United States House of Representatives
Select Committee on the Climate Crisis

Hearing on April 30, 2019
"Solving the Climate Crisis: Drawing Down Carbon and Building Up the American Economy"

Questions for the Record

Dr. Diana Liverman
Regents Professor of Geography and Development
University of Arizona

Dear Congresswoman Castor,

Thank you for your letter with follow up questions about my testimony before the Select Committee on the Climate Crisis on Tuesday, April 30, 2019. It was a privilege to meet you and the committee and receive such thoughtful and important questions. I provide answers to the questions below, including some research that has been published since the release of the IPCC 1.5°C report.

Sincerely,

Regents Professor of Geography and Development, University of Arizona

<u>The Honorable Kathy Castor</u>

1. Is the US emissions trajectory consistent with limiting warming to 1.5°C or even 2°C?

The most recent research shows that the US emissions trajectory is not consistent with limiting warming to 1.5°C or 2°C.

The IPCC Special Report on 1.5°C (August 2018) did not examine emissions by country. The report does assess the consistency between the current Paris commitments (NDCs or Nationally Determined Contributions) and scenarios that would limit warming to 1.5°C, and concludes that the full implementation of the current Paris commitments would produce a global average temperature increase by 2100 of 2.9-3.4°C (5.2-6.1°F) above preindustrial levels at 66% probability.

IPCC finds that there is high agreement that the current Paris commitments are not in line with pathways to achieve either a 1.5° or 2°C target.

The UNEP Emissions Gap report (November 2018) supports the 2.9°C-3.4°C of warming estimate by 2100 under a scenario where Paris commitments are fully implemented.

UNEP reports that US emissions decreased from 2004 to 2017, and in 2017 were 13.1% of total global greenhouse gas emissions. UNEP states that the United States Paris target was to reduce emissions 17% below 2005 levels by 2020, and 26-28% by 2025, but noted that with the current intention to withdraw from the Paris agreement the US is unlikely to meet either target.

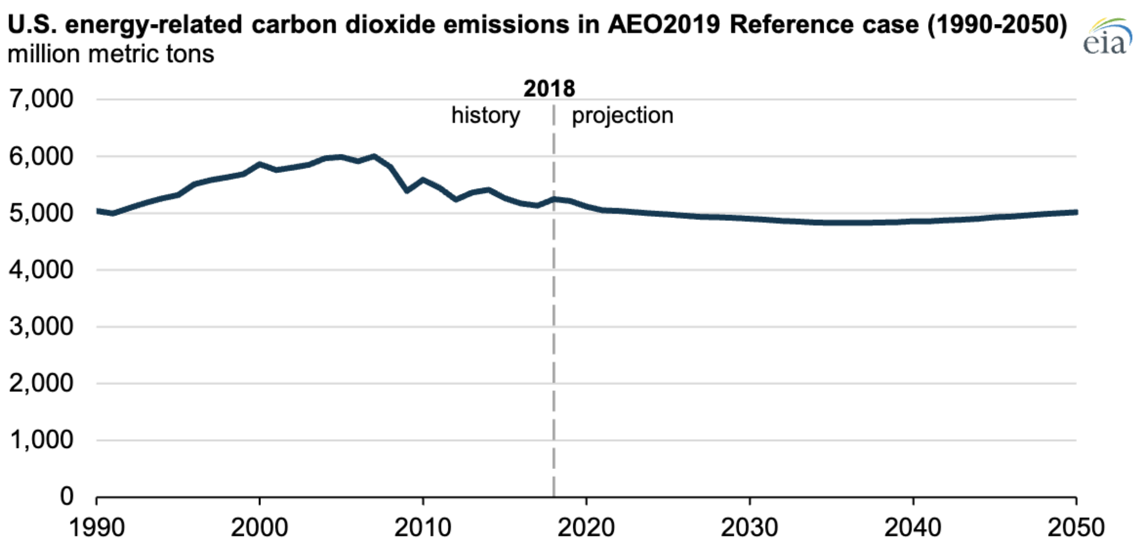
The latest analysis of the Global Carbon Project (Dec 2018) estimates that global carbon dioxide emissions rose by 2.7% between 2017 and 2018, projecting US emissions as 2.5% higher in 2018 than 2017 after several years of decline as coal was displaced by gas, solar and wind.

The US Energy Information Administration (USEIA) Monthly Energy Review for May 2019 reports that energy related carbon dioxide emissions, which were around 6 billion metric tons in 2005, had fallen to 5.17 billion metric tons in 2017, a reduction of 14.4% from 2005 and approaching emission levels for 1990 (5.04 billion metric tons). However, 2018 reversed this trend increasing by 2.7% over 2017 to 5.26 billion metric tons.

In March 2019 the USEIA Annual Energy Outlook projected that US energy consumption will remain near current levels of 5 billion metric tons through 2050 (see figure below) if there are no changes in laws and regulation and if current trends shifting from oil and coal to gas consumption continue.

MARCH 20, 2019

EIA projects U.S. energy-related CO2 emissions will remain near current level through 2050



Source: U.S. Energy Information Administration, *Monthly Energy Review*, *Annual Energy Outlook 2019* Reference case

Carbon dioxide emissions from U.S. energy consumption will remain near current levels through 2050, according to projections in EIA's *Annual Energy Outlook 2019*. The AEO2019 Reference case, which reflects no changes to current laws and regulations and extends current trends in technology, projects that U.S. energy-related carbon dioxide (CO2) emissions will be 5,019 million metric tons in 2050, or 4% below their 2018 value, as emissions associated with coal and petroleum consumption fall and emissions from natural gas consumption rise.

Some recent studies (e.g. America's Pledge Initiative on Climate 2018, Kuramuchi et al 2017) suggest that *actions by non-Federal actions by states, cities and business could contribute to emission reductions* *of up to 21% below 2005 levels by 2025*, approaching the Paris reduction commitment of 26-28% even without new Federal policies.

The IPCC 1.5°C report concludes that for a chance of limiting warming to 1.5°C, global CO_2 emissions must decline by about 45% from 2010 levels by 2030, and reach net zero emissions by 2050. For 2°C emissions would need to decline by 20% between 2010 and 2030 and reach net zero around 2075.

According to the Energy Information Administration, US CO_2 emissions from energy consumption were about 6 billion metric tons in 2010. To be consistent with the IPCC 1.5°C pathway, and if the US were to follow this global average pathway, emissions would need to decline to 3.2 billion metric tons by 2030. Given that we are now in 2019, and emissions are at 5.3 billion metric tons, energy related emissions would need to decline annually by at least 3-4%.

Finally, the research literature on responsibility for emissions suggests that the U.S. should be making even steeper cuts than the global average because of our historical responsibility for emissions and high per capita current emissions (e.g. Holz et al, 2018; Van Den Berg, 2019). Carbon dioxide, once emitted, has a long residence time in the atmosphere (between 20 and 200 years according to IPCC) and thus some analysts believe that cumulative emissions should be the basis for emission reductions. This implies that those having greatest historical emissions making greater cuts. The US is the largest historical emitter with responsibility for around 25% of accumulated CO_2 emissions, compared to 12% for China (WRI 2019).

2. Please provide more information on the economic damages associated with global warming of 1.5°C and 2°C and how many dollars of those damages might take place in the United States?

Assessing the economic damages of global warming is extremely challenging. They depend on detailed and robust estimates of the impacts across regions and for key sectors such as agriculture, coastal infrastructure, and health, and assumptions about how to convert non-market impacts, such as those on ecosystems and disease, into dollar values. Results also vary with assumptions about discount rates and future economic growth.

The IPCC 1.5°C report discusses several major studies of economic damages. First, Warren et al (2018) estimate that by limiting warming to 1.5°C rather than 2°C damages are reduced by 22% (range 10-26%) and are reduced by 87% (range 74% to 91%) compared to the current trajectory that would take warming to 3.5°C. Damages included are costs associated with climate change-induced both market and non-market impacts, impacts due to sea level rise, and impacts associated with large scale discontinuities This the source of the $54 trillion at 1.5°C and $69 trillion at 2°C estimates of the IPCC, and also estimates cumulative damages of $551 trillion if temperatures rise to 3.7C by 2100. Global GDP in 2017 was about $80 trillion, of which the US was responsible for almost 25% (~$20 trillion). *If losses were equally distributed and proportional to GDP then the damages to the US, based on this paper, would be about $13 trillion at 1.5°C and $16.6 trillion at 2°C by 2100, compared to more than $130 trillion at 3.5°C.*

IPCC also discusses research by Burke et al (2018) that finds that "limiting warming to 1.5ºC instead of 2ºC would save 1.5–2.0% of Gross World Product (GWP) by mid-century and 3.5% of gross world product (GWP) by end-of-century". Under a 3% discount rate this corresponds to avoided damages of $8.1 trillion-$1.6 trillion by 2050, and $38.5 trillion by 2100 (this is the source of the number included in my original testimony).

More recent research by Jevrejeva et al (2019) examines the global economic costs of coastal flooding and conclude that annual global flood costs will be $10.2 trillion a year (1.8% of GDP) in 2100 at 1.5°C (projecting .52m of sea level rise) and 11.7 trillion (2% GDP) under a 2°C scenario (projecting .63m of sea level rise) if no further adaptation is undertaken. *The US annual flood cost is reported as $394 billion a year at 1.5C (0.9% of GDP) and 446 billion at 2C (1% of GDP)*

IPCC discusses two studies focusing only on the USA which find that economic damages are projected to be higher by 2100 if warming reaches 2°C than if it is constrained to 1.5ºC. The first study is that of Hsiang et al. (2017) concluded that *the USA could lose 2.3% Gross Domestic Product (GDP) each year per degree of global warming. They find that the baseline if no further action is taken to reduce emissions results in economic damages reaching 4.5% (range 2.5% to 8.5%) of GDP per year by 2100. Avoided damage from achieving a 1.5°C temperature limit is 4% of GDP (range 2.0% – 7.0%) by 2100. Avoided damages in the US from achieving a 2°C temperature limit are 3.5% of GDP (range 1.8% - 6.5%). The second study by Yohe (2017) finds an annual GDP loss in the US of 1.2% per degree of warming, or approximately 0.6% for a half a degree increase from the current 1°C warming to 1.5°C.*

Economic damage estimates for the US are also provided in the 4th US National Climate Assessment (NCA4). The technical report for NCA4 (EPA 2017) compares annual economic damages in 2090 for two IPCC scenarios, RCP8.5 which approximates to a no further action scenario (e.g. a 3.5°C (range 2.6-3.8) global warming by 2100) and RCP4.5 which approximates to a 2°C (1.1 to 2.6) scenario (by 2100). Damages are estimated for sectors that include air quality, extreme temperature mortality, loss of labor, health, agriculture, infrastructure, energy and fisheries. For example, *annual damages in 2050 under the RCP4.5 (~2°C) scenario include $6.9 billion in air quality, $32 billion from extreme high temperature mortality, $35 billion in lost labor hours, $1.8 billion to fisheries, $9.5 billion to roads, bridges and rail, and $69 billion in damage to coastal property. This totals $154 billion and rises to $262 billion in annual damages by 2090. $56 billion (85%) of the coastal property losses estimated for 2050 under the 2°C scenario would occur in the Southeastern United States if no further adaptation occurs.*

Since this question was asked Representative Levin from California's 49th congressional district, I include a regional example of damages to the US from the recent California Climate Assessment (August 2018, Appendix B). The estimates of economic damages to different sectors in California by the middle of this century (2050) due to climate change include those to health from high temperature mortality ($50 billion a year), transport ($1 billion from 2040-2070), inland flooding ($42 billion/yr), sea level rise ($18 billion/yr to replace flooded property), and water shortages (around $3 billion a year) (see Table 6 for California below from Bedsworth et al 2018). The California assessment notes that "many other important impacts have not been quantified, including public health and property damage from wildfires, impacts on human morbidity from high temperatures, impacts of drought on water quality, and impacts to habitat and other ecosystem services. All of these damages are likely to be costly".

TABLE 6 | ORDER OF MAGNITUDE ESTIMATION OF DIRECT ECONOMIC IMPACTS FROM CLIMATE CHANGE BY 2050.

EFFECT OF ACTIVITY	MAIN CLIMATE DRIVER	COST ($ billion/year)	COMMENTS
Human mortality*	High ambient temperatures	50	Premature annual mortality (Ostro et al., 2011) translated into monetary terms using a value of a statistical life of $7.5 million.
All sectors of the economy	Mega-flood** similar to the one that devastated California in 1861-1862	42	One recent study by Swain et al., (2018) suggests a substantial likelihood of these floods in the rest of this century
Replacement value of buildings (residential and commercial sector)	Permanent inundation	18	Assuming 50 cm (~20 in) of sea-level rise, which is in the upper range (~95th percentile) of potential sea-level rise outcomes by 2050 (Pierce et al., 2018). Costs obtained from *https://www.usgs.gov/apps/hera/* accessed on July 7, 2018.
Water supply and agriculture	Potential effect of a long drought	> 3	Assuming reductions in precipitation from 5 to 30 percent from historical conditions. Actual impacts would be much higher than $3 billion because the economic models assume very efficient adaptation. (Herman et al, 2018; Medellín-Azuara et al., 2018).
Energy demand: residential sector	Increase temperatures	< 0.2	Increases in electricity demand ($0.65 billion) would be compensated by reductions of demand for space heating ($0.5 billion). (Auffhammer et al., 2018). Expected increases in energy efficiency will also lower costs even further.
Other impacts (e.g., human morbidity, loss of human lives and properties during wildfires)	Changes in temperature, aridity, wildfires, inland flooding, etc.		Unquantified or poorly quantified (see Appendix B).
Ecological impacts	Changes in temperature, aridity, wildfires, inland flooding, etc.		Unquantified. Some argue that it is impossible to estimate the value of ecosystems in monetary terms for both practical and ethical reasons. Others are working to quantify the value of ecosystem services.

See Appendix B for a more detailed table and documentation of assumptions.

* Implementation of adaptation measures (e.g., increased penetration and access of space cooling) could substantially reduce these impacts.

** Swain et al., 2018 is the only study suggesting an increased probability of a mega flood with a changing climate. Given the high costs associated with this event, it is listed in this table to highlight the importance of additional studies on this topic using different methods. The $42 billion cost is estimated taking into account the probability of this event in a 5 year period centered in 2050.

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