# Going deep in energy consumption in buildings: How to achieve the best case scenario for deep savings in building energy consumption

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## Abstract

The building sector has been identified as a sector with large potential for delivering energy savings and mitigation of GHG emissions. Yet it has been unclear what the specific role of building energy efficiency codes play in achieving these savings. Therefore, between July 2011 and June 2012 the Global Buildings Performance Network, facilitated the development of scenarios for energy savings and GHG mitigation related to thermal energy efficiency in buildings and an international survey of the impact of policy best-practices. The scenarios produced support the view that building energy efficiency offers a greater potential for final energy savings than previous models. However the survey of the impact of best-practice policies in the field identified an alarming gap between the trajectory our current policy settings are taking us and the technically potential savings available with the application of state of the art policies and technologies. This paper presents the outcomes of this and more recent research on how to implement 'the deep path' scenario in USA, EU, China and India; the four regions representing about 65 % of the energy savings potential of the building sector.

## Introduction

Globally, buildings account for 25–40 % of total final energy demand and 35 % to 40 % of all energy-related $CO_2$ emissions (UNEP, 2010). However, four regions of the world – the US, Europe, China, and India – collectively offer almost 65 % of the total energy savings potential from the sector and present significant opportunities to reduce global $CO_2$ emissions (McKinsey, 2010). This paper presents a synthesis of research into the potential of the building sector to tackle climate change and the opportunities and limitations of today's best policy practices.

The GBPN commissioned the Central European University Centre for Climate Change and Energy Policy, Hungary (CEU), to determine the best-possible $CO_2$ mitigation scenarios globally and in each of our target regions, and the Lawrence Berkeley National Laboratory (LBNL), USA to identify and analyse the best performing building energy policies implemented today. The research summarized and presented in this paper identifies significant final energy savings and GHG emissions mitigation potential in buildings both globally and across four priority regions (US, Europe, China & India). The results show that it is technically possible to move towards a 'deep' path that, despite an increase in new floor area of about 130 % by 2050, will lead to:

- 30 % global reduction in final building thermal energy use by 2050 as compared to 2005 levels.
- Reduce $CO_2$ emissions[1] globally by up to 3.2 Gt by 2050; a 40 % reduction of 2005 emissions.

These findings show a greater technical potential for energy savings and GHG mitigation from buildings than those identi-

1. To obtain regional emission factors, country level emission factors were aggregated. For the country level emission factors the main sources used were: (IEA 2007; IEA 2011; IPCC 2006).

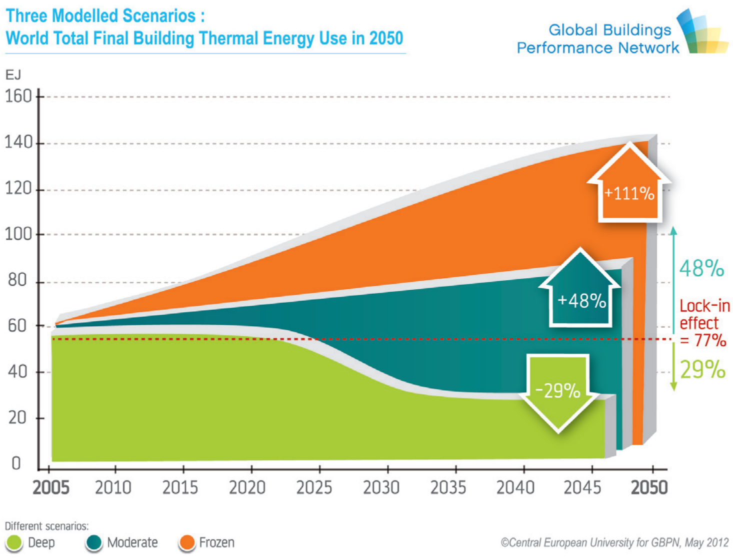


*Figure 1. Comparison of 'Frozen', 'Moderate' and 'Deep' scenarios for thermal energy use in buildings between 2005 and 2050.*

fied by the Intergovernmental Panel on Climate Change (IPCC, 2007), and have since contributed to the scenarios published in the 2012 World Energy Outlook (IEA, 2012) and the United Nations Environment Program (UNEP, 2012).

These savings are realizable with the application of existing technologies and knowledge. However, the scenario modelling also shows that even if the ambitious goal of fully implementing our current building energy policy regimes can be achieved, final thermal energy demand and associated GHG emissions would still rise by about 46 % compared to 2005 levels (approximately 25 EJ). However, if we go for a deep scenario we could achieve an absolute reduction in final thermal energy demand of 28 % compared to 2005 – an energy saving of approximately 18 EJ and abatement of about 3.2 Gt $CO_2$ by 2050 (GBPN-a, 2012).

The 'deep' scenario is the only scenario, which predicts total thermal energy demand and $CO_2$ emissions reductions in the building sector. Only by reducing total energy consumption can we be brought closer to achieving international targets of limiting global warming to 2 degrees by 2050. According to the scenarios we have a window of opportunity between now and 2022 to shift energy policies in the building sector on to a path that will deliver the magnitude of $CO_2$ mitigation necessary to avoid the worst-case scenarios of climate change.

## RETHINKING policy settings and rates of innovation in building energy performance

What is the state of building policies and what policy packages are proving most effective in delivering mitigation from the building sector? GBPN commissioned LBNL to investigate this question. The research analysed best-practice case studies in the US, EU, China and India (GBPN-b, 2012).

The term 'best practice' used in the research describes implementation of policies and policy packages that result in large energy cost-efficient and $CO_2$ savings in buildings. The criteria used to screen potential 'best practice' policies were those that: achieve large energy savings per buildings; are highly cost effective[2]; are implemented effectively; and are scalable in states, countries, or a collection of countries (for case study policies).

The study found that despite some regional successes in establishing building energy efficiency policies and programs, continuing to implement and improve today's policy practices at the current rate does not deliver the 'deep' energy savings and $CO_2$ mitigation required to effectively tackle climate change. While the lack of good documentation of the impact of policies presented a limitation to the research At best full implementation might be able to bring us to a moderate savings scenario if these policies are continued and further enforced.

There is therefore a gap between the opportunities in the 'deep' energy scenario and related $CO_2$ abatement potentials from buildings and the capacity of building energy policies most widely used today to achieve this potential. Given this context, GBPN commissioned CEU to identify the best possible $CO_2$ mitigation and energy savings potential from buildings. They produced three scenarios; A 'frozen' efficiency scenario as is the hypothetical reference scenario, assuming that the specific energy consumption of new and retrofit buildings does not improve as compared to their 2005 levels; A 'moderate' scenario which assumes that current policies will be fully implemented; and an ambitious 'deep' scenario under which todays best practices are assumed to become standard practice for both retrofit and new construction (refer to Figure 1) (GBPN-a, 2012).

The energy performance gap between the 'moderate' and 'deep' scenarios is significant. As shown in Figure 1, implementing today's policy directions will lead to nearly 50 % of global building thermal energy saving potential being lost (as compared to the 'deep' scenario) and inefficiency 'locked-in' by 2050 due to the long life span of buildings. The 'moderate' scenario predicts that there will be a continuous rise of energy consumption, which will consequently exacerbate the building sector's impact on climate change. Only action to achieve the 'deep' scenario will reduce total building energy use and $CO_2$ emissions over time.

Other common investments, such as cars, industrial equipment are replaced much more frequently than buildings. Renovation of existing buildings offer compelling opportunities for improvements but existing buildings are only renovated a few times in their life-cycle. Therefore, unless an investment in improving the energy performance at the outset the opportunity may be lost for decades.

This high lock-in risk points to the crucial importance of early action, strategic policy planning, as well as setting ambitious energy performance levels in building codes for new construction and deep renovation. Reducing building energy use by the mid-century in a meaningful way requires worldwide building codes to adopt performance levels as demonstrated by state-of-the-art approaches within a particular climate zone, even if it is not yet common practice. Globally, the combined

2. Cost-effectiveness is not globally defined in the LBNL study. Rather it depends on the relationship between the policy instrument under consideration and market conditions.

'deep' scenario savings compared to 'moderate' actions by 2050 is around 50 EJ, which is larger than the total energy use of all residential buildings in these four regions today. The combined 'deep' scenario savings compared to the 'moderate' scenario is around 25 EJ.

Energy savings and $CO_2$ mitigation potentials vary dramatically between the four regions. This section provides an overview of how far we can go in reducing energy use and related $CO_2$ emissions globally and in these regions by 2050. All figures are drawn from the scenario analysis conducted for GBPN by CEU (GBPN-a, 2012).

### USA

The US moderate scenario would see a growth from current 2.8 Gt per year to 3.1 Gt of $CO_2$ emissions by 2050. However, if the 'deep' scenario was implemented this would lead to a reduction to less than 1 Gt of $CO_2$ by 2050. Shifting to 'deep' action in the US by 2050 would allow a reduction of final thermal energy use of more than 65 % of 2005 levels (approx. 7 EJ).

If no action is taken (the 'frozen scenario), the US will face a 12 % growth in energy use (14.6 EJ). The difference in 2050 between the frozen and deep scenarios is almost 73 % of the US building consumption today, this accounts for more than the total residential energy consumption in the US today. The difference between the moderate and deep scenario is around 50 %. Therefore, without major changes to current energy policies and building practices, the US risks locking-in 50 % of 2005 final thermal energy uses. The lock resulting from too little or too slow action in the four regions is further described below.

### EUROPEAN UNION

While the moderate scenario for the EU could be improved by including more specifics of EPBD implementation of each member state, the initial modelling indicates the EU can achieve the greatest reduction in final energy use (65 %) and $CO_2$ emissions (66 %) by 2050 compared to 2005 levels despite an increase in floor area (of 27 %), population and economic activity. However, if no action is taken (the 'frozen' scenario), the EU will experience a growth of 5 % in final thermal energy demand (increase of approx. 1.2 EJ). The EU is expected to see a growth from current 2.0 Gt per year to 2.1 Gt of $CO_2$ emissions by 2050, however, if the 'deep' scenario was implemented this would lead to a reduction to 0.7 Gt of $CO_2$ by 2050. Shifting to 'deep' action in the EU would allow a reduction of energy use of around 70 % (approx. 10 EJ) by 2050. The EU could consume 3 times less energy to provide thermal comfort by 2050 than is required today. By comparison with other regions, the EU has a relatively small lock-in effect (10 %) as a result of strong energy reductions that could be driven by the full implementation of the EPBD.

### CHINA

The difference between the frozen and deep scenarios in 2050 is more than 70 % of Europe's building consumption today; this is greater than the total consumption in all of Europe's residential building stock today. Yet, if 'deep' action is taken the final thermal energy demand in 2050 could be 1 % less than 2005 levels. This represents a saving of approx. 8.6 EJ compared to the moderate scenario. This means that although

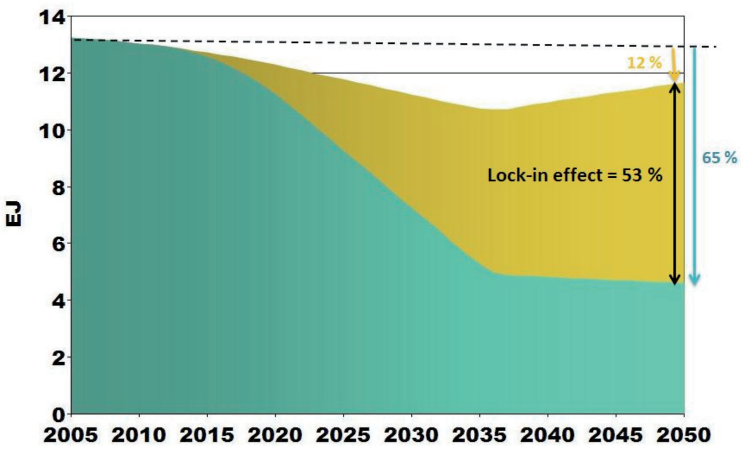


*Figure 2. Comparison of 'Moderate and Deep' thermal energy scenarios for USA showing potential for saving and lock-in.*

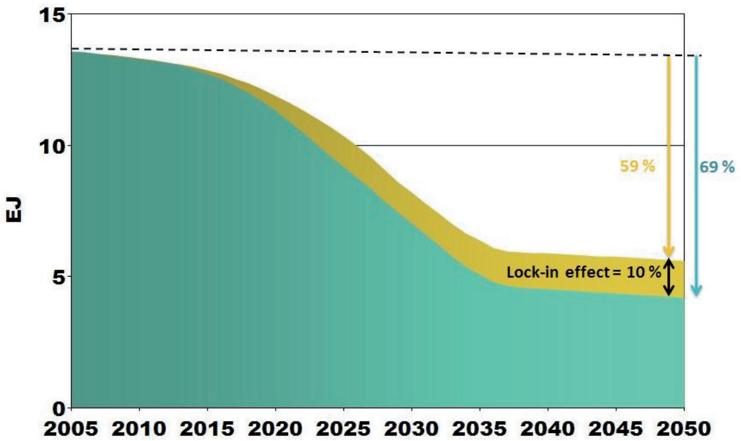


*Figure 3. Comparison of 'Moderate and Deep' thermal energy scenarios for EU showing potential for saving and lock-in.*

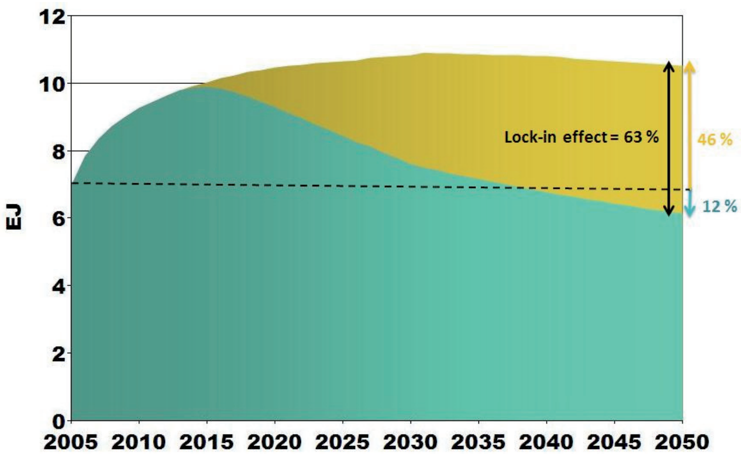


*Figure 4. Comparison of 'Moderate and Deep' thermal energy scenarios for China showing potential for saving and lock-in.*

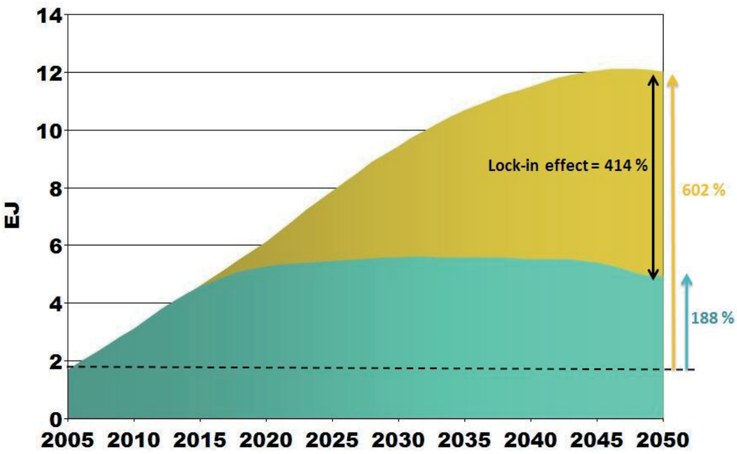


*Figure 5. Comparison of 'Moderate and Deep' thermal energy scenarios for India showing potential for saving and lock-in.*

China is experiencing a rapid growth in the buildings sector, it is possible for their energy use to be kept about the same as today's levels.

Consequently by 2050, the growth of $CO_2$ emissions, projected as 1.6 Gt can be reduced to 0.84 Gt under a deep scenario. The difference between frozen and deep is around 150 % or almost one and a half times the consumption of today's Chinese buildings. The difference between the moderate and deep scenarios in 2050 is around 63 %. Therefore, without major changes to current energy policies and building practices, China risks locking-in 63 % of 2005 final thermal energy use by 2050.

#### INDIA

If no action is taken (the 'frozen' scenario), India will face a growth of almost 700 % (20.6 EJ). If India shifts to a 'deep' scenario this will limit the growth in final thermal energy demand to around 130 % of 2005 levels. This savings potential is more than 5 times greater than what India uses in buildings today.

The 'deep' scenario, predicts India's $CO_2$ emissions will grow from 0.13 Gt to 0.44 Gt, but with no action the emissions will increase to 1.1 Gt by 2050. In 2050 the difference between the consumption of the frozen and deep scenarios is similar to almost 7 times the consumption of all of India's building consumption today. The difference between the moderate and deep scenarios in 2050 is around 400 percentage points. Most of the growth in India comes from new buildings. The short-term focus should then be on achieving the energy savings potential of new construction. India's 414 % lock-in risk, together with a 400 % growth in floor area, clearly indicates the crucial importance of working to achieve the 'deep' scenario.

### RENEWING policy settings and RESTARTING on a 'Deep Path'

While EU policy settings carry the least lock-in risk compared with USA, China and India there is still considerable lock-in risk globally – and that is not a good scenario if we are aiming to avoid the worst-case scenarios of climate change. A rethink of policy settings and rates of innovation is required. This rethink was presented at a Building Sector Summit in Paris in May 2012. Based on the feedback received and involvement of our advisory groups, a strategy was developed for renewing policy settings and closing the gap called the 'Deep Path' – state of the art policy packages that achieve net zero new buildings & promote deep retrofitting. Each region is at a different point so where we restart the process of implementation of 'deep' pathways and address the various attitudes of the business community (who we surveyed with the Economist Intelligence Unit) is also interesting to compare. The goals of this strategy are to support the rapid widespread adoption of policies that:

- Set net zero energy as mandatory performance targets for new buildings,
- Encourage more and deeper renovation of existing building stock.

In order to be on track to achieve the mitigation potential of the building sector, these goals need to be achieved in the next ten years. A rapid uptake of today's state-of-the-art policy practices is required and can be achieved by coordinated efforts to develop and implement policy packages of six essential enablers:

- Performance-based building energy codes;
- Data and mandatory rating & disclosure of building energy performance;
- Ensuring compliance with minimum performance requirements;
- Financing energy efficiency investments and retrofitting;
- Monitoring the co-benefits;
- Integrating renewables.

The policy packages must ensure that new constructions are based on integrated and bioclimatic design supporting the use of passive energy and the incorporation of renewable energy in buildings, this requires:

- *The development of ambitious performance based building codes:* The building energy target must be set as an absolute target rather than a relative target, energy efficiency codes for new buildings will ensure that energy efficiency becomes the norm and will cover most new buildings. Increasing the stringency of performance requirements with a target of mandating zero energy, zero carbon or energy positive buildings as standard in the next decade.
- *Adopting a holistic approach to building design:* Based on passive and bio-climatic design – first of all by reducing the energy needs of the building and then by ensuring efficient supply of energy and optimised use of renewable energy.
- *Focusing on the overall performance of buildings:* Looking at buildings as systems rather than individual demands for separate parts of buildings.

- *Encouraging the use of renewable energy:* Encouraging passive climatic design and active technological strategies for integrating renewable energy through incentives and other policy measures.
- *Focus on the lifetime costs, energy & benefits:* This approach should ensure economic optimisation of the policy measures over the building life-span and not just in the short term. Life-cycle costs, energy savings and co-benefits should be taken into consideration.
- *Proper implementation and enforcement:* Implementation and enforcement of these ambitious building energy efficiency codes to ensure that the full potential of savings in new buildings is harvested.
- *Supporting buildings that go beyond minimum requirements:* Energy efficiency demands should be a minimum and support building to go beyond the minimum requirements in order to drive innovation and develop new and cost effective solutions. Public buildings must demonstrate the way for other new constructions.

#### ENGAGING THE PRIVATE SECTOR

Key to succeeding in rapid implementation of deep path policies is engaging with the private sector and encouraging demand for and investment in low energy buildings. A survey commissioned by GBPN of 423 real estate and construction executives in the US, Europe, India and China shows that there is a large consensus among executives on the issue of climate change (EIU, 2012). The study, conducted by the Economist Intelligence Unit found more than seven in ten executives in the European Union, India, China and the USA (75 %), think energy efficiency legislation benefits the building sector. One third (34%) of the respondents say a lack of enforcement of existing regulations is a leading obstacle to investments in efficiency. This positive view of legislation presents significant opportunities for decision makers in all regions to develop policy tools that can achieve 'deep' scenario savings. The study shows how real estate and construction executives from some of the world's largest firms approach energy efficiency regulation in their business. Key findings include:

- There is a large consensus among executives worldwide on the issue of climate change. In Europe, China and India, 84 % of respondents consider cutting carbon missions associated with their business to be their responsibilities. In the US, however, only 60 % of respondents are of that opinion.
- Many companies are ill informed about energy realities and the true cost of energy consumption. One third of the respondents underestimate the financial significance of energy consumption in their own business. Many are also unclear about the cost of constructing energy efficient buildings. While the actual cost varies between 5 and 15 %, two thirds of respondents overestimate the cost saying that energy efficient buildings cost 15 % more than a standard structure.
- The view that energy efficiency is good for business is gaining momentum across the building sector. 63 % of the respondents say that energy efficiency influences their investment decisions; and this is true across all regions. Half of respondents are taking a longer-term view of investments. More than 50 % of respondents are ready to tolerate payback terms of 5 years or longer.
- Companies are already taking action. 40 % of respondents say they are going beyond equipment upgrades. Half of respondents are adding building insulation, almost the same proportion is adopting more efficient HVAC systems and replacing inefficient lighting (57 %).
- Businesses welcome carrots and sticks. They see legislation as a means of levelling the playing field, thus strengthening the business case for energy investments. 68 % of respondents estimate that carbon taxes are helpful to drive investments in efficient buildings. The same proportion believes that global agreements limiting carbon emissions would create a level playing field for businesses in which there is more certainty in the future policy commitments of governments.

## Conclusion

The building sector has the largest cost-effective GHG abatement potential compared with other sectors (IPCC, 2007; IEA, 2012). Our 2012 scenario modelling showed a significant technical GHG mitigation potential for building sector, while our best-practice policy research revealed that building sector energy consumption and related GHG emissions is likely to increase by about 50 % by 2050 if we maintain our current rate of building energy policy implementation. Alternatively we can follow a 'deep' mitigation scenario, which leads to absolute reductions in building energy consumption and associated emissions of around 30 % of 2005 levels (avoiding a 77 % lock in of inefficiency) by 2050. Under the 'deep' scenario we estimate achieving global savings 3.2 Gt by 2050. Achieving this abatement potential requires today's state of the art building energy performance codes and complimentary policies to be optimized in regional jurisdictions towards net zero energy targets for new buildings and deep renovation for existing buildings. This translates into a strategic definition of best-practice actions as being those that encourage adoption of policy frameworks for achieving these ambitious goals.

The 'deep' path can be realised by developing roadmaps for developing and implementing policy packages built around effectively enforced performance based building energy codes. Policy makers should be encouraged by the private-sector's readiness to accept more stringent performance standards in the building sector. Finally, It is important to realize that our ability to achieve the significant energy and $CO_2$ emission reductions becomes increasingly difficult and expensive if action is delayed. Immediate action and significant changes are required before 2020 to bring building thermal energy use to the predicted savings of the 'deep' scenario by 2030 and 2050. After 2020 the gap between the trajectory of current practices and the 'deep' scenario becomes increasingly difficult to bridge. The actions taken now and implemented the next ten years are therefore critical.

## References

GBPN-a, Diana Urge-Vorsatz, Ksenia Petrichenko, Miklos Antal, Maja Staniec, Michael Labelle, Eren Ozden, Elena Labzina (2012): Best Practice Policies for Low Energy and Carbon Buildings. A Scenario Analysis. Research report prepared by the Center for Climate Change and Sustainable Policy (3CSEP) for the Global Buildings Performance Network. Paris, May.

GBPN-b, Mark Levine et al. (2012) Building Energy Efficiency Best Practice Policies and Policy Packages a report to the Global Buildings Performance Network. Paris, May.

EIU, Economist Intelligence Unit (2012) Energy Efficiency and Energy Savings: A view from the building sector a report commissioned by the Global Buildings Performance Network, New York, October.

IEA, International Energy Agency (2007) Foreign Electricity Emission Factors, 1999–2002 IEA, Paris.

IEA, International Energy Agency 2011.Voluntary reporting of Greenhouse Gases Program, Emission Factors and Global Warming Potentials, Online: http://www.eia.doe.gov/oiaf/1605/emission_factors.html. Updated 31/01/2011.

IEA, International Energy Agency (2012) World Energy Outlook IEA, Paris.

IPCC, Intergovernmental Panel on Climate Change (2007) 4th Assessment Report

IPCC, Intergovernmental Panel on Climate Change (2006). Revised IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.