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Low Carbon Pulse - Edition 38

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to the **Edition 38** of Low Carbon Pulse. This edition reports on the third part of the Intergovernmental Panel on Climate Change (***IPCC***) ***Sixth Assessment Report*** - the ***Climate Change 2022, Mitigation of Climate Change*** report (***IPCC WGIII Report***). Also this edition reports on IRENA's ***World Energy Transitions Outlook 2022*** (***WETO 2022***).

This **Edition 38** provides a high level summary of key findings in the ***IPCC WGIII Report***, and ***WETO 2022*** report, and is divided as follows: **1**. Introduction; **2**. What the reader needs to know; **3**. The Headlines; **4**. What is past is prologue; and **5**. What needs to be done.

Section 1: Introduction:

1.1: Background:

IPCC AR6**:** On **April 4**, **2022**, the ***IPCC Working Group III*** **(*Mitigation of Climate Change*)** published the ***Climate Change 2022 Mitigation of Climate Change*** report (the ***IPCC WGIII Report***).

The ***IPCC WGIII Report*** is the final report from three ***IPCC Working Groups***, ***I***, ***II*** and ***III***. The three reports comprise, together, the ***IPCC Sixth Assessment Report*** (***AR6***). The ***IPCC WGI*** ***Climate Change 2021, The Physical Science Basis*** report was published on August 9, 2021 (which was covered in **Edition** 24 of Low Carbon Pulse) and the ***IPCC WGII*** ***Climate Change 2022: Impacts, Adaptation and Vulnerability*** report was published on February 28, 2022 (which was covered in **Edition** 36 of the Low Carbon Pulse).

As noted in previous editions of Low Carbon Pulse, in **September 2022** the ***IPCC*** will publish the ***Synthesis Report***. The ***Synthesis Report*** will synthesise findings from the three reports, and from three Special Reports (***Global Warming of 1.5°C***, ***Climate Change and Land*** and ***The Ocean and Cryosphere in a Changing Climate***) that have also been undertaken for the purposes of ***AR6***. The ***Synthesis Report*** will be in two parts, the ***Summary of Policymakers*** (***SPM***) and the ***Longer Report***. It is not anticipated that either part of the ***Synthesis Report*** (***SPM*** or ***Longer Report***) will be anywhere near the length of the reports from ***IPCC Working Groups***, ***I***, ***II*** and ***III***.

The ***Synthesis Report*** is expected to inform the agenda for the 27th session of the Conference of the Parties (***COP-27***), which will take place in Sharm El-Sheikh, South Sinai, Egypt from **November 7** to **18**, **2022**. Without wishing to assume the agenda, or the dynamics in the lead up to, and at, ***COP-27***, the nationally determined commitments (***NDCs***) of each country that is party to the Paris Agreement need to be increased and accelerated.

IRENA WETO 2022: On **March 29**, **2022**, the International Renewable Energy Agency (***IRENA***) published ***World Energy Transitions Outlook 2022*** (***WETO 2022***). In 2021, ***IRENA*** published its World Energy Transitions Outlook 2021 (***WETO 2021***) which considered how to achieve net-zero ***GHG*** emissions by 2050. ***WETO 2022*** focuses on the near to medium term, critically, "*the steps needed by 2030 to deliver climate and near term energy solutions, simultaneously and urgently*", consistent with achieving net-zero by 2050. ***WETO 2022*** "*positions justice and fairness at the heart of planning and actions so that energy transition will have a truly positive impact*".

1.2: Why consider the *IPCC WGIII Report* and *WETO 2022* together?

Edition 29 of Low Carbon Pulse described the themes that emerged in the lead up to ***COP-26***, including as follows:

- By 2030, ***GHG*** emissions need to reduce by 45% (at least) to limit the increase in global warming to within the ***1.5°C*** to ***2°C*** range, and by at least 50 to 52% to limit to a ***1.5°C*** increase; and
- Without increased and accelerated reductions in ***GHG*** emissions, critically, increased reductions and accelerated rates of reductions under ***NDCs***, as warned by United Nations Secretary General, Mr Antonio Guterres, we are tracking to a ***2.7°C*** increase. What Mr Guterres warned as a ***Catastrophic Pathway***.

Low Carbon Pulse – Edition 38 – Published on April 14, 2022.

The researcher and author of each edition of Low Carbon Pulse is Michael Harrison.

1.2: The perspective of the author:

In the context of reviewing the ***IPCC WGIII Report***, the author had the benefit of the sage advice shared by Ms Roberta Boscolo (the advice having originated from Joeri Rogeli) on how to interpret the findings in the ***IPCC WGIII Report***.

The advice helps assess both the ***IPCC WGIII Report*** and the assessments of it, since its publication on April 4, 2022. The advice is as follows:

1. Do not interpret the findings (including in the form of the scenarios) as a statistical sample, rather take them as representing agreement across the literature considered for the purposes of the ***IPCC WGIII Report***;
2. Do not focus on the median, consider the full range of findings (and as such each scenario);
3. Do not cherry-pick individual findings (and the attendant scenario or scenarios) to make general conclusions;
4. Do not over-interpret any finding (and the attendant scenario or scenarios), and do not venture too far from the original purpose of the ***IPCC WGIII Report***, this will make it easier to avoid extrapolation; and
5. Finally, do not conclude that the absence of any scenario does not mean that that scenario is not possible.

1.3: By way of a reminder:

Greenhouse Gases (*GHG*):

In this **Edition 38** of Low Carbon Pulse, ***GHG*** refers to the following well-mixed greenhouse gases, the basis for ***IPCC WGI*** *Climate Change 2021, The Physical Science Basis* report.

CONCENTRATIONS OF WELL MIXED GHG			
Average concentration	***CO_2***	***CH_4***	***N_2O***
2019	410 ppm	1866 ppb	331 ppb
JUNE 2020	416.60 ppm	1876 ppb	332.7 ppb
JUNE 2021	418.54 ppm	1891 ppb	334.1 ppb
MARCH 2022	418.81 ppm	1900 ppb	334.3 ppb

Every tonne of well mixed ***GHG*** emitted contributes to an increase in average global atmospheric temperature. Stated another way, the root cause of climate change is the increase in temperature caused by increased mass of ***GHGs*** in the climate system, increasing the concentration of ***GHGs*** in the climate system, principally ***CO_2***, ***CH_4*** and ***N_2O***.

The ***CO_2*** concentrations are higher than at any time in the last two million years, and concentrations of ***CH_4*** and ***N_2O*** are higher than at any time in at least 800,000 years.

The Paris Agreement:

CO_2-e (carbon dioxide equivalent) recognises that different ***GHGs*** have different global warming effects, with the use of ***CO_2-e*** allowing a like-for-like comparison taking account of potency and time retained in the climate system. What is clear however is that ***CO_2*** is the ***GHG*** on which ***GHG*** reduction and ***GHG*** removal initiatives need to concentrate because globally, by mass, it is, by far, the most emitted ***GHG***. At the same time, there needs to be a near term concentration on the reduction of ***CH_4***.

The key provisions of the Paris Agreement are as follows:

KEY PROVISIONS OF THE PARIS AGREEMENT FOR *COP-26*	
Article 2.1: This Agreement … aims to strengthen the global response t the threat of climate change … including by: (a) Holding the increase in global average temperatures to we below 2^{O}C [***Stabilisation Goal***] above pre-industrial levels ar pursuing efforts to limit the temperature increase to 1.5^{O} [***Stretch Goal***] above pre-industrial levels, recognising tha this would significantly reduce the risk and impacts of clima change; (b) Increasing the ability to adapt to the adverse impacts climate change and foster climate resilience and lo greenhouse gas emissions development, in a manner that doe not threaten food production; and (c) Making finance flows consistent with a pathway towards lo greenhouse gas emissions and climate-resilient development	**Article 4:** In order to achieve the long-term temperature goal set in Article 2, Parties aim *to reach global peaking of greenhouse gas emissions as soon as possible*, … and to undertake *rapid reductions thereafter in accordance with best available science*, so as to achieve a balance between anthropogenic emissions by sources and *removals to sinks in greenhouse gas in the second half of this century* … . **Article 6:** 1. Parties recognise that some Parties choose to pursue voluntary cooperation in the implementation of their nationally determined contributions to allow for higher ambition in their mitigation and adaptation actions and to promote sustainable development and environmental integrity. 2. Parties shall, where engaging on a voluntary basis … promote sustainable development, and ensure … integrity and transparency … and shall apply *robust accounting* … to ensure .. *avoidance of double counting* consistent with guidance adopted by the Conference of Parties … .

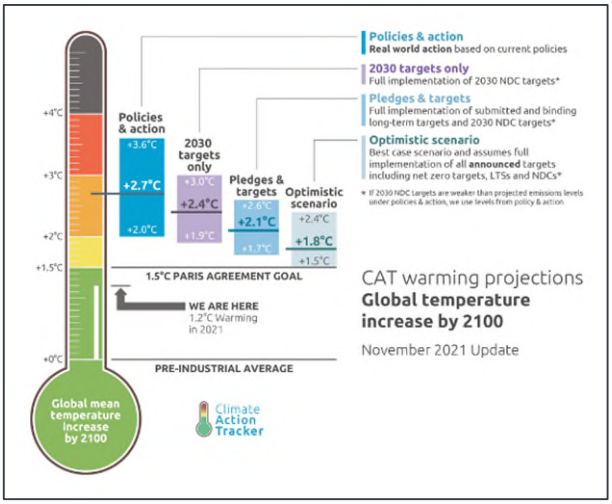
2: What the reader needs to know:

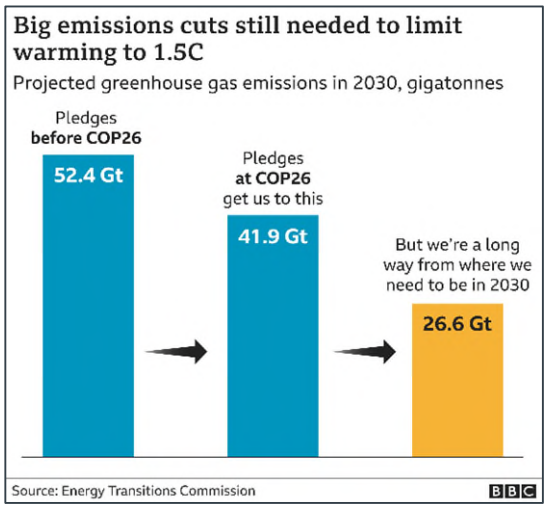
2.1 Overarching theme:

In the weeks leading up to ***COP-26*** some countries increased and accelerated their ***NDCs***. During ***COP-26*** further commitments were made. **Edition 30** of Low Carbon Pulse reported on the work and conclusions of the good folk at Climate Tracker to model the impact of those further commitments.

After ***COP-26***, as reported by Climate Tracker, the best case scenario arising from the announced increased ***NDCs*** would be to hold the increase in global warming to ***1.8^{O}C***, assuming implementation of those increased ***NDCs***. This

was positive, certainly more positive than the ***Catastrophic Pathway***. It did not, however, and it does not, provide certainty of a 45% reduction in ***GHG*** emissions by 2030.





From ***COP-26*** a number of themes emerged (see **Edition** 30 of Low Carbon Pulse), but the overarching theme was the need to increase levels of action to address climate change, and to accelerate the reduction in ***GHG*** emissions.

The overarching theme from ***COP-26*** is carried forward in both the ***IPCC WGIII Report*** and ***WETO 2022***, each emphasising that by the end of the current decade considerably more action needs to have been taken than is represented by the current combined ***NDCs*** of each country party to the Paris Agreement.

2.2: Fundamental choices need to be made, quickly:

Each of the ***IPCC WGIII Report*** and ***WETO 2022*** are clear – the world faces fundamental choices that will determine whether global warming is limited to ***1.5^{o}C*** or ***2^{o}C***, or not. The ***IPCC WGIII Report*** contemplates a worst case outcome of a ***3.2^{o}C*** increase, beyond the ***Catastrophic Pathway***. Time is a luxury, and collectively our carbon budget does not allow any luxuries.

2.3: Increased and accelerated reductions in *NDCs* are required, quickly:

It is known that increased and accelerated reductions in ***GHG*** emissions by 2030 and 2040 are required, particularly reductions in methane (***CH_4***), to achieve lower peak ***GHG*** emissions, and lower peak warming (which will happen after peak ***GHG*** emissions). This will place less reliance on ***GHG*** removal (including negative ***GHG*** emission initiatives).

2.4: None of this is new:

It is important to note that none of this is new. What is new is the increasing realisation that the choices available to us are narrowing, and there is a real risk that neither the ***1.5^{o}C*** nor ***2^{o}C*** limit on global warming will be achieved.

Section 3: The Headlines:

3.1: Peaking GHG emissions:

Many of the headlines reporting on the ***IPCC WGIII Report*** do not seem to reflect the sage advice described in **Section 1.2** above. In context, as reported in previous editions of Low Carbon Pulse, and as noted above, there is a gap between the ***NDCs*** of countries that are party to the Paris Agreement and the level, and rate, of reductions in ***GHG*** emissions required to limit global warming to ***1.5^{o}C*** or ***2^{o}C***. At the moment, ***GHG*** emissions are increasing, as is the rate of increase, and as such it is difficult to discern when peak ***GHG*** emissions will be reached.

Given the current rate of ***GHG*** emissions, we can discern the mass of ***GHG*** emissions in the atmosphere that will result in a ***1.5^{o}C*** increase in average temperature compared to pre-industrial times. Below, a simple scenario (under section 4.1.7) is provided that would allow us to limit the temperature increase to ***1.5^{o}C*** by 2100, assuming reductions of a level and at a rate consistent with achieving net-zero by 2050. Depending on the mass of ***GHG***s emitted, by 2100 the increase may exceed ***3^{o}C*** compared to pre-industrial time (a worst case scenario is a ***3.2^{o}C*** increase).

3.2: Key message:

The key message from the ***IPCC WGIII Report*** is that, starting now, increased and accelerated reductions in ***GHG*** emissions are required across all sectors, using multiple means. It is imperative that this happens. If it does not happen it seems highly unlikely that keeping the increase in average global temperatures to ***1.5^{o}C*** will be achieved.

As Mr Bill Gates said, in ***How to Avoid A Climate Disaster***, reducing ***GHGs*** to net-zero by 2050 "will be hardest thing humanity's ever done". But it is technically feasible. The basis for Mr Gate's book is that: "There are two numbers you need to know about climate change. The first is 51 billion. The other is zero". The ***IPCC WGIII Report*** increases the first number to between 54 and 66 GtCO2 (reflecting the mass of ***GHG*** emissions emitted in 2019). It is harder!

3.3: What needs to be done is known:

The scale of the task is known, the degree of difficulty is known. Objectively viewed, the fundamental choices are clear, and decisions should be easy, but execution is the hardest thing humanity's ever done.

In short, in the words of the Co-Chair of the ***IPCC WGIII***, Mr Jim Skea: "***It's now or never***" to make and to act upon those fundamental choices.

In a quote used on a number of occasions in Low Carbon Pulse, "***What's past is prologue***", taken, without any intended cynicism or irony, from *The Tempest*, by William Shakespeare. The phrase is emblematic.

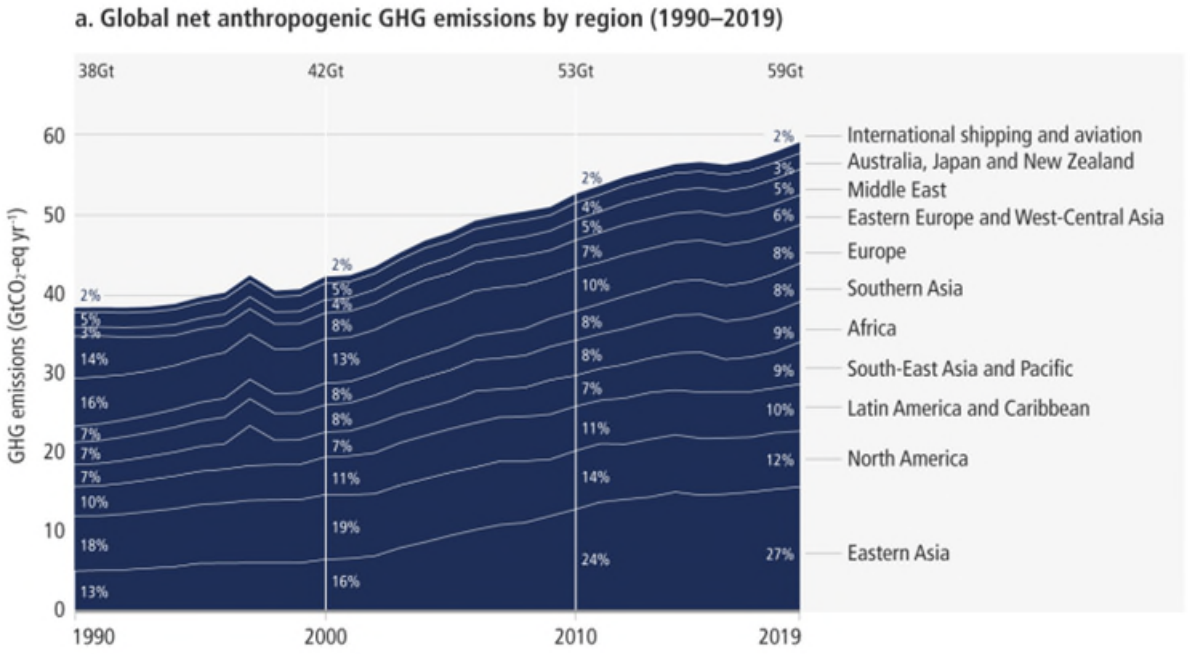
To the ever-optimistic author, this means that it is time to draw a line under the past, and move on, as quickly as possible, to increase the level and to accelerate the rate of reductions in ***GHG*** emission by all means practicable.

Section 4: What is past is prologue

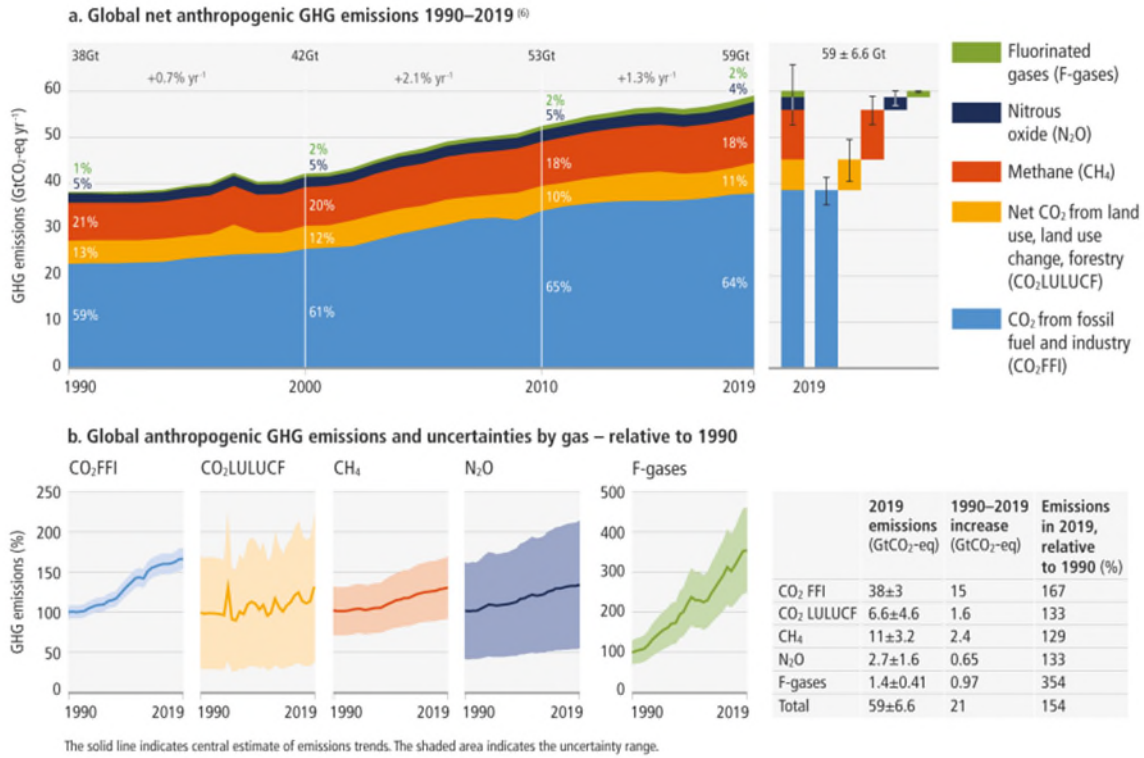
4.1.1: Carbon budget to the end of 2019:

The ***IPCC WGIII Report*** states that:

"Historical cumulative net CO2 emissions from 1850 to 2019 were 2,400 ± 240 $GtCO_2$ (high confidence). Of these, more than half (58%) occurred between 1850 and 1989 [1,400 ± 195] $GtCO_2$, and about 42% between 1990 and 2019 1,000 ± 90 $GtCO_2$".



Global net anthropogenic emissions have continued to rise across all major groups of greenhouse gases.



	2019 emissions ($GtCO_2$-eq)	1990–2019 increase ($GtCO_2$-eq)	Emissions in 2019, relative to 1990 (%)
CO_2 FFI	38±3	15	167
CO_2 LULUCF	6.6±4.6	1.6	133
CH_4	11±3.2	2.4	129
N_2O	2.7±1.6	0.65	133
F-gases	1.4±0.41	0.97	354
Total	59±6.6	21	154

The focus of the ***IRENA WETO 2022*** is ***GHG*** emissions arising from the energy sector. The following pie-chart and infographic illustrate the mass of ***GHG*** emissions arising (36.9 GtCO2) and the means by which those emissions are

to be reduced. The infographic and accompanying narrative represents the required reduction in the mass of ***GHG*** emissions by 2030.

FIGURE ES.1 Reducing emissions by 2050 through six technological avenues

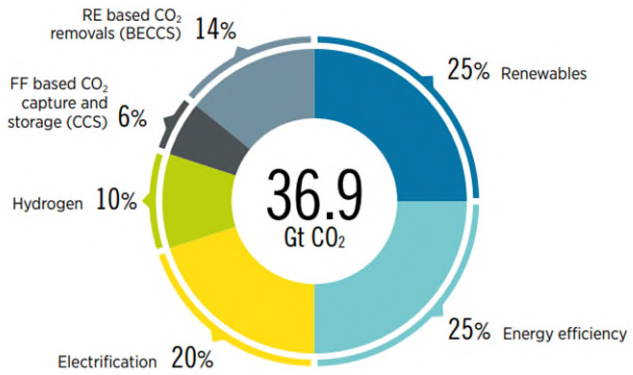
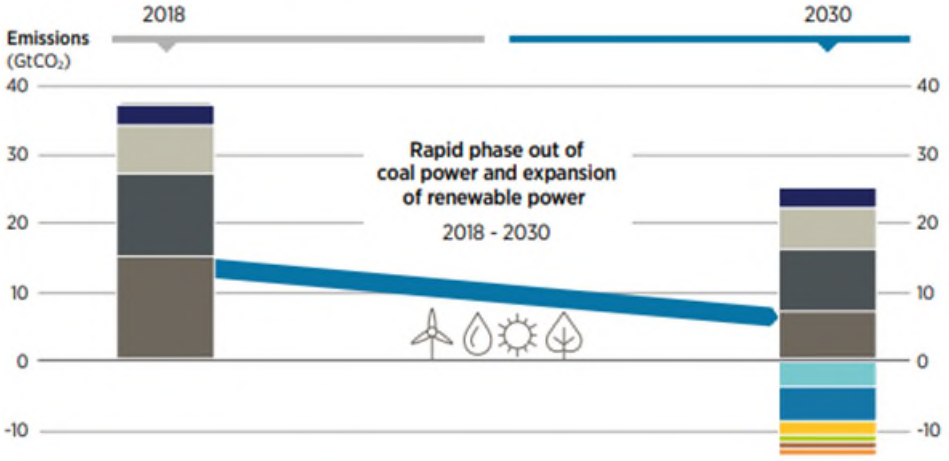


FIGURE ES.2 Emission reductions 2018-2030



Renewable energy share in electricity generation must increase to 65% by 2030.

- An additional 8 000 GW of renewable capacity in this decade.
- Installed capacity of onshore wind of 3 000 GW, four times that of 2020.
- Offshore wind to scale up to 380 GW, 11 times more than in 2020.
- Installed capacity of solar PV to reach 5 200 GW, more than seven times that of 2020.
- Hydropower capacity to increase to 1 500 GW, 30% more than in 2020.
- Other renewable technologies to reach 750 GW, up six-fold from 2020.

The share of direct electricity in total final energy consumption (TFEC) must rise from 21% to 30%; deployment of energy efficiency measures must increase 2.5 times.

- A drop in TFEC from ca. 390 EJ today to 370 EJ.
- Expanded electrification of energy services, especially in transport sector.
- Improved energy efficiency standards and retrofitting of existing buildings.
- Process changes in industry, relocation of industries, and circular economy practices.

Direct renewables in end use sectors must grow from 12% in 2019 to 19% by 2030.

- Hydrogen consumption to reach a minimum of 19 EJ by 2030.
- Total consumption of bioenergy and feedstock in industry to increase to 25 EJ, 2.5 times more than in 2019.
- Solar thermal, geothermal and district heating solutions to be scaled up to 60 EJ, 1.3 times the 2019 levels.
- Biofuel's share for energy consumption in transport to increase from 3% in 2019 to 13%.
- Increase ambition on biojet to reach 20% of total fuel consumption by 2030.

Process and non-energy
Natural gas
Oil
Coal

Energy conservation and efficiency
Renewables (power and direct uses)
Electrification of end uses (direct)

Hydrogen and its derivatives
CCS in industry
BECCS and other carbon removal measures

4.1.2: Reduction in *GHG* emissions and impact:

The mass of ***GHG*** emissions arising each year, and more importantly the global warming potential of those ***GHG's***, will inform the rate at which global warming occurs, and as such at what point we will reach a ***1.5^{o}C*** increase and, possibly, a ***2^{o}C*** increase in global average temperatures around which the Paris Agreement is framed.

In this context, considerable work has been done to determine the rate at which ***GHG*** emissions can be emitted before the ***1.5^{o}C*** limit or ***2^{o}C*** limit is reached. The ***IPCC WGIII Report*** indicates that in 2019, 59 $GtCO_2$ (plus or minus 6.6 Gt) of ***GHG*** emissions arose. This is relevant for the purposes of the carbon budget.

4.1.3: Carbon budget from 2020 onwards:

The ***IPCC WGIII Report*** states that:

> *"Remaining carbon budgets depend on the amount of non-CO2 mitigation (± 220 GtCO₂) and are further subject to geophysical uncertainties. Based on central estimates only, cumulative net CO₂ emissions between 2010-2019 compared to about four fifths of the size of the remaining carbon budget from 2020 onwards for a 50% probability of limiting global warming to 1.5°C and about one third of the remaining carbon budget for a 67% probability to limit global warming to 2°C. Based on central estimates only, historical cumulative net CO₂ emissions between 1850-2019 amount to about four firths of the total carbon budget for a 50% probability of limiting global warming to 1.5°C (central estimate 2,900 GtCO₂, and to about two thirds of the total carbon budget for a 67% probability to limit global warming to 2OC (central estimate about 3,350 GtCO₂)."*

What emerged clearly from ***COP-26*** was an understanding of the criticality of staying as close as possible to a ***1.5°C*** increase in average global temperatures (see **Editions** **29** and **30** of Low Carbon Pulse).

What has emerged since ***COP-26*** is that the rate of ***GHG*** emissions is increasing at a faster rate than was thought (including because of an under-recognition of ***CH₄*** emissions), and the point of peak ***GHG*** emissions, and the level of the peak, is further into the future, and at a higher mass of ***GHG*** emissions at peak level, than thought. These dynamics explain the reason for the expression of urgency.

4.1.4: Where we are now - in summary:

Based on an assumed mass of ***GHG*** emissions of say 60 $GtCO_2$ a year, it is possible to estimate how much is left in the carbon budget before we reach global warming of ***1.5°C*** (or ***2°C***), but, as will be explained, is not possible to determine exactly when the carbon budget will be depleted, because this depends on the mass of net ***GHG*** emissions.

Various models and reports indicate that four fifths of the carbon budget is 2,400 $GtCO_2$ to limit global warming to ***1.5°C*** has been used. Leaving a fifth remaining, or 600 $GtCO_2$. Once the remaining fifth is used, we will need to remove ***CO₂*** from the atmosphere to be able limit global warming to ***1.5°C***. This is not new (see Article 4 of the Paris Agreement).

In simple terms, at the current rate of ***GHG*** emissions during 2019, by 2030 we will have depleted the carbon budget. This is one part of the equation.

The other parts of the equation include knowing when peak ***GHG*** emissions will occur, and at what level of ***GHG*** emissions, and the rate of reduction in ***GHG*** emissions after reaching peak ***GHG*** emissions. These other parts to the equation will determine the extent to which we "overdraw" from the carbon budget, and, as a result, the mass of ***CO₂*** that will need to be removed from the atmosphere, and the rate at which this will have to occur.

4.1.5: Understanding peak emissions and the level of peak emissions:

It is not simple to determine is when ***GHG*** emissions will peak, and at what mass of ***GHG*** emissions will peak. More than this, it is critical to note that once peak ***GHG*** emissions are reached, the aggregate of all ***GHG*** emissions emitted to peak ***GHG*** emissions, and the rate of the decrease in ***GHG*** emissions after reaching peak ***GHG*** emissions, will determine the peak of global warming.

As such, assuming that we reach net zero ***GHG*** emissions by 2050, this does not mean that the rate of global warming will slow, or that global warming will reverse, this will depend upon the period of time taken for the global warming effect of ***GHGs*** emitted to dissipate, and the use of carbon removal (including negative greenhouse emission reduction initiatives).

4.1.6: Recurring headline illustrates the core issue:

One of the recurring headlines arising from the ***IPCC WGIII Report*** has been that to be able to have a chance of limiting global warming to ***1.5°C*** it will be necessary to achieve peak ***GHG*** emissions by the end of 2025.

The basis for this headline is that if we were to achieve peak ***GHG*** emissions by 2025 (assuming no increase in the mass of ***GHG*** emissions arising each year before 2025), this will leave 300 $GtCO_2$ left in the carbon budget (at the current assumed rate of GHG emission, 60 GtCO2 a year). Clearly if the level of ***GHG*** emissions increase, we will use up the carbon budget at a faster rate.

But, and it is a big but, for global warming not to exceed ***1.5°C***, the cumulative mass of ***GHG*** emissions arising from the end of 2025 (assuming the peak ***GHG*** emissions arise then) to the time at which we achieve net-zero emissions should not exceed 300 $GTCO_2$.

This is not going to happen, but what is?

While headlines are intended to capture our attention, the recurring headline described above leads us to the core of the issue, and, it is hoped, explains why policy makers are adamant that steep reductions in ***GHG*** emissions are required by 2030 and 2040. To explain this thinking, the following simple scenario may help.

4.1.7: A simple scenario (from the author):

If a 50% reduction in ***GHG*** emissions was to be achieved by 2030, ***GHG*** emissions would have to have reduced to 30 $GtCO_2$ in 2030. If the rate of reduction was say 6 $GtCO_2$ a year from an assumed peaking of ***GHG*** emissions in 2025 at 60 $GtCO_2$. This would result in 280 $GtCO_2$ being emitted (from 2025 to 2030). Out of the 300 GtCO2 carbon budget, about 90 $GtCO_2$ would be left i.e. 300 $GtCO_2$ less 210 $GtCO_2$ of ***GHG*** emissions (noting that this takes no account of dissipation of ***GHG*** emission in the atmosphere). (This would not guarantee limiting global warming to ***1.5°C***, but it would make the task of removing ***CO₂*** a lesser task than might otherwise be the case.)

Continuing with the simple scenario. If during the period 2030 to 2040, ***GHG*** emissions could be reduced at a rate of 2 $GtCO_2$ a year, by 2040 the carbon budget of 300 GtCO2 carbon budget would have been used, and it would be 70 $GtCO_2$ "overdrawn" (i.e. positive integer 90 $GtCO_2$ less 160 $GtCO_2$ of ***GHG*** emissions) against the carbon budget that would limit global warming to a ***1.5°C*** increase.

Assuming that from 2040 to 2050 ***GHG*** emissions are reduced at a rate of 1.2 GtCO2 a year to reach net zero ***GHG*** emissions by 2050, we would be 105 $GtCO_2$ "overdrawn" by (i.e. negative integer 70 $GtCO_2$ plus 35 $GtCO_2$ of ***GHG*** emissions) against the ***1.5°C*** carbon budget, but the task of removing ***CO₂*** from the atmosphere would be a lesser task than what might otherwise be the case, and, more likely than not, would allow us to limit global warming to ***1.5°C*** by the end of the 21st century.

In putting numbers to a concept, it is hoped that this simple scenario provides a firm basis for what follows. From one simple scenario, to multiple scenarios.

The ***IPCC WGIII Report*** and the ***WETO 2022*** provide a range of scenarios, some of which will allow us to limit global warming to ***1.5°C*** by the end of the 21st century, others that will not.

4.2 What might the future hold:

4.2.1: From 2020 to peak *GHG* emissions:

Of course, the mathematics in the simple scenario work only if ***GHG*** emissions start to slow before and decrease at an appropriate rate after peak ***GHG*** emissions are reached.

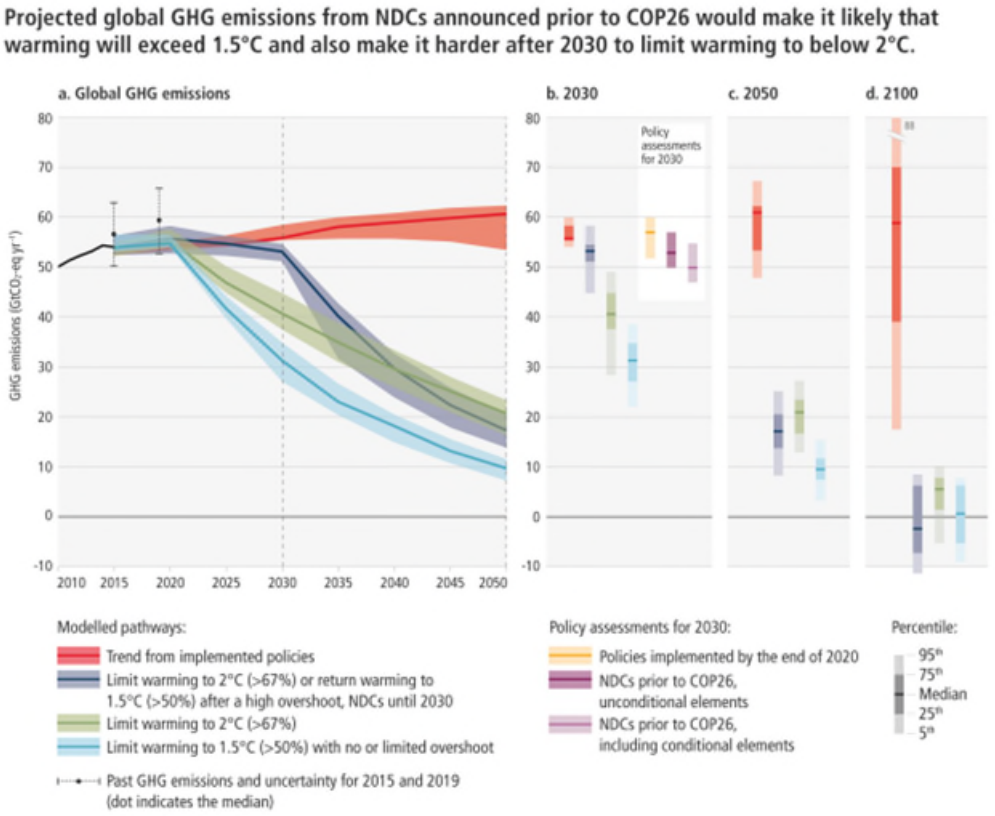
The ***IPCC WGIII Report*** notes that the mathematics will not work given the announced ***NDCs*** pre-***COP-26***, and, as noted above, the best scenario immediately post-***COP-26*** (taking into account increased ***NDCs***) is a ***1.8°C*** increase in average global temperatures.

The ***IPCC WGIII Report*** states that based on pre-***COP-26 NDCs*** it is likely that global warming will exceed ***1.5°C*** during the 21st century, and that limiting global warming to below ***2°C*** would require accelerated mitigation efforts after 2030.

Even allowing for the increased ***NDCs*** before, during and after ***COP-26***, the rate of ***GHG*** emissions is increasing, not decreasing.

It is accepted broadly that ***GHG*** emissions need to reduce by between 45 to 50% by 2030 for there to be a chance of limiting global warming to ***1.5°C***. This is not new, and the core of the issue is explained above.

The graphic below, and accompanying analysis, provides a good sense of the ***GHG*** reductions that need to be achieved, and the range of outcomes that may arise if those ***GHG*** reductions are not achieved.



4.2.2: Fossil fuels:

Consistent with a plethora of reports finding that countries are not taking into account in setting their ***NDCs*** for continued use of fossil fuels (see **Editions** 29 and 30 of Low Carbon Pulse), the ***IPCC WGIII Report*** notes that without additional reductions to take account of continued use of fossil fuels (both existing and currently planned) projected reductions will not be achieved. Again, this is not new.

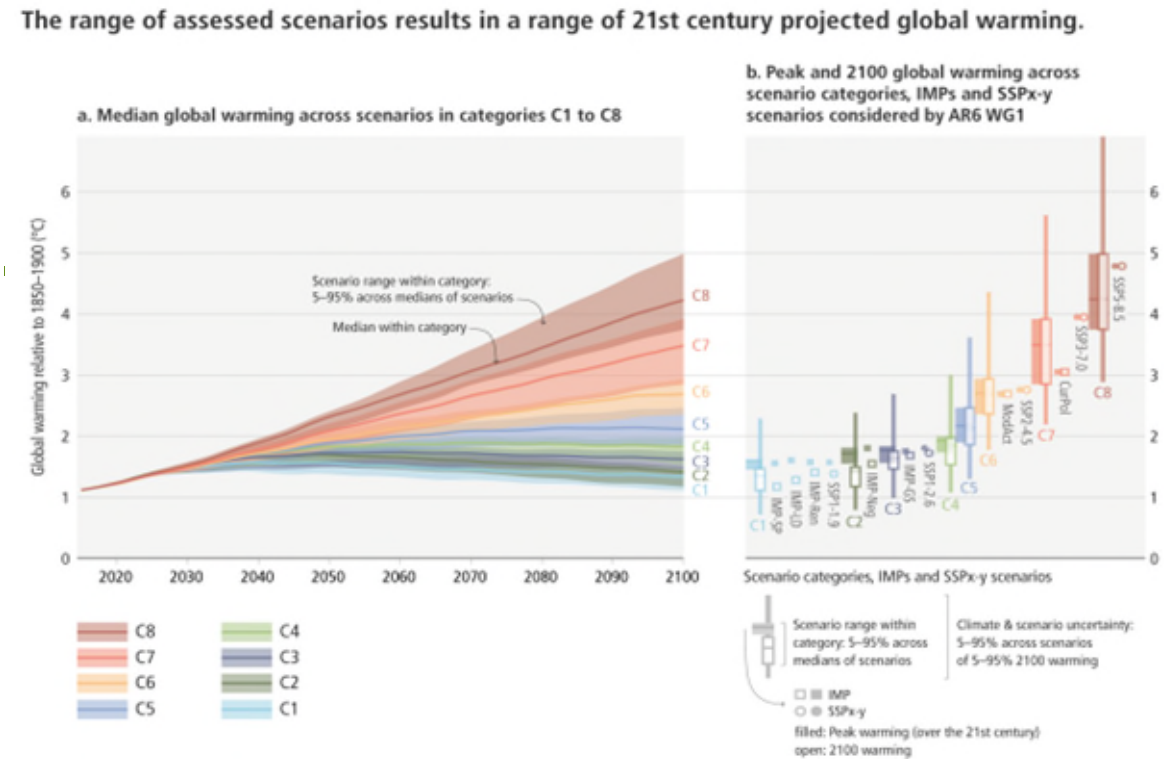
The narrative and reporting around the phasing out of fossil fuels remains challenging, both in terms of a reduction in revenue (direct for national oil companies, indirect for Governments currently receiving royalties and taxes from the production and sale of fossil fuels, and customs and duties from downstream import and sale of fossil fuels, and indeed any carbon tax) and the level of revenue required to allow Governments to support the development of infrastructure to allow progress to the achievement of net-zero emissions, and the fiscal incentives that Governments are giving, and are likely to have to continue to give, to allow continued progress to the achievement of net-zero emissions.

Governments in many countries are facing a "fiscal squeeze" (and will continue to do so), as the expectations of the funding support that Government will provide to achieve progress towards net-zero emissions increases, while at the same time the Governments face a diminishing lower fiscal base with the phase out of fossil fuel. This "fiscal squeeze" needs to be understood, and overcome.

Both the ***IPCC WGIII Report*** and the ***WETO 2022*** are clear about the need to phase out fossil fuels. The author notes that pragmatism, and good sense, is required in this context.

The table provides a summary on a page of a range of outcomes canvassed in the ***IPCC WGIII Report***. To the author, it is pretty much an ideal summary.

p50 [p5-p95] [1]			GHG emissions Gt CO_2-eq/yr [7]			GHG emissions reductions from 2019 % [8]			Emissions milestones [9,10]				Cumulative CO_2 emissions Gt CO_2 [13]		Cumulative net-negative CO_2 emissions Gt CO_2	Global mean temperature change 50% probability [14] °C		Likelihood of peak global warming staying below (%) [15]		
Category [2, 3, 4] [# pathways]	Category / subset label	WG I SSP & WG III IP/IMP alignment [5, 6]	2030	2040	2050	2030	2040	2050	Peak CO_2 emissions (% peak before 2100)	Peak GHG emissions (% peak before 2100)	Net-zero CO_2 (% net-zero pathways)	Net-zero GHG_{12} [11, 12] (% net-zero pathways)	2020 to net-zero CO_2	2020-2100	Year of net-zero CO_2 to 2100	at peak warming	2100	<1.5°C	<2.0°C	<3.0°C
Modelled global emissions pathways categorised by projected global warming levels (GWL). Detailed likelihood definitions are provided in SPM Box1. The five illustrative scenarios (SSPx-y) considered by AR6 WGI and the Illustrative (Mitigation) Pathways assessed in WGIII are aligned with the temperature categories and are indicated in a separate column. Global emission pathways contain regionally differentiated information. This assessment focuses on their global characteristics.			*Projected median annual GHG emissions in the year across the scenarios, with the 5th-95th percentile in brackets. Modelled GHG emissions in 2019: 55 [53-58] Gt CO_2-eq*			*Projected median GHG emissions reductions of pathways in the year across the scenarios compared to modelled 2019, with the 5th-95th percentile in brackets. Negative numbers indicate increase in emissions compared to 2019*			*Median 5-year intervals at which projected CO_2 & GHG emissions peak, with the 5th-95th percentile interval in square brackets. Percentage of peaking pathways is denoted in round brackets. Three dots (…) denotes emissions peak in 2100 or beyond for that percentile.*		*Median 5-year intervals at which projected CO_2 & GHG emissions of pathways in this category reach net-zero, with the 5th-95th percentile interval in square brackets. Percentage of net zero pathways is denoted in round brackets. Three dots (…) denotes net zero not reached for that percentile.*		*Median cumulative net CO_2 emissions across the projected scenarios in this category until reaching net-zero or until 2100, with the 5th-95th percentile interval in square brackets.*		*Median cumulative net-negative CO_2 emissions between the year of net-zero CO_2 and 2100. More net-negative results in greater temperature declines after peak.*	*Projected temperature change of pathways in this category (50% probability across the range of climate uncertainties), relative to 1850-1900, at peak warming and in 2100, for the median value across the scenarios and the 5th-95th percentile interval in square brackets.*		*Median likelihood that the projected pathways in this category stay below a given global warming level, with the 5th-95th percentile interval in square brackets.*		
C1 [97]	**limit warming to 1.5°C (>50%) with no or limited overshoot**		31 [21-36]	17 [6-23]	9 [1-15]	43 [34-60]	69 [58-90]	84 [73-98]	2020-2025 (100%) [2020-2025]		2050-2055 (100%) [2035-2070]	2095-2100 (52%) [2050-…]	510 [330-710]	320 [-210-570]	-220 [-660–20]	1.6 [1.4-1.6]	1.3 [1.1-1.5]	38 [33-58]	90 [86-97]	100 [99-100]
C1a [50]	**… with net-zero GHGs**	SSP1-1.9, SP LD	33 [22-37]	18 [6-24]	8 [0-15]	41 [31-59]	66 [58-89]	85 [72-100]			2055-2060 (100%) [2045-2070]	2070-2075 (100%) [2050-2090]	550 [340-760]	160 [-220-620]	-360 [-680–140]	1.6 [1.4-1.6]	1.2 [1.1-1.4]	38 [34-60]	90 [85-98]	100 [99-100]
C1b [47]	**… without net-zero GHGs**	Res	29 [21-36]	16 [7-21]	9 [4-13]	48 [35-61]	70 [62-87]	84 [76-93]				…-… [0%] […-…]	460 [320-590]	360 [10-540]	-60 [-440-0]	1.6 [1.5-1.6]	1.4 [1.3-1.5]	37 [33-56]	89 [87-96]	100 [99-100]
C2 [133]	**return warming to 1.5°C (>50%) after a high overshoot**	Neg	42 [31-55]	25 [17-34]	14 [5-21]	23 [0-44]	55 [40-71]	75 [62-91]	2020-2025 (100%) [2020-2030]	[2020-2025]	2055-2060 (100%) [2045-2070]	2070-2075 (87%) [2055-…]	720 [530-930]	400 [-90-620]	-360 [-680–50]	1.7 [1.5-1.8]	1.4 [1.2-1.5]	24 [15-42]	82 [71-93]	100 [99-100]
C3 [311]	**limit warming to 2°C (>67%)**		44 [32-55]	29 [20-36]	20 [13-26]	21 [1-42]	46 [34-63]	64 [53-77]	2020-2025 (100%) [2020-2030]	[2020-2025]	2070-2075 (93%) [2055-…]	…-… (30%) [2075-…]	890 [540-1160]	800 [510-1140]	-40 [-290-0]	1.7 [1.6-1.8]	1.6 [1.5-1.8]	20 [13-41]	76 [68-91]	99 [98-100]
C3a [204]	**… with action starting in 2020**	SSP1-2.6	40 [30-49]	29 [21-36]	20 [14-27]	27 [13-45]	47 [35-63]	63 [52-76]	2020-2025 (100%) [2020-2025]		2070-2075 (91%) [2055-…]	…-… (24%) [2080-…]	860 [540-1180]	790 [480-1150]	-30 [-280-0]	1.7 [1.6-1.8]	1.6 [1.5-1.8]	21 [14-42]	78 [69-91]	100 [98-100]
C3b [97]	**… NDCs until 2030**	GS	52 [47-56]	29 [20-36]	18 [10-25]	5 [0-14]	46 [34-63]	68 [56-82]			2065-2070 (97%) [2055-2090]	…-… (41%) [2075-…]	910 [720-1150]	800 [560-1050]	-60 [-300-0]	1.8 [1.6-1.8]	1.6 [1.5-1.7]	17 [12-35]	73 [67-87]	99 [98-99]
C4 [159]	**limit warming to 2°C (>50%)**		50 [41-56]	38 [28-44]	28 [19-35]	10 [0-27]	31 [20-50]	49 [35-65]	2020-2025 (100%) [2020-2030]		2080-2085 (86%) [2065-…]	…-… (31%) [2075-…]	1210 [970-1490]	1160 [700-1490]	-30 [-390-0]	1.9 [1.7-2.0]	1.8 [1.5-2.0]	11 [7-22]	59 [50-77]	98 [95-99]
C5 [212]	**limit warming to 2.5°C (>50%)**		52 [46-56]	45 [37-53]	39 [30-49]	6 [-1-18]	18 [4-33]	29 [11-48]			…-… (41%) [2080-…]	…-… (12%) [2090-…]	1780 [1400-2360]	1780 [1260-2360]	0 [-160-0]	2.2 [1.9-2.5]	2.1 [1.9-2.5]	4 [0-10]	37 [18-59]	91 [83-98]
C6 [97]	**limit warming to 3°C (>50%)**	SSP2-4.5 Mod-Act	54 [50-62]	53 [48-61]	52 [45-57]	2 [-10-11]	3 [-14-14]	5 [-2-18]	2030-2035 (96%) [2020-2090]	2020-2025 (97%)	no net-zero		no net-zero	2790 [2440-3520]	no net-zero	temperature does not peak by 2100	2.7 [2.4-2.9]	0 [0-0]	8 [2-18]	71 [53-88]
C7 [164]	**limit warming to 4°C (>50%)**	SSP3-7.0 Cur-Pol	62 [53-69]	67 [56-76]	70 [58-83]	-11 [-18-3]	-19 [-31-1]	-24 [-41–2]	2085-2090 (57%) [2040-…]	2090-2095 (56%)				4220 [3160-5000]			3.5 [2.8-3.9]	0 [0-0]	0 [0-2]	22 [7-60]
C8 [29]	**exceed warming of 4°C (>=50%)**	SSP5-8.5	71 [69-81]	80 [78-96]	88 [82-112]	-20 [-34–17]	-35 [-65–29]	-46 [-92–36]	2080-2085 (90%) [2070-…]					5600 [4910-7450]			4.2 [3.7-5.0]	0 [0-0]	0 [0-0]	4 [0-11]



Section 5: What needs to be done:

5.1: What needs to be done in a general sense?

The ***IPCC WIII Report*** notes that all models that limit global warming to ***1.5^{o}C*** assume that peak ***GHG*** emissions will be achieve by 2025, and that all models that limit global warming to ***2^{o}C*** assume immediate action to achieve the model ***GHG*** emission reductions.

5.2: What will the consequences be if what needs to be done is not done?

Without implementing policy settings that address the short-comings of the pre-***COP-26 NDCs***, peaking ***GHG*** emissions will not be achieved by 2025, rather ***GHG*** emissions will continue to increase after 2025. Again, this is not new, nor is the projection that global warming may reach ***3.2^{o}C*** if action is not taken to achieve appropriate levels and rates of reduction in ***GHG*** emissions.

As a general statement, the ***IPCC WGIII Report*** contemplates the need for immediate increased and accelerated ***GHG*** emission reductions across all sectors.

5.3: The means of reductions are known:

5.3.1: *IPCC WGIII Report:*

The ***IPCC WGIII Report*** provides considerable narrative on the following needs: to develop and to deploy renewable electrical energy; to transition from fossil fuels (that do not use CCS) to transition to very low or no carbon energy fuels; to achieve effective demand management, including to achieve efficient use of energy and reduced use of energy; to reduce ***CH_4*** emissions; and to develop and to deploy carbon dioxide removal (***CDR***) methods.

In this context, the ***IPCC WGIII Report*** provides Illustrative Mitigation Pathways (***IMPs***)

5.3.2: WETO 2022:

In addition to the ubiquitous need for countries that are parties to the Paris Agreement to increase the level and rate of ***GHG*** emission reductions, ***WETO 2022*** builds on the six technological means to reducing emissions identified in ***WETO 2021***: those means being renewable electrical energy, energy efficiency, electrification, hydrogen and hydrogen-based fuels, fossil fuel based CCS and bio-energy based CCS. These means are covered in detail in ***WETO 2021***, and summarised, amongst others, in **Edition** 21 of Low Carbon Pulse.

The focus of ***WETO 2022*** is the ***2030 priorities*** are as follows:

1. replacing coal-fired power stations with clean power generation;

2. phasing out fossil fuels in tandem with market development and reform to incentivise net-zero transition;

3. increasing the rate of development and deployment of renewable electrical energy and "aggressive energy efficiency" strategies;

4. infrastructure development and expansion, and upgrading, to assure, or to increase infrastructure and system, integrity and reliability to allow timely deployment of renewable electrical energy;

5. green hydrogen to become mainstream by 2030;

6. triple the supply and demand for bio-energy by 2030, requiring considerable work to collect and to allow use of bio-energy feedstock arising from waste streams;

7. the majority of car sales should be electric by 2030;

8. new buildings must be energy efficient and renovation rates of existing buildings must be increased (including to avoid production of cement for concrete and iron and steel for construction);

9. demand side management initiatives to ensure efficiency, including recycling and repurposing; and

10. policy settings that cover all avenues that technology development may take.

5.4: Nothing new under the sun:

There is nothing new in the ***IPCC WGIII Report*** or the ***WETO 2022***. This said, were one reading news items and commentary on each report, one could be forgiven for concluding that carbon dioxide removal was new, and that conclusions in respect of it were new.

As is apparent from Article 4 of the Paris Agreement, ***CDR*** has always been contemplated. The issue now is that ***CDR*** should be accelerated.

While not new (see **Editions** 28 of Low Carbon Pulse, under ***NZE not enough CDR required now***), there is a new emphasis on the need for ***CDR*** now: boiling down to the essentials, there is a need to commence ***CDR*** (including negative ***GHG*** emission initiatives (***NGHGEIs***)) as soon as possible.

In the blur of headlines, a number of commentators and participants have expressed a range of views on ***CDR***, and its role in ***IMPs***. ***CDR*** is used in a broad sense to include carbon capture arising from Bioenergy with CCS (BECCS) and Direct Air Carbon Capture and Storage (DACCS), and negative emission reduction initiatives in the AFOLU sector.

While understandable, some commentators and participants have overstated the findings in the ***IPCC WGIII Report*** on the use of particular means of achieving ***CDR***.

The good thing is that it is recognised that ***CDR*** needs to be developed and deployed at the same time as ***GHG*** emission reductions. This recognises the reordering of the three means of achieving the outcomes contemplated in the Paris Agreement: from ***RPR*** – Reduction, Peaking and Removal, to ***RRP*** – Reduction, Removal and Peaking. (See the **Anniversary Edition** of Low Carbon Pulse.)

5.5: Means to reduce GHG emissions: The following graphic illustrates the range of means for reducing ***GHG*** emissions identified by the ***IPCC WGIII***.

Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potentials and costs will vary across countries and in the longer term compared to 2030.

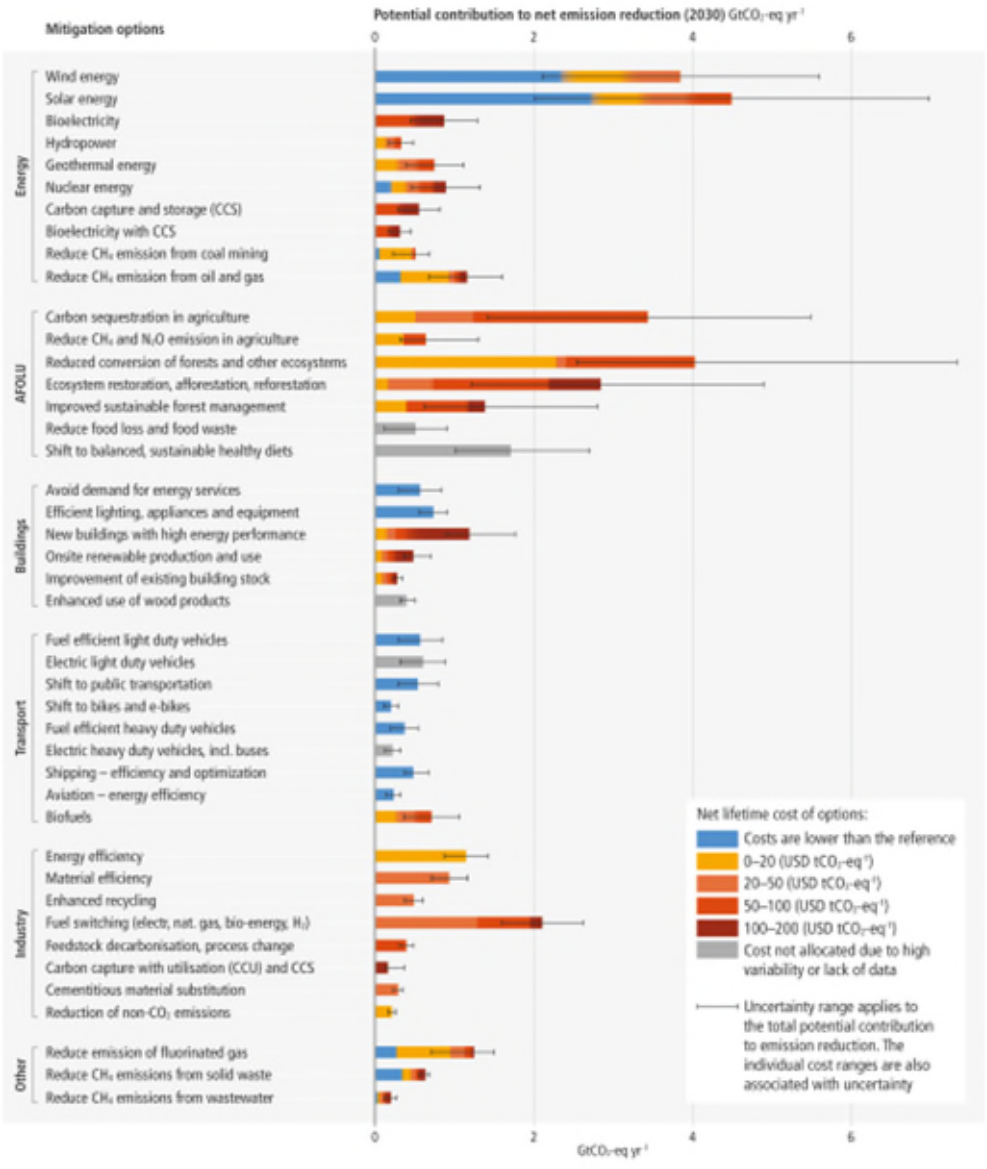
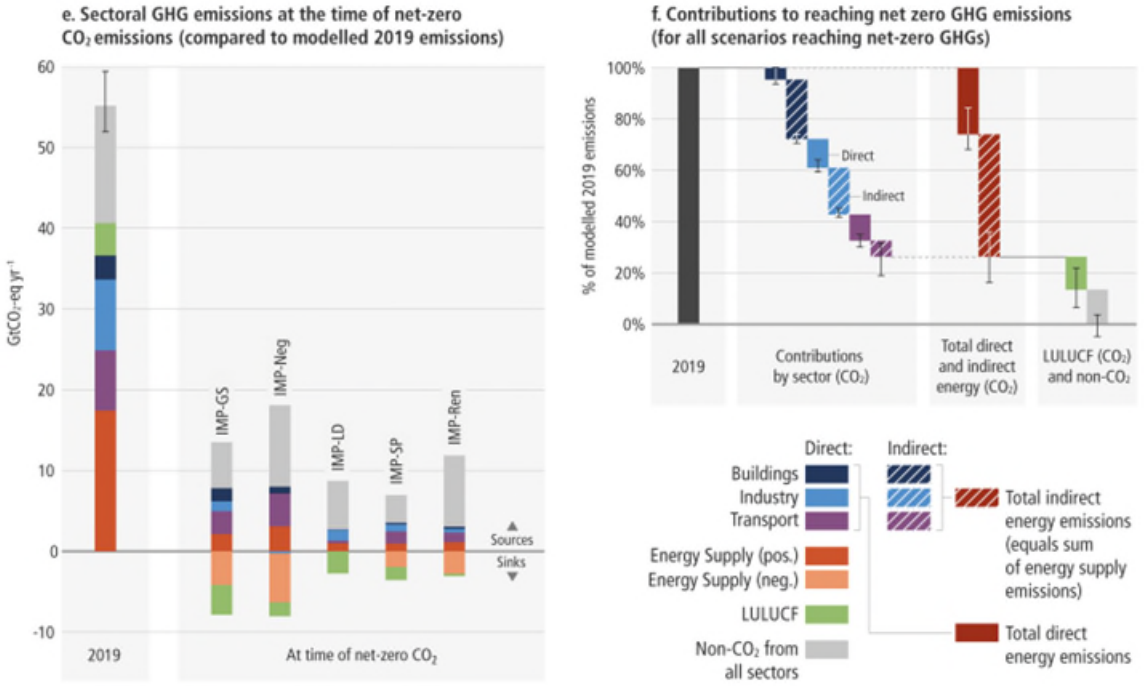


Figure SPM.7: Overview of mitigation options and their estimated ranges of costs and potentials in 2030.

Net zero CO_2 and net zero GHG emissionsare possible through different modelled mitigation pathways.



5.7: Reductions in *GHG* emissions sector by sector:

In the context of the following sectors the ***IPCC WGIII Report*** identifies the following principal means of mitigation by sector:

- **AFOLU:** the greatest mitigation will arise from conservation and preservation, reforestation, restoration of grasslands, peatlands, savannas and wetlands, reduced and then cessation of deforestation. In the context of cultivated or farmed land, improved and sustainable crop and livestock management, and carbon sequestration in agriculture, including soil carbon management, agroforestry and biochar use, will be key.
  It is noted that AFOLU mitigation actions cannot compensate for delayed reductions in ***GHG*** emissions across other sectors.
  This is a key theme from both the ***IPCC WGIII Report***, and the ***WETO 2022*** – all policy settings, all means of mitigation need to be developed and deployed as quickly as possible and as broadly as possible.
- **Built environment:** In the context of the continued growth in population and increasing urbanisation, changing and reducing energy demand, increased electrification (using renewable electrical energy), and use of CCS are identified as key ***IMPs***.
- **Industry:** demand side management, energy and materials efficiency, circular material flows, as well as abatement technologies and changes to production processes are required.
- **Transport:** electric vehicles, sustainable bio-fuels, low emission hydrogen and synthetic fuels may mitigate ***CO_2*** emissions arising in the aviation, heavy-vehicle land transport and shipping, but for wide, and timely, adoption require improved production processes, including to achieve reductions in cost.

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