who want to pursue their normal activities, such as commercial development, are faced with permit refusals, if priority is given to those displaced by climate change and to households suffering from energy poverty.
- The need to deal with repair and remedial work may lead governments to say that they will have to defer more GHG mitigation measures until some future date.

Although a disturbing prospect, the only possibility for quick and effective action to minimize such future developments will probably depend on a few major weather-related events that will cause major damage and loss of life in Washington, Hamburg, London, Shanghai or other symbolically important cities. In such cases, attention will become focused on dealing with climate change in a way that logic and science can never do. Based on the history of catastrophic events, we can assume that the shock effect will open the minds of the public and decision-makers to radical measures, but only for a short time. Unfortunately, when faced with a real crisis, desperate leaders will grab whatever plans are available on the shelf, and the result is likely to be hasty, ad-hoc and poorly considered actions.

Certain characteristics of the building sector make rapid and concerted action difficult, including differentiated building types and ownership, different levels of technical and economic capabilities in various regions and major cultural differences.

We therefore need a set of short-term measures that can be implemented very quickly to deal with the impacts of extreme weather events and new climatic conditions. However, to focus only on the immediate needs mean that longer-term adaptation and greenhouse gas mitigation measures will be seen as a second priority, which would greatly worsen the situation in the long term. It is therefore clear that we also need to implement a series of long-term mitigation measures to reduce GHG emissions, similar but more radical than those currently proposed by major governments. Given the lag time in reducing the accumulated emissions, these must be launched immediately.

The proposed measures that follow are broad-brush proposals aimed at both of these objectives. They are designed as initial guidance in a variety of regions, climates, geophysical context, cultures and economic states of development. Given the huge differences that exist between Western European countries and others located in tropical South America, the usefulness of such an approach may well be questioned. However, the generic actions proposed here will be a useful starting point that may become of practical value if

[4] According to the FEMA Data Center, quoted by CNN in "Hurricane Katrina Statistics Fast Facts", August 23 2016.
[5] Hurricane Sandy FEMA After-Action Report, July 1, 2013.

supplemented by regional or local factors.[6]

The time remaining for effective action is very limited. 2020 is identified by some experts as the year after which GHG emissions must be on a declining path if we are limit global warming to less than 2ºC (personal communication from Christiana Figueres[7]).

It should be noted that our proposals do not include all issues that are relevant to sustainable construction, since the focus here is on actions needed for rapid GHG reductions and resilience of the built environment. Our approach also reflects a concern that extreme conditions caused by climate change effects may cause social instability and thereby impede effective action. There are some fully-developed plans to deal with some of the impacts anticipated in urban areas, but they are few[8].

We assume that national and/or large urban governments will play leading roles in preparing for the effects of climate change, but that complementary initiatives will also need to be launched at the level of small communities, leading to a top-down and bottom-up strategy. The potentially strong role that may be played by local communities in meeting climate change challenges is explored in a recent special issue of *Building Research & Information*, and are well summarized by the guest editor.[9]

A necessary preliminary step: identify regional vulnerabilities and risks

Primary effects of climate change will include changes in local climate, ambient temperatures, precipitation and wind regimes, and these may vary greatly depending on the climatic region and exposure.

Secondary effects include changes in the frequency of forest fires, riverine or coastal flooding, loss of soil stability, and damage to buildings and infrastructure. These effects may, in turn, lead to disruption of business or educational activities, the relocation or migration of sections of the local population or, in extreme cases, social unrest. Conversely, if other regions are more vulnerable there may be an influx of climate refugees from these areas, if there are no substantial barriers to such migration.

Each local area or region has its own combination of locational, geophysical and developmental issues that lead to different levels of risk and potential cost. A careful assessment of the key areas of vulnerability of the region or local area will therefore be necessary before specific short-term or long-term actions can be developed.

Key actions to rapidly respond to extreme climate and weather conditions

1. **Reduce locational risks**: Prohibit new construction in areas with a high risk of flooding or fire and/or ensure that insurance companies support efforts to rebuild in less vulnerable locations

2. **Protect critical infrastructure:** Ensure that facilities and services of critical importance, such as hospitals, public transportation systems, food supplies, water and sewage treatment and pumping systems, can remain functional at a basic level of performance under extreme conditions. Such facilities and services are vital for the functioning of any modern urban area.

3. **Prepare to house relocated populations:** Emergency housing may be needed if there is an influx of people from other areas displaced by climate change. Specific measures include Identification of empty dwellings that may be useful for relocated populations, and identification of hotels, office buildings, schools and other public-use buildings that may be suitable for rapid conversion to residential uses.

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[6] To support the generation of locally-specific information, an appendix to this paper allows the insertion of relevant information. We will produce regional versions as this information is generated.

[7] Vice Chair of Global Covenant of Mayors for Climate & Energy and former Executive Secretary of UNFCCC. See also 2020 The Climate Turning Point, Potsdam Institute for Climate Impact Research, 2017.

[8] A comprehensive report, *Managing Risks and Increasing Resilience; The Mayor's Climate Change Adaptation Strategy*, October 2011 is one positive example. It describes the estimated impacts on the greater London area of climate change impacts. The report states that... *Extreme weather, such as heat waves and very heavy rainfall will become more frequent and intense. Very cold winters will still occur, though they will become less frequent. Sea levels are expected to continue to rise for centuries to come*. The report goes on to outline measures required to deal with direct impacts such as flooding, drought and local atmospheric overheating.

[9] See Fionn Stevenson & Doina Petrescu (2016) Co-producing neighbourhood resilience, Building Research & Information, 44:7, 695-702, DOI: 10.1080/09613218.2016.1213865

4. **Limit speculative price increases:** Introduce measures to control speculation in real estate that results in large numbers of under-utilized or empty dwellings, and minimize short-term speculative increases in labour rates and costs of construction materials under extreme conditions.

5. **Reduce carbon emissions:** Introduce policy measures to radically and rapidly cap and reduce carbon emissions linked to the built environment. Possible measures include carbon taxes, cap and trade or personal allowances. Such measures have the added benefit of reducing air pollution.

   One successful approach can be found in the Tokyo Cap-and-Trade Program (TCTP)[10], implemented in 2010. The TCTP an important measure to accelerate the building sector's emission reduction to achieve Tokyo's greenhouse gas target, 25% reduction by 2020 from a year 2000 baseline level. Data indicate that TCTP has been effective in reducing energy consumption in participating facilities to meet … emission reduction goals, to introduce new technologies, and to raise awareness and drive behavioural changes for energy demand reduction.

   In 2008, British Columbia implemented the first comprehensive and substantial carbon tax in North America. By 2012, the tax had reached a level of C$30/t CO2, and covered approximately three-quarters of all greenhouse gas emissions in the province. Empirical and simulation models suggest that the tax has reduced emissions in the province by 5–15%. At the same time, models show that the tax has had negligible effects on aggregate economic performance, though certain emissions-intensive sectors have faced challenges. Studies differ on the effects of the policy on income distribution but agree that they are relatively small. Finally, polling data show that the public initially opposed the tax but now generally supports it…[11]

6. **Clean energy and renewables:** Take immediate steps to minimize reliance on fossil fuels for electricity generation, upgrade power grids to accommodate renewable input sources, accelerate the introduction of decentralized renewable power sources, and ensure that feed-in tariff policies do not distort energy markets.

7. **Limit peak electrical demand:** Rapidly reduce peak loads in electrical networks through rate structures to meet demand and to ensure that existing generating facilities are efficiently used. Peak demand to provide space cooling in retail and commercial facilities may be reduced by limitation of operating hours, use of electrical or thermal storage systems and/or renewable power sources.

8. **Mitigate heat island effect:** Implement steps to reduce ambient temperature increases due to urban heat island effect. Measures can include increasing areas devoted to trees and park areas, higher albedo of building roofs, streets and parking areas; installation of green roofs and vegetated walls, and promotion of effective urban ventilation.

9. **Limit new development:** In developed countries, except for cases of replacement or planned density increases within existing development zones, impose a freeze on new construction and supporting infrastructure in un-serviced or low-density areas.

10. **Encourage urban agriculture:** Availability of small and localized plots of land for urban agriculture will become of increasing importance as the use of trucks and private vehicles is discouraged in urban areas and, depending on the location, traditional supply chains are disrupted.

11. **Support a shift from private to public transport:** Support the viability of local public transport and discourage use of private cars through mixed uses, higher urban densities, location of residential development v. public transport stops and limitations on on-street and off-street parking for vehicles;

12. **Limit embodied energy and emissions:** Support adoption of environmental product declarations and require estimates of embodied emissions for heavy construction materials in major projects. Systems such as high-performance windows, external shading devices or added insulation or thermal mass, all require an investment of added embodied energy and emissions compared to conventional systems, but can all improve operating performance.

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[10] Yuko Nishida, Ying Hua & Naomi Okamoto (2016) Alternative building emission-reduction measure: outcomes from the Tokyo Cap-and-Trade Program, Building Research & Information, 44:5-6, 644-659, DOI: 10.1080/09613218.2016.1169475

[11] Murray & N. Rivers. 2015. "British Columbia's Revenue- Neutral Carbon Tax: A Review of the Latest 'Grand Experiment' in Environmental Policy." NI WP 15-04. Durham, NC: Duke University. http://nicholasinstitute.duke.edu/publications.

13. **Deep green renovation**: Where substantial performance gains are possible in a large number of residential and non-residential buildings, establish major programs for deep green renovation that result in improved resilience to extreme flood or wind conditions, while aiming for nearly-zero operating emissions, better hot weather performance, reduced peak electrical loads and water consumption.

    Minimum renovation rates of 5% per year of floor space in OECD regions and 3% per year in other regions have been suggested by *Climate Action Tracker*.[12] Obviously, these global goals will need adjustment for sub-regional or national variations in the suitability of existing building archetypes, the availability of appropriate equipment and of skilled workers. Intensive training will be required in many locations.

14. **Ensure very high performance and resilience of new buildings:** For new construction that is permitted, maximize use of on-site renewables, limit embodied emissions, require nearly zero operating GHG emissions, limit peak electrical loads and water consumption. Traditional performance assessment areas must now be broadened to include consideration of measures to improve building resilience against new conditions of extreme wind, precipitation and flooding events and increased urban temperature regimes. Where climatic, cultural and technological conditions are appropriate, vernacular residential building design and construction techniques may be appropriate.

15. **Appliance and equipment efficiencies:** Prohibit the sale of appliances and equipment that do not meet high operating efficiency criteria and provide incentives to reach the best possible performance.[13]

16. **Assess and monitor performance, track key indicators and maintain data:** Establish performance targets for a range of building types and ensure that performance assessments for major projects are undertaken prior to completion of the design stage. Ensure that performance assessments take into account possible future climate change impacts that may affect the safety, function or performance of the subject buildings and of its surrounding areas. Such assessment activities should be complemented by performance monitoring systems, with data maintained in public databases to provide building operators and local communities with annual feedback for action on energy, water and occupancy performance. The EVALOC project in the UK provides a good model for participatory evaluations in six small urban areas that are moving towards low-carbon status.[14]

Conclusions

The set of measures proposed above has been developed considering a relative lack of action in the face of the impending existential threat of climate change Some readers may find our proposed approach to be excessively pessimistic, but it should be noted that many of the provisions outlined here are logical and, assuming the generic actions are informed by a thorough understanding of local factors, they can be implemented with no regrets, even if we have not yet reached the state of extreme weather events that would make them inevitable and urgent. [15].

[12] See http://climateactiontracker.org

[13] e.g. A+++" label in Europe. See also http://www.superefficient.org

[14] The program ran from 2011-15 and was sponsored by the UK Department of Climate Change. See www.evaloc.org.uk.

[15] *This paper was developed by Nils Larsson of iiSBE with substantial input from Gregor Herda (UN Habitat), Richard Lorch and Fionn Stevenson (UK), Stella Bezerra and Roberto Lamberts (Brazil), Teresa Coady, Jean Cinq-Mars, John Crace, Gary Martin and Mark Gorgolewski (Canada), Teresa Parejo-Navajas (Spain), Randa Mahmoud (Egypt), Daniel Charles (France). Ann Edminster and Giancarlo Mangone (USA), Norman Goijberg (Chile), Wynn Cam (Singapore), Andrea Moro (Italy),*

Appendix 1: Predicted climate change impacts on the built environment

from IPCC AR4 (2007), AR5 (2014) and other sources

From IPCC AR4 and AR5		Primary and secondary impacts on urban areas and buildings	
Global effects	**Examples of major projected impacts**	**Possible direct effects on urban areas, people and buildings**	**Secondary effects**
IPCC AR5, SYR overview: In urban area climate change is projected to increase risks for people, assets, economies and ecosystems, including risks from heat stress, storms and extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, water scarcity, sea level rise and storm surges (5). These risks are amplified for those lacking essential infratsructure and services or living in exposed areas.			
It is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales (1) It is very likely that heat waves will occur with a higher frequency and longer duration. (2)	Reduction in quality of life for those people in warm areas without appropriate housing; health impacts on the elderly, very young and poor.	Reduced hydro or nuclear generation because of reduced flow rates and increased water temperatures.	Intermittent or reduced and more expensive power supply.
		Summer overheating in housing and buildings with poor hot-weather performance and no space cooling, leads to illness or mortality and greater demand for retrofit and space cooling.	Emergency building retrofits to improve hot weather performance.
			More space cooling installations leads to more pressure on power supply, greater GHG emissions and smog formation.
Warmer and fewer cold days and nights over most land areas (1)	Reduced energy demand for heating; increased demand for cooling, declining air quality in cities	Growth of harmful insect populations, such as termites, mosquitos.	Damage to wooden structures from termites, health problems from insects.
		Melting permafrost in extreme North causes soil instability and release of Methane.	Repair, rebuilding, population relocation needed.
		Reduced space heating requirements in winter.	Reduced energy consumption and emissions
Warmer and more frequent hot days and nights over most land areas (1)		Increased urban heat island effect lead to higher ambient temperatures.	Negative health effects from heat stress and smog formation. Increased peak power demand from fossil-based power generation plants, with high GHG emissions.
		Reduced feasibility of night cooling	
		Increased building space cooling requirements.	
Area affected by droughts increases (3)	Water shortages … reduced hydro generation, potential for population migration.	Water shortages because of reduced supplies and drought conditions.	Prohibition of new construction in areas with insufficient renewable water resources.
		Reduced hydro or nuclear generation because of reduced flow rates and increased water temperatures.	Intermittent or reduced and more expensive power supply.
Intense tropical cyclone activity increases (3)	Disruption by flood and high winds, loss of insurance, population migration, loss of property.	Damage to infrastructure and buildings by storm events.	Temporary shelters Emergency repairs
			Higher requirements for construction quality and durability.
		Relocation of large populations after storm events	Prohibition of new construction in vulnerable areas, such as coastal areas.
Increased incidence of extreme high sea level, excluding tsunamis (3)	Costs of coastal protection v. relocation, loss of insurance, population migration, loss of property.	Relocation of large populations over the long term	Increased pressure on developable land; pressure also on land valuable for agricultural or ecological purposes.
		Temporary shelters Greenfield infrastructure, housing and other building construction	Very high capital expenditures, high GHG emissions from materials production and construction.

IPCC classification: 1 = Virtually Certain, 99% probability, 2 = Very likely (>90% probability), 3 = Likely (>66% probability)

N. Larsson, iiSBE, 2009 & 2016