CONSTRUCTING THE FUTURE: WILL THE BUILDING SECTOR USE ITS DECARBONISATION TOOLS?

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Climate Action Tracker

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KEY MESSAGES

- Nearly one fifth of global greenhouse gas emissions come from the building sector. Under current policies, energy consumption in buildings is set to rise by 1% per year[1]
- This continuing growth in building sector emissions contrasts with the maturity of the technological solutions available to reduce emissions.
- Decarbonisation of the building sector plays a key role in achieving the Paris Agreement long-term temperature goal.
- Getting this sector onto a pathway consistent with limiting global warming to 1.5°C requires urgent and highly ambitious action.
- CAT analysis shows that a scenario where new buildings are zero-energy[2] by 2020 in OECD countries, and by 2025 in non-OECD countries, combined with deep renovation rates of 5% and 3% per year respectively, could bring the building sector onto a 1.5°C compatible pathway. But such a scale-up of efforts cannot happen overnight.
- Every new building that is not "Paris Agreement-proof" in its construction will lead to a further "lock-in" of emissions, and will require future renovation.
- Existing renovation efforts in developed regions such as the EU are currently too slow (~1% of stock renovated per year[3]), and too shallow.
- Delayed action will put additional pressure on emission reductions in other sectors (e.g. industry, transport) and/or increase the need for negative emissions approaches.

BUILDING SECTOR EMISSIONS ARE STILL STEADILY RISING

In the Paris agreement it was agreed to hold global warming to well below 2°C above pre-industrial levels and to pursue efforts to limit this increase to 1.5°C. The building sector plays a key role in achieving the more ambitious 1.5°C goal. 2050 building sector emissions in 1.5°C scenarios are around 50% lower than 2°C scenarios.[4]

From 1990–2010, GHG emissions stemming from the building sector more than doubled to over 9 $GtCO_2e$, and now represent one fifth of global emissions.[5] This growth has overwhelmingly come from indirect emissions, largely from increased electricity use. Indirect emissions account for 6 $GtCO_2e$, while direct emissions (i.e. emissions from fuel use in buildings, mostly for heating and cooking) have stagnated at 3 $GtCO_2e$.[6]

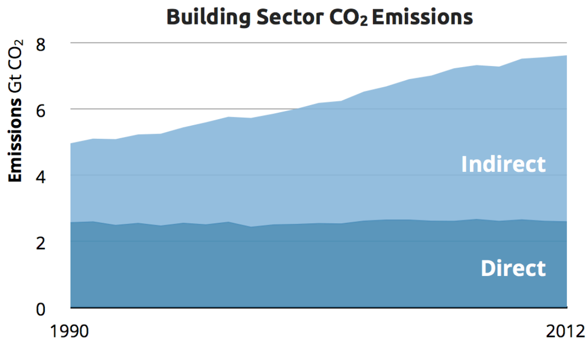

Figure 1 - Total building sector CO_2 emissions
Source: Own calculation based on data from the IEA[7,8].

Increasing the efficiency and share of renewables in the power sector can reduce indirect emissions, although end-use energy efficiency also plays a critical role. Direct emissions, on the other hand, can mainly be reduced by modifications in the buildings themselves (both building envelopes and heating/cooling systems installed).

The increase in indirect emissions from the building sector is mainly driven by population and economic growth, improved access to electricity and higher use of electrical appliances as a consequence of increasing living standards.[9] Economic growth must be decoupled from emissions growth to decarbonise the sector. Unsurprisingly, the geographic split of the emissions growth in buildings is heavily skewed towards newly-industrialised countries such as China, whose building sector emissions rival those of developed regions today (see Figure 2).[10]

Under current policies, energy consumption in buildings would continue to rise for decades - by an average of 1% per year.[11] Electricity use sees by far the largest projected increase (at 2.5% per year), while coal and oil use for heating may slowly decline.

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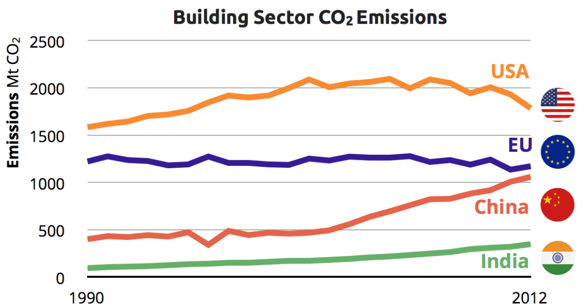

Figure 2 - Total building sector CO_2 emissions for selected countries/regions. Source: own calculation based on data from the UNFCCC[12] and IEA[13,14].

Appliances and lighting account for more than 60% of the building sector's electricity use. This category represented 20% of building sector final energy demand in 2013, and is projected to rise to 30% by 2050.[15]

While the growth in energy demand is in line with some 2˚C-compatible scenarios,[16] it would take a strong shift to renewable energy to achieve the emissions reduction rate of around 3% per year[17] required to be in line with holding global warming to 2°C. However, to achieve the Paris Agreement's long-term temperature limit of 1.5°C, the growth in energy demand needs to be curbed. Scaling up action in the building sector provides opportunities for achieving and raising ambition of the emissions targets laid out in countries' (Intended) Nationally Determined Contributions.

The continued growth in buildings emissions contrasts starkly with the maturity of the technological solutions available: we have known how to build zero-energy buildings for several decades. Initial designs were very expensive, but now they can be designed and constructed cost effectively.[18] The world's first zero-energy skyscraper is currently being constructed in Jakarta.[19]

In this briefing, we survey progress towards decarbonisation in the building sector, discuss what is needed to limit global warming to 1.5°C, and discuss some of the barriers to progress and highlight success stories.

CURRENT DEVELOPMENTS ARE NOT ON TRACK TO LIMIT GLOBAL WARMING TO 2°C, LET ALONE 1.5°C

It is instructive to look at average emissions per citizen, rather than just total emissions, especially when comparing very different sized economies. Figure 3 shows the buildings emissions per capita[20] for five selected major regions and countries.

The USA has by far the highest building carbon intensity per capita, but at the same time the largest absolute carbon intensity reductions in recent years, largely due to improved efficiency for appliances and better building envelopes.[21]

Most other developed countries also show a downward trend—or at least stagnant emissions. Per capita emissions from buildings in the EU are less than half those of the USA, mainly due to smaller building sizes. They are also slowly decreasing, due to steadily-improving building and appliance standards. While this trend is in the right direction, it is not yet on track with reductions required to limit global warming to 2°C, let alone 1.5°C.

China now leads the world in total emissions, but its buildings emissions- intensity per capita is still low compared to other major polluters. However, with a per capita emissions growth rate of 7% per year over the last decade, China is outpacing other countries, and risks significantly overshooting the safe worldwide average emissions level for a 2°C-pathway within the next 15 years; and likely sooner for a 1.5˚C pathway. Consequently, China needs to drastically increase its emissions reductions ambitions in the building sector.

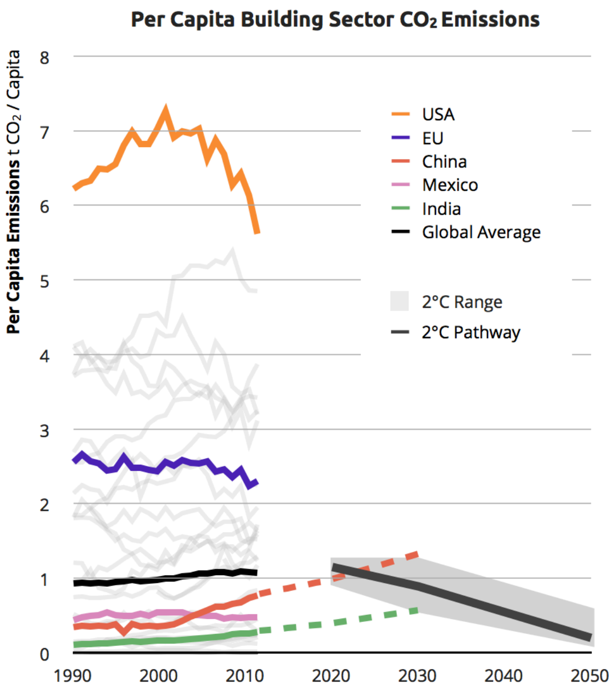

Figure 3 - Buildings intensity (CO_2/cap/a) for major countries. Shown are China, EU, India, Mexico and USA.
Source: Own calculation based on data from the UNFCCC,[22] IEA,[23,24] UN,[25] and IPCC.[26] The 2°C range represents the 10th to 90th percentile of building sector per capita emissions in 2°C-compatible scenarios. The 2°C pathway represents the median of those scenarios.[27] Data for other countries and indicators can be accessed at: http://climateactiontracker.org/decarbonization/intro

The picture for India is similar: although absolute per capita emissions from buildings are still low (only a quarter of the global average), growth rates exceed those of most other countries.

The most important policy drivers in both developed and developing countries are the enforcement of—and compliance with—building codes with high, economy-wide, energy efficiency standards, and appliance standards and labelling to curb indirect emissions. It is especially important that developing countries—where large numbers of new buildings are expected in the coming decades—apply these standards in all new buildings. This would avoid further lock-in effects.

BOX 1 NON-STATE INITIATIVES IN THE BUILDING SECTOR

Over the course of the last decade, a growing number of non-state initiatives have been created - aimed at unlocking the large untapped emissions reduction potential in the building sector. We highlight three of them here:

- **Architecture 2030**[28] issued the "2030 Challenge," adopted by 70% of the top 20 architecture, engineering, and planning firms in the USA, setting targets aimed at achieving carbon-neutrality by 2030 for all new buildings, developments and major renovations.
- The **World Green Building Council**[29] is a network of national green building councils, active in over 100 countries. Their main purpose is to support new and emerging Green Building Councils by providing them with the tools and strategies to establish strong organisations and leadership positions in their countries.
- Launched at COP21, **The Global Alliance for Buildings and Construction**[30] has a goal of scaling up ambitious actions in the building sector by bringing together relevant global players on a large scale.

Other important non-state initiatives include the Global Buildings Performance Network (GBPN), Connected Urban Development, Building Efficiency Accelerator Platform, Super-Efficient Equipment and Appliance Deployment Initiative (SEAD) and Renovate Europe.

LARGE UNTAPPED POTENTIALS, BUT LOCK-IN CONTINUES

Under current polices, energy demand from the building sector is expected to be, by 2050, almost 50% higher than 2010 levels. However, in a global emissions scenario in line with the Paris Agreement's long-term goal, emissions from the building sector need to be phased out within the next few decades.

Not only does this require a wholesale shift to low-carbon electricity, it also needs ambitious increases in energy efficiency, such as those being pursued in the USA, EU and China, as well as a fuel shift away from coal, gas and oil.[31] All these developments are underway, not least helped by fossil fuel price increases resulting from a phase-out of fossil fuel subsidies in some countries[32], but they need a rapid scale-up to reach a trajectory compatible with the Paris Agreement.

While the technologies needed to achieve zero emissions in the building sector are already available, all too often cost-effective measures are still not applied. For example, while rooftop solar panels and collectors are now cost-effective investments in many regions,[33] most suitable newly built houses are not equipped with them. Given that buildings last for many decades, a radical change is needed to avoid a further lock-in of building sector emissions. The vast majority of the buildings built today will still be used in 2050. This implies that virtually every new building that is not a (nearly) zero-energy building will need to be renovated at some point in the next 35 years. Renovations are considerably less cost-effective than up front, efficient design, such as poorly-insulated walls and windows.

An integrated view towards building energy use is necessary for both renovations and new buildings, to ensure technologically suitable and cost-effective solutions that combine multiple measures.

Differences in culture (e.g. building types and occupant behaviour) as well as geography (e.g. heating/cooling needs and renewable energy resources) prohibit a one-size-fits-all approach toward building design. Integrated solutions should always be tailored to the specific situation. Road maps towards zero-energy buildings play a key role here, to overcome lack of capacity and knowledge in certain regions.

RAPID SCALE-UP OF EFFORTS REQUIRED TO KEEP THE WINDOW OPEN FOR 1.5°C

1.5°C-compatible pathways require reductions of direct emissions in the building sector of 75%–90% below 2010 levels by 2050., with reductions of 20%–35% as early as 2020.[34]

We have analysed three possible scenarios for the building sector (for methodology see Annex A).

The **immediate action scenario** represents a highly ambitious scenario where the following measures are implemented:

- All new buildings are zero-energy buildings by
  - 2020 in OECD countries, and
  - 2025 in non-OECD countries.
- Very high renovation rates for deep renovations (90% reduction of fuel and heat demand) are achieved, reaching
  - 5% of floor space renovated per year in OECD regions, and
  - 3% per year in non-OECD regions.

The next two scenarios are where these actions are delayed: a **five-year delayed action** scenario, and a **ten-year delayed action** scenario.

In all three scenarios, total building sector emissions decrease rapidly if the actions are accompanied by a complete decarbonisation of the power sector by 2050. Cumulative emissions are, however, considerably higher in both delayed action scenarios (see Figure 4).

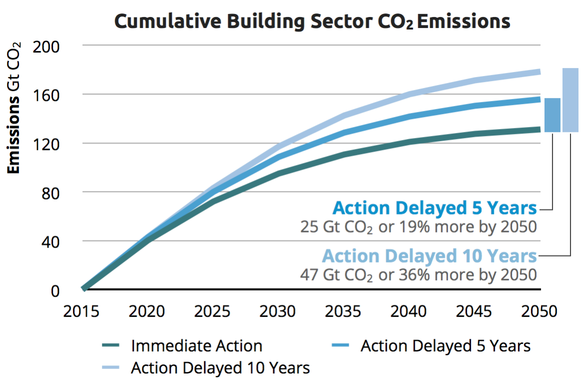

Figure 4 - 2015–2050 cumulative building sector emissions (direct and indirect) in three scenarios (for methodology see Annex A)

Where direct emissions are concerned, only the immediate action scenario is roughly in line with a 1.5 °C compatible pathway (see Figure **5**). Both delayed action scenarios overshoot the safe emissions levels.

This analysis shows the urgency of rapidly scaling-up action in the building sector. However, such a transformation cannot happen overnight, and achieving all of the ambition level of the immediate action scenario may not be realistic on such a short timescale. For example, in the EU, the current renovation rate is ~1% of stock renovated per year, while a rate of 3% would be required to achieve the emissions goals the EU has already committed to.[35] Reaching a renovation rate of 5% requires an even more rapid scale-up. More positively, the target of near-zero-energy buildings by the end of 2020 is already enshrined in law in the European Performance of Buildings Directive.[36]

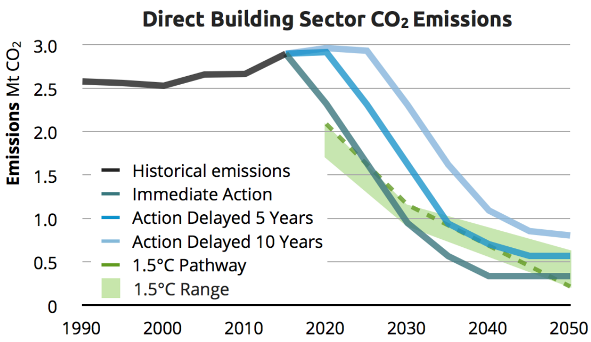

*Figure **5** - 1990–2050 direct building sector emissions in three scenarios compared to 1.5°C[37] (for methodology see Annex A)*

Given that the 2020 emissions levels required for a 1.5°C-compatible pathway are most likely already out of reach, it is extremely challenging to bring the building sector onto a pathway consistent with limiting global warming to 1.5°C. Overshooting the 2020 safe emissions levels will require even deeper reductions in the longer term. If these are not reached within the building sector, compensation for these emissions will have to be found elsewhere. Any delayed action will therefore put additional pressure on mitigation efforts in other sectors (e.g. industry, transport) and/or increase the need for negative emissions technologies in the second half of the century.

CO-BENEFITS ARE HIGH, BUT (FINANCIAL) BARRIERS REMAIN

Given the technologies needed for (nearly) zero-energy buildings are already available, the main barriers are financial. While many energy efficiency investments are cost-effective, these investments often fail to materialise for two main reasons:

- **High upfront costs:** investment costs are often high and have to be paid up-front, while the savings, even if they are substantial, occur over a longer period. Financial incentives are needed to encourage more people to realise these investments. This can be especially challenging for countries with limited public finances.
- **Landlord-tenant problem:** in most instances, the party investing (the developer or the landlord) is not the one benefitting from the reduced energy bill (the buyer or the tenant). This calls for innovative financing schemes (see Box 2).

There are also non-financial barriers, such as lack of information, low consumer awareness and poor public acceptance.[38] However, there are also clear gains: households benefit from energy efficiency improvements through reduced heating bills. Primarily in countries where the share of costs for energy is relatively high, this has the potential to lift people out of energy poverty. Aside from financial savings, energy-smart homes provide additional benefits to the occupants, such as a more comfortable indoor climate and better air quality, resulting in health benefits.[39]

BOX 2 HIGHLIGHT: ZERO ENERGY HOMES AT ZERO UPFRONT COST[39]

As part of the Dutch national Energy Agreement, social housing corporations have committed to achieving an average energy label B (on a scale from A to G) in their existing housing stock by 2020. To support this target, an innovative scheme called Stroomversnelling (meaning "rapid" - but also translatable as "electricity acceleration") was developed by Energiesprong ("Energy leap"), a non-profit market development team.

The aim of Stroomversnelling is to refurbish 111,000 rental houses to zero-energy houses by 2020 (exceeding the requirements for energy label A). The scheme develops state-of-the-art renovation methodologies using prefabricated building elements, allowing renovation to be achieved within 10 days.

This scheme successfully overcomes the common barriers in the building sectors (landlord-tenant problem and high upfront costs) by funding the upfront capital costs from a social bank. The costs are to be paid for by the energy cost savings over a 30-year period, keeping the housing costs (rent + energy) for the tenants the same.

POLICY HIGHLIGHT: MEXICO ADDRESSES FINANCING HURDLE THROUGH DIRECT STATE BANK LOANS

An important barrier to many profitable investments in buildings efficiency is the often high, up-front cost. Mexico has improved the energy efficiency of millions of buildings by providing a "green mortgage." This mortgage has a low interest rate and is available from state-owned banks for buildings that can prove compliance with energy efficiency standards.

The green mortgage programme targets both refurbishments of old buildings, and construction of new buildings. This method of improving building efficiency has produced negative abatement costs of -73 to -15 USD/tCO_2e.[41]

If countries with a similar climate[42] were to adopt the Mexican green mortgage programme, it could reduce annual emissions by 129 MtCO_2e by 2030.[43]

CONCLUSION

While the technologies to reach a low-carbon building sector already exist, and various developments are on the way, a more rapid transformation is needed to meet the Paris Agreement long-term temperature goal. This requires tailored and integrated approaches to ensure cost-effective and technologically sound solutions are applied.

While this transformation will not happen overnight, rapid and urgent scale-up is required. Any delayed action in the building sector will put additional pressure on emission reductions in other sectors (e.g. industry, transport) and/or increase the need for negative emissions technologies.

Scaling up action in the building sector provides opportunities for achieving and raising ambition of the emissions targets laid out in countries' (Intended) Nationally Determined Contributions.

ANNEX A: METHODOLOGY

Our analysis is based on a simple stock model, with the following approach:

- The model considers CO_2 emissions only, both direct and indirect (electricity and heat). The base year is 2015.
- The model tracks the energy intensity and floor area of the following building stock categories from 1990 to 2050:
  - OECD vs non-OECD economies
  - Residential vs commercial buildings
  - Stock existing before 2015 ('old') vs stock renovated after 2015 ('renovated') vs stock built after 2015 ('new')
- Total floor area projections[44] are split up into 'old', 'renovated' and 'new' based on building lifetimes (assumed 100 years for all categories) and renovation rates; see Figure 6.
- Energy and emissions are based on the 'residential' and 'commercial and public services' categories in IEA energy[45] and emissions[46] balances.
- The energy intensity per floor area (excluding electricity) of renovated buildings is 90% below the average 2015 level. The energy intensity of new buildings decreases gradually to zero in a specified target year.
- The emission intensity of electricity is assumed to linearly decrease reaching 0 gCO_2/kWh in 2050. The emission factors of fuel and heat are assumed to remain constant.
- Reduction percentages of direct CO_2 emissions required to reach a 1.5°C pathway are taken from Rogelj et al. (2015).[47] The 1.5°C pathway represents the minimum required reductions in early years to pick out the late action scenarios, and the maximum required reductions in later years to compensate for lost emissions reductions in early years.

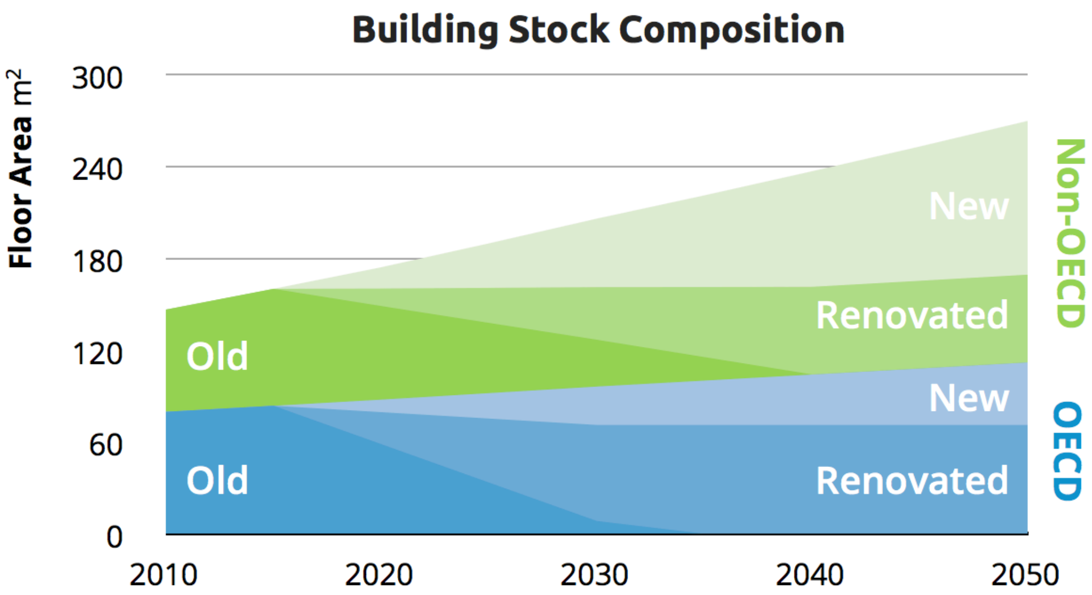

Figure 6 - Building stock composition in the 'immediate action' scenario

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ENDNOTES

[1] Current Policies Scenario from: IEA (2015). World Energy Outlook 2015, Paris, France: International Energy Agency

[2] In this briefing we use the term "zero-energy building" which is we define as *a building that generates as much renewable energy on-site as it consumes annually.* This can also be referred to as "net zero-energy building". Zero-energy buildings are by definition also zero-emissions buildings. Non-zero energy buildings can however be zero-emissions by the use of renewable energy generated off-site.

[3] BPIE (2013). Boosting Building Renovation. An overview of good practices. Available at: http://bpie.eu/wp-content/uploads/2015/10/Boosting_building_renovation_-_Good_practices_BPIE_2013_small.pdf

[4] Rogelj, J.; Luderer, G.; Pietzcker, R.C., Kriegler, E.; Schaeffer, M.; Krey, V., Riahi (2015). Energy system transformation for limiting end-of-century warming to below 1.5°C. In: Nature Climate Change, Vol 5, June 2015.

[5] IPCC. (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler,.] Cambrigde, UK; New York, NY, USA.

[6] Idem.

[7] IEA. (2014). World Energy Statistics and Balances 2014. Paris: International Energy Agency

[8] EA. (2014). CO2 Emissions from fuel Combustion. IEA Statistics. Paris: International Energy Agency

[9] IEA (2014). World Energy Outlook 2014, Paris, France: International Energy Agency

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[11] Current Policies Scenario from: IEA (2015). World Energy Outlook 2015, Paris, France: International Energy Agency

[12] UNFCCC. (2015). Greenhouse Gas Inventory Data. Greenhouse Gas Inventory Data. Retrieved from http://unfccc.int/di/DetailedByParty.do

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[14] EA. (2014). CO2 Emissions from fuel Combustion. IEA Statistics. Paris: International Energy Agency

[15] IEA. (2016) Energy Technology Perspectives 2016. Paris: International Energy Agency. www.iea.org/etp2016

[16] Own analysis of 2°C compatible scenarios with sufficient level of detail available, based on:

IPCC. (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler,.] Cambrigde, UK; New York, NY, USA.

Scenario data retrieved through: IIASA. (2015). AR5 Scenario Database. Version 1.0.1

[17] IPCC. (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler,.] Cambrigde, UK; New York, NY, USA.

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[18] Leach, M., Pless, S., Torcelli, P. (2014). Cost Control for Net Zero Energy Building Projects. Available at: http://www.nrel.gov/docs/fy14osti/61365.pdf

[19] SOM: http://www.som.com/projects/pertamina_energy_tower

[20] Other buildings indicators, such as buildings activity (in terms of m²/cap) and buildings intensity (in terms of $kgCO_2/m^2$) are not included in this analysis due to a lack of data coverage across countries. Available data can be accessed at: http://climateactiontracker.org/decarbonization/intro

[21] IEA (2014). World Energy Outlook 2014, Paris, France: International Energy Agency

[22] UNFCCC. (2015). Greenhouse Gas Inventory Data. Greenhouse Gas Inventory Data. Available at: http://unfccc.int/di/DetailedByParty.do

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Scenario data retrieved through: IIASA. (2015). AR5 Scenario Database. Version 1.0.1.

[27] Due to the limited availability of scenarios with enough underlying details, it is not possible to show similar ranges for 1.5°-compatible scenarios.

[28] Architecture 2030: http://architecture2030.org/

[29] World Green Building Council: http://www.worldgbc.org/

[30] UNEP: http://web.unep.org/climatechange/buildingsday/about-us

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[37]The 1.5°C pathway represents the minimum required reductions in early years to pick out the late action scenarios, and the maximum required reductions in later years to compensate for lost emissions reductions in early years.

[38] IEA (2013). Transition to Sustainable Buildings. Available at: http://www.iea.org/publications/freepublications/publication/Building2013_free.pdf

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[41] Sitra (2015). Green to Scale. Available at: https://www.sitra.fi/julkaisut/Selvityksi%C3%A4-sarja/Selvityksia105.pdf

[42]Sitra (2015). Green to Scale. Available at: https://www.sitra.fi/julkaisut/Selvityksi%C3%A4-sarja/Selvityksia105.pdf. Countries: Afghanistan, Albania, Algeria, Argentina, Australia, Azerbaijan, Chile, People's Republic of China, Cyprus, Ecuador, Eritrea, Greece, Islamic Republic of Iran, Israel, Jordan, Lebanon, Malta, Mexico, Morocco, Namibia, Nepal, New Zealand, Peru, Portugal, South Africa, Spain, Turkey, United States, Italy, Japan, Uruguay, Zimbabwe.

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[44] IEA (2013). Transition to Sustainable Buildings. Available at: http://www.iea.org/publications/freepublications/publication/Building2013_free.pdf

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