<u>Executive Brief</u>

The Roadmap to Climate Stabilization

Based on IPCC Fifth Assessment Climate Accounting Protocols

The 50% rise in global temperatures over the past three years (from +0.8°C to +1.2°C over the 1750 pre-industrial baseline) has caused major irreversible structural impacts and shocked the fundamental earth's support ecosystems. The weight of the evidence suggests that the much-feared climate tipping point has now been crossed at much lower temperatures than the +2.0°C temperature target of COP 21. The latest consensus climate mitigation options presented in the IPCC 5th assessment offer the most effective, up-to-date technical routes to climate stabilization.

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The Crisis

+1.2°C is the Irreversible Climate Tipping Point

The threat of irreversible climate change has loomed for years. Scientists have modeled scenarios to predict impacts on earth systems, while policy makers have debated whether, when, and how to respond to these predictions.

The abrupt increase in global temperatures experienced over the past three years, and the accompanying observed impacts, have brought stark clarity to this issue. The weight of the evidence shows that, at an average global temperature about 1.2°C warmer than the pre-industrial world, we have now reached the threshold of irreversible climate change – well below the +2°C COP 21 Paris Treaty upper target, and well ahead of anticipated timeframes.

From 1750 to 2013, the average global temperature rose – at first gradually, then at an increasing rate – to about 0.8°C above the pre-industrial baseline. Since 2013, however, the pace of change has accelerated dramatically, with average global temperature lurching ahead by 50% to +1.2°C, and rising temporarily during the first few months of 2016 by 80% to +1.5°C (Figure 1).[1] In other words, the earth reached a temperature not been expected to occur until mid-century.

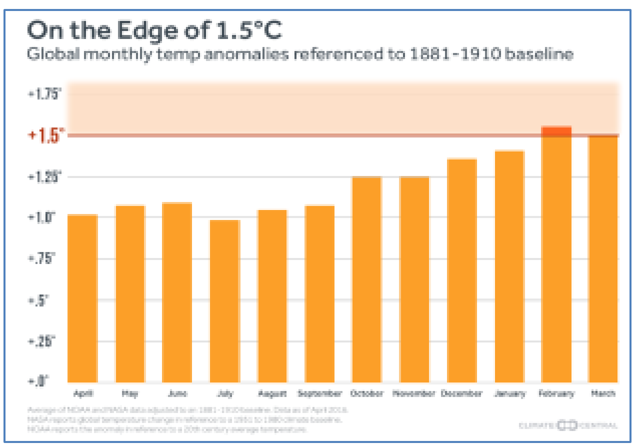

Figure 1. Global average temperature by month, April 2015 to March 2016, compared to 1881-1910 baseline.
(Source: Climate Central, see footnote 1)

Tipping Point Level Impacts

The unprecedented rise in global temperatures over the past two years has caused major irreversible structural changes to earth support systems.

- The world's coral reefs, which have been in existence for 250 million years and support one-quarter of all marine life, are suffering from extensive bleaching, acidification and disintegration, and are rapidly heading toward extinction.[2]
- The oceans have become so hot that its dissolved oxygen is literally boiling off, representing a major threat to marine life. This loss of vital oxygen is already observable in major parts of the world, and two-thirds of the Pacific Ocean could be devoid of sea life by 2025.[3]
- The most powerful "super-typhoons" ever recorded devastated parts of the Philippines within the last three years. The historic record shows that at today's temperatures, +1.2°C, "megastorms" occurred, with 300 mph winds and 100-foot tsunami-like sea surges that hurled 1,000-ton boulders onto shore.[4]
- Deadly forest fires in Alaska, Canada, and Siberia, and other northern regions have exploded in size and ferocity as the forests have dried out and the fire season has doubled due to these extreme temperatures. These fires release huge amounts of greenhouse gases, raising Canada's annual emissions by 30%, as well as huge plumes of soot containing dangerous black carbon.[5]
- Permanent droughts that were not predicted for another 40 years are now spreading throughout the world. 330 million people in India are currently facing unprecedented conditions after two failed monsoon seasons, with less than 20% of groundwater reserves remaining.[6, 7]
- In March 2016, the Arctic winter sea ice maximum extent set a new low record since satellite records have been kept.[8] September 2015 marked the fourth lowest summer sea ice extent. The Arctic sea could be "ice-free" by or before 2020, 50 years ahead of predictions.[9] Global impacts include the potential of a methane hydrate emissions pulse that would double atmospheric concentrations of greenhouse gases.
- Both Greenland and Antarctica are now undergoing unparalleled rates of melting. Data now suggest that sea levels could rise by as much as 9 feet by 2050-2060, flooding coastal cities and displacing millions of people around the globe.[10]
- Climate change is altering the timing of seasonal life-cycle events, food-web disruptions, and habitat ranges, threatening the survival of species.[11] Earth is now in the midst of its sixth mass extinction of plants and animals.

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Ironically, April 2016 – the month during which the Paris Agreement was formally signed –was the third straight month during which global temperatures reached +1.5°C, and the 12th straight month of record-shattering temperatures.[12]

It is now critical to implement significant reductions in atmospheric heat without delay, in order to stabilize the global average temperature at or below the +1.2° tipping point.

Figure 1. The lag-time between rising radiative forcing levels and global average temperature

Just as it takes several minutes of continuously applied heat to warm water to the boiling point, sustained RF levels drive global temperatures up over a period of decades.

Updated Climate Accounting

IPCC Fifth Assessment Report Climate Accounting Protocols

The state-of-the-climate report series published every five years by the Intergovernmental Panel on Climate Change (IPCC) represents the consensus of thousands of climate scientists around the world. In addition to describing the latest climate research findings, the IPCC Fifth Assessment Report (2013) presented new methods for projecting increases in average global temperature, considering a variety of scenarios.[14] It also provided the technical framework needed to integrate new findings and observations, informing our under-standing of climate tipping points.

Linking Excess Heat to Global Temperature Rise

While temperatures receded in May 2016 off the +1.5° high,[13] and the overall average for the year will likely be about +1.2°C, projections in the Fifth Assessment Report make clear that average global temperatures will reach and surpass +1.5°C in the very near future. The principal reason for this inevitable rise is the amount of excess heat that has already built up in the oceans and the atmosphere.

In short, there is a lag time between the build-up of excess heat and the resulting rise in average global temperatures. This delay is akin to putting cold water on the stove: it takes time for the applied heat to drive the water to the boiling point (Figure 2).

The excess heat (+1.6 W/m^2) needed to drive global temperatures to today's temperature, +1.2°C, was reached over a decade ago. Today's excess heat level, +2.3 W/m^2, will push global temperatures well past +1.5°C to about +1.8°C, unless effective mitigation measures are undertaken immediately. On the current trajectory, the excess heat level could reach +3 W/m^2 by 2025, enough to increase global temperature far beyond +2°C. As a result, the window of time to act is now.

In addition to providing accurate methods for determining when and how much temperatures will rise, the IPCC Fifth Assessment Report provides the new metrics needed to update global climate accounting protocols. These updates reflect the current state of climate knowledge, accounting for short-lived climate pollutants, revised values for methane, and the effects of pollutants that reflect incoming solar radiation.

The updated protocols are essential to scientifically assess the full spectrum of climate mitigation projects and technologies available, in order to identify those options that will be most cost-effective and best-suited for stabilizing climate at +1.2°C within 10 years. The protocols have been introduced for standardization to the international ISO 14000 process, and integrated with advanced life-cycle assessment (LCA) to allow for identification of unintended environmental or human health impact trade-offs that might be associated with deployment of specific mitigation options.

Table 1 shows the level of reduction in "radiative forcing" – the source of the excess heat – needed to stabilize average global temperature at +1.2°C over a five-decade time horizon, as compared to business-as-usual (the "RCP 8.5" scenario modeled by the IPCC using the Fifth Assessment protocols).

Table 1. The Radiative Forcing Reductions needed compared to Business-as-Usual to maintain +1.2°C [15]

Target Dates	RF reductions from BAU needed to maintain 1.2°C
2025	-1.4 W/m^2
2035	-2.0 W/m^2
2045	-2.8 W/m^2
2055	-3.5 W/m^2
2065	-4.3 W/m^2

Table 2. The IPCC Fifth Assessment Climate Stabilization Roadmap at +1.2°C through 2045
(Force Reductions are global unless otherwise indicated)

Mitigation Project Scope	Options to Achieve -1.4 W/m² Reduction by 2025	Options to Achieve -2.0 W/m² Reduction by 2035	Options to Achieve -2.8 W/m² Reduction by 2045
Cloud albedo enhancement for: a) Antarctic Stabilization b) Global Cooling *Solar Radiation Stabilization*	Global and Antarctic Ocean Cooling through the use of Sea Salt **Force Reduction = -2.0 W/m²** **Regional Ocean Cooling = -3°C** vital to return these waters back to their historic range for Antarctic ice stability	Global and Antarctic Ocean Cooling through the use of Sea Salt **Force Reduction = -2.0 W/m²** **Regional Ocean Cooling = -3°C** vital to return these waters back to their historic range for Antarctic ice stability	Combination of SRM and ERM required: Global and Antarctic Ocean Cooling through the use of Sea Salt: **Force Reduction = -2.0 W/m²** **Regional Ocean Cooling = -3°C** Arctic Clear Skies: **Arctic Force Reduction = -4 W/m²** Ambient temperature reduction < -5°C **Force Reduction = -2.7 W/m²**
Cloud nucleation for: a) Arctic Clear Skies b) Global Cooling c) Protection of Arctic Ice Sheet *Earth Radiation Stabilization*	Arctic Clear Skies would greatly increase the release of excess heat currently being trapped by Cirrus Clouds. These clouds are new to Arctic from global warming **Arctic Force Reduction = -4 W/m²** Ambient temperature reduction < -5°C **Force Reduction = -2.7 W/m²**	Arctic Clear Skies would greatly increase the release of excess heat currently being trapped by Cirrus Clouds. These clouds are new to Arctic from global warming **Arctic Force Reduction = -4 W/m²** Ambient temperature reduction < -5°C **Force Reduction = -2.7 W/m²**	
Long-term reductions in annual CO_2 emissions	Given long-term atmospheric concentrations and annual emissions, mitigation is essential but will not contribute to +1.2°C stabilization by 2025. **Force Increase = +0.3 W/m²**	**50% Reduction in Annual Emissions** -25% from avoided emissions from the cooling brought about by early deployment of SRM and ERM. -25% from combination of projects: • Deployment of non fossil fuel energy systems and energy efficiency • Afforestation/reforestation • 1 billion acres of soil sequestration and grassland albedo enhancement **Force Reduction = Negligible**	**80% Reduction in Annual Emissions** - 40% from avoided emissions from the cooling brought about by early deployment of SRM and ERM. -40% from combination of projects: • Deployment of non fossil fuel energy systems and energy efficiency • Afforestation/reforestation • 2 billion acres of soil sequestration and grassland albedo enhancement **Force Reduction = Negligible**
Reduction in annual methane emissions	20% reduction in anthropogenic emissions **Force Reduction = -0.2 W/m²**	40% reduction in total biogenic and anthropogenic emissions from the 2005 baseline **Force Reduction = -0.4 W/m²**	Attempt to maintain 40% reduction from the 2005 baseline in the face of potentially sharp increases in total biogenic emissions. **Force Reduction = -0.4 W/m²**
Reduction in urban black carbon and tropospheric ozone precursor emissions	Mitigation of 4 key regional hot spots: India, China Central, Central Western Africa, and Brazil must reduce emissions by 20%. **Force Reduction = > -0.5 W/m²**	Mitigation of 4 key regional hot spots: India, China Central, Central Western Africa, and Brazil must reduce emissions by 40%. **Force Reduction = -1.0 W/m²**	Mitigation of 4 key regional hot spots: India, China Central, Central Western Africa, and Brazil must reduce emissions by 40%. **Force Reduction = -1.0 W/m²**
Reduction in annual tropospheric ozone formation	Reduce the Middle East Tropospheric Ozone Hot Spot linked to combined emissions from North America, Europe, and Brazil **Regional Force Reduction = < -1.0 W/m²**	Eliminate the Middle East Tropospheric Ozone Hot Spot linked to emissions from North America, Europe, and Brazil. **Regional Force Reduction = -1.0 W/m²**	Monitor for resurgence of the Middle East Tropospheric Ozone Hot Spot linked to emissions from North America, Europe, and Brazil. **Regional Force Reduction = -1.0 W/m²**

More detailed information on the force reduction per project is provided in the New Work Item Proposal prepared for the introduction of the updated climate accounting protocols to ISO-14000 (ask for a copy).

For example, the amount of CO_2 already accumulated in the atmosphere over the past 200 years is more than 1,000 billion tonnes. Even if annual CO_2 emission rates (currently at 32 billion tonnes) are reduced dramatically in a given year, this reduction would not materially affect the reduction in forcing. However, without such abatement, force increases from CO_2 will become the main driver of future temperature increases well over +3°C.

It is particularly important to note that all current conventional mitigation options combined only reduce forcing in very small increments. Without polar solar and earth radiation stabilization (SRS and ERS) projects, climate stabilization either at +1.2 or +1.5°C is not technically possible. Most importantly, unless the polar SRS and ERS projects level off temperatures in the near term, the vital mitigation of CO_2 will not be possible. That's because avoiding future increases in CO_2 emissions depends on minimizing electric power demand so that power systems will not have to be fully deployed. When temperatures in major urban areas reach extremes (>120°F), air conditioning is essential. This air conditioning is dependent on power systems that will still be largely fossil fuel driven for years to come, causing an explosion in CO_2 emissions. By deploying SRS and ERS projects in the near term, such added emissions would be avoided. As can be seen in Table 2, these polar SRS and ERS projects have the additional capacity to provide some level of stabilization to both Antarctic and the Arctic, a prerequisite for preventing major flooding of the world's population centers.

Standardizing the Roadmap

A new voluntary international standard, *IPCC Fifth Assessment Climate Stabilization Protocols,* is now being proposed to reinforce this roadmap.

Uses

- More comprehensive climate footprints
- Validation of claims of radiative forcing (RF) reduction
- Development of RF reduction markets, to support buying and selling of RF reduction credits
- Incorporation into public climate reporting platforms
- Improved corporate risk management, regulatory and adaptation planning
- Guidance for revisions of COP 22 INDCs

Benefits

- Scientific, actionable framework for project planning and organization footprinting
- Focuses mitigation efforts on projects that can most effectively slow the rise in RF
- Improves the efficacy of carbon registries
- Increases opportunities for organizations and projects to gain recognition climate mitigation activities
- Optimizes expenditures on climate mitigation

The IPCC Fifth Assessment Climate Stabilization Roadmap highlights the need to continue focusing on reducing and removing the major sources of overall excess heat linked to both CO_2, methane, black carbon and tropospheric ozone, while using SRM and ERM project to keep the lid on temperatures in the near-term. Without using these options, there is no chance to halt the rise in temperatures to well over 1.5°C and beyond in the next few years, with irreversible climate change consequences.

The Roadmap Forward

The Climate Stabilization Council

A multi-stakeholder Climate Stabilization Council is being established, with advisory support from leading climate scientists. The Council's mission is to scientifically vet major force reduction projects and technologies, then link projects to funding sources. In this way, it will facilitate rapid deployment to stabilize average global temperature at +1.2°C over the next decade, and support deployment of a combination of longer-term stabilization options. Specifically, the Council will:

- scientifically evaluate the ability of projects and technologies to contribute to climate stability, along with any potential environmental or human health trade-offs;
- develop implementation protocols for these projects, providing required best practice guidance and a mechanism to verify projects achieve the stated stability goals;
- connect potential funders with project proponents; and
- help lay the groundwork for COP 22 in 2020.

The Council's aim to provide COP 22 with a robust set of options that have the potential for climate stabilization at +1.2°C by 2025. This goal can only be reached if effective mitigation projects are well underway by 2020 with Council direction and funding.

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Footnotes

1 "Flirting with the 1.5°C Threshold," Climate Central, April 20, 2016. http://www.climatecentral.org/news/world-flirts-with-1.5C-threshold-20260#interactive

2 For example: Brian Clark Howard, "Corals Are Dying on the Great Barrier Reef," *National Geographic*, March 21, 2016. http://news.nationalgeographic.com/2016/03/160321-coral-bleaching-great-barrier-reef-climate-change/

3 "Widespread loss of ocean oxygen to become noticeable in 2030s: Deoxygenation due to climate change threatens marine life", *Science News*, April 27, 2016. Source: Study by National Center for Atmospheric Research/ University Corporation for Atmospheric Research, published in *Global Biogeochemical Cycles*. https://www.sciencedaily.com/releases/2016/04/160427150914.htm

4 James Hansen, *et al.,* "Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2°C global warming could be dangerous," *Atmos. Chem. Phys*., 16, 3761-3812, 2016.

5 Brian Kahn, "Here's the Climate Context for the Fort McMurray Wildfire," Climate Central, May 4, 2016.

6 "Indian drought 'affecting 330 million people' after two weak monsoons," *The Guardian*, April 20, 2016. https://www.theguardian.com/world/2016/apr/20/india-drought-affecting-330-million-people-weak-monsoons

7 Juliet Perry and Huizhong Wu, "Much-anticipated monsoon may not solve India's drought crisis," CNN, May 5, 2016. http://www.cnn.com/2016/05/05/asia/india-heat-wave-drought/

8 National Snow and Ice Data Center, "Another record low for Arctic sea ice maximum winter extent." March 28, 2016. http://nsidc.org/arcticseaicenews/2016/03/another-record-low-for-arctic-sea-ice-maximum-winter-extent/

9 Jessie Guy-Ryan. "Climate Scientist Claims the Arctic Could Be Ice-Free This Summer," Atlas Obscura, June 5, 2016. http://www.atlasobscura.com/articles/climate-scientist-claims-the-arctic-could-be-icefree-this-summer

10 New projections described by Margaret Davidson, NOAA senior advisory for coastal inundation and resilience science and services, and Michael Angelina, executive director of the academy of Risk Management and Insurance, in a presentation titled "Environmental Intelligence: Quantifying the Risks of Climate Change."

11 For example, see https://www3.epa.gov/climatechange/impacts/ecosystems.html

12 "April 2016 Was 12th Consecutive Warmest Month on Record, NOAA Says," The Weather Channel, May 18, 2015 https://weather.com/news/climate/news/record-warmets-april-earth-2016

13 0.1 - 0.2°C of the early 2016 rise to +1.5°C was attributed to El Niño. See, for example, "Why is 2016 smashing heat records?" Karl Mathesen, *The Guardian*, March 4, 2016. https://www.theguardian.com/environment/2016/mar/04/is-el-nino-or-climate-change-behind-the-run-of-record-temperatures. Notably, according to Dr. Michael Mann, "We would have set an all-time global temperature record [in 2015] even without any help from El Niño."

14 "Climate Change 2013: The Physical Science Basis," Intergovernmental Panel on Climate Change http://www.ipcc.ch/report/ar5/wg1/

15 The business-as-usual scenario used for this table is the IPCC Fifth Assessment Report Representative Concentration Pathway scenario calibrated to a temperature of +8.5°C by the end of the century (RCP 8.5).