THE **NEW** CLIMATE **ECONOMY**

The Global Commission on the Economy and Climate

Technical Note

Estimates of Emissions Reduction Potential for the 2015 Report

NEW CLIMATE ECONOMY PROJECT

CONTENTS

Disclaimer

This paper was compiled by the New Climate Economy (NCE) project team as part of the research conducted for the Global Commission on the Economy and Climate's report, *Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate*. Much of the analysis was conducted for the New Climate Economy by Ecofys, and the paper also draws on analysis by the Stockholm Environment Institute, and World Resources Institute.

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1. INTRODUCTION

The Global Commission on the Economy and Climate's 2015 report, *Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate*,[1] identifies actions in ten key areas which can simultaneously foster economic growth and development and reduce projected greenhouse gas (GHG) emissions. It makes recommendations on how international and multi-stakeholder partnerships of various kinds – between national and sub-national governments, businesses, investors, international organisations and civil society – can scale up current efforts in these areas. The report provides estimates of the potential GHG emissions reductions which could be achieved by implementation of its recommendations.

The report's conclusion is that implementation of the recommendations could reduce annual global GHG emissions by between 16 and 26 Gt CO_2e by 2030, relative to a 'business as usual' baseline. It notes that this represents 59-96% of the 'emissions gap' between the business as usual baseline and the level of emissions estimated to be needed to have a likely chance (66% or greater) of holding global warming to under 2˚C, the internationally-agreed goal (see Figure 1).

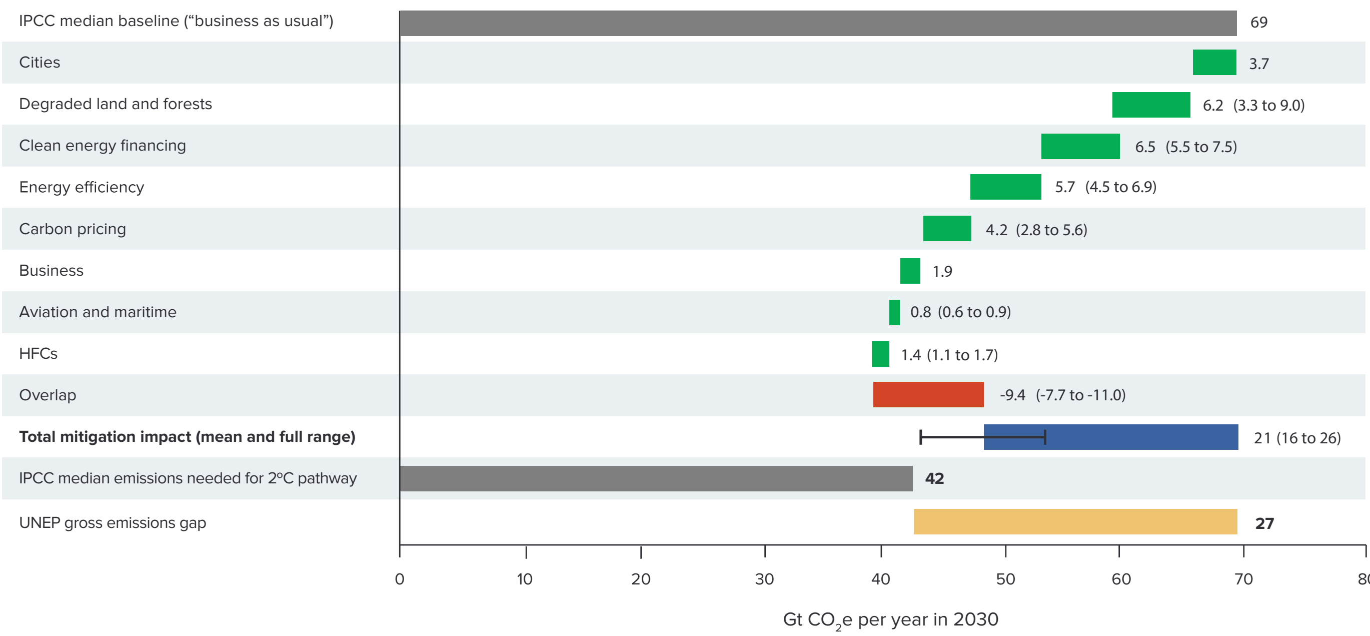
This technical note sets out the analysis underpinning this estimate. It explains the baseline scenarios from which emissions reductions have been calculated, and the estimate of the emissions 'required' for a 2˚C pathway. It sets out the methodologies and sources used in each recommendation area to estimate emissions reduction potential, and the uncertainties which generate ranges of possible impact. It then explains how the overlaps between the recommendations have been subtracted in order to arrive at the aggregate emissions reduction potential of the recommendations as a whole. It also explains how the report's calculations relate to the estimates of the emissions gap in the UN Environment Programme's Emissions Gap reports, and to the aggregation of emissions targets set out in the national climate pledges ('intended nationally determined contributions' or INDCs) being brought forward for the UN climate conference in Paris in December 2015.

This note should be read in conjunction with the full *Seizing the Global Opportunity* report.

Figure 1

The emissions reduction potential of the report recommendations

Full implementation of the Commission's recommendations could achieve up to 96% of the emissions reductions in 2030 needed to keep global warming under 2°C.



2. Overall methodology

The overall methodology for estimating the emissions reduction potential of the recommendations made in *Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate* involved four steps:

- Identification of a business as usual (BAU) level of global emissions in 2030.
- Identification of a level of global GHG emissions in 2030 consistent with holding the rise in average global temperature to 2°C.
- Estimation of the range of potential emissions reductions which could be achieved by implementation of the report's recommendations, where amenable to such analysis.
- Determination and subtraction of the overlaps between the recommendations in order to arrive at an aggregate estimate for the recommendations as a whole.

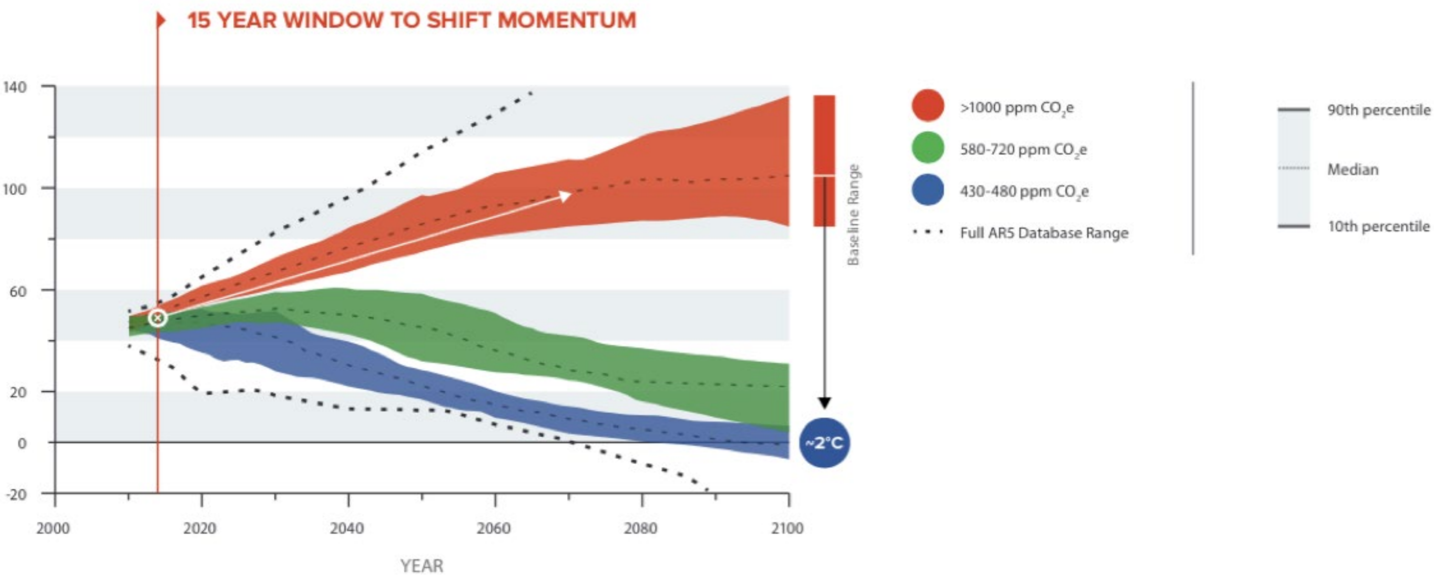
IDENTIFICATION OF BUSINESS AS USUAL (BAU) GLOBAL EMISSIONS IN 2030

Although some of the recommendations in the report are for actions to take effect well before 2030, this was selected as an appropriate year to project their potential emissions reductions in order to achieve consistency across them and with many of the national climate pledges being brought forward for the UN climate conference in Paris.

The BAU estimate for 2030 emissions was taken from modelling scenarios surveyed by the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC),[2] and analysed by the UNEP Emissions Gap Report 2014.[3] As in the UNEP Report, the level chosen is the median value for emissions in 2030 from the IPCC's BAU pathways (Figure 2, >1,000 ppm CO_2e). These pathway project emissions today of around 50 Gt CO_2e rising to 63-72 Gt CO_2e in 2030, with a median value of 68-69 Gt CO_2e.[4] The single median figure should therefore be treated with some caution.

It is important to note that 'business as usual' in this baseline assumes no significant mitigation action after 2010. It therefore does not reflect the impact of policies introduced since then and which are now being implemented. To ensure consistency, the same concept of BAU has been used in calculating the emissions reduction potential of the recommendations in this report. This is discussed further below.

Figure 2
IPCC baseline and mitigation scenarios



Source: IPCC, 2014.[5]

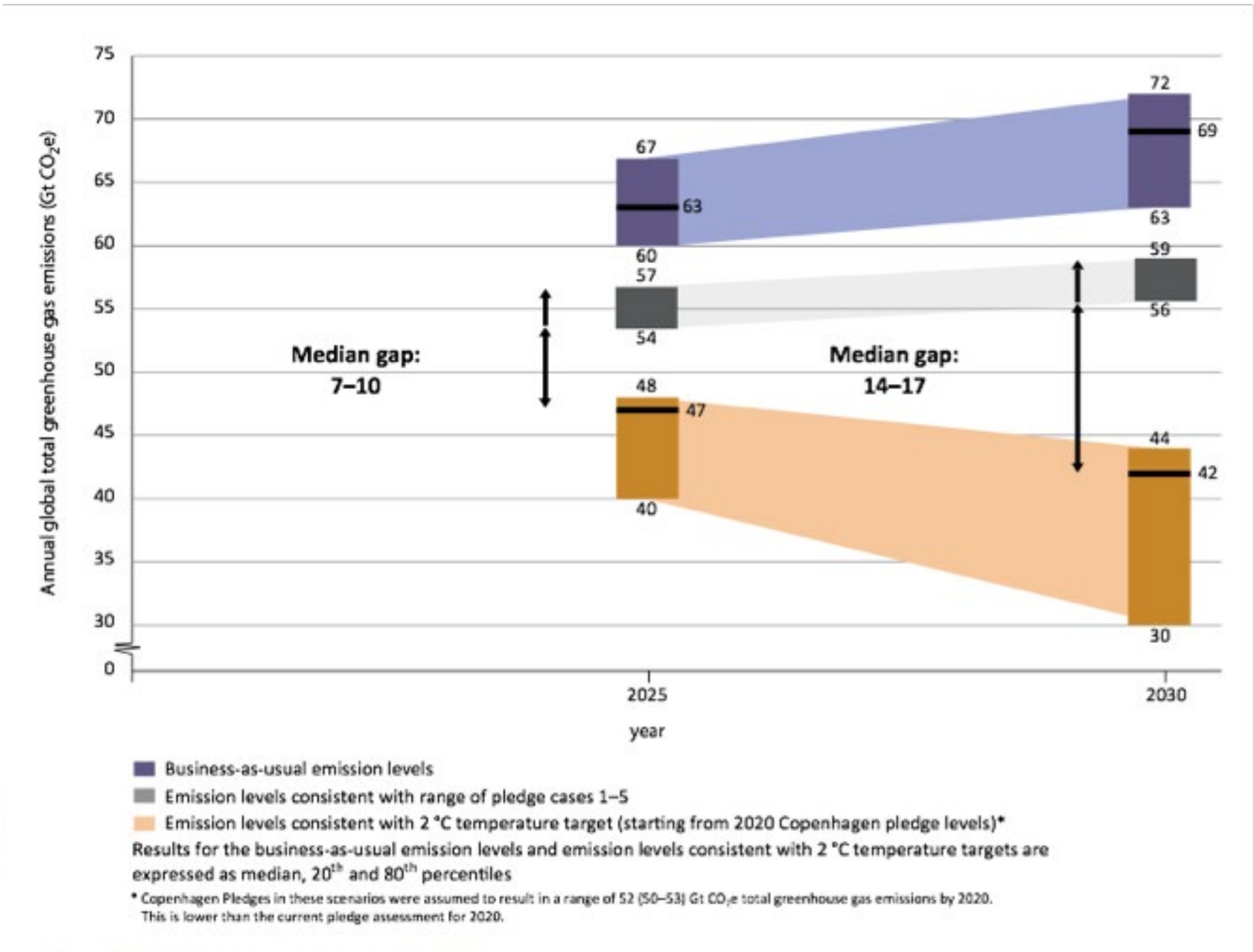
IDENTIFICATION OF THE 'REQUIRED LEVEL' OF GLOBAL GHG EMISSIONS IN 2030 FOR A 2°C PATHWAY

The IPCC survey a range of modeling scenarios consistent with a 'likely' (greater than 66%) chance of holding average global temperature rise to 2°C or less (Figure 2, 430-480 ppm CO_2e).[6] As analysed in the UNEP Emissions Gap Report (Figure 3), these project a level of emissions between 30 and 44 Gt CO_2e in 2030, with a median value of 42 Gt CO_2e in 2030. This is therefore taken in this report as the level of emissions in 2030 'required' for a 2°C pathway. Again, however, some caution should be exercised in relation to this figure. It is a median of a range of least-cost scenarios, all of which include negative emissions in the second half of the century, and which give only a 'likely' chance of meeting the 2°C goal.[7] It therefore embodies considerable uncertainty.

It is also critical to recognize that whether a particular annual level and composition of GHG emissions in 2030 is ultimately consistent with a 2°C pathway depends on many factors, not least how emissions fall thereafter, including the potential for net negative in the second half of the century. Importantly, the fact that emissions decline in a given period is not necessarily a sign of further decreases in the future. For example, high-carbon infrastructure investments could be made today that lock in higher future emissions and make subsequent reductions more difficult and costly, resulting in high future cumulative emissions. Many of the recommendations in the report are specifically aimed at avoiding such lock-in, but the analysis of mitigation potential does not specifically model this and the implications beyond 2030.

Figure 3

The Emissions Gap in 2030



Source: UNEP, 2014.[8]

The difference between the BAU baseline in 2030 (69 Gt CO_2e) and the level of emissions consistent with a 2°C pathway (42 Gt CO_2e) gives a 'gross emissions gap' of 27 Gt CO_2e in 2030. This is the gap which policies since 2010 need to close if the world is to be on a pathway to achieving this internationally-agreed goal.

It is important to note that this "gross emissions gap" is not the same as the "remaining emissions gap" upon which the UNEP reports focus. The latter is the gap between the expected impact of current policies, and the level of emissions required for a 2°C pathway. The UNEP Emissions Gap reports have focused on the remaining emissions gap in 2020, since that is the year for which most countries have up to now set targets. UNEP will publish a new emissions gap report later in 2015 which will attempt to calculate the 'remaining emissions gap' in 2030 after consideration of the national climate pledges ('intended nationally determined contributions' or INDCs) made in advance of the Paris conference. Since only some INDCs had been published at the time of publication of the present New Climate Economy report, this has not been attempted here. The emissions gap referred to in this report is the gross gap from business as usual, not the remaining gap after policy commitments.

ESTIMATION OF THE POTENTIAL EMISSIONS REDUCTIONS FROM THE REPORT'S RECOMMENDATIONS

The emissions reduction potential of the report's recommendations was calculated for all recommendations except those on ensuring climate-smart infrastructure and on galvanising low-carbon innovation. These were not amenable to quantitative estimation of impact.

A two-step process was used to calculate the emissions reduction potential in each field. First, GHG emissions in 2030 were estimated for a scenario in which the report recommendation was implemented, using various conservative assumptions. The emission reductions estimates, and assumptions underpinning them, were estimated conservatively to not overstate the likely impact of the recommendations. These estimates were then aggregated and then subtracted from the emissions in 2030 under a BAU baseline scenario to give the emissions reduction potential of the recommendation.

To quantify the potential mitigation impact of each recommendation, a detailed and well-documented baseline was needed. This had to be more granular than most of the IPCC scenarios surveyed above, with specific 'bottom-up' emissions projections in each field of the recommendations, including a breakdown of (i) energy-related CO_2 emissions, principally resulting from the combustion of fossil fuels; (ii) non-energy CO_2 emissions, largely related to land-use changes; and (iii) non-CO_2 emissions, resulting from industrial processes, agriculture and waste as well as energy.[9] A range of scenarios developed or aggregated by leading organisations and institutions were reviewed; the following estimates and sources were used for BAU emissions in 2030:

- 45.1 Gt CO_2e for energy-related CO_2 emissions, as given by the 2014 Energy Technology Perspectives (ETP) 6 degree scenario (6DS) of the International Energy Agency (IEA);[10]
- 3.5 Gt CO_2e for non-energy emissions, estimated from the median baseline used by the IPCC.[11]
- 15.4 Gt CO_2e for non-CO_2 emissions, as given in the latest estimate of the US Environmental Protection Agency (EPA).[12]

These estimates combine widely acknowledged and broadly used projections from leading institutions, with well-documented scenarios providing detail on underlying assumptions. This allowed estimation of the potential impact of the recommendations in the Commission's report.

These scenarios give aggregate "bottom up" baseline BAU emissions of 64 Gt CO_2e in 2030. This is within the range of 63-72 Gt CO_2e in 2030 given by the IPCC / UNEP scenario analysis, but lower than the 69 Gt CO_2e median IPCC / UNEP value. This discrepancy is largely a result of differences in the baseline for energy-related emissions resulting from modelling differences between the scenarios used by the IPCC (the median of which amounts to approximately 49 Gt CO_2e) and the IEA's 6DS scenario (45 Gt CO_2e). The higher IPCC / UNEP baseline implies a higher emissions reduction potential and therefore the possibility to bridge an even larger part of the emissions gap. Therefore, the estimates made in this report using a baseline of 64 Gt CO_2e in 2030 should be regarded as conservative.

In the energy field the IEA 6DS scenario from its 2014 Energy Technology Perspectives (ETP) report has been used as the BAU baseline. The 6DS scenario is an extension of current emission trends. In this scenario, energy use grows steadily to 2050, where it is forecast to be two thirds higher than 2011 levels. The scenario is consistent with a global temperature rise of at least 6°C. The other ETP scenarios are a 4 degree scenario (4DS) and 2 degree scenario (2DS) with emissions of 39 and 28 Gt CO_2e, respectively. The 4DS in 2030 is consistent with current policy and pledges, which if achieved would be consistent with a global temperature rise limited to approximately 4°C. The 2DS scenario describes an energy system that is consistent with mitigation pathways that have at least 50% chance of limiting global warming to 2°C. Under this scenario, energy-related emissions are cut by more than half by 2050, and additional efforts are needed from non-energy and non-CO_2 emissions.

DETERMINATION AND SUBTRACTION OF THE OVERLAPS BETWEEN THE RECOMMENDATIONS

For each recommendation, the emissions reduction potential has been calculated, in most cases with a range. However, several of the recommendations overlap – for example, investment in energy efficiency in buildings is one of the impacts of the recommendations on cities, on clean energy financing and on energy efficiency standards. These overlaps have therefore been subtracted in order to arrive at the aggregate potential of the recommendations as a whole. This has, like the individual estimates themselves, been done on a conservative basis. So, for example, the entire impact of introducing carbon pricing among G20 countries has been subtracted, on the grounds that some of the impact of this policy instrument will also be the result of, say, energy efficiency standards or major businesses undertaking emissions reductions. It is analytically difficult to know exactly how much of an overlap there might be; so to be conservative 100% of the impact has been subtracted. This and the treatment of other overlaps are detailed in Section 4 below.

UNCERTAINTY AND LIMITATIONS OF THE ANALYSIS

The estimates of emissions abatement potential and costs and benefits have been based on existing literature and new research commissioned for NCE. There are many uncertain factors that affect the analysis – from technical aspects, to the feasible pace and extent of implementation given significant barriers to action in some cases. Given those uncertainties, the estimates cannot be precise. In most cases ranges are given, reflecting the literature where available. The high end of the range would require early, broad and ambitious implementation, with decisive policy change and leadership, rapid learning and sharing of best practices, and the very strong international cooperation that the report calls for.

Some additional limitations of the analysis include:

- Baseline estimates. As discussed, this analysis collates multiple separate analyses, which means that underlying assumptions differ in some cases. Important examples include future baseline emissions and assumptions about the costs of key technologies and inputs. This gives rise to the ranges provided in a number of cases.
- Interactions between measures. As already indicated, double-counting of emissions reductions has been avoided by subtracting those likely to arise from more than one recommendation.
- Consideration of wider impacts. Integrated models of emissions abatement have identified important knock-on impacts of measures that reduce emissions. Examples include 'rebound' effects, whereby economic activity can increase as a result of productivity improvements (e.g. increased energy consumption as a result of higher energy efficiency), and changes in relative fuel prices in response to changing energy consumption patterns. Within the analysis of energy efficiency standards assumptions have been made, based on the analytical literature, of the likely rebound effects, and emissions reduction impacts reduced accordingly. But it cannot be guaranteed that other wider impacts have been fully taken onto account.

These uncertainties, and the assumptions used to account for them, are detailed in each section.

3. Assessment of mitigation potential

RECOMMENDATION 1: ACCELERATE LOW-CARBON DEVELOPMENT IN THE WORLD'S CITIES

All cities should commit to developing and implementing low-carbon urban development strategies by 2020, using where possible the framework of the Compact of Mayors, prioritising policies and investments in public, non-motorised and low-emission transport, building efficiency, renewable energy and efficient waste management.

Estimate of annual mitigation potential by 2030: 3.7 Gt CO_2e

The estimate of mitigation potential is based on analysis conducted by the Stockholm Environment Institute (SEI) of 11 different possible urban measures in the building, transport and waste sectors. It draws heavily on a study by the Stockholm Environment Institute.[13]

The analysis is based on a baseline scenario of economic activity, energy use and GHG emissions in the absence of aggressive urban climate action, but which included recently adopted national policies, such as vehicle efficiency standards in China, the EU, and the US. The reference case draws heavily from the IEA's ETP 4DS, with consideration of additional, urban-focused research from a number of other institutions, including the Global Buildings Performance Network (GBPN) and the Institute for Transportation and Development Policy (ITDP). For urban areas in each region, the reference scenario was constructed by multiplying urban population by activity drivers (e.g. passenger travel or residential floor space per person), by energy-intensity (e.g. energy per unit of passenger travel or floor space) and/or by GHG-intensity of energy. These emission reductions would be additional to those generated by any national policies adopted as a result of recent pledges and actions. The baseline used here is therefore somewhat different from the BAU baseline used for other recommendations. Since under the BAU scenarios less ambitious action takes place than is currently planned by nation states, the mitigation potential in cities of these actions would be even higher than given here. The estimates used in the report should therefore be considered conservative.

The baseline case is compared with an 'urban action scenario' that assumes the application of a set of aggressive technologies and practices to curb urban energy use and GHG emissions. Again, the urban action scenario is constructed by multiplying key activity drivers by urban population as a proportion of total population in each country or region (depending on data availability).

The urban action scenario in the building sector includes new building standards at passive house levels and deep building shell retrofits, including heat pumps in buildings with average heating degree days between 2000 and 5000. Construction rates, energy retrofit rates and energy intensities were guided by analysis from the Global Buildings Performance Network.[14] Assumptions for more efficient appliances and lighting were based on the IEA's 2DS.[15] Estimates for solar PV potential in cities assumes that half of the solar PV in the IEA's 2DS is distributed PV, and that this is built in urban areas proportional to the share of urban population. For any given city, generation capacity is limited at the maximum (0.5 W/m2) level identified by an assessment by the International Institute for Applied systems Analysis (IIASA).[16] It is estimated that the urban mitigation potential of the buildings sector is 2.4 Gt CO_2e in 2030. Realising this would require investment of US$23.7 trillion between 2015 and 2050, generating economic savings of US$961 billion per year by 2030 and US$3.4 trillion per year by 2050.

The urban action scenario in the transport sector includes land use planning for compact urban form reduces passenger travel activity (pkm per capita) up to 7% in OECD countries and 25% in developing countries, based on allocating all reduction in road passenger transport demand in ETP to urban areas.[17] These reductions are generally consistent with the opportunity found in studies of individual cities.[18] In addition, freight transport logistics improvements lead to a 5% reduction in tkm per capita by 2030 and 12% by 2035.[19] Assumptions about expanded mode share of public transport are adapted from a study from the ITDP.[20] The energy intensity of passenger vehicle electrification is based on the 2DS scenario (this is the 2DS sub-scenario which incorporates electrification of transport), while one quarter of energy demand for freight transport is assumed to be electrified. Estimates of increased operational efficiency of the road network and transport system are based on vehicle efficiency improvements resulting from ramp metering, active traffic management, integrated corridor management, incident management, and signal control management.[21] It is estimated that the urban mitigation potential of the transport sector is 1.1 Gt CO_2e in 2030. Realising this would require investment of US$10.4 trillion between 2015 and 2050, generating economic savings of US$618 billion per year by 2030 and US$2.4 trillion per year by 2050.

The urban action scenario in the waste sector includes increasing the fraction of waste collected to 90% and increasing the recycling rate to 80% of recyclables in all regions. Methane capture rates are projected to increase by increasing the share of facilities that capture methane (up to 80% in OECD and 50% in non-OECD countries by 2050, relative to a reference scenario of 65% and 30% respectively) and increasing the efficiency of methane capture by 1.3% per annum in all regions.[22] A 2% annual growth in methane capture capable facilities that also generate grid electricity is assumed, compared to 0% growth in the reference scenario. It is estimated that the urban mitigation potential of the waste sector is 0.2 Gt CO_2e in 2030. Realising this would require investment of US$34 billion between 2015 and 2050, generating economic savings of US$657 million per year by 2030 and US$3 billion per year by 2050.

This assessment does not consider avoided investment costs, such as reduced expenditure on new cars and roads, or savings beyond 2050, although many of the infrastructure investments have long lifespans. Accounting for these benefits would significantly increase the net present value of these investments. On the other hand, this analysis does not account for either rebound effects or interactions among measures that could reduce the net abatement potential. It is therefore possible that these urban actions might not yield the full carbon savings estimated.

RECOMMENDATION 2: RESTORE AND PROTECT AGRICULTURAL AND FOREST LANDSCAPES AND INCREASE AGRICULTURAL PRODUCTIVITY

Governments, multilateral and bilateral finance institutions, the private sector and willing investors should work together to scale-up sustainable land use financing, towards a global target of halting deforestation and putting into restoration at least 500 million ha of degraded farmlands and forests by 2030. Developed economies and forested developing countries should enter into partnerships that scale up international flows for REDD+, focused increasingly on mechanisms that generate verified emission reductions, with the aim of financing a further 1 Gt CO_2e per year from 2020 and beyond. The private sector should commit to extending deforestation-free supply chain commitments for key commodities and enhanced financing to support this.

Estimate of annual mitigation potential by 2030: 3.3-9.0 Gt CO_2e

The estimates of mitigation potential are taken from the 2014 Global Commission report *Better Growth, Better Climate* report and its accompanying technical note, using a range of estimates surveyed by the IPCC.

Forests

There is significant uncertainty about the net GHG emissions from land use change. The IPCC recently surveyed 13 global process models assessing net emissions from all sectors for the period 2000–2009.[23] It found the average estimate of emission reductions from halting deforestation as 4.4 Gt CO_2e, but with a substantial range of uncertainty of +/- 2.2 CO_2e. More recent estimates for the period 2002–2011 are lower (2.93 Gt CO_2e +/- 2.2) than those for 2000–2009.[24]

Another significant source of uncertainty is the extent to which lowered deforestation (land use change) implies lowered degradation (tree removal). It is possible to significantly increase tree removal, but have no impact on deforestation if the harvested areas are allowed to regenerate into forest instead of being converted to some other use. Higher degradation means greater immediate carbon loss, and the success in halting tree removal is thus a strong determinant of the extent to which emissions savings can be realised.

The starting assumption for the analysis is that baseline emissions remain relatively stable over time in the absence of additional policy action.[25] A central estimate of 3 Gt CO_2e net savings from halting deforestation and associated degradation is used, based on the IPCC mean estimate for 2002–2011.[26] For a high-end estimate the IPCC's meta-analysis average of 4.4 Gt CO_2e for 2000- 2009 is used, and an equal proportionate lower-end estimate of 1.6 Gt CO_2e, to represent a case with lower baseline emissions, less success in halting deforestation, and/or less success in halting tree removal where deforestation is halted. The estimated range is therefore 1.6-4.4 Gt CO_2e.

Land degradation
For agricultural (mainly soils) restoration, it is assumed that the 150 million hectares are generated from 15 million hectares in intensive projects[27] and 135 million hectares of farmer-managed natural regeneration (FMNR) over 15 years to 2030. For the abatement potential from 15 million hectares in intensive projects, the estimates are based on the carbon savings achieved by two World Bank watershed rehabilitation projects in the Loess Plateau of China. These represent good practice in intensive landscape restoration projects implemented by multilateral financial institutions in concert with national governments. If the carbon savings achieved in this example were applicable to 15 million hectares, emissions would be reduced by 0.1 Gt CO_2e per year in 2030.[28]

For the 135 million hectares of FMNR the good practice example of 5 million hectares of agricultural landscape restoration in the Maradi-Zinder region of Niger is used. This achieved significant benefits at scale with minimal fiscal investment.[29] Independent estimates suggest carbon sequestration in this case of 2 tonnes of carbon per hectare per year (corresponding to 7.33 Gt CO_2e per ha per year), a common figure for drier tropical woody areas.[30] If this rate of sequestration were applicable to the full 135 million hectares, it would give a mean estimate of 1.0 Gt CO_2e per year in 2030.

The total illustrative estimate from intensive projects and FMNR therefore is 1.1 Gt CO_2e. In consideration of the uncertainties around both sequestration rates (i.e. whether the Niger value is representative for a global portfolio of projects) and feasible implementation, a range is used around the mean of +/- 0.6 CO_2e, or 0.5–1.7 Gt CO_2e per year in 2030.

For forest restoration (mainly trees), the estimates are based on Verdone et al. (forthcoming), which estimates 1 Gt CO_2e sequestered from 150 million hectares of restoration. Applied to the area of 350 million hectares by 2030, this implies sequestration of 2.3 Gt CO_2e.[31] The study reported in Verdone et al. is based on an assumed mix of planted forest, naturally regenerated forests and agroforestry with different carbon sequestration potentials. For a lower end of the range, it is assumed that the same mix would apply to the 350 million hectares, but that only half of the potential would actually be achievable. This results in a lower-end estimate of 1.2 Gt CO_2e per year in 2030. For the upper end of the range, it is assumed that the full 350 million hectares are implemented, and the mix includes a greater proportion of agroforestry and other types of plantations with greater sequestration potential. The number is therefore adjusted up by 25% from 2.3 Gt CO_2e to 2.9 Gt CO_2e per year to account for this possibility. The estimated range is therefore 1.2-2.9 Gt CO_2e.

Total
Adding together the estimates of mitigation potential from forests (1.6-4.4 Gt CO_2e), restoration of degraded agricultural land (0.5-1.7 Gt CO_2e) and restoration of degraded forest land (1.2-2.9 Gt CO_2e) gives a total range of mitigation potential for this recommendation of 3.3-9.0 Gt CO_2e.

RECOMMENDATION 3: INVEST AT LEAST US$1 TRILLION A YEAR IN CLEAN ENERGY

To bring down the costs of financing clean energy and catalyse private investment, multilateral and national development banks should scale up their collaboration with governments and the private sector, and their own capital commitments, with the aim of reaching a global total of at least US$1 trillion of investment per year in low-carbon power supply and (non-transport) energy efficiency by 2030.

Estimate of annual mitigation potential by 2030: 5.5 - 7.5 Gt CO_2e

The estimate of mitigation potential is based on analysis produced by the International Energy Agency (IEA) on the emission savings that would flow from US$1 trillion of clean energy investments by 2030 in the sectors of energy supply and (non-transport) energy efficiency.

The goal of investing US$1 trillion in clean energy by 2030 arises from the investments set out in the IEA's 450 scenario in its 2014 World Energy Investment Outlook report.[32] The report provides projections for cumulative investments in clean in the period 2014-2035. In order to determine the shares in 2030 of the different forms of clean energy investment (renewables, nuclear, CCS, and energy efficiency in buildings and industry), the more detailed investment path set out in the New Policies scenario (which is not given for the 450 scenario) is used. The same shares are applied to the cumulative investments under the 450 scenario, as shown in Table 1.

Table 1

Clean energy investments under New Policies and 450 scenarios based on IEA WEIO, US$ trillion

	New Policies Scenario			450 scenario	
	Cumulative 2014-35	Cumulative 2014-30	Share before 2030	Cumulative 2014-35	Implied 2014-30
Fossil fuels	2,635	2,010	76%	2,877	
Implied CCS	-	-	76%	933	712
Nuclear	1,061	857	81%	1,722	1,391
Renewables	5,857	4,227	72%	8,809	6,357
EE industry	739	502	68%	1,371	931
EE buildings	2,334	1,689	72%	4,040	2,924
Total Clean Energy Finance	**9,991**	**7,275**	**-**	**16,875**	**12,315**

The 2014 WEO report[33] gives total energy-related emissions under the 450 scenario in 2030 as 25.4 Gt CO_2e, which is 15.4 Gt CO_2e lower than the 40.8 Gt CO_2e given in the Current Policies scenario. Moreover, the Current Policies scenario already assumes investments in renewables and nuclear increase towards 2030, resulting in 5522 TWh additional clean energy capacity. Applying an emission factor[34] based on the mix of fossil fuel-capacity under Current Policies in 2030 (0.76 t CO_2e/MWh), the equivalent emission reductions triggered by these investments under Current Policies are 4.2 Gt CO_2e.[35] As a consequence, the emissions projected under the 450 scenario are 19.6 Gt CO_2e (15.4 Gt CO_2e + 4.2 Gt CO_2e) lower than under a business as usual scenario.

Table 2

CO_2e emissions in 2030 under Current Policies and 450 scenario in IEA WEO, Mt CO_2e

	Total emissions[38]	Power	Transport	Other final energy use	Emissions from other energy sector
Current Policies	40,848	17,717	9,194	12,059	1,878
450 scenario	25,424	7,262	6,742	10,007	1,413
Difference	**15,424**	**10,455**	**2,452**	**2,052**	**465**

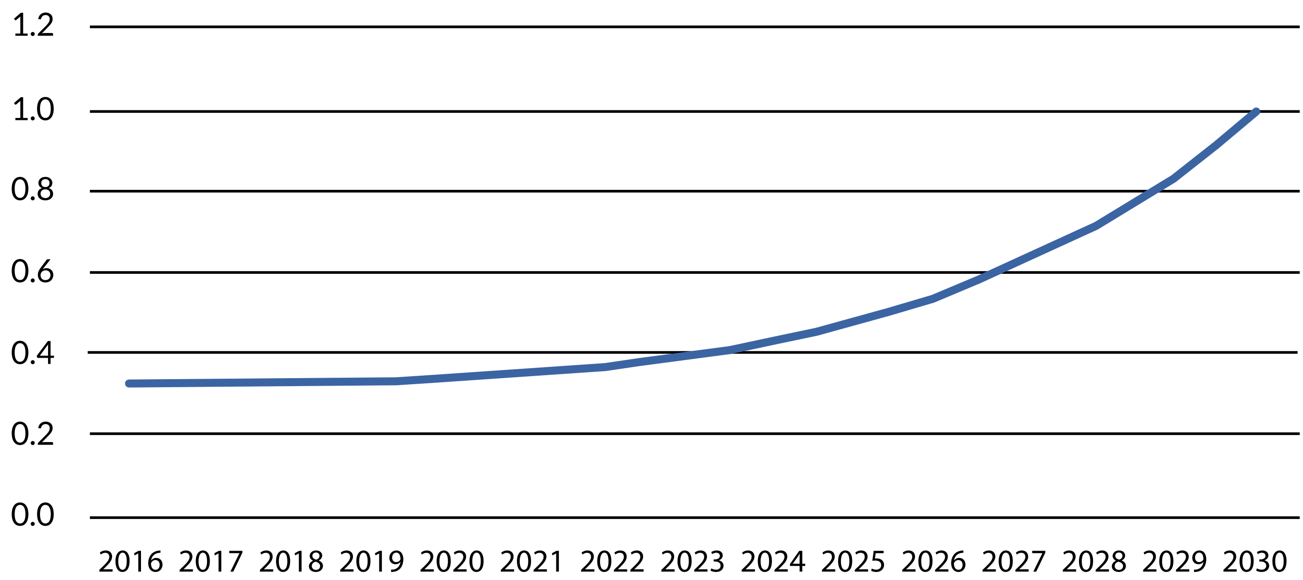
In order to assess the mitigation impact of the measure, two corrections need to be made to these emission reductions. First, not all reductions in emissions can be attributed to investments under the 450 scenario. The investments covered by the report recommendation focus on renewables, nuclear, CCS and industrial and buildings energy efficiency, but exclude transport. Therefore, the 2.45 Gt CO_2e of emission reductions due to transport measures in the 450 scenario are deducted (see Table 2).

In addition, the 450 scenario includes 2.05 Gt CO_2e of emissions reductions from other final energy use', compared to Current Policies.[37] This reduction cannot be completely attributed to investment, since it can also be triggered by pricing policies, by efficiency gains through technology improvements that do not require explicit investments or by good housekeeping measures and activity shifts. The magnitude of this effect is difficult to quantify. Therefore it is conservatively assumed that only 50% of the reductions through energy efficiency in other final energy use can be attributed to investments. (In energy supply, it is plausible to link all emission reductions to investments.) Applying both corrections, the total reduction in emissions from the Current Policies BAU baseline realised through the cumulative investment of US$12.3 trillion by 2030 is 16.1 Gt CO_2e.

A second correction relates to the assumed investment path. Whereas the WEIO assumes an optimistic (almost linear) increase in funds, towards a level of investments of US$1 trillion in 2030, here a more conservative, exponential path is assumed. In this path, the available funds show a modest rise in the early years, and a strong increase during the last 5 years before 2030. In 2025, investments will exceed US$500 billion for the first time, and in 2030 they reach a level of US$1 trillion (see figure 4). The cumulative investments by 2030 are US$8.01 trillion, which is 34% lower than the US$12.3 trillion derived in Table 1 above. Applying this 34% downward correction to the 16.1 Gt CO_2e reduction calculated gives an emissions reduction figure of 10.6 Gt CO_2e attributable to the investment of US$8.01 trillion. Subtracting the 4.2 Gt CO_2e reduction already included in the Current Policies scenario, a net mitigation potential of 6.5 Gt CO_2e is estimated for the US$1 trillion of investment in clean energy 2030.

Figure 4

Assumed increase in clean energy investment, 2014-2030 (US$ billion)



Source: IEA, 2014 and NCE calculations.[38]

Finally, the uncertainties in these calculations are assessed. The two key uncertainties are the assessment of cumulative investments by 2030 (applying shares of the 2014-2035 time window) and the 50% correction for energy efficiency measures. Given the magnitude of both modifications a +/- 1 Gt CO_2e uncertainty range is applied. The range of potential emissions reduction is therefore 5.5 – 7.5 Gt CO_2e.

Table 3

Summary of calculation steps to determine impact of the financing clean energy recommendation

Calculation step	Impact
Emission reductions through renewable and nuclear investments in IEA Current Policies Scenario	4.2 Gt CO_2e
Difference between 450 scenario and Current Policies Scenario	15.4 Gt CO_2e
Impact of clean energy investments in 450 scenario	**19.6 Gt CO_2e**
Correction 1: exclude impact of transport	-2.5 Gt CO_2e
Correction 2: exclude energy efficiency improvements not attributable to investments	-1.0 Gt CO_2e
Emission reductions by 2030 through clean energy finance under linear growth path	**16.1 Gt CO_2e**
Correction 3: assume a more conservative growth path	-34%
Emission reductions by 2030 through clean energy finance under a more conservative growth path	**10.7 Gt CO_2e**
Emission reductions through renewable and nuclear investments in CPS	-4.2 Gt CO_2e
Total mitigation potential of clean energy investment recommendation (Emission reductions through Clean Energy Finance measures by 2030, comparing 450 to CPS, assuming a moderate growth path of investments)	**6.5 Gt CO_2e**
Uncertainty margin	+/- 1 GtCO_2e
Potential mitigation range of clean energy investment recommendation	**5.5-7.5 Gt CO_2e**

RECOMMENDATION 4: RAISE ENERGY EFFICIENCY STANDARDS TO THE GLOBAL BEST

G20 and other countries should converge their energy efficiency standards in key sectors and product fields to the global best by 2025, and the G20 should establish a global platform for greater alignment and continuous improvement of standards.

Estimate of annual mitigation potential by 2030: 4.5- 6.9 Gt CO_2e

The estimate of mitigation potential is based on analysis conducted across appliance and lighting; industry; transport; and buildings based on studies from the Collaborative Labelling and Appliance Standards Program (CLASP), International Council on Clean Transportation (ICCT), the International Energy Agency, The Global Building Performance Network (GBPN), and the Intergovernmental Panel on Climate Change.

The overall estimate of mitigation potential of this recommendation is estimated by adding together the mitigation potential for four sector and product groups as follows:

- Appliances, equipment & lighting
- Industry (electric motors only)
- Transport (including light-duty vehicles and heavy-duty vehicles
- Buildings (new buildings only

This includes sectors, sub-sectors and products for which standardisation is possible and for which the mitigation impact can be quantified. For this recommendation, the findings of several leading studies have been consolidated, namely:

- A study by the Collaborative Labelling and Appliance Standards Program (CLASP), which examines the impacts of energy savings and the mitigation impact of better harmonisation of standards and labelling for 24 products.[39]
- A study by the International Council on Clean Transportation (ICCT), which quantifies the climate benefits of transport policies.[40] In particular, this study includes analyses for light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs), which focuses on energy efficiency standards. The mitigation impact in the maritime and aviation sectors is reported separately (see recommendation 9).
- Studies by the GBPN,[41] IEA[42] and IPCC,[43]which examine the potential energy savings and emissions reductions for buildings in different scenarios. This includes only new buildings, for which standards have already been developed and implemented.

Several corrections of the findings of the above studies have been applied to ensure alignment with the report's recommendation:

- A baseline correction to ensure alignment of the assumptions in the respective studies with the chosen energy-related emissions baseline (IEA ETP's 6DS scenario);
- A geographical correction to ensure the mitigation impact is provided for G20 countries only;
- A rebound correction to account for rebound effects; and
- A range correction to ensure an adequate reflection of uncertainty, for example to consider enforcement issues or discrepancies between theoretical and practical energy efficiency savings.

Baseline, geographical and range corrections are applied separately in the different sectors. A rebound correction is applied of 20% across all sectors, meaning that only 80% of the energy savings register in terms of reduced energy use. This is based on a study by the American Council for an Energy-Efficient Economy,[44] which is itself an assessment of a range of studies. It concludes that the total rebound effect, both direct and indirect, is in the order of 20% - although this remains an estimate with significant uncertainty. The IEA also investigated rebound effects in the World Energy Outlook 2012.[45] The report notes that depending on the country or the consumption sector at stake, the direct rebound effect generally ranges from 0-10%, and that estimates of the indirect rebound effect vary widely. Accounting for this, the IEA estimates the overall rebound effect to be 9%. Uncertainty remains on the extent of the rebound effect and some studies have estimated numbers higher than 20%. However, as the correction is applied at an aggregate level, the figure of 20% is considered to be realistic.

Appliances, equipment and lighting

The study by CLASP[46] reports a potential mitigation impact of 2.6 Gt CO_2e by 2030 (corresponding to 12% energy savings relative to BaU) for the worldwide adoption of the 'current most broadly based and stringent equipment energy efficiency regulations'. It further reports that the universal adoption of 'today's most energy efficient technologies by 2030' hold a mitigation impact of 6.7 Gt CO_2e (slightly over 40% energy savings). These numbers are consistent with a recent study by Ecofys[47] which evaluated the European Commission's Energy Labelling[48] and Ecodesign Directives[49] and estimated energy savings of 19% by 2020 compared to business as usual.

To arrive at an estimation of the mitigation potential of achieving "global best" standards in G20 countries for appliances, equipment and lighting, a number of steps are taken:

- The estimated mitigation impact for electric motors (0.15 to 0.3 Gt CO_2e) is removed, as this is included separately (see industry section below).
- A base year correction is applied, as the CLASP study uses 2006 as the base year for electricity consumption, while the ETP's 6DS uses 2011 as a base year. For this correction, efficiency gains for the period 2006-2011 are removed, assuming linear growth in efficiency gains between 2006 and 2030. This correction is likely to be conservative as efficiency gains are typically lower in early years due to progressive uptake of energy efficient equipment as a result of standardisation policies.
- A geographical correction is applied to limit impacts to G20 countries. This is based on the ratio between the total net electricity consumption of G20 countries (scope of the recommendation) and worldwide (scope of the CLASP study) as obtained from the IEA.[50] Current data is used, rather than projected data for 2030, which are subject to uncertainty.
- A rebound correction of 20% is applied.
- Lastly, an uncertainty range of 25 to 75% is applied between the mitigation impact of current regulations and best-available technologies reported in the CLASP study to reflect uncertainty in the level of standardisation achievable by 2025. It is assumed that improvements are possible relative to the current and most broadly-based standards reported in the study, yet that universal adoption of current most efficient technologies is not possible by 2025.[51] The range also acknowledges a degree of uncertainty in the enforcement and convergence of standards toward best practices, as the estimate of the mitigation impact presented by CLASP is based on a simplified global analysis.[52]

As a result of these calculations, the mitigation potential of the recommendation for appliances, equipment and lighting is estimated to be between 1.8 and 2.9 Gt CO_2e in 2030.

Table 4

Overview of the correction for energy efficiency in equipment, appliances and lighting

	Low (Gt CO_2e)	High (Gt CO_2e)	Description
Starting range	**2.5**	**6.4**	The low number corresponds to current standards and the high number corresponds to current best available technologies (this excludes the potential impacts from electric motors).
Baseline correction	-0.5	-1.3	The baseline correction accounts for temporal differences between the CLASP and the IEA ETP's base years (2006 and 2011 respectively).
Geographical correction	-0.3	-0.8	The geographical correction limits the mitigation impact to G20 countries (the CLASP study's estimates are global).
Rebound correction	-0.3	-0.9	The rebound correction corrects for rebound at an aggregate level.
Range correction	0.5	-0.5	The range correction assumes that standards in 2025 will be more demanding than current standards (increase of the low range) but will not meet current best technologies (decrease of the high range).
Final range	**1.8**	**2.9**	The final range results from the successive corrections.

Industry
For industry, only electric motor standards are included. This is also based on the study by CLASP.[53] The report notes that electric motors are estimated to represent 15% of the final energy demand of industry and to account for a total emissions of 4.4 Gt CO_2e. The report estimates that the adoption of best practice minimum energy performance standards holds a mitigation potential of 0.15 to 0.3 Gt CO_2e worldwide by 2030. Another study by the Lawrence Berkeley National Laboratory estimates the cost-effective potential of minimum efficiency performance standards for electric motors in industry in a selection of major economies[54] to be 0.14 Gt CO_2e, which is broadly consistent.[55]

For this recommendation the range provided by CLASP (2011) is used. Base year, geographical and rebound corrections are applied as for appliances, equipment and lighting. As a result, the mitigation potential of the recommendation for electric motors by 2030 is estimated to be between 80 and 160 Mt CO_2e. The details of the calculations are provided below.

Table 5
Overview of the correction for industry (electric motors)

Steps	Low (Gt CO_2e)	High (Gt CO_2e)	Description
Starting range	**150**	**300**	The range reflects the estimates provided by CLASP.
Baseline correction	-30	-60	The baseline correction accounts for temporal differences between the CLASP and the IEA ETP base years (2006 and 2011 respectively).
Geographical correction	-20	-40	The geographical correction limits the mitigation impact to G20 countries (the CLASP study's estimates are global).
Rebound correction	-20	-40	The rebound correction corrects for rebound at an aggregate level.
Range correction	na	na	No range correction is applied to electric motors
Final range	**80**	**160**	The final range results from the successive corrections.

Transport
For 'global best' energy efficiency standards in transport, the potential for cars and light duty vehicles (LDVs) and heavy duty vehicles (HDVs) is included. The ICCT study reports a mitigation potential of 1.76 Gt CO_2e for existing standardisation policies (1.5 for LDVs and 0.26 for HDVs). Additionally, it reports an additional mitigation potential of 1.1 Gt CO_2e for LDVs if best practices were implemented in all countries studies,[56] and an additional mitigation potential of 0.65 Gt CO_2e for HDVs if best practices were implemented worldwide.

For the transport sector, it is assumed for this report that the best practices reported in the ICCT report form the basis for convergence in G20 countries by 2025. The mitigation impact of existing policies is included in our assessment, given the use of the ETP 6DS as a baseline, which is based on current trends rather than current policies. The following steps are then taken to ensure alignment of the ICCT findings with the report's recommendations:

- A base year correction is applied, as the ICCT report and 6DS scenario present different estimates of transport related emissions, respectively 7.1 Gt CO_2e in 2010 and 6.8 Gt CO_2e in 2011. A correction is applied based on the ratio of these numbers.

- A geographical correction is applied to extend (LDVs) or limit (HDVs) the analysis to G20 countries. This is based on the total energy demand of the transport sector, as obtained from the IEA.[57]
- A rebound correction of 20% is applied.
- A range correction is applied to reflect uncertainty. This takes the sum of the mitigation impact from existing policies and best practice implementation reported by the ICCT as a maximum and applies a range of 25% below this value as a minimum. This range correction accounts for uncertainty in the degree of convergence and enforcement of best-practice standards.

Table 6

Overview of the correction for energy efficiency in transport

Steps	Low (Gt CO_2e)	High (Gt CO_2e)	Description
Starting range	**1.8**	**3.5**	The lower range corresponds to current policies in a selection of countries. The upper range corresponds to additional energy efficiency measures and extension of existing policies to the countries of study (LDVs) or worldwide (HDVs).
Baseline correction	-0.1	-0.1	The baseline correction accounts differences in the ICCT and this study's baseline emissions for the transport sector.
Geographical correction	0.1	0.1	The geographical correction extends (LDVs) or limits (HDVs) the mitigation impact to G20 countries. The overall effect of this correction is positive as a result of the balance of these sub-corrections.
Rebound correction	-0.4	-0.7	The rebound correction corrects for rebound at an aggregate level.
Range correction	0.7	0	We apply a range correction assuming that existing policies will be exceed by 2030 and that the combined effect of current policies and extended policies from the ICCT study corresponds to the maximum mitigation impact.
Final range	**2.1**	**2.7**	The final range results from the successive corrections.

As a result of these calculations, the mitigation potential of achieving global best standards in transport is estimated to be between 2.1 and 2.7 Gt CO_2e in 2030.

Buildings
For the building sector, findings from a number of different studies are combined. Only the mitigation potential of best practice standards for new buildings is included, as mandatory standards have not yet been developed and applied widely for building renovations. Further, as energy efficiency gains in appliances and lighting are reported separately, these are not included these in this assessment. As such, the focus is on energy efficiency gains resulting from standards on building envelopes and materials, heating and cooling devices.

In a recent report, the IEA calculates the requirements for buildings to close the gap between the ETP's 6DS and 2DS scenarios.[58] It reports that energy savings of 40 EJ are possible in the building sector, and that total emissions reductions of 8.9 Gt CO_2e can be achieved by 2050. Interpolating to 2030 suggests approximately 4.6 Gt CO_2e of potential emissions reductions, of which only approximately 0.7 Gt CO_2e relate to heating and cooling or building envelopes, and the remainder to cooking, lighting, appliances and fuel switching (0.8 Gt CO_2e) and electricity decarbonisation (3.1 Gt CO_2e).

Another study by the Global Buildings Performance Network (GPBN), examines the energy saving and emissions reduction potential from space heating & cooling and water heating in new and existing buildings.[59] It explores three scenarios: a 'frozen efficiency' scenario (FES), which is based on 2005 conditions, a 'moderate efficiency' scenario (MES), which takes into account existing policies and standards such as the EU's Energy Building Performance Directive, and a 'deep efficiency' scenario (DES), which is based on best practices. The study reports that energy use related to space heating and cooling could more than double by 2050 relative to 2005 levels in the FES (from 52.7 to 106.9 EJ), increase by half in the MES (to 79.5 EJ) and could be reduced by a third in the DES (34.9 EJ). With regard to emissions, the study reports emissions related to heating & cooling of 7 Gt CO_2e as a baseline in 2005, and of 11.2, 8.2 and 3.6 Gt CO_2e in 2050 for FES, MES and DES respectively.

These reports do not provide data on the specific mitigation impact for new buildings in 2030. Extrapolation based on IEA suggests that the heating and cooling potential of new buildings only is lower than 0.7 Gt CO_2e. Extrapolation based on data provided in the GBPN report suggests a potential for heating and cooling in new buildings of the order of 1.3 Gt CO_2e, assuming the mitigation impact in 2030 corresponds to the difference between the MES and DES and that approximately half of the potential is attributable to new buildings.

Another study by SEI includes estimates on the mitigation impact from heating efficiency in new buildings, reporting that cities could reduce emissions by 0.9 Gt CO_2e by 2030.[60] This number however uses the ETP 4DS scenario as a baseline. Corrections relative to the 6DS scenario would suggest a mitigation impact of approximately 1.2 Gt CO_2e.

Based on this review of relevant studies the mitigation potential of energy efficiency in new buildings is estimated to be in the range of 0.7 to 1.3 Gt CO_2e. Applying a rebound correction of 20% yields a mitigation impact of between 0.6 and 1.0 Gt CO_2e.

Total mitigation potential
Adding the estimates for mitigation potential of the four sectors / product groups the total range for recommendation as a whole is 4.5 – 6.9 Gt CO_2e.

Table 7
Overview of 2030 emissions savings from energy efficiency

Sector	Mitigation potential
Appliances, equipment & lighting	1.8 - 2.9 Gt CO_2e
Industry (electric motors only)	0.08 - 0.16 Gt CO_2e
Transport (including light-duty vehicles and heavy-duty vehicles)	2.1 - 2.7 Gt CO_2e
Buildings (new buildings only)	0.6 - 1.0 Gt CO_2e
Total	**4.5 - 6.9 Gt CO_2e**

RECOMMENDATION 5: IMPLEMENT EFFECTIVE CARBON PRICING

All developed and emerging economies, and others where possible, should commit to introducing or strengthening carbon pricing by 2020, and should phase out fossil fuel subsidies.

Estimate of annual mitigation potential by 2030: 2.8 – 5.6 Gt CO_2e

The estimate of mitigation potential is based on analysis conducted by the International Energy Agency (IEA) on the impact of carbon pricing of US$35 t$CO_2e$ in developing countries and US$75/t CO_2e in developed countries and the phasing out of fossil fuel subsidies.

The total mitigation potential of the carbon pricing recommendation is estimated to lie in the range of 2.8 - 5.6 Gt CO_2e by 2030, based on an average global carbon price of around US$50 per tonne by 2030. For phasing out fossil fuel subsidies an additional effect is assumed, which has been taken from the estimate in the Commission's 2014 report.[61] This is 0.4–1.8 Gt CO_2e. IEA presents a lower number, namely 0.37 Gt CO_2e by 2020.[62] To avoid potential overestimation, and given the uncertainty around overlap, the impact of removing fossil fuel subsidies is not included in the estimate of total potential of this recommendation.

The impact of carbon pricing is assessed based on two leading global projections: the IEA's 2014 ETP,[63] and the IES's 2014 WEO.[64] Both publications contain several scenarios, including a scenario that assumes carbon pricing at a global scale by 2030, and including one with no, or limited carbon pricing. By analysing the differences in projected emissions in these scenarios, and correcting for other differences between the scenarios which may affect this variation in emissions, the difference in emissions between the scenarios that can be attributed to carbon pricing is estimated. The steps taken in this analysis are summarized in Table 8.

As part of the 2DS scenario in the ETP, IEA assumes that carbon prices (in real terms) will range between US$80-100 per tonne by 2030.[65] The 6DS scenario only assumes carbon prices (of US$40/tonne) in Europe, and only for those sectors that are currently included in the EU Emissions Trading Scheme. The total level of energy-related CO_2e emissions by 2030 amounts to 27.8 Gt CO_2e in the 2DS scenario, and to 45.1 Gt CO_2e in the 6DS scenario.

The average price by 2030 is taken to be around US$50/tonne, which can be considered to be roughly halfway between the assumptions of the 6DS and the 2DS scenarios. As an extension of the ETP scenarios, assuming global prices, a differentiation is made between the emerging economies and the developed world, assuming a carbon price of US$35/tonne for the former group, and US$75/tonne for the latter. Linear interpolation between the two projections for total emission levels in 6Ds and 2DS yields emissions of 31.1 Gt CO_2e under a carbon price of US$75, and 39.7 Gt CO_2e under a carbon price of $35 by 2030.

Next, weights are applied according to the projected contribution to global GDP of both groups (65% for the developing world and 35% for the developed)[66] to calculate saved emissions under a differentiated price regime. This results in weighted average emissions of 36.7 Gt CO_2e. Compared to emissions under the 6DS scenario this implies a reduction of 8.4 Gt CO_2e. Finally, it is assumed that only 33-66% of the difference in emission levels can be attributed to carbon pricing. Consequently, the range of the total reduction potential is estimated to be between 2.8 and 5.6 Gt CO_2e.

As a triangulation to this method, an assessment was also made based on the World Energy Outlook 2014 using a similar interpolation between the Current Policies scenario and the 450 scenario using a CO_2e price of 50 US$/t. Again, the share of the mitigation impact attributable to the carbon pricing was varied from one third to two thirds. This resulted in a range for the mitigation potential of between 2.3 and 4.7 Gt CO_2e by 2030.

The analysis also checked carbon prices as adopted in scenarios in the IPCC Fifth Assessment Report for Working Group III.[67] The median of carbon price levels used in 430-480 ppm scenarios is approximately 90 US$/t CO_2e, with 25th and 75th percentiles at around 70 and 130 US$/t$CO_2e$. This is similar to the 80-100 US$/t CO_2e price range adopted in the 2DS scenario by the IEA ETP. Using IPCC scenarios for this analysis would therefore likely have resulted in similar estimates of GHG emissions reductions.

It must be noted that the ETP scenario relies on carbon pricing as a proxy to represent wider climate policies. If other effective policy instruments are implemented apart from carbon prices, as part of a well-aligned and integrated policy portfolio, the carbon price level could be lower to achieve the same level of emissions reductions.

Table 8

Estimates of total GHG emissions by 2030 under a differentiated CO_2e price regimes

	CO_2e price by 2030 US$/t CO_2e	Total GHG emissions 2030 Gt CO_2e
6DS	40 (in the EU only)[68]	45.1
2DS	80-100	27.8
Linear interpolation	35	39.7
Linear interpolation	75	31.1
Weighted average	35 for developing countries 75 for developed countries	36.7

RECOMMENDATION 6: ENSURE NEW INFRASTRUCTURE IS CLIMATE-SMART

G20 and other countries should adopt key principles ensuring the integration of climate risk and climate objectives in national infrastructure policies and plans. These principles should be included in the G20 Global Infrastructure Initiative, as well as used to guide the investment strategies of public and private finance institutions, particularly multilateral and national development banks.

Estimate of annual mitigation potential by 2030: Not estimated

The estimate of mitigation potential for this recommendation was not quantified as this recommendation refers to a general policy principle for all investments.

RECOMMENDATION 7: GALVANISE LOW-CARBON INNOVATION

Emerging and developed country governments should work together, and with the private sector and developing countries, in strategic partnerships to accelerate research, development and demonstration (RD&D) in low-carbon technology areas critical to post-2030 growth and emissions reduction.

Estimate of annual mitigation potential by 2030: Not estimated

The estimate of mitigation potential for this recommendation was not quantified as this the impact of the recommendation would only have significant influence on emission reductions after 2030.

RECOMMENDATION 8: DRIVE LOW-CARBON GROWTH THROUGH BUSINESS AND INVESTOR ACTION

All major businesses should adopt short- and long-term emissions reduction targets and implement corresponding action plans, and all major industry sectors and value chains should agree on market transformation roadmaps, consistent with the long-term decarbonisation of the global economy. Financial sector regulators and shareholders should actively encourage companies and financial institutions to disclose critical carbon and environmental, social and governance factors and incorporate them in risk analysis, business models and investment decision-making.

Estimate of annual mitigation potential by 2030: 1.9 Gt CO_2e

The estimate of mitigation potential is based on analysis of the emissions of the Global 500 in 2030 (calculated from CDP, Thompson Reuters and the IEA) if they were to assume an emission reduction target of 30% against BAU by 2030.

The mitigation impact of this recommendation has been calculated as the product of base year emissions, a growth factor, and an indicative reduction target. The breakdown of the estimates are provided in Table 9.

The estimate for base year emissions of the Global 500 is based on two estimates for 2012 emissions of the Global 500 companies. Based on data collected by CDP, 2012 emissions from 379 disclosing companies out of the Global 500 were 3.1 Gt CO_2e.[69] A simple extrapolation to 500 companies results in an estimate of 4.09 Gt CO_2e. Alternatively, emissions for the full Global 500 may be based on Thompson Reuters analysis including an estimate for non-disclosing companies of 4.91 Gt CO_2e.[70] A midpoint is assumed between these two estimates, given an estimate of 2012 emissions of 4.5 Gt CO_2e.

Growth to 2030 under a BAU scenario is a based on the trend for industrial final energy demand in the IEA ETP 6DS scenario. This is growth of 38% to 2030, which applied to the base year gives BAU emissions of 6.2 Gt CO_2e in 2030.

To model the impact of emissions reductions consistent with the long-term decarbonisation of the global economy, an average reduction of 30% against BAU emissions in 2030 is assumed. This can be justified by company targets adopted to date. A recent study for UNEP demonstrates that companies participating in company initiatives on average took up commitments of 22-23% compared to BAU by 2020.[71] This is based on average GHG reduction commitments in 50 companies sampled from 167 companies in the Global 500 which participate in one or more of the leading climate-related initiatives, including the Business Environmental Leadership Council (BELC), Cement Sustainability Initiative (CSI), World Wide Fund for Nature (WFF) Climate Savers, Ultra-Low CO_2e Steelmaking ULCOS0, Caring for Climate and Science Based Targets. Based on this average commitment of 22-23% over BAU by 2020, it is assumed that for 2030 stronger action can be taken, of the order of a 30% reduction. Applied to the 2030 BAU emissions level across the Global 500, this average 30% reduction would give a 2030 emissions figure of 4.3 Gt CO_2e.

On this basis the impact on 2030 BAU emissions of this recommendation for the Global 500 can be estimated at 1.9 Gt CO_2e.

Table 9

Estimate of 2030 GHG emissions from the Global 500 from a 30 percentage reduction in emissions from all Global 500 companies (2012 composition)

Target group	2012 Base year emissions Gt CO_2e	2030 emissions growth	2030 BAU emissions Gt CO_2e	Reduction of emissions from all Global 500 companies (2012 composition)	2030 emissions with business action Gt CO_2e	Impact of recommendation Gt CO_2e
Global 500	4.5	38%	6.2	30%	4.3	1.9

RECOMMENDATION 9: RAISE AMBITION TO REDUCE INTERNATIONAL AVIATION AND MARITIME EMISSIONS

Emissions from the international aviation and maritime sectors should be reduced in line with a 2°C pathway through action under the International Civil Aviation Organization (ICAO) to implement a market-based measure and aircraft efficiency standard, and through strong shipping fuel efficiency standards under the International Maritime Organization (IMO).

Estimate of annual mitigation potential by 2030: 0.6 – 0.9 Gt CO_2e)

For the aviation sector, the estimate of mitigation potential is based on a study by the International Civil Aviation Organization (ICAO), which analyses the 2030 impacts of a market-based mechanism capping emissions at 2020 levels.[72]

For the maritime sector, the estimate of mitigation potential was based on analysis by the ICCT and (calibrated to the IEA) which analysed the impacts of energy efficiency standards on shipping emissions.[73]

Aviation

To estimate the mitigation potential of the recommendation in the aviation sector, a study by the International Civil Aviation Organization (ICAO) is used. This models the impacts of the adoption of a market-based measure (MBM) to 2036.[74] This study is based on six scenarios reflecting the adoption of three different types of MBMs: global offsetting, global offsetting with revenue, and a global emissions trading scheme. The quantitative results presented in the study reflect economic modelling without revenue generation, and thus relate to an offsetting scheme. In these scenarios it is assumed that emissions will be capped at 2020 levels.

The study finds that the introduction of a market-based measure would mitigate 464 Mt CO_2e by 2036, relative to the baseline scenario. Of this, 12 Mt CO_2e would be the result of in-sector CO_2e reduction caused by a reduction of the traffic demand, and 452 Mt CO_2e would result from capping emissions at 2020 levels. Results from a supplementary study presenting two additional scenarios are also presented. Under these, the mitigation impact is 443 Mt CO_2e in 2036 for low technology and moderate operational improvements, and 609 Mt CO_2e in 2036 for optimistic technology and operational improvements.

As the ICAO's results are presented for 2036, a correction is applied of the mitigation impact in 2030. This is done through linear interpolation using traffic demand projections. To reflect uncertainty, a range of 25% above and below the ICAO core study findings is used. Based on these calculations, the mitigation impact from the implementation of an MBM in the aviation sector is estimated to be between 0.2 and 0.3 Gt CO_2e in 2030.

Maritime

For the maritime sector, the analysis is based on estimates provided by the ICCT.[75] The study indicates that efficiency standards adopted by the International Maritime Organization (IMO) have a mitigation potential of 0.34 Gt CO_2e in 2030.[76] Further, additional efforts to strengthen the standards for new ships and to increase the operational efficiency of existing ships could result in an additional mitigation of 0.4 Gt CO_2e in 2030.[77]

Other studies provide comparable insights. A recent study by the IMO models carbon dioxide emissions in the maritime sector to 2050.[78] In this study, various scenarios are developed and, for each, two efficiency improvement options are modelled. In the high-efficiency gain scenario, a 60% efficiency gain is assumed between 2030 and 2050. In the low efficiency gain scenario, 40% is assumed between these dates. Although these efficiency improvements take place between 2030 and 2050, their magnitude is informative. Another study by the IMO dating back to 2009 estimated that efficiency gains in the maritime sector could amount to between 25% and 75%.[79] Lastly, a study by DNV examined the broader mitigation impact in the maritime sector, including non-efficiency measures, and concluded that emissions reduction of 33% from a baseline scenario were achievable in 2030.[80] Together, these studies suggest that the estimate provided by the ICCT is credible and that additional reductions are possible through the implementation of alternative measures.

It is assumed that both the efficiency gains resulting from existing policies and additional efficiency measures should be counted toward the mitigation impact relative to the IEA ETP's 6DS scenario, which is based on current trends rather than current policies. The following steps are then taken to ensure alignment with the report's recommendations. These steps are similar to those taken for the recommendation on energy efficiency in the transport sector.

- A baseline correction is applied to account for discrepancies in the estimates of transport related emissions by the IEA[81] and ICCT[82] (7.1 and 6.84 Gt CO_2e respectively).
- A conservative range of 25% is applied below the cumulative mitigation impact of existing policies and additional efficiency gains reported by the ICCT.
- A rebound correction of 20% is applied.

No geographical correction is applied as the ICCT's estimates refer to international shipping, which is also the scope of the recommendation. As a result, the mitigation potential of efficiency gains in the maritime transport sector is estimated to be between 0.4 and 0.6 Gt CO_2e in 2030.

Total
Adding the mitigation potential in the aviation sector (0.2 to 0.3 Gt CO_2e) to the potneital in the maritime sector (0.4 to 0.6 Gt CO_2e) gives a total estimated mitigation potential of 0.6 to 0.9 Gt CO_2e.

RECOMMENDATION 10: PHASE DOWN THE USE OF HYDROFLUOROCARBONS (HFCS)

Parties to the Montreal Protocol should approve an amendment to phase down the production and use of HFCs.

Estimate of annual mitigation potential by 2030: 1.1 – 1.7 Gt CO_2e

The estimate of mitigation potential was based on analysis conducted in the paper Velders et al[83] which out new HFC baseline (high and low growth) and phasedown scenarios for HFC's. The phasedown scenario closely represents what could be expected from an amendment within the Montreal Protocol.

The estimated impact of phasing down the use of HFCs is taken from a recent study by Velders et al[84] which elaborates a baseline for HFC emissions under both high and low growth scenarios, and corresponding phasedown scenarios. The phasedown scenario envisages a freeze in the growth of HFC consumption and production at 2014 levels for developed countries and 2024 for developing countries. The freeze is then followed by an annual 4% decrease in consumption and production. The phasedown envisaged in the recommendation is assumed to be these.

In the high baseline scenario HFC emissions amount to 3.8 GtCO_2e in 2030. In the corresponding phasedown scenario this is reduced by 1.7 to a level of 2.1 Gt CO_2e. In the low HFC baseline scenario 2.5 Gt CO_2e are emitted in 2030. In the corresponding phasedown scenario this is reduced by 1.4 to a level of 1.1 Gt CO_2e. The estimated mitigation potential is therefore estimated to be between 1.1 and 1.7 Gt CO_2e.

4. Overlaps between the recommendations

Several of the report's recommendations overlap with one other. To avoid double-counting in calculating the aggregate impact of the recommendations as a whole, these overlaps have been excluded. The total overlap is estimated to be between 7.7 and 11.0 Gt CO_2e.

Table 10

Overview of the overlaps accounted for between different recommendation

Recommendation	Overlap with	Overlap to remove (Gt CO_2e)
1. Cities	3. Clean energy financing, 4. energy efficiency	3.1
4. Energy efficiency (new buildings only)	3. Clean energy financing	0.6 - 1.0
5. Carbon pricing	All	2.8 - 5.6
8. Business	All	1.0
9. Aviation	All	0.2 - 0.3
Total		**7.7 - 11.0**

Cities

The mitigation potential of several of the actions analysed under the cities recommendation overlap with other recommendations. As it is difficult to quantify the exact overlap between these elements, 100% of the mitigation impact of these components of the cities recommendation has been excluded. This is 3.1 Gt CO_2e in total. The overlaps occur with two other recommendations:

- Clean energy investment: this overlap concerns heating retrofits and fuel switching, which may result from investments in the building sector. While it is likely that such investments will mostly be made by private individuals and businesses for residential and commercial buildings respectively, it is probable that governments, multilateral and national development banks will contribute funds. The overlap excluded is therefore conservative.
- Energy efficiency: the mitigation impact for the cities recommendation includes various energy efficiency measures in the building and transport sector. Cities are likely to hold additional potential relative to the energy efficiency recommendation which focuses on standardisation. As such, exclusion of 100% of the energy efficiency-related components of the cities recommendation is conservative.

Energy efficiency and clean energy financing

One component of the energy efficiency recommendation concerns new building energy efficiency. This overlaps with the recommendation on clean energy financing which includes financing in the building sector. 100% of the mitigation impact from the implementation of standards in new buildings (0.6-1.0 Gt CO_2e) has therefore been excluded. This is likely to be conservative, as a portion of the investments and financing needed would be provided by the general public and businesses outside of the financing scope included in the recommendation on clean energy financing.

Carbon pricing

The specific mitigation impact of carbon pricing is subject to considerable uncertainty as carbon prices have significant economy-wide impact. Detailed, robust and reliable models on the impact of carbon pricing are also not yet available. In the absence of reliable modelling, the estimate for the overlap is subject to significant uncertainty. Erring on the side of caution it is assumed that 100% of the identified mitigation impact overlaps with other measures. This is 2.8-5.6 Gt CO_2e.

Business
It is likely that the adoption of emission reduction targets by leading companies will result in overlaps with other recommendations, particularly those on clean energy financing and energy efficiency. 50% of the mitigation impact of the recommendation for business (1.0 Gt CO_2e) has therefore been excluded.

Aviation
ICAO is currently developing a market-based mechanism for international aviation and exploring different possibilities. It is likely that an offsetting scheme will be preferred, which implies that the overlap between the recommendation on aviation and other recommendations is likely significant. Additionally, according to the ICAO's model, only 12 of the 464 Mt CO_2e that is projected to be avoided by 2036 occur within the sector. Additional in-sector emissions could result from the adoption standards in the aviation sector or from increased use of bio-jetfuels. However, these options are not considered in the quantification of the mitigation potential in the aviation sector. Conservatively, therefore 100% of the mitigation impact from the recommendation for aviation is excluded, which is 0.2-0.3 Gt CO_2e.

5. Aggregate mitigation potential

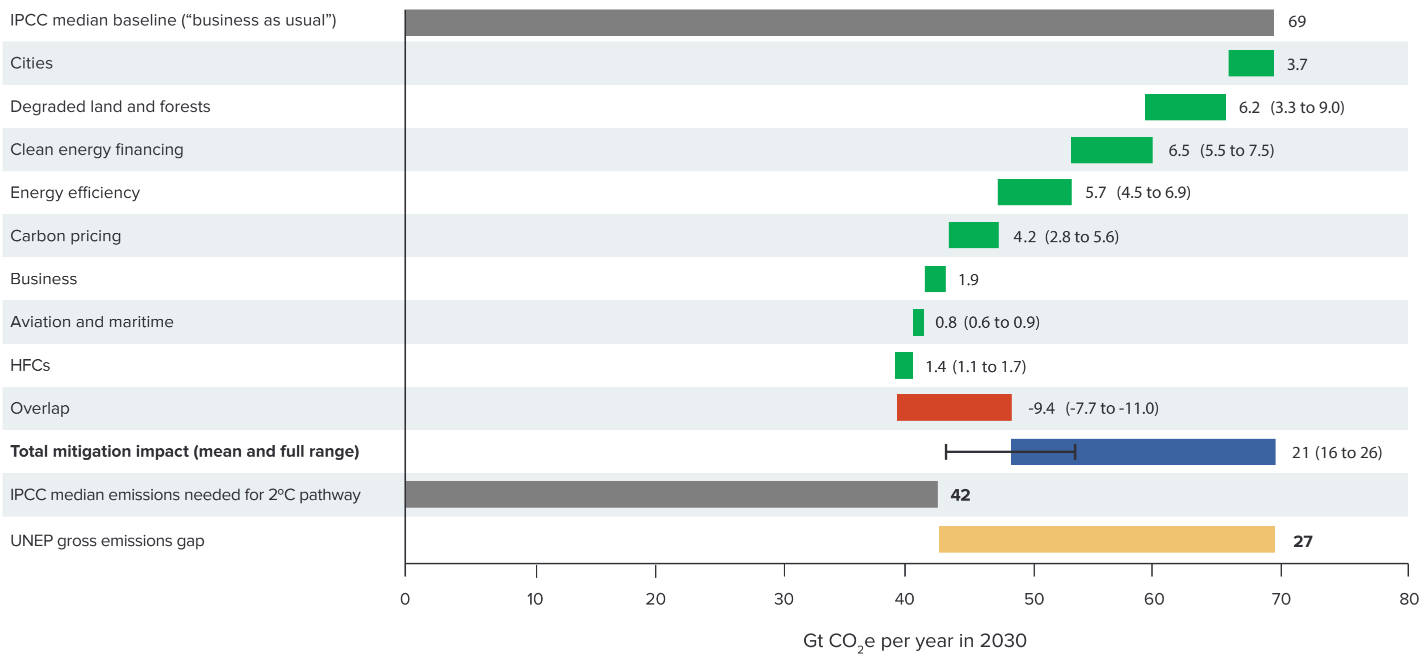
Based on our evaluation of the recommendations for global climate action from the Commission, the total mitigation potential of the report's recommendations is estimated to be between 16 and 26 Gt CO_2e of annual GHG emissions in 2030. This estimate is based on the cumulative mitigation impact of eight measures (21 to 34 Gt CO_2e) from which the estimated overlap (7.7 to 11 Gt CO_2e) has been subtracted.

As discussed in Section 2, this can be compared with the 'gross emissions gap' in 2030 – the difference between business as usual emissions and the level required for a 2˚C pathway. This is 27 Gt CO_2e (69 – 42 Gt CO_2e).

The aggregate emissions reduction potential of the recommendations in the report (16 to 26 Gt CO_2e) therefore constitutes between 59% and 96% of the gross emissions gap.

The emissions reduction potential of the report recommendations

Full implementation of the Commission's recommendations could achieve up to 96% of the emissions reductions in 2030 needed to keep global warming under 2°C.



THE RELATIONSHIP BETWEEN THIS MITIGATION POTENTIAL AND INDCS

Countries are currently in the process of announcing their 'intended nationally determined contributions' (INDCs) for the Paris agreement. These set out their emissions reduction targets for 2025 or 2030. Now that many of the world's largest emitters, including the US, China, the EU, Russia and Canada have published their INDCs, it is clear that when all have been added together, the sum total of countries' national mitigation ambitions will fall well short of the level required in 2030 for a 2°C pathway. The emissions reduction potential identified in this report, however, cannot simply be 'added' to the INDCs to show how the emissions gap could be closed. This is for three reasons.

First, the emissions reduction potential identified in the report is taken from a baseline of 'business as usual' emissions which includes no significant mitigation action after 2010. It therefore includes some emissions reductions which may already be achieved by existing policies begun after 2010, and some which may be part of INDCs published in 2015.

Second, since many INDCs have not been published, and most of those that have do not specify in detail how or where their emissions reductions will be achieved, it is not possible to say how much of the action recommended in this report might already be included within them. Some of the emissions reductions identified in this report may be included in INDCs; some will be in addition. We do not know how much.

Third, all but the international aviation and maritime emissions identified in this report (which are not counted in national totals) will take place on national territories – they will therefore become part of a national emissions inventory. The actions taken by the cities of Sao Paulo and Rio de Janeiro, for example, will in the end become part of Brazil's national mitigation outcomes.

The 16-26 Gt CO_2e range of emissions reduction potential identified in this report therefore cannot be 'added' to the aggregate emissions reductions projected to arise from INDCs. Rather, it indicates the potential for INDCs to be strengthened in ways which will also foster growth and development. It suggests that more mitigation potential is available to countries than they are currently planning for. This forms the basis of the conclusion reached by the report that INDCs should be able to be raised in the future as new opportunities for cost-effective emissions reductions arise.

ENDNOTES

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25 Some studies assume LULUCF emissions may decline between 2010 and 2030 (for example, OECD's World *Environmental Outlook, 2012*).

However, other bottom-up estimates – such as that undertaken by McKinsey (2014) for a new Global Abatement Cost Curve – suggest emissions from forestry will still account for 7 Gt in 2030, remaining static over time. Moreover, a declining baseline is not consistent with
the latest evidence on the trends in global gross tree cover loss from remote sensing (see www.GFW.org, for example). There is also a lot of uncertainty about the projected trends, but the main global drivers of forest degradation remain significant (e.g. timber and pulp demand in the BRICS countries and charcoal in Africa).

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27 This is based on a ceiling of 1 million hectares of degraded agricultural landscape that could reasonably be expected to be brought into restoration projects for the first time each year through intensive projects, providing a total of 15 million hectares

in net area added over 15 years.

28 A World Bank evaluation of the Loess Plateau projects in 2005 estimated 6.25 t/ha in net CO_2e savings per year which we use as an average: 0.09 Gt CO_2e/year = 6.25 X 20 X 50,000 X 15.

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36 Total emissions includes power, transport, other final energy use and 'emissions from other energy sector'

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ABOUT THE NEW CLIMATE ECONOMY

The Global Commission on the Economy and Climate, and its flagship project **The New Climate Economy**, were set up to help governments, businesses and society make better-informed decisions on how to achieve economic prosperity and development while also addressing climate change.

The New Climate Economy was commissioned in 2013 by the governments of seven countries: **Colombia, Ethiopia, Indonesia, Norway, South Korea, Sweden and the United Kingdom**. The Commission has operated as an independent body and, while benefiting from the support of the seven governments, has been given full freedom to reach its own conclusions.

In September 2014, the Commission published *Better Growth, Better Climate: The New Climate Economy Report*. Since then, the project has released a series of country reports on the United States, China, India and Ethiopia, and sector reports on cities, land use, energy and finance. It has disseminated its messages by engaging with heads of governments, finance ministers, business leaders and other key economic decision-makers in over 30 countries around the world.

The Commission's programme of work has been conducted by a global partnership of eight leading research institutes: World Resources Institute (WRI, Managing Partner), Climate Policy Initiative (CPI), Ethiopian Development Research Institute (EDRI), Global Green Growth Institute (GGGI), Indian Council for Research on International Economic Relations (ICRIER), Overseas Development Institute (ODI), Stockholm Environment Institute (SEI) and Tsinghua University.