May 2014

Briefing

Climate change mitigation – what the climate scientists say

The main points from the 2014 IPCC Working Group 3 report

This briefing summarises the main findings of the 2014 Intergovernmental Panel on Climate Change (IPCC) Working Group 3 report on climate change mitigation. There are five sections in the briefing:

- The cost of delay
- Future pathways
- Equity considerations
- Co-benefits
- Friends of the Earth's conclusions

The briefing shows that delay in cutting emissions has made the task of avoiding dangerous climate change more difficult but not impossible. It also shows that the cost of doing so is low and there are significant co-benefits. Like with the causes of climate change and the impacts of it there are important equity considerations in climate change mitigation.

The cost of delay

Despite the recognition by governments at the 1992 Rio Earth Summit that climate change posed a significant threat to the natural environment and human welfare, emissions of greenhouse gases have soared. In fact, total emissions have risen more rapidly from 2000 to 2010 than in the previous three decades, with greenhouse gas emissions growing on average 2.2% per year compared to 1.3% per year over the entire period from 1970 to 2000[1]. The IPCC says growth in economic output and population are the two main drivers, outpacing emission reductions from improvements in energy intensity[2].

The largest share of anthropogenic CO2 emissions is emitted by a small number of countries. In 2010, 10 countries accounted for about 70% of carbon dioxide (CO2) emissions from fossil fuel combustion and industrial processes. A similarly small number of countries emit the largest share of consumption-based CO_2 emissions as well as cumulative CO_2 emissions going back to 1750[3].

Because carbon dioxide (CO_2) remains in the atmosphere over thousands of years, and because of this delay in cutting emissions over the last decades, it will now be necessary to achieve a peak in global emissions in the near-term and achieve zero or less than zero emissions by 2100 in order to have a reasonable chance of avoiding 2 degrees of global warming compared to pre-industrial times[4]. The IPCC pathways suggests emissions will need to peak at different times in different regions (e.g. in OECD countries around 2010, Asia around 2020), but all regions will need to peak soon[5]. And even with this the concentration of GHGs in the atmosphere will exceed target levels for a period of time, according to the majority of emission pathways identified by the IPCC (so called overshooting)[6].

The GHG concentration target of between 430 to 480 ppm CO_2eq in 2100 are *likely* to keep temperature change below 2°C over the course of the century relative to pre-industrial levels, according to the majority of IPCC scenarios. In addition to the need to peak emissions soon it will be necessary according to the vast majority of IPCC scenarios to also remove carbon dioxide from the atmosphere (so called negative emissions)[7]. Negative emissions technologies to remove carbon dioxide are not yet proven at scale.

Only a limited number of studies have explored emissions pathways consistent with limiting long-term temperature change to below 1.5°C in 2100 relative to pre-industrial times. In these scenarios, the global temperature peaks over the course of the century and is brought back to 1.5°C with a *likely* chance at the end of the century. The deployment of negative emissions technologies is critical to these scenarios, as is the rapid upscaling of the full portfolio of mitigation technologies combined with low energy demand in order to bring concentration levels below 430 ppm CO_2eq in 2100[8].

Current governmental pledges made for reducing emissions for 2020 (Cancun Pledges) are broadly consistent with scenarios reaching 550 ppm CO_2eq to 650 ppm CO_2eq by 2100 (2-3 degrees of global warming)[9]. Modelling suggest that delayed mitigation can substantially increase the mitigation costs of achieving the 2 degree goal or make it unachievable[10].

The long delay in cutting emissions is making the challenge of avoiding 2 degrees of global warming much more difficult, i.e. now needing to rely on overshooting and the development of negative emissions technologies in addition to rapid deployment of energy efficiency and low carbon energy supply. Delay is also more costly[11].

Future pathways

Energy

The IPCC provided three examples of energy system transformation pathways that are consistent with limiting CO_2eq concentrations to about 480 ppm CO_2eq by 2100. All three showed the importance of measures to reduce energy demand in the short-term[12]. By 2030, between 40–90% of the emissions reductions are achieved through energy-demand savings[13].

The IPCC says that the stabilization of greenhouse gas concentrations at low levels requires a fundamental transformation of the energy supply system, including the long-term phase-out of unabated fossil fuel. Improving the energy efficiencies of fossil power plants and/or the shift from coal to gas will not by themselves be sufficient they say[14]. For example, in the majority of mitigation scenarios reaching 430–480 ppm CO2eq concentrations by 2100, the share of low-carbon energy in electricity supply increases from the current share of around 30% to more than 80% by 2050[15]. In the long term, the reduction in electricity emissions is accompanied by an increase in the share of electricity in end uses (e.g., for space and process heating, potentially for some modes of transport).[16]

Excluding nuclear power from the available portfolio of technologies would result in only a slight increase in mitigation costs compared to the full technology portfolio according to the IPCC[17]. However significant restrictions on the use of bioenergy or no availability of carbon capture and storage (CCS) could increase costs significantly (by 65% in the case of bioenergy, and 138% in the case of CCS) they say[18].

The aggregated global technical potential for renewable energy (RE) as a whole is significantly higher than global energy demands, although the long-term percentage contribution of some *individual* RE sources to climate change mitigation may be limited by the available technical potential if deep reductions in GHG emissions are sought (e.g., hydropower, bioenergy, and ocean energy), while even RE sources with seemingly higher technical potentials (e.g., solar, wind) will be constrained in certain regions. Competition for land and other resources among different RE sources may impact aggregate technical potentials. As might economic factors, environmental concerns, public acceptance, and/or the infrastructure required to manage system integration[19].

Energy storage might play an increasing role in the field of system balancing says the IPCC report. With the exception of pumped hydro storage, storage costs are still high, but are expected to decline with technology development. ‘Power to heat’ and ‘power to gas’ (hydrogen or methane) technologies might allow for translating surplus renewable electricity into other useful final energy forms, they say[20].

However many models cannot reach 2100 concentration levels between 430 ppm and 480 ppm CO2eq if the full suite of low carbon technologies is not available, particularly bioenergy[21]. It is acknowledged that bioenergy creates competition for land between food, feed, and energy uses[22]. The IPCC says that conversion of high carbon density ecosystems (forests, grasslands and peatlands) for bioenergy should be avoided and best-practice land management should be is implemented. Not doing so could lead to increased emissions, and compromise livelihoods, biodiversity and ecosystem services[23].

The transformational pathways modelled by the IPCC suggested bioenergy could provide 5 to 95 EJ/yr in 2030, 10 to 245 EJ/yr in 2050, and 105 to 325 EJ/yr in 2100 (some models project 35% of total primary energy from bioenergy in 2050, and as much as 50% of total primary energy from bioenergy in 2100)[24]. Recently published estimates for global technical bioenergy potentials in 2050 span a range of almost three orders of magnitude, from <50 EJ/yr to >1,000 EJ/yr. There is no consensus on the magnitude of the future global technical bioenergy potential, although most studies agree that the technical bioenergy in 2050 is at least approximately 100 EJ/yr. Different views about sustainability and socio-ecological constraints lead to very different estimates, with some studies reporting much lower figures says the IPCC[25].

In mitigation scenarios reaching 430-480 ppm CO2eq concentrations by 2100, the contribution of natural gas power generation without CCS globally is below current levels in 2050 and further declines in the second half of the century[26] (and the contribution of coal will be even lower). However according to the IPCC, even taking into account revised estimates for fugitive methane emissions, recent lifecycle assessments indicate that specific GHG emissions are reduced by one half (on a per-kWh basis) when shifting from the current world-average coal-fired power plant to a modern natural gas combined-cycle (NGCC) power plant. State of the art combined heat and power gas plants are able to approach efficiencies over 85%[27]. Therefore the IPCC say where natural gas is available and the fugitive emissions associated with its extraction and supply are low, near-term GHG emissions from energy supply can be reduced by replacing coal-fired with highly efficient natural gas combined cycle (NGCC) power plants or combined heat and power plants[28]. Friends of the Earth advocates a switch from coal to renewable energy as this will bring even greater emission reductions than coal to gas.

As of mid-2013, CCS has not yet been applied at scale to a large, commercial fossil-fired power generation facility. However, all of the components of integrated CCS systems exist and are in use today by the hydrocarbon exploration, production, and transport, as well as the petrochemical refining sectors[29]. CCS is unlikely to occur without sufficiently stringent limits on GHG emissions (regulatory mandates) or sufficient direct or indirect financial support[30]. It has the potential to reduce GHG emissions to 70–290 gCO2eq/kWh for coal and 120–170 gCO2eq/kWh for gas (assuming a low leakage rate of 1% of natural gas)[31]. It is worth noting that in the UK the Committee on Climate Change has recommended that electricity production should release no more that 50g/KWhr by 2030, which suggests that the proportion of fossil fuel CCS in electricity supply would need to be small.

Transport

In transport, electric, hydrogen, and some biofuel technologies could help reduce the carbon intensity of fuels, but their total mitigation potentials are very uncertain. In particular, the mitigation potential of biofuels will depend on technology advances and sustainable feedstocks. Energy efficiency measures through improved vehicle and engine designs have the largest potential for emission reductions in the short term with potential energy efficiency and vehicle performance improvements ranging from 30–50% relative to 2010 depending on mode and vehicle type. Realizing this efficiency potential will depend on large investments by vehicle manufacturers, which may require strong incentives and regulatory policies in order to achieve GHG emissions reduction goals[32]

Urban areas and buildings

Urbanization is a global trend transforming human settlements, societies, and energy use. In 1900 some 200 million people lived in urban areas, today it is roughly 3.6 billion and by 2050 the urban population is expected to increase to 5.6–7.1 billion. Already urban areas account for more than half of global primary energy use and energy-related CO2 emissions. The majority of infrastructure and urban areas has yet to be built[33].

This migration to cities - coupled with decreasing household size, increasing levels of wealth, and lifestyle changes, including increasing dwelling size and number and use of appliances - contributes to considerable increases in building energy services demand say the IPCC. The substantial amount of new construction taking place in developing countries represents both a risk and opportunity from a mitigation perspective. Recent advances in technology, design practices and know-how, coupled with behavioural changes, can achieve a two to ten-fold reduction in energy requirements of individual new buildings and a two to four-fold reduction for individual existing buildings largely cost-effectively or sometimes even at net negative costs[34]. The IPCC says especially strong barriers in this sector hinder the market uptake of cost-effective technologies and practices; as a consequence, programmes and regulation are more effective than pricing instruments alone[35].

Land-use and diet

Changes in diet strongly affect future GHG emissions from food production, for example it was estimated that agricultural non-CO2 emissions (CH4 and N2O) would triple by 2055 if current dietary trends and population growth were to continue. The potential to reduce GHG emissions through changes in consumption was found to be substantially higher than that of technical mitigation measures. A recent study also found that cropland and pastures required for the production of beef, lamb, calf, pork, chicken, and milk could annually sequester an amount of carbon equivalent to 30–470% of the GHG emissions usually considered in LCA of food products if the land were to be reforested. Freeing up land for bioenergy or afforestation and related carbon sequestration has a strong and non-linear effect says the IPCC[36].

Behavior

The IPCC says that Emissions can be substantially lowered through changes in consumption patterns (e.g. mobility demand and mode, energy use in households, choice of longer-lasting products); and dietary change and reduction in food wastes[37].

Investment and costs

A transformation to a low-carbon economy implies new patterns of investment. A limited number of studies have examined the investment needs for different mitigation scenarios. Information is largely limited to energy use says the IPCC.

Mitigation scenarios that stabilize atmospheric CO2eq concentrations in the range from 430 to 530 ppm CO2eq by 2100 show substantial shifts in annual investment flows during the period 2010–2029 if compared to baseline scenarios. Annual investment in the conventional fossil fuelled power plants and fossil fuel extraction would decline by roughly 20% to around USD120 billion whereas investment in low emissions generation technologies would double to around USD300 billion per year during the same period. An increase by USD 336 billion in energy efficiency investments in the building, transport and industry sectors would also be required. Mitigation scenarios also reduce deforestation against current deforestation trends by 50% reduction with an investment of USD 21 to 35 billion per year[38].

The additional costs from both supply and demand sides are estimated to about USD 800 billion/year with developing countries requiring more investments than the developed countries. This is small within the context of the total value of the world's financial stock, which (including global stock market capitalization) stood at more than USD 210 trillion at the end of 2010. Moreover, the investment needs described above would be offset, to a degree, by the lower operating costs of many low-GHG energy supply sources, as well as those due to energy-efficiency improvements in the end-use sectors[39].

Most of these mitigation scenarios assume a global single carbon price, applied to well-functioning markets, with key technologies are available for all sectors of the economy[40]. In these idealised scenarios global consumption losses are only 1% to 4% in 2030, 2% to 6% in 2050, and 2% to 12% in 2100 relative to what would happen without mitigation. These consumption losses do not consider the benefits of mitigation, including the reduction in climate impacts. To put these losses in context, studies assume increases in consumption from four-fold to over ten-fold over the century without mitigation[41].

Equity considerations

The causes of climate change are not evenly spread across people and nations. As the Working Group 2 report on climate impacts identified neither are the impacts. As the Working Group 3 report identifies the costs of mitigation and the impacts of mitigation are also not evenly spread.

The IPCC Working Group 3 report says that maintaining and advancing human wellbeing, in particular overcoming poverty and reducing inequalities in living standards, while avoiding unsustainable patterns of consumption and production, are fundamental aspects of equitable and sustainable development. It says because these aspects are deeply rooted in how societies formulate and implement economic and social policies generally, they are critical to the adoption of effective climate policy.[42]

Whether mitigation scenarios will have adverse distributional effects and thus impede achieving energy access objectives will depend on the climate policy design and the extent to which complementary policies are in place to support the poor.

It notes that about 1.3 billion people worldwide do not have access to electricity and about 3 billion are dependent on traditional solid fuels for cooking and heating with adverse effects on development, ecosystems and severe health implications. Scenario studies show that the costs for achieving nearly universal access are between USD 72–95 billion per year until 2030.[43]

In order to reach atmospheric concentration levels of 430 to 530 ppm CO2eq by 2100, the majority of mitigation relative to baseline emissions over the course of century will need to occur in the non-OECD countries, says the IPCC, raising issues of who pays. They say this is, in large part, because baseline emissions from the non-OECD countries are projected to outstrip those from the OECD countries, and non-OECD countries have higher carbon intensities (notwithstanding this, emissions still need to peak earlier in the OECD countries – 2010 - than in the non-OECD countries – 2015-2030)[44]. They argue that international financial transfers effort-sharing frameworks can help to address discrepancies between the distribution of costs based on mitigation potential and the distribution of responsibilities based on ethical principles. They identified that studies estimate that the financial transfers to ameliorate this asymmetry could be in the order of hundred billions of USD per year before mid-century to bring concentrations within the range of 430-530 ppm CO2eq in 2100.[45]

In comparison, current flows of finance are very small, estimated to range from USD 39 to 120 billion per year during the period 2009 to 2012, covering public (USD 35-49 billion) and the more uncertain flows of private funding for mitigation and adaptation. Most public finance is through bilateral and multilateral institutions usually as concessional loans and grants. Under the UNFCCC, climate finance is provided funding to developing countries of only USD 10 billion per year on average from 2005 to 2010[46]

In other words there is a very large gap in terms of the scale of finance flows to developing countries compared to current flows.

In addition, any large-scale change in land use, for biomass for energy, or for sequestration in vegetation, will likely increase the competition for land, water, and other resources, and conflicts may arise with important sustainability objectives such as food security, soil and water conservation, and the protection of terrestrial and aquatic biodiversity. These risks do not have equal impacts across societies and nations (the IPCC recognised that these risks could be reduced by focusing on multifunctional systems that allow the delivery of multiple services from land)[47].

Co-benefits

There would be significant co-benefits resulting from action to reduce greenhouse gas emissions according to the IPCC. Mitigation scenarios leading to atmospheric concentration levels between 430 and 530 ppm CO2eq in 2100 are associated with significant co-benefits for air quality, human health and ecosystem outcomes. For example:

- Welfare gains from GHG mitigation are expected to be particularly high where currently legislated and planned air pollution controls are weak. Co-benefits for health are particularly high in today's developing world.
- In countries with a high consumption of animal protein, co-benefits are reflected in positive health impacts resulting from changes in diet[48], although cultural and social barriers against a widespread adoption of dietary changes to low-GHG food may be expected say the IPCC[49].
- Large regional expansion of forest cover for carbon sequestration, if through the expansion of natural vegetation, could enhance biodiversity and a range of other ecosystem services provided by forests. If afforestation occurs through large-scale plantations however some negative impacts on biodiversity, water, and other ecosystem services could arise[50].
- Reduction of subsidies to fossil energy can achieve significant emission reductions at negative social cost *The* IPCC notes that although political economy barriers to this change are substantial, many countries have successfully reformed their tax and budget systems to reduce fuel subsidies that actually accrue to the relatively wealthy, and utilized lump-sum cash transfers or other mechanisms that are more targeted to the poor[51].

Friends of the Earth's conclusions

Decades of continuing growth in greenhouse gas emissions have made the task of avoiding dangerous more difficult and more costly. Energy efficiency is clearly critical, although in many countries is poorly funded despite the benefits from doing so.

Development of low carbon energy supply is also clearly necessary, and there is no shortage of renewable energy to tap into. All regions of the world will need to peak emissions within the next ten years or so and energy efficiency plus renewable energy are critical to this.

Fossil fuels do not have a long-term future. Coal, as the most polluting source of energy, much be rapidly phased out. Unabated gas, if it has a role at all, is only a bridging fuel according to the IPCC. The known resources and reserves of gas far outstrip the quantity of gas that can be burnt if 2 degress warming is to be avoided according to the IPCC[52]. Friends of the Earth has identified exciting reserves of gas are also likely to outstrip what can be safely burnt[53].

If development goals and climate mitigation goals are to be achieved then financial transfers to developing countries from developed in the order of hundreds of billions of dollars a year are necessary. But it would be wrong to look at the costs of mitigation without full consideration of the avoided impacts and risks, together with the very clear co-benefits that accrue from mitigation actions as diverse as changes in diet to reducing the use of coal-fired power stations. Taken together, and in the context of the size of the global economy, avoiding dangerous climate change is not expensive.

References – all references are to the Summary for Policy Makers (SPM) or the Technical Summary (TS) of the Working Group 3 report or the chapters as published on April 15th 2014.

[1] TS, P10
[2] TS, P18
[3] TS, P16
[4] Chapter 6, P5
[5] Chapter 6, P28
[6] Chapter 6, P25
[7] Chapter 6, P26
[8] TS, P25
[9] TS, P29
[10] TS, P31
[11] TS, P29
[12] Chapter 7, P59
[13] Chapter 7, P61
[14] TS, P46
[15] TS, P46
[16] TS, P42
[17] TS, P47
[18] SPM, Table SPM2, P18
[19] Chapter 7, P17

[20] Chapter 7, P29
[21] TS, P28
[22] TS, P28
[23] Chapter 11, P6
[24] Chapter 11, P96
[25] Chapter 11, P79-80
[26] TS, P49
[27] Chapter 7, P19
[28] Chapter 7, P6
[29] Chapter 7, P25
[30] Chapter 7, P26
[31] Chapter 7, P34
[32] TS, P52
[33] TS, P76
[34] TS, P58
[35] TS, P62
[36] TS P72
[37] SPM, P23
[38] TS, P96-97
[39] Chapter 7, P54
[40] TS, P31
[41] TS, P31
[42] TS, P7
[43] TS, P38
[44] TS, P28
[45] TS, P33
[46] TS, P98
[47] Chapter 11, P6-7
[48] TS P71
[49] Chapter 11, P36
[50] Chapter 11, P68
[51] TS, P88
[52] Chapter 6, P38
[53] Friends of the Earth (2013), The UK, shale gas and unburnable carbon
http://www.foe.co.uk/sites/default/files/downloads/unburnable_gas_2013.pdf