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University of Dundee

Do The Paris Agreement Commitments Go Far Enough?

Author:
Genevra E. L. Harker-Klimeš *

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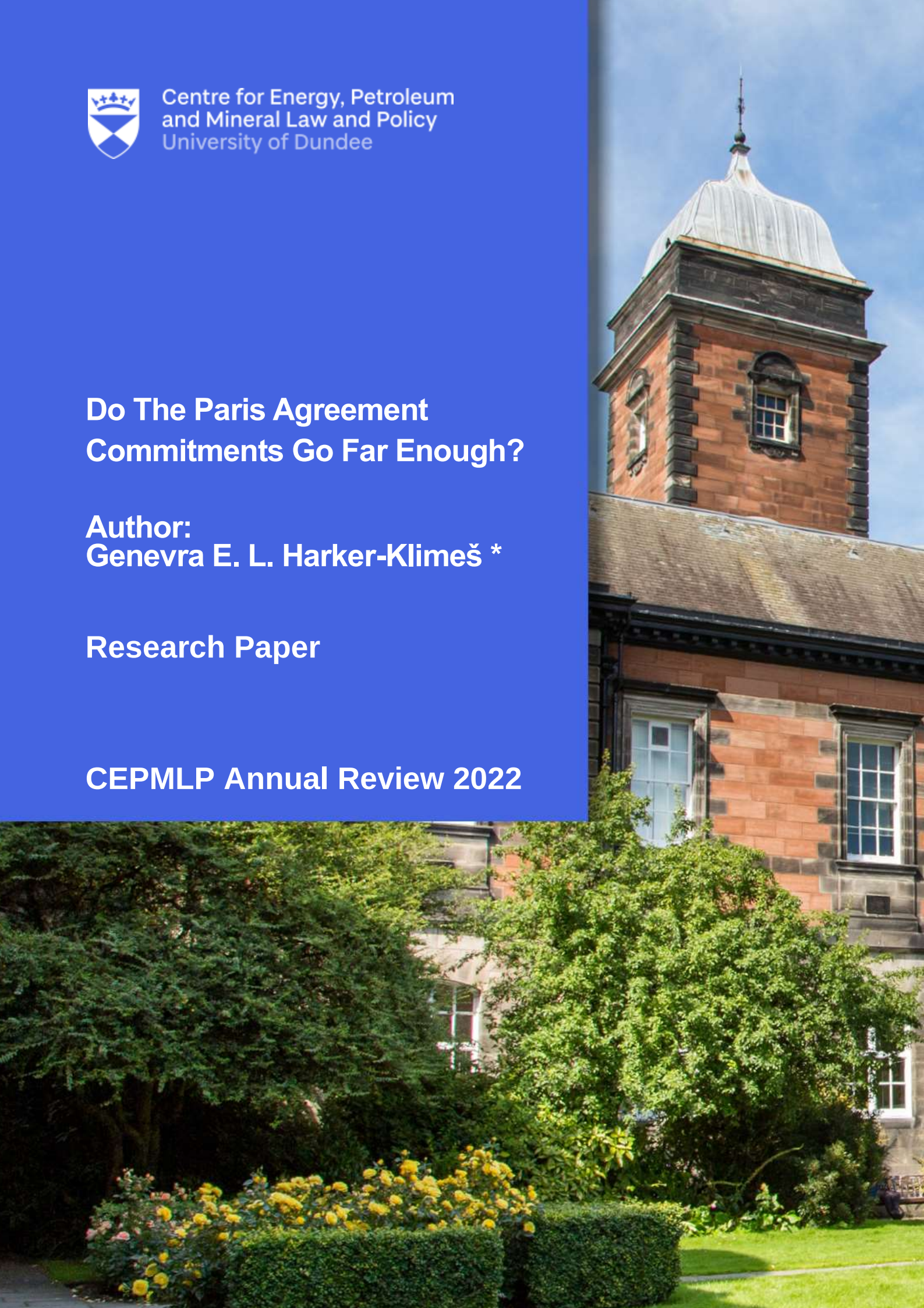

* Genevra Harker-Klimeš is an advisor to the US Department of Energy on offshore energy. She has a PhD and MSc in physical oceanography from Bangor University, Wales, and a BSc in physical geography from the University of Sheffield, England. In 2020, she was awarded an LLM in Energy Law and Policy, from the University of Dundee, Scotland. After her doctorate she worked for an oceanographic survey company taking offshore measurements for numerous projects around the world (usually in high seas!). She then became an environmental consultant working on both offshore and onshore wind farms, solar parks, and wave and tidal developments in Europe, before moving to the US in 2015. Here she led an initiative on environmental monitoring technologies for the Pacific Northwest National Laboratory. Three years later she became the Director for the Coastal Sciences division and the lead scientist at the Marine and Coastal Research Laboratory, transitioning to her advisor role in early 2022.

Acronyms

CO_2	Carbon dioxide
EU	European Union
FOLU	Forestry and other land use
G20	Group of Twenty
GCF	Green Climate Fund
GDP	Gross domestic product
GHG	Greenhouse gas
$GtCO_2e$	Gigatons of carbon dioxide equivalent (metric tons)
GW	Giga-watts
IPCC	Intergovernmental Panel on Climate Change
LUCF	Land use change and forestry
$MtCO_2e$	Megatons of carbon dioxide equivalent (metric tons)
NDC	Nationally Determined Contribution
PBL	Planbureau voor de Leefomgeving - Netherlands Environmental Assessment Agency
R&D	Research and development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework for Climate Change Convention
USA	United States of America

Contents

1. Introduction

The aim of this paper is to review whether the current commitments by different countries under the Paris Agreement are sufficient to limit global warming to less than 1.5 °C by 2100.

Since the United Nations Framework for Climate Change Convention (UNFCCC) was developed in 1992, countries have been working together under its framework to combat climate change. The aim is to stabilize "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic activity", ensuring that ecosystems can adapt naturally, food production will not be compromised, and economic development can continue sustainably[1]. The commitment within the convention was to reduce greenhouse gas (GHG) emissions to below 1990 levels (Article 4 (a) and (b), UNFCCC).

This goal was judged as inadequate at the 1995 meeting, and it was recognized that a more stringent agreement was needed. In 1997, the Kyoto Protocol was signed as a legally binding document to reduce the sum of six specific GHG emissions to 5% under 1990 levels by 2008-2012 (taken as an average across the five years).

Subsequently, there was an extension to the Kyoto Protocol, namely the Doha Amendment, which quantifies the commitments made between 2012 and 2020, setting a goal of reducing GHG emissions by 18% compared to 1990 levels by 2020. However, 144 Parties needed to ratify the Amendment for it to come into force, and that ratification did not happen until 1 October 2020 (the Amendment then came into force 90 days later, on 31 December 2020). In 2015, also under the auspices of the UNFCCC, the Paris Agreement (or convention) was reached to cover commitments from 2020 onwards; regarding which, countries are now establishing their specific commitments. These are termed 'Nationally Determined Contributions' (NDCs).

This review considers the commitments made under the Paris Agreement, whether countries are on target for fulfilling their commitments, and whether these are sufficient to

[1] United Nations (1992) *United Nations Framework Convention on Climate Change* Available at: https://unfccc.int/resource/docs/convkp/conveng.pdf (Accessed: 7 February 2022)

keep the predicted temperature rise low enough for ecosystem adaptation. Throughout this document commitments are referred to from the NDC documents that are available online[2].

2. Paris Agreement

As of February 2022, the Paris Agreement has been ratified by 193 Parties of the 195 signatories (as of February 2022)[3]. It came into force in November 2016, 30 days after the ratification threshold was reached. That threshold was to achieve ratification by 55% of the Parties to the Agreement, accounting for at least 55 % of total global greenhouse emissions. This is an ongoing, non-binding agreement, where each country determines its own commitments to reducing climate change and developing adaptation methods.

The aim of the Paris Agreement is to keep the global temperature rise at less than 2°C above pre-industrial levels, and preferably under 1.5°C. It also addresses the need for climate change adaptation; and aims to target financial flows to promote low GHG emissions and climate-resilient nations. All Parties determine their own NDCs that consist of their best efforts to reduce their GHG emissions and improve their climate-resiliency. Every year, as per the Agreement, each country must report on their emissions and sinks, and every five years, there is an assessment to determine progress towards the overall goal.

Many countries distinguish between “unconditional” and “conditional” goals in their NDCs. The unconditional goals are those the country commits to through using its own finances and resources, while the conditional goals are those it will aim for if it receives international funding and technology transfer to enable the financing and realisation of those goals.

The United States of America (USA) originally ratified the Agreement on 3 September 2016, but announced its intention to withdraw from the Agreement on 1 June 2017 – it was the first, and, so far, only country to withdraw from the Agreement. In line with the provisions of the Agreement, this withdrawal was not enacted until 4 November 2020. However, with the change of federal administration in early 2021, the USA officially re-joined the Agreement

[2] United Nations (2022) *Nationally Determined Contributions (NDCs)* Available at: https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs (Accessed: 7 February 2022)
[3] United Nations (2022) *United Nations Treaty Collection* Available at: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en (Accessed: 7 February 2022)

on 19 February 2021[4]. This means that all countries are now Party to the Paris Agreement. Initially, Nicaragua did not sign as it considered that the agreement was not ambitious enough[5], but it did sign in 2017 to show a united stance.[6]

[4] Blinken, A.J. (2021) *The United States Officially Regjoins the Paris Agreement* Available at: https://www.state.gov/the-united-states-officially-rejoins-the-paris-agreement/ (Accessed: 8 February 2022)
[5] Carbon Brief (2015) *Paris 2015: Tracking Country Climate Pledges* Available at: https://www.carbonbrief.org/paris-2015-tracking-country-climate-pledges (Accessed: 6 February 2022)
[6] Global Citizen (2017) *Nicaragua Joins Paris Climate Agreement, Leaving US and Syria As Outliers* Available at: https://www.globalcitizen.org/en/content/nicaragua-joins-paris-climate-agreement-leaving-us/#! (Accessed: 22 February 2022)

3. Nationally Determined Contributions

Each country that signed the Agreement is required to submit its NDCs. Before ratification, the submissions were termed the "intended Nationally Determined Contributions" to set out the expectations for each country; 189 Parties submitted these by April 2016. On ratification by each country, these became their first Nationally Determined Contributions. To date, 194 Parties[7] have submitted their first NDCs, with 13 submitting their second[8]. While only 193 Parties have ratified the Agreement, Eritrea has submitted its first NDC without being a Party to the Agreement.

The contributions consist of mitigation and adaptation components. Within the NDCs, 194 include mitigation aspects, and 146 include adaptation[9].

[7] A Party to a convention is a state or entity that formally agrees to be bound by that convention.
[8] United Nations (2022) *Nationally Determined Contributions Registry* Available at: https://www4.unfccc.int/sites/NDCStaging/Pages/Home.aspx (Accessed: 7 February 2022)
[9] World Bank (2022) *NDC Summary Visualisation* Available at: http://spappssecext.worldbank.org/sites/indc/Pages/INDCFilterVisualization.aspx (Accessed: 6 February 2022)

5. Balance of NDCs, Emissions and Sinks

5.1 Baseline

The difficulty in establishing the impact and effectiveness of the NDCs is that the Agreement specified limiting the temperature increase relative to pre-industrial global temperature but did not specify what that temperature was. There is some uncertainty related to this, as pre-industrial is not defined, and temperature measurements were not common, or necessarily accurate, at that time. Pre-industrial commonly refers to pre-1750, but the period 1850-1900 is often used for the reference global mean surface temperature. This period has limitations as industrial emissions had already been occurring for 100 years, and the 19th century included various periods of volcanic activity that affected global temperature[10].

The period 1850-1900 was chosen due to the availability of reliable temperature data, but may be slightly warmer than 'true' pre-industrial temperatures. Even so, the UK Met Office calculated that temperatures in 2016 were 1.1 °C above the 1850-1900 'pre-industrial' levels[11], which shows how close the target 1.5 °C is. The motivation behind aiming for 1.5 °C rather than 2 °C is to slow down the rate of sea level rise, so that habitats and species are able to adapt to the changes.

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change, and was set up to provide policy makers with regular scientific assessments.[12] The IPCC Special Report on Global Warming of 1.5 °C, states that the temperature increase assessed includes both anthropogenic and natural variation. It is referenced to the baseline period 1850-1900 as an approximation of pre-industrial levels. Specifically, the IPCC report provides the following specificity: "warming at a given point in time is defined as the global average of combined land surface air and sea surface temperatures for a 30-year period centred on that time, expressed

[10] Hawkins, E. (2017) *Climbate Lab Book: Defining 'Pre-Industrial'* Available at: http://www.climate-lab-book.ac.uk/2017/defining-pre-industrial/ (Accessed: 6 February 2022)
[11] Amos, J. (2017) *Defining a true 'pre-industrial' climate period* Available at: https://www.bbc.com/news/science-environment-38745937 (Accessed: 5 February 2022)
[12] The Intergovernmental Panel on Climate Change (2022) *The Intergovernmental Panel on Climate Change* Available at: https://www.ipcc.ch (Accessed: 5 February 2022)

relative to the reference period 1850–1900"[13]. The 30-year average ensures short term variations due to volcanic activity or solar variations are minor relative to the overall average.

5.2 Country Contributions

From 2012 data, the countries or unions that contribute most to global greenhouse emissions are: China (23.75%), USA (12.10%), European Union (EU) (8.97%), India (5.73%), Brazil (5.70%), Russia (5.35%), Japan (2.82%), Canada (1.96%), and the Democratic Republic of the Congo (1.53%)[14]. Many of the least developed countries, such as eSwatini (formally Swaziland), South Sudan and Cape Verde, currently have a negligible contribution to GHGs, and therefore have focused on adaptation and avoiding increasing their emissions as their economies develop. G20[15] member nations contribute approximately 80 % of global greenhouse emissions[16].

5.2.1 High Contributors

Focussing on the countries that contribute most, it is important that these countries make the largest reductions as they will have the most impact on the overall climate situation.

China emitted 11,705.81 $MtCO_2e$[17] of GHG emissions in 2018[18], including land use change and forestry (LUCF), which accounts for carbon storage mechanisms through forestry and

[13] Allen, M. R., O. P. Dube, W. Solecki, F. Aragon–Durand, W. Cramer, S. Humphreys, M. Kainuma, J. Kala, N. Mahowald, Y. Mulugetta, R. Perez, M. Wairiu, K. Zickfeld, 2018, *Framing and Context*. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Portner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Pean, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]

[14] Percentages relate to 2012 emissions, Carbon Brief (2015) *Paris 2015: Tracking country climate pledges* Available at: https://www.carbonbrief.org/paris-2015-tracking-country-climate-pledges (Accessed: 6 February 2022)

[15] The G20 (Group of Twenty) is an intergovernmental forum for 20 of the world's largest economics that was set up in 1999. The annual summit brings countries together to discuss economic and financial issues, and world issues that affect these. The 20 participants are: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, the United Kingdom (UK), and the United States. Spain is invited as a permanent guest.

[16] UNEP (2021). *The Heat is On, Emissions Gap Report 2021*. United Nations Environment Programme (UNEP), Nairobi

[17] Megatons of carbon dioxide equivalent (million metric tons) – the metric ton of carbon dioxide equivalent is the standard unit of measure for GHG emissions standardized to one ton of CO_2

[18] Climate Watch (2022) *Data Explorer* Available at: www.Climatewatchdata.org (Accessed: 10 February 2022)

similar land use. These emissions have been steadily increasing, although the rate slowed down from 2013 onwards. It has committed to the following actions by 2030:

- to achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early;
- to lower carbon dioxide emissions per unit of gross domestic product (GDP) by 60% to 65% from the 2005 level;
- to increase the share of non-fossil fuels in primary energy consumption to around 20%; and
- to increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level.

China has committed to proactively adapt to climate change by enhancing mechanisms and capacities to effectively defend against climate change risks in key areas such as agriculture, forestry and water resources, as well as in cities, coastal and ecologically vulnerable areas. It also committed to progressively strengthen early warning and emergency response systems, and disaster prevention and reduction mechanisms.

This commitment means China needs to supply 800-1,000 GW of non-fossil fuel energy generation[19] by 2030. China is on track to meet its NDC targets, but given emissions are still rising, peaking by 2030 does not equate with the reduction that is needed to minimize the global temperature increase.

The **USA**, contributing over 11.8% of global greenhouse emissions at a level of 5,794.35 $MtCO_2e$ of GHG emissions in 2018[18], originally committed to an economy-wide target of reducing its GHG emissions by 26%-28% below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%. This NDC was revised in 2021 after the USA re-joined the Paris Agreement, and it now commits to 50-52% below 2005 levels in 2030, plus 100% carbon pollution-free electricity by 2035. In 2005, the USA was emitting 6,927.72 $MtCO_2e$ of GHG, so the target for 2025 is 4,987.96 $MtCO_2e$ of GHG emissions, and for 2030 is 3,463.86 $MtCO_2e$. While USA emissions were trending downwards, they

[19] Fransen, T., R. Song, F. Stolle, G. Henderson (2015) *A Closer Look at China's New Climate Plan (INDC)* Available at: https://www.wri.org/blog/2015/07/closer-look-chinas-new-climate-plan-indc Accessed 16 June 2019

increased by 3.5% from 2017 to 2018[20], and policies that were put in place to limit emissions were being rolled back. These policies have since been revised, but, as of February 2022, the USA is still not on track for meeting the NDC commitments. However, recent targets have been set for a net-zero GHG economy in 2050[21].

The **EU** accounts for 6.81% of emissions, equivalent to 3,401.95 $MtCO_2e$ of GHG emissions in 2018[18], and has committed to a binding target of at least 55% domestic reduction in GHG emissions by 2030 compared to 1990, to be fulfilled jointly, as set out in the European Green Deal[22,23]. The long-term goal is to reach carbon neutrality by 2050[24].

As per all Member States of the EU, the United Kingdom was originally included within the EU targets, but it has since left the EU and in 2021[25] set targets to reduce emissions by 78% by 2035 compared with 1990 levels. This is the most ambitious target set by any country. It has also made its own commitment to achieve net-zero GHG emissions by 2050[26]. In 2018, the UK contributed 441.1 $MtCO_2e$ in GHG emissions, and has been steadily reducing overall emissions each year[18].

The EU overall has been reducing its GHG emissions, which peaked before 1990. In 1990, the emissions were 4,949.77 $MtCO_2e$, so a reduction of 55% would give total emissions of

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[20] Mooney, C. and B. Dennis (2019) *U.S. greenhouse gas emissions spiked in 2018 – and I couldn't happen at a worse time* Available at: https://www.washingtonpost.com/national/health-science/us-greenhouse-gas-emissions-spiked-in-2018--and-it-couldnt-happen-at-a-worse-time/2019/01/07/68cff792-12d6-11e9-803c-4ef28312c8b9_story.html?utm_term=.0e3e156b5d4f (Accessed: 5 February 2022)

[21] U.S. Department of State and the U.S. Executive Office of the President (2021) *The Long-Term Strategy of the Unisted States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050* Available at: https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf (Accessed: 7 February 2022)

[22] European Commission (2019) *Communication from the Commission: The European Green Deal* Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640 (Accessed: 9 February 2022)

[23] The European Green Deal is a set of proposals adopted by the European Commission to ensure no net emissions of greenhouse gases by 2050, economic growth decoupled from resource use, and no person and no place left behind.

[24] European Commission (2022) *A European Green Deal – Striving to be the first climate-neutral continent* Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en (Accessed: 10 February 2022)

[25] Department for Business, Energy & Industrial Strategy (2021) *UK enshrines new target in law to slash emissions by 78% by 2035* Available at: https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035 (Accessed: 11 February 2022)

[26] Enerdata (2019) *British government commits to net zero GHG emissions by 2050* Available at: https://www.enerdata.net/publications/daily-energy-news/british-government-commits-net-zero-ghg-emissions-2050.html?utm_source=Enerdata&utm_campaign=403931e15c-Email_Daily_Energy_News_06_2019&utm_medium=email&utm_term=0_838b1c9d18-403931e15c-124307913 (Accessed: 7 February 2022)

2,227.40 $MtCO_2e$. As a whole, the EU is on track for reaching its NDC commitments by 2030, following their existing policies[27]. The EU also contributes through funding and technology transfer to developing countries.

India emitted 3,346.63 $MtCO_2e$ of greenhouse gas emissions in 2018[18], 6.84% of total emissions, and this has been steadily increasing. India's culture promotes harmony between nature and people, and the government is particularly aware of the vulnerability of India and the high risk of catastrophic events from climate change. Its NDC covers multiple mitigation and adaptation plans, and summarises its commitments as[28]:

"1. To put forward and further propagate a healthy and **sustainable way of living** based on traditions and **values of conservation and moderation**.
2. To adopt a **climate friendly and a cleaner path** than the one followed hitherto by others at corresponding level of economic development.
3. To **reduce the emissions intensity of its GDP** by **33 to 35 percent by 2030** from **2005 level**.
4. To achieve about **40 percent cumulative electric power installed capacity** from **non-fossil fuel based energy resources** by **2030** with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF)[29].
5. To **create an additional carbon sink of 2.5 to 3 billion tonnes** of **CO2 equivalent** through additional forest and tree cover by **2030**.
6. To **better adapt** to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
7. To mobilize **domestic and new & additional funds** from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.

[27] PBL Netherlands Environmental Assessment Agency (2022) *PBL Climate Pledge NDC tool* Available at: https://themasites.pbl.nl/climate-ndc-policies-tool/ (Accessed: 5 February 2022)
[28] United Nations (2022) *Nationally Determined Contributions Registry* Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/India%20First/INDIA%20INDC%20TO%20UNFCCC.pdf (Accessed: 7 February 2022)
[29] The Green Climate Fund was set up in 2010 as a financial mechanism of the UNFCCC and subsequently the Paris Agreement. The fund supports developing countries to realize their NDC commitments. https://www.greenclimate.fund/about#overview

8. To **build capacities**, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies."

India is the fourth largest energy consumer in the world[30], and is rapidly growing, so its energy generation policies are critical, particularly as it balances economic development and population growth with emission reduction. As of 2022, current analysis suggests it is likely to achieve its commitments with current policies, but their unconditional/policy targets are 25% lower than their conditional targets, which shows the unconditional target is significantly lower than the preferred scenario[27], and achieving the necessary commitments is dependent on foreign financing.

Russia is the fifth highest contributor at over 4% of global emissions, emitting 1,992.08 $MtCO_2e$ including LUCF in 2018[18]; this value has stayed at approximately the same level since 2011. In its NDC, Russia has a target to limit GHGs to 70% of 1990 levels by 2030. The Russian pledge includes maximum possible account of the absorbing capacity of forests. In 1990, Russian emissions were 3,227.3 $MtCO_2e$, and therefore a 30% reduction would produce 2,259.11 $MtCO_2e$, which is greater than emissions in 2018. This means Russia could theoretically increase its current emissions[31] and remain within its target. Consequently, Russia is likely to achieve its NDC commitments as it can increase its current emissions.

Indonesia is the next highest emitter, with GHG emissions of 1,703.86 $MtCO_2e$ including LUCF in 2018[18]. Indonesia committed to a 29% reduction in emissions by 2030, compared to the "business as usual" scenario. It says it will increase its reduction goal to 41%, conditional on support from international cooperation. The NDC focuses on adaptation as well as mitigation. It is the largest economy in southeast Asia, and is the world's largest exporter of thermal coal[32]. Deforestation accounts for a significant portion of the emissions, with emissions varying widely each year due to peatland megafires (see Figure 1). This

[30] Luthra S. (2014) *India's shift to a sustainable energy future* Available at: https://www.wri.org/blog/2014/03/indias-shift-sustainable-energy-future (Accessed: 16 June 2019)
[31] Levin, K. and T. Damassa (2015) *Russia's New Climate Plan May Actually Increase Emissions* Available at: https://www.wri.org/blog/2015/04/russia-s-new-climate-plan-may-actually-increase-emissions (Accessed: 17 June 2019)
[32] Dunne, D. (2019) *The Carbon Brief Profile: Indonesia* Available at: https://www.carbonbrief.org/the-carbon-brief-profile-indonesia (Accessed: 16 June 2019)

high annual variation makes it difficult to conclude whether the overall emissions reductions and mitigation measures will be achieved, although the PBL (Planbureau voor de Leefomgeving[33]) Climate Pledge NDC Tool predicts they are likely to miss (undershoot) them[27].

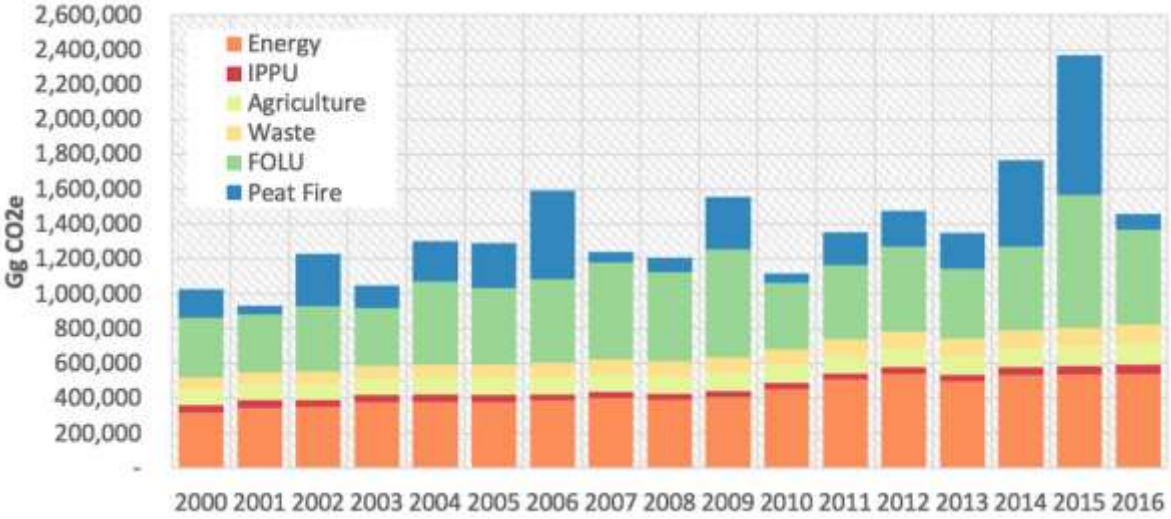

Figure 1 Indonesia's total emissions from 2000-16. Emissions from peatland fires (blue), forestry and other land use ("FOLU"; green), waste (yellow), agriculture (pale green), industry ("IPPU"; red) and energy (orange) are shown. Emissions are shown in gigagrams of CO2 equivalent (GgCO2e, millions of tonnes). It is worth noting that the figures are self-reported. Source: Ministry of Environment and Forestry, Indonesia.[32]

Brazil used to be the fourth highest emitter, until its emissions dropped in 2011. In 2018, its GHG emissions were 1,420.58 $MtCO_2e$ including LUCF[18]. Brazil's commitment in its original NDC is to reduce GHG emissions by 37% below 2005 levels in 2025. Its 2005 emissions were estimated as 1,939.66 $MtCO_2e$ including LUCF, so by 2025 this would reduce to 1,221.99 $MtCO_2e$ including LUCF. Its largest source of emissions is unsustainable land use and forestry[34], caused by deforestation of the Amazon and methane from cattle.

Brazil also pledged an 'indicative' 2030 target of 43% reduction in emissions from 2005 levels, which became an official target when the NDC was updated in 2020. However, the updated NDC redefined the emissions baseline to a higher level (due to different methods of calculating the emissions in 2005), so it is not committing to the same level of emissions reduction. In addition, the original NDC stated that these were unconditional goals, whereas the update version says the targets are conditional on receiving $10 billion per year to meet

[33] Netherlands Environmental Assessment Agency
[34] Timperley, J. (2018) *The Carbon Brief Profile: Brazil* Available at: https://www.carbonbrief.org/the-carbon-brief-profile-brazil (Accessed: 16 June 2019)

its various challenges[35]. Brazil currently generates over 75% of its electricity supply through hydropower[36], and has pledged to increase its share of renewables, other than hydropower, to at least 23% of the overall power supply by 2030 through wind, biomass and solar. Current data suggest Brazil will reach its target commitments, although these are now less ambitious than its original commitments.

Of the remaining countries, Japan announced that it intends to become carbon neutral by 2050, incorporating carbon capture as an economic opportunity, and promoting the uptake of electric vehicles[37]. There are 30 countries that are members of the Carbon Neutrality Coalition, with the original Declaration signed in 2017[38]: Andorra, Austria, Canada, Chile, Colombia, Costa Rica, Denmark, Ethiopia, Fiji, Finland, France, Germany, Iceland, Ireland, Italy, Japan, Luxembourg, Marshall Islands, Mexico, Monaco, Netherlands, New Zealand, Norway, Portugal, Republic of Korea, Spain, Sweden, Switzerland, Timor-Leste, and the United Kingdom. These countries have committed to long-term policies to reach net-zero emissions by the middle of the 21st century, and aim to be leaders in implementing successful strategies. Their long-term climate strategies aim to maximise:

- the socioeconomic benefits of the transition to net-zero GHGs;
- building climate-resilient economies; and
- accelerating global climate action at the necessary speed and scale.

The policies also intend to mainstream climate action throughout their economies, whilst promoting inclusive economic and social development, and also incentivise investment flows and technological innovation.

[35] World Wildlife Fund-Brazil (2020) *New Brazilian NDC reduces the country's climate ambition, against the spirit of the Paris Agreement* Available at: https://www.wwf.org.br/?77508/New-Brazilian-NDC-reduces-the-country-s-climate-ambition-against-the-spirit-of-the-Paris-Agreement (Accessed: 11 February 2022)
[36] International Hydropower Association (2019) Available at: https://www.hydropower.org/country-profiles/brazil (Accessed: 16 June 2019)
[37] Enerdata (2019) *Japan aims to become carbon nerutral by 2050* Available at: https://www.enerdata.net/publications/daily-energy-news/japan-aims-become-carbon-neutral-2050.html?utm_source=Enerdata&utm_campaign=b5fd584779-Email_Daily_Energy_News_06_2019&utm_medium=email&utm_term=0_838b1c9d18-b5fd584779-124307913 (Accessed 17 June 2019)
[38] Carbon Neutrality Coalition (2022) *The Carbon Neutrality Coalition* Available at: https://www.carbon-neutrality.global/ (Accessed: 5 February 2022)

5.2.2 Net-zero Targets

Carbon neutrality, otherwise referred to as net-zero carbon emissions, would stabilize global warming, but climate neutrality, or net-zero GHG emissions, would result in the peak and then decline in global warming[39]. Therefore, achieving net-zero GHG emissions is needed to meet the Paris Agreement goals. To remain within the 1.5°C warming target, there would need to be net-zero carbon emissions by 2050, and net-zero GHG emissions within the following 10-20 years. Currently, 52 Parties (51 countries plus the EU) have pledged a net-zero target of some sort, although only 13 of these have actually enacted it in law[39]. Despite these pledges, the commitments within the NDCs do not show a strong path to achieving these targets.

5.3 Temperature Increase

While some countries are likely to reach their commitments and others are not, the NDC commitments themselves do not align with the necessary reduction in temperature increase. Implementation of the non-conditional NDCs would result in a global reduction of emissions by only 7.5% by 2030, whereas 30% is needed to stay within 2 °C warming by 2100, and 55% reduction is needed to stay under 1.5 °C warming.

This 7.5% reduction results in global GHG emissions of 55 $GtCO_2e$[39, 40] in 2030. (2030 is a critical year as emissions need to have peaked by then to prevent temperature increases continuing past 2100[13].) However, this is still 13 $GtCO_2e$ greater than the emissions required to stay below a 2 °C temperature increase. If the conditional NDCs are also implemented then the gap is reduced to 2 $GtCO_2e$, but this is still insufficient to achieve warming goals[41].

Using the Climate Action Tracker[42], which compares whether commitments are in line with reducing emissions to achieve a temperature rise of less than 2 °C, the results fall significantly short of what is needed (Table 1).

[39] UNEP (2021) *The Emissions Gap Report 2021: The Heat is On*, United Nations Environment Programme, Nairobi
[40] Gigatons of carbon dioxide equivalent
[41] PBL Netherlands Environmental Assessment Agency (2022) *Climate Pledge NDC tool* Available at: https://themasites.pbl.nl/climate-ndc-policies-tool/ (Accessed: 6 February 2022)
[42] Climate Action Tracker (2022) *State of Climate Action 2021* Available at: https://climateactiontracker.org (Accessed: 7 February 2022)

Table 1 Summary of status of commitments made by highest emitting countries (Information source: Climate Action Tracker)

Country	Grading	Temperature increase if all countries within this grade
China	Highly insufficient	<4°C
USA	Insufficient	<3°C
EU	Insufficient	<3°C
India	Highly insufficient	<4°C
Indonesia	Highly insufficient	<4°C
Brazil	Highly insufficient	<4°C
Russia	Critically insufficient	4°C+

The Climate Action Tracker is maintained by three research organisations and monitors the largest emitters and a subset of smaller emitters to gauge progress towards meeting global temperature goals[43]. From their analysis of 38 countries, that cover 85% of global emissions, none have made NDC commitments that were considered compatible with a temperature rise under 1.5 °C.

A comparison of different scenarios with current policies and NDC commitments, shows that there is a shortfall of approximately 28 $GtCO_2e$ between the unconditional commitments and the level of emissions in 2030 required to remain under a 1.5°C increase. This is shown in Figure 2, taken from the United Nations Environment Programme (UNEP) 2021 Emissions Gap Report.

[43] Climate Action Tracker (2022) *The Climate Action Tracker* Available at: https://climateactiontracker.org/about/ (Accessed: 7 February 2022)

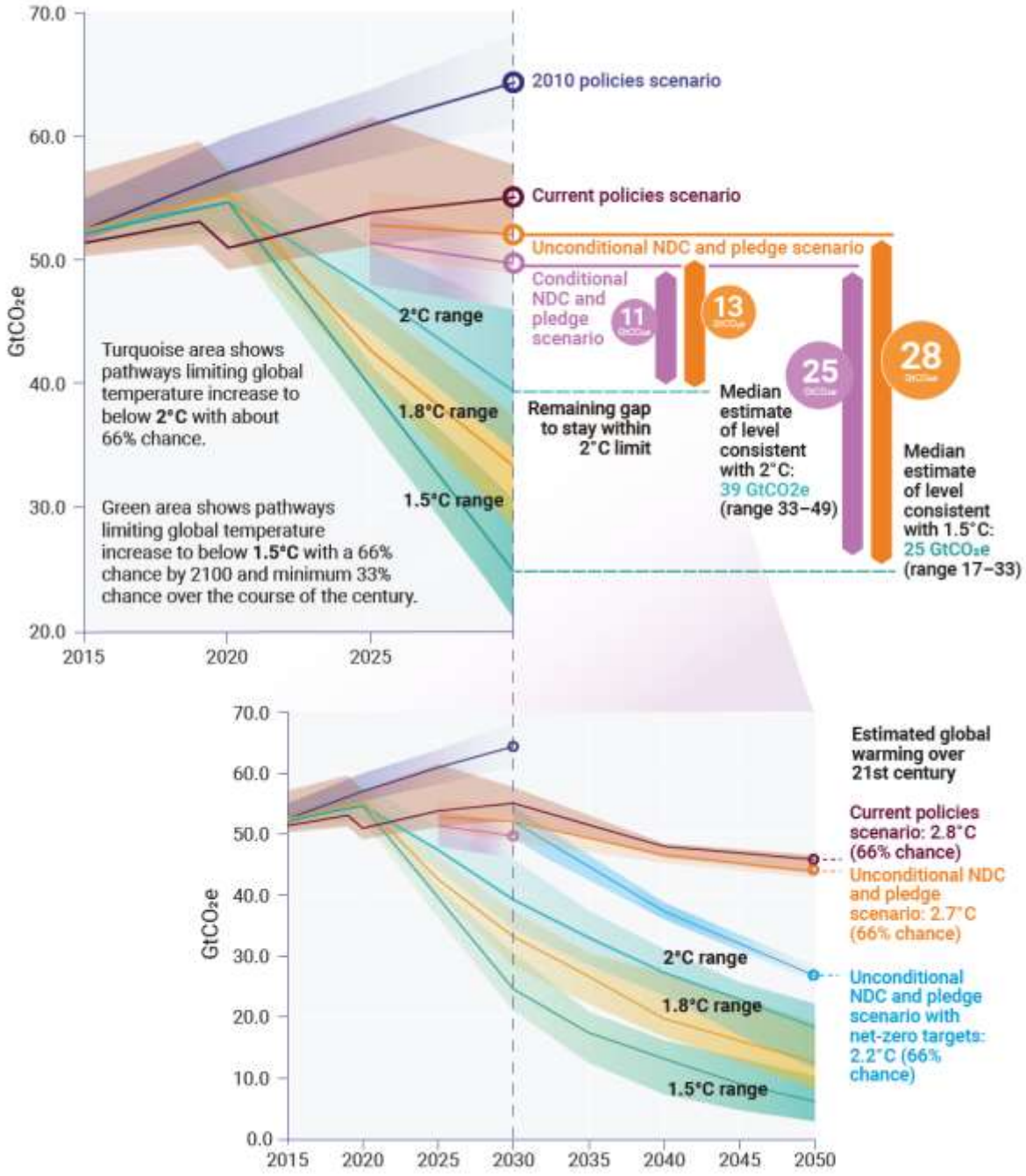

Figure 2 Global greenhouse gas emissions under different scenarios and the emissions gap in 2030 (median estimate and 10th to 90th percentile range). [Source: UNEP (2021) Emissions Gap Report (Figure 4.2)]

Assuming that climate action continues on the same trajectory as currently, the predicted temperature rise this century is approximately 2.8 °C, with continued CO_2 release resulting in further temperature increase beyond 2100[39]. However, if the country commitments to reach net-zero carbon emissions by 2050 are met, this increase will be approximately 0.5 °C lower.

6. Conclusions

The Paris Agreement has motivated countries to study how they might cut GHG emissions, and put in adaptation policies to improve their country's resilience. However, considering the NDC commitments from the countries that have the highest emissions, the commitments do not come close to reducing emissions to a level, and in a timeframe, that will limit global temperature increase to 2 °C by the year 2100.

Models predict that emissions need to have peaked by 2030 and be decreasing consistently after that to prevent continued temperature increase beyond 2100, and this is not anticipated from the commitments made. Plus, many countries are not currently on track to meet their NDC commitments, so the temperature is likely to rise more than is predicted when using the Paris Agreement figures. This shows that greater and binding restrictions are needed.

The USA is the second highest emitter after China, and in 2018 announced its withdrawal from the Paris Agreement, which occurred in 2020. However, with a change in Administration, the USA re-joined the Paris Agreement, and made much greater commitments to reduce emissions, including a target of net-zero GHG emissions by 2050. While pathways are being developed to achieve this, the continued work towards this target is highly dependent on the country's Administration, and with elections every 4 years, there is a degree of uncertainty regarding the implementation of these pathways.

Many studies highlight the economic impact that continued temperature increases will have on countries and that the cost to reduce GHG emissions is lower than the cost of responding to changes[44,45]. However, this is comparing a cost now with a cost in the future, and few governments are changing their policy paradigm to force emission reductions in sufficient amounts.

From the information reviewed, it is likely that in 2030 GHG emissions will be up to 13 $GtCO_2e$ greater than needed to remain below a 2 °C temperature increase this century,

[44] Burke, M., W.M. Davis & N.S. Diffenbaugh (2018) *Large potential reduction in economic damages under UN mitigation targets* Available at: https://www.nature.com/articles/s41586-018-0071-9 (Accessed: 11 February 2022)

[45] United Nations (2016) *Scientists warn against economic disruption from climate change* Available at: https://unfccc.int/news/scientists-warn-against-economic-disruption-from-climate-change (Accessed: 17 June 2019)

and up to 28 $GtCO_2e$ greater than levels needed to remain below 1.5 °C. This raises concerns that ecosystems will not be able to adequately adapt to the temperature changes, which may result in unexpected and catastrophic effects on both habitats and economies.

Centre for Energy, Petroleum
and Mineral Law and Policy
University of Dundee

Centre for Energy, Petroleum and Mineral Law and Policy
University of Dundee
Nethergate
Dundee
DD1 4HN