Best Practice Policies for Low Carbon & Energy Buildings

Based on Scenario Analysis

Executive Summary
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Background, Aims and Scope

Buildings are both a key contributor to climate change, and hold the largest and most cost-effective mitigation potential. They account for about a third total global final energy demand and about 30% of global energy-related CO_2 emissions. It is often suggested that buildings have the largest low-cost climate change mitigation potential. Despite this tremendous hypothesized opportunity to significantly decrease the consumption of energy and emissions in buildings, there are few studies that rigorously quantify this potential.

This report presents a unique attempt to assess the importance of the buildings sector in mitigating climate change using scenario analysis, and to offer policy insights on how the savings potentials can be best captured based on the scenario analysis. Over half of the global building final energy use is for space heating and cooling; water heating adds another 10-20%. Therefore, the focus of this particular report is on thermal energy uses, which account for approximately two thirds of the total final energy use. The report focuses on four regions: USA, EU-27, China and India. Together, these regions were responsible for more than 60% of the 2005 final building energy use (see Figure 1).

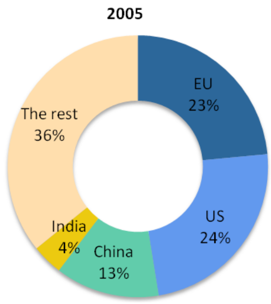

Figure 1. Share of building final thermal energy use by key world region in 2005.

The scenarios developed in this study are policy-relevant techno-economic scenarios, which do not aim at forecasting the future. Rather, the scenarios present the potential trends of building energy use under different decision regimes.

The purpose of the scenario assessments is to highlight the consequences of certain policy directions/decisions in order to inform policy-making. The primary aim of this particular scenario analysis is to illustrate how far the building sector can contribute to ambitious climate change mitigation goals ("deep" scenario); how these might be different from a hypothetical reference scenario ("frozen efficiency" scenario), and to show an intermediate scenario ("moderate efficiency" scenario). Since the ambitious scenario offers the main insights, we often focus on findings from this "deep" scenario.

This report focuses on the efficiency "lever" of building sector mitigation, and few interventions from the other two key levers (behavioural change and decarbonisation through renewable energy) have been covered: only where they were essential to be considered for the efficiency lever, too. Therefore, the three scenarios depict three worlds in which buildings have very different energy efficiency levels – reached through different dynamics.

The Executive Summary mainly focuses on final energy use. The reason for this is due to CO_2 projections being a composite of demand-side developments and supply-side decarbonisation trends, and such figures may distort building-sector achievements. Concretely, major improvements in CO_2 emissions may not mean good results in the building sector but rather successful fuel switches to low-carbon fuels; and vice versa.

Key Global Findings: Potentials for Climate Change Mitigation

The research has reaffirmed the hypothesis: buildings are a key lever in mitigating climate change.

The scenario assessment has shown that by 2050, global world building final energy use can be reduced by about one-third, (- 29% with water heating; -34% for space heating and cooling only) as compared to 2005 values (Figure 2) despite an approximate 127% simultaneous increase in floor area as well as a significant increase in thermal comfort levels – assuming full thermal comfort in all the buildings of the world.

This is in stark contrast with a hypothetical no-action scenario in which energy use increases by 111% (frozen efficiency scenario). However, even if today's policy trends and ambitions are implemented, global building energy use will still increase by about a half of 2005 levels (+48%, moderate scenario, Figure 2), pointing out the significant gap between what is possible and where even today's ambitious policy trends are taking us.

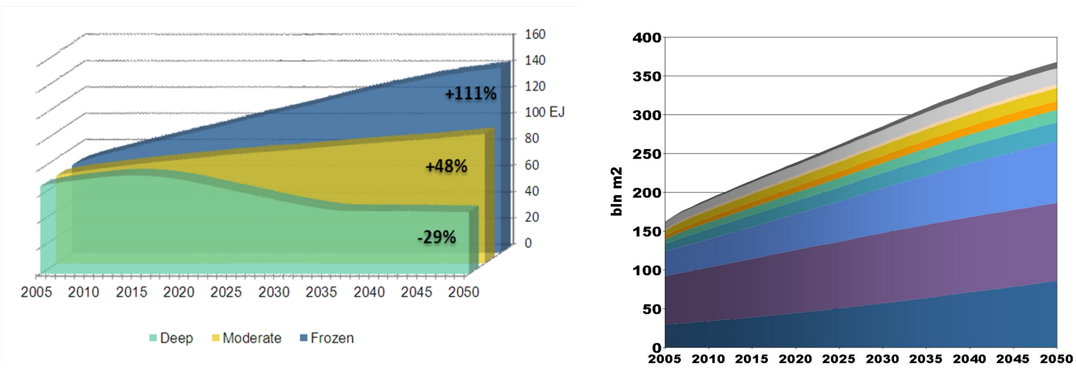

Figure 2. World total final building thermal energy for three scenarios, contrasted by floor area development during the same period. For the final energy, percentage figures show the change of the scenario in 2050 as compared to 2005. Floor area is by main building type.

We have reviewed eighteen global and selected regional[1] studies that assess energy saving or CO2 reduction potential in the building sector, including those from the IEA, WBCSD, Greenpeace, and McKinsey[2]. Although most studies have different projection periods, assumptions, methods and thus their results should be compared with caution, a few trends are clear:

- Building energy use is projected to grow significantly in the next few decades. Without action, total building final energy use, and thus corresponding emissions, is expected to grow by 60 – 90% of the 2005 value by 2050, as demonstrated by different reference scenarios), from about 110 EJ to approximately 165 – 200 EJ
- Improved efficiency alone will not bring the sector's emissions anywhere near what is needed for reaching ambitious climate targets. Total final energy use at best stays constant until 2050 for the entire sector. This means that in order to reach stringent climate goals, policies pushing for energy-efficiency need to go hand-in-hand with the other levers such as switching to low-carbon fuels (renewables) and encouraging behavioural and lifestyle change.
- There are significantly larger opportunities for bringing heating/cooling energy use down compared to other building end-uses; up to a 60% reduction can be achieved by 2050, as compared to 2005 (Laustsen model).
- Policies focusing on holistic/systemic opportunities in buildings are likely to achieve much more significant reductions than those focusing on individual building components. Performance-based building policies are able to unlock substantially larger heating/cooling energy efficiency potentials than policies focusing on individual technologies/components.
- Another interesting finding from comparing the 18 models was that studies optimizing mitigation over a longer period achieved higher and more dynamic reductions as opposed to studies focusing on the shorter-term. This points to the crucial importance of strategic, long-term policy-making and the stability of policy structures.

[1] Regional studies were reviewed if they covered the same focus regions as in this study. For a full list and references to the studies please see the main report.
[2] Section 6.2 in the full report provides details on the studies.

Key Global Findings: Insights From the Scenario Analysis

1. How a low-energy future is possible for buildings – and how it can go very wrong

The message from the scenario analysis is clear: a low energy pathway is feasible for thermal building energy uses.

Globally, today's final building thermal energy use can be reduced one-third by 2050, despite the major (111%) growth in floor area and service levels during the period. The worldwide roll-out of already proven and cost-effective best-practices and technologies for the building envelope, including space heating, cooling and water heating requires strong policy support, but there are no insurmountable technological barriers.

On the other hand, if policy efforts are not ambitious enough, like in the Moderate Efficiency scenario, global thermal energy use will increase 46% by 2050, instead of declining (see Figure 3). This means that 80% of the 2005 thermal final energy use will be locked-in by 2050 due to the long-term presence and relatively slow major retrofit cycle of the built infrastructure. The size of the lock-in effect is considerable in all regions. Therefore if ambitious climate mitigation targets become the policy targets later, it will not be possible to utilize much of this unlocked potential, unless only at prohibitive costs.

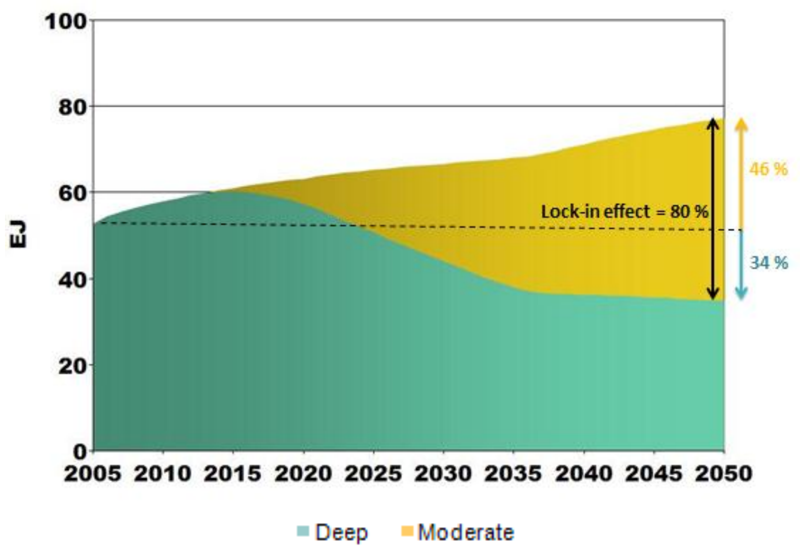

Figure 3. The lock-in effect: World final energy use for space heating and cooling for Moderate Efficiency and Deep Efficiency scenarios.

2. Why fast policy action is crucial

The research demonstrates the crucial importance of immediate action and the high cost of delay. The high lock-in risk points to the crucial importance of early action, strategic policy planning, as well as the primary importance of ambitious energy performance levels in building codes for new construction and retrofits. Reducing building energy use by the mid-century in a meaningful way requires worldwide building codes to adopt performance levels demonstrated by the state-of-the-art technology in a particular climate zone, even if it is not yet common practice. An accelerated transformation of the construction industry and markets is of paramount importance for determining 2050 emissions.

3. Why action in the developing world is crucial

The major increase in energy use and related CO_2 emissions will come from the developing world due to rapid economic development, expanded access to energy services and population growth. Global building floor area is projected to increase by almost 127% by 2050 with most of this growth coming from developing countries. How such an expansion will affect building energy use and GHG emissions greatly depends on the energy performance of the buildings constructed in the next 40 years, the energy used in these buildings, including how energy will be utilized in these buildings. In developed countries the depth of building renovation is most crucial, as the buildings that determine emissions levels on a mass scale in 2050 already mostly exist.

4. Why action in urban areas is crucial

The report for the first time quantified the role of cities in building energy use: buildings in urban areas account for 70% of the total, despite the fact that the rural population is still larger with as high values as 82% for the US (see Figure 4).

With increasing urbanization this trend continues: 85% of growth in building energy use during the projection period comes from urban areas, 70% of it from developing country cities. Urban policies in developing countries, partially at limiting floor space growth, sprawl and energy performance levels are especially crucial for a low-carbon building world.

A key policy implication is that policies and programs that are defined and implemented by cities can play an equally important or even larger role in curbing building thermal energy use as those by national governments. Urban policies that affect building energy use (beyond building codes – if in their authority - and support programs), can include: optimized urban planning and (de)zoning (these all affect building energy use), building permission conditions, mitigating heat islands, promotion of energy cascading opportunities, preferential property tax regimes, etc. Urban policies in developing countries, partially at limiting floor space growth, sprawl and energy performance levels are especially crucial for a low-carbon building world.

5. Why action on specific building type is crucial

The importance of building type is extremely variable by region.

Final energy use as well as reduction opportunities from residential buildings dominate in most regions and scenarios, with 75% of 2005 thermal energy use in this subsector, declining to 70% by 2050 in the deep scenario. Worldwide, a large proportion of final thermal energy use, and thus emission reduction opportunities, comes from single-family (SF) houses, using 54% of all world thermal energy demand, with multifamily buildings adding another 21%.

In the US, urban single-family buildings are responsible for approximately half of final thermal building energy use, commercial for approximately 27%, with MF and rural SF buildings both having an approximately equally small role. In contrast, in the China, commercial buildings dominate (especially towards the end of the period), followed by urban multifamily buildings, urban SF almost playing no role, and rural buildings declining in their importance. In India, energy use from SF rural buildings dominate throughout the period despite urbanization, with MF buildings growing from 9% to 25% of all thermal building energy use by 2050. In the EU, there is more balance among these four building types, although their importance changes slightly with a steadily declining role of rural SF building energy use and growing commercial sector. The growing importance of commercial buildings, particularly in India and China must be highlighted and be treated as a crucial factor in reducing GHG emissions globally.

Key Findings: Further Major Regional Messages

While the feasibility message is universal, there are very large regional differences (see, for instance,

Figure 4). Increased energy efficiency offers large opportunities to reduce absolute thermal energy use in the EU and the USA; after an initial period of growth it can also be feasible to slightly reduce Chinese energy use; but in India, keeping building thermal energy use growth under 200% of 2005 levels by 2050 will already be a significant achievement. Reduction potentials in the EU and the US are above 60%; CO_2 savings can be measured in gigatons (1.8 and 1.3Gt, respectively). In China, the growth of floor space can be offset by energy efficiency improvements. Similarly, most developing countries will increase their thermal energy use in all scenarios due to the rapid growth in population and affluence, while most developed countries can achieve considerable reductions in energy use.

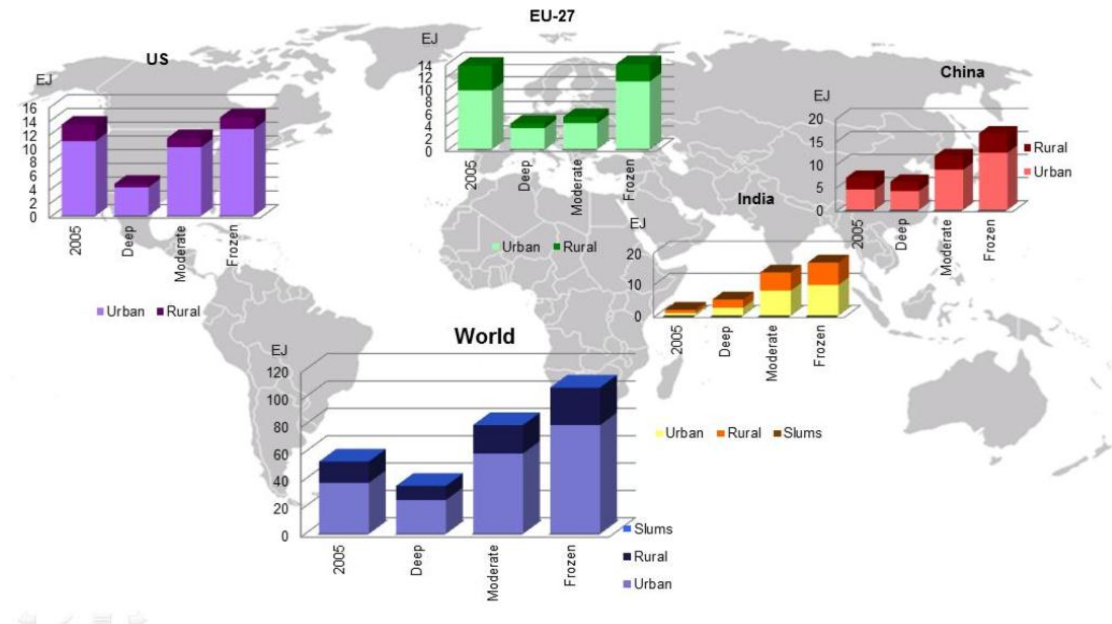

Figure 4. Final Thermal Comfort Energy in Rural and Urban buildings for the world and four key regions under the three scenarios

Compared to thermal, hot water represents a smaller contribution of building energy use as well as CO_2 emissions universally with a range of 15-25% of thermal final energy use in the different regions, the world average being 20%.

The research in the report highlighted that in 2050 building thermal energy use in the USA and Europe will mainly be determined by the retrofitted building stock, whereas in China and India (especially the latter) the key driver is new construction, thus new construction; requiring the main policy attention. While policies in Europe are already strong in terms of new construction, the major impact is offered by very low energy retrofits with an accelerated retrofit dynamic. In the EU-27 policies and policy directions in place have the potential of capturing a large fraction of the cost-effective potentials, however, all other regions are still heading towards a significant lock-in. In the US, this is approximately half of 2005 final energy use that is to be locked in by 2050; in China, approximately two-thirds; and in India over 400%. In India this points to the crucial importance of the ambition of building codes in terms of energy performance.

Key Messages from the Sensitivity Analysis

The sensitivity analysis demonstrated that even large changes in the achievable specific energy consumption figures for advanced new and retrofit buildings do not alter the main message of the scenarios: the finding that a low-energy pathway is possible is robust even against relatively large changes in assumed specific energy consumption values.

The sensitivity analysis to retrofit rates demonstrated that a too fast acceleration in retrofit rates is not desirable. An increased retrofit rate also has a slightly higher lock-in effect. As a policy implication, in an ideal case, the retrofit dynamic is accelerated only when the market is ready for advanced retrofits. In fact, the research warned that if performance levels in building codes and retrofits remain far from state-of-the-art levels, accelerating building retrofits will not bring climate benefits or may even increase the lock-in risk.

Sensitivity to adjustment factors underscored that, especially in India, but also in China, policies to encourage limitations in residential floor space per capita are a crucial lever influencing building energy use and emissions. Therefore, policies such as progressive property taxes, zoning and building size restrictions, etc., are all crucial policies affecting future building energy use in these countries.

Model Description and Key Assumptions

Figure 5 illustrates the modelling logic. To produce practical results globally, seventeen climate zones are differentiated; the most important building types in both rural and urban areas are handled separately; five building vintages are distinguished (existing, new, retrofitted, advanced new, advanced retrofitted), and a number of demographic and macroeconomic factors are applied (including population predictions, urbanization rates and GDP values).

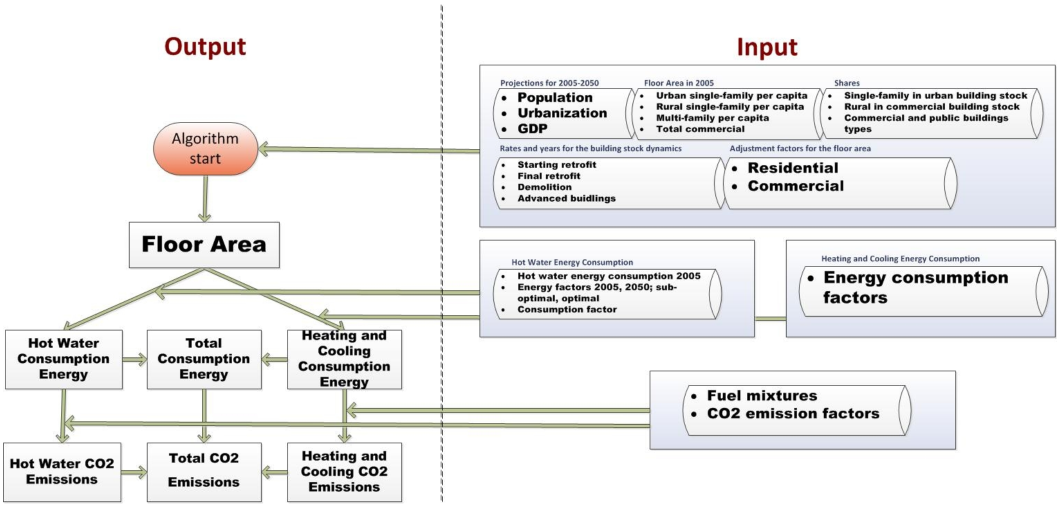

Figure 5. Flowchart representing the modelling logic for 3CSEP-HEB.