

HOW 'GEOENGINEERING' CAN FIGHT AGAINST CLIMATE CHANGE AND GLOBAL WARMING

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Global Warming. In simple words, Global warming refers to the exponential increase in the earth's surface temperature which further disrupts the natural habitats and biodiversity and hinders various physical processes of nature, therefore bringing us closer to the doomsday. It is too hot lately? Has it been all over the news recently? The answer is an obvious yes, and that being because Global Warming is an alarming issue. According to the article, "2016 is going to be the hottest year ever", published in *The Fortune* by Jonathan Chew states, "Last month was the hottest March in 137 years of tracking, according to the National Oceanic and Atmospheric Administration, making it 11 straight months that the Earth hit record highs in average temperature." We have been seeing the thermometers setting up new records every year. Does it affect you in any way? It may not do so right now, but it will surely very soon. Over the past few years, there have been several articles and research studies that elucidate on the cause of climate change and global warming, and how much of climate change one can expect in the future. Around 97% of the scientists from all around the world are in accordance with the fact that global warming is a natural occurring phenomenon but human intervention is amplifying the process to touch unprecedented rates (NASA 2014). The central purpose of this research paper is not to illustrate the possible solutions that would cease the process of climate change, but rather to examine the potential mitigations in order to fight the wrath of global warming. Due to the recent rise in industrial process and the increase of human dependence on non-renewable energy sources, human race is on the verge of extinction but it is not too late yet. The common man has two ways that lead from the present condition- he can either start his journey back to a secure heaven by making probable adjustments in the natural processes or he can continue his way further to the verge of extinction. As history has shown, the dated ineffective individuals efforts of reducing the carbon footprints in the environment have proved nothing but fruitless. Even though global warming and climate change may not have been a joint effort of the anthropological race, it is the need of the hour for the common man to unite and fight against the catastrophe of global warming using the technique of geoengineering i.e. the use of technological advancements to intervene in the natural biodiversity and reduce the impact of climate change.

Before we move forward into the scientific explanation and application of geoengineering, it is necessary for us to analyze and unveil the reasons responsible for the failure of the common approaches that the common being used to fight climate change. Several and varied methods have

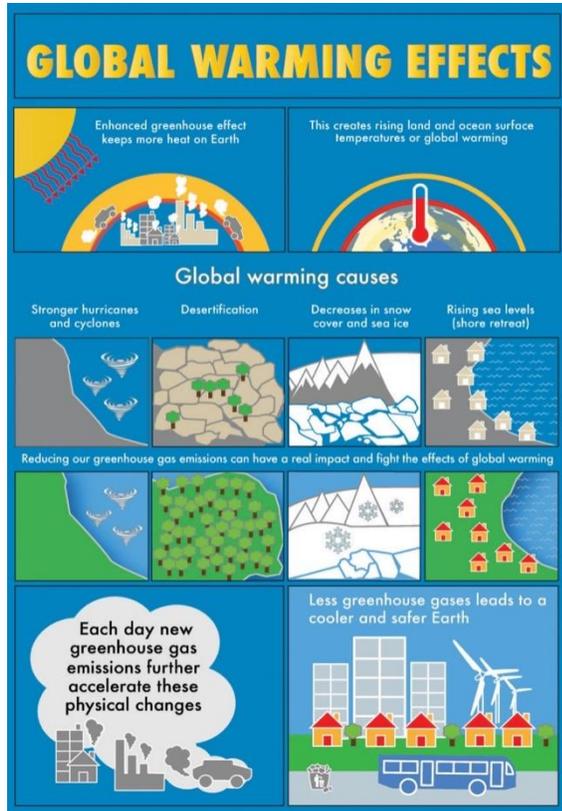


Figure 1 An Infographic displaying the causes and further effects of Global Warming and Climate change.

change required.

The wrath of global warming and climate change are continuously disrupting our mother planet. It is because of the sun? or It is because of the recklessness of the homo-sapiens? The article, "Global warming is being caused by humans, not the sun, and is highly sensitive to carbon, new research shows", published in *The Guardian* by Dana Nuccitelli states, "The recent Intergovernmental Panel on Climate Change (IPCC) statement states that 95% of global warming is caused due to anthropological activities." In addition to this, the research study, "Small influence of solar variability on climate over the past millennium", published in *Nature Geoscience*, inspects the impact of the sun on the global climate over the span of 1000 years. The paper also indicates that the energy released from the sun, solar energy, and trivial effect on the planet's temperature change and cannot be accounted for the increasing warmth (Schurer, Tett, Hegerl 2).

The authors of the above mentioned paper also concluded that the exponential increase of climate change is because of the rapid rise in the emission of the greenhouse gases after the 20th century, and are in accordance with the IPCC and Imbers statement that we, the common man, are the central cause of recent climate change (Schurer, Tett, Hegerl 3). Well in this case, if humans have the capability to ruin the Earth's temperature because of their deeds and desires, then they very well have to potential to solve this problem and make mother Earth a merry heaven again.

The next major question that arises is, "How do we influence or cause temperature change?" Knowingly or Unknowingly, even the smallest of our everyday actions sum up slowly and gradually to increase the Earth's surface temperature. The article, "Contribution of anthropogenic and natural forcing to recent tropospheric height changes", by B. D. Santer, M. F. Wehner et. al. states, "our actions resulting in global warming can be as small as eating meat and exotic foods or can be as immense as burning fossil fuels and practicing deforestation." The emissions of greenhouse gases, some of them being: - methane, carbon dioxide, nitrous oxide etc. cause disturbance in the Earth's ecosystem and thereby mark the start of the awry of global warming and climate change (Santer, B.D, M.F. Wehner et. al. 2). According to the study, "A blanket around Earth", by The National Aeronautics and Space Administration (NASA), "The industrial activities that our modern civilization depends upon have raised atmospheric carbon dioxide levels from 280 parts per million to 400 parts per million in the last 150 years." The National Oceanic and Atmospheric Administration (NOAA) has confirmed that the present escalation in carbon dioxide is 100 time faster than it was at the start of the industrial revolution (Robert Kunzig, "Climate Milestone: Earth's CO₂ Level Passes 400 ppm" 1). The below given pie chart displays the major human activities that cause global warming and temperature change: -

Annual Greenhouse Gas Emissions by Sector

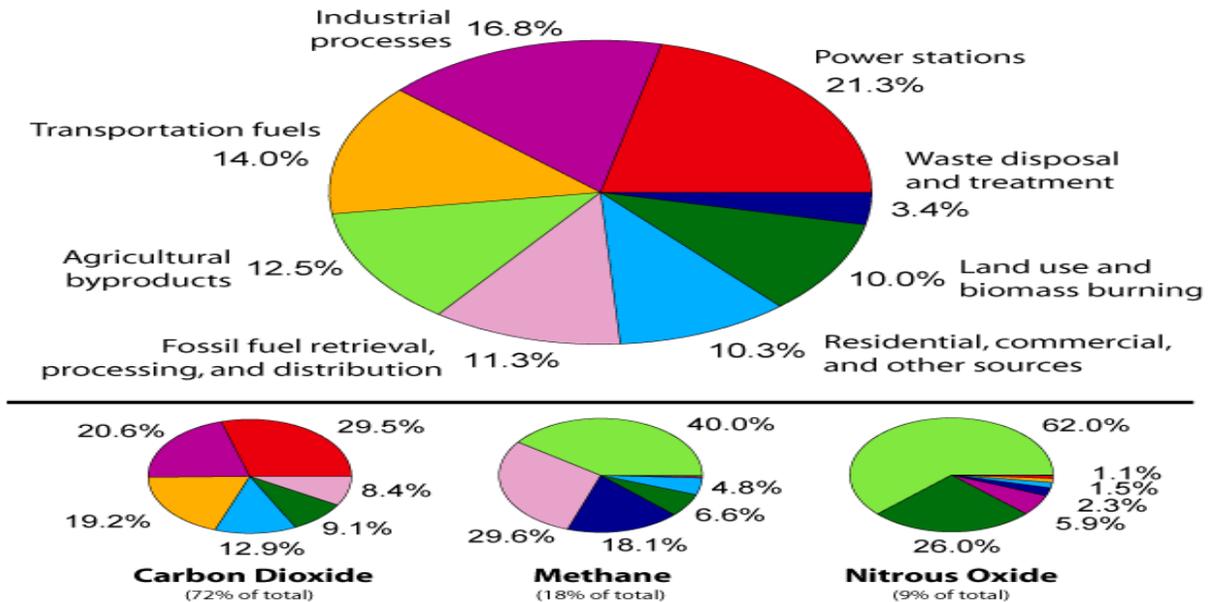


Figure 2 The Greenhouse Gas emissions annually due to human activities.

Thinking about the past and wondering about why it happened does no good to us today. We surely cannot jump back in time and alter the human activities that has resulted in the present condition. However, there is one thing we can do, hit the forward button and plan ahead for the future by undertaking immediate steps that can help us create a habitable place for our further descendants. According to David W. Keith's (a chemistry professor at the Harvard University) paper, "Geoengineering", "Geoengineering Climate has usually been applied to proposals to manipulate the climate with the primary intention of reducing undesired climatic change caused by human influences." The scientific method of geoengineering is a measured intervention, for a good cause, by common man in the Earth's ecosystem and its physical workings to minimize the effect of climate change. Because Geoengineering will completely alter the workings of the world for good, this scientific technique is altogether a new kind of response to global warming, and hence, cannot be incorporated under any prevailed responses of mitigation and adaptation to global warming. The newspaper report, "International governance of a possible geoengineering intervention to combat climate change", by John Virgoe states that there have been several research studies that intent to find the most suitable technology to practice the scientific approach of geoengineering. In simple words, most of the geoengineering processes target to mitigate the effect of activities like deforestation and fossil fuel burning on climate without actually terminating these activities.

As compared to all the nuclear and fossil practices, renewable energy and technologies are one of the most suitable and eco-friendly means to generate energy in the environment. A proficient thermal geoenvironmental method, Ocean Thermal Energy Conservation (OTEC), uses the temperature difference between the different layers of the ocean to generate electricity. The topmost zone or layer of the ocean, also called as the epipelagic zone, which is hot in temperature and lacks rich nutrient, is now mixed with the inner surface of the ocean that is cold, rich in nutrients and is

pathogen free, to generate electricity or create energy. Though the technology is proved to be quite skilled at its work, OTEC has been in the spotlight for debate and scrutiny. A lab programmer at the National Renewable Energy Laboratory in Colo, Terry Penney argues that the vast technology used in OTEC requires a huge amount of financial resources. In his paper, Penney also writes that, "all that investment, and you don't even know if two months after you deploy it whether a tropical storm will then wipe it out." Though there have been several debates about the application of OTEC in the real world, this applied science has several advantages. In Karen Anne Finney's engineering journal, "Ocean Thermal Energy Conversion", the research professor at The University of Guelph states the three shortages that can be solved through the OTEC technology. To start

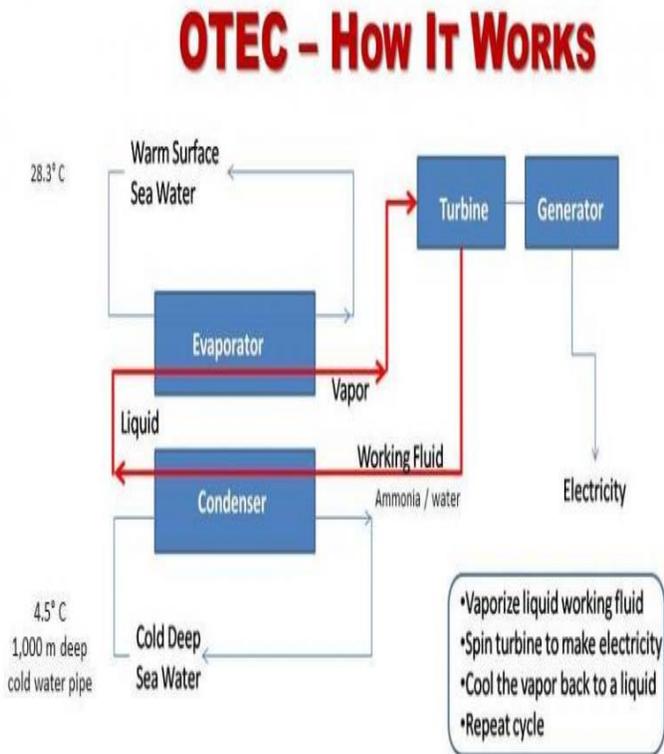


Figure 3 Working of the OTEC Technology.

with, Finney claims that "for every 1,000 liters of water that is processed in the OTEC process, 5 liters of fresh water is created," therefore playing an important role in the production of clean and fresh water. Secondly, the paper illustrates the fact that OTEC, in no way causes thermal pollution, because processing of cold sea water has no further impact on the climate. Lastly, the writer explains how the scientific method of OTEC regulates the amount of carbon dioxide, one of the leading greenhouse gases, in the environment. "OTEC does not discharge any CO₂ and the deep water mixing with the upper layers of the ocean actually helps to grow phytoplankton, algae and coral which may lead to an increase on CO₂ fixation in the atmosphere" (Finney 36). As stated earlier, the ocean thermal energy conservation may have several drawbacks when it comes to infrastructure and expenditure. However, the scientific approach is a consistent renewable source of energy and is something that the present society needs

to include in their lives in order to support and practice the ideal practice of sustainable development.

Apart from the OTEC technology, there are still some economic and practical stones that we can step on and save the planet we call home. Making clouds more reflective, enhancing weathering of rocks and fertilizing the oceans are the Other noteworthy practices that can be included in Geoengineering. One of the most basic and simple way to cool the planet down is to make the stratosphere and the clouds more reflective to the incoming sunlight. The research study, “The geoengineers: geoengineering and the geopolitics of planetary modification”, by a professor at The Queen Mary University of London, Kathryn Yusoff, proposes the possible techniques that could make the clouds more reflective to heat and sunlight. “Some scientists have proposed seeding

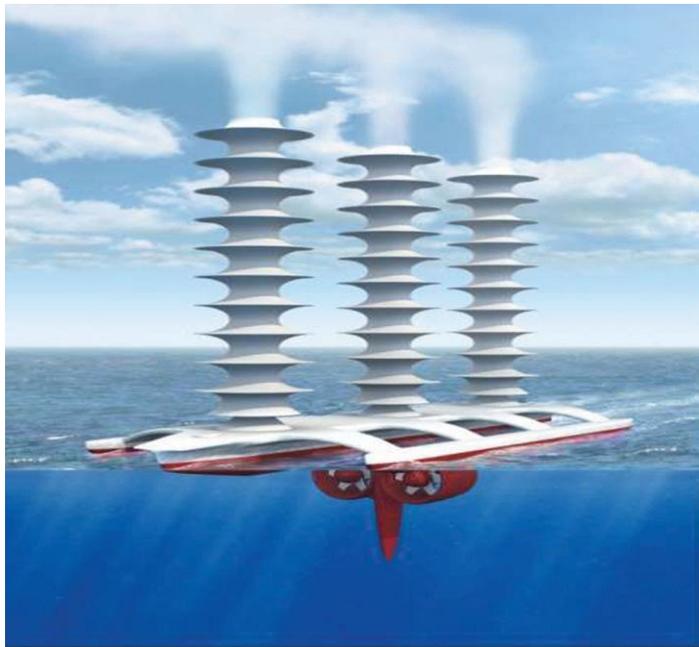


Figure 4 The working of how Sulphur particles would be emitted in the atmosphere.

clouds with sulfate particles, which are highly reflective, which would float in the stratosphere for years, reflecting heat and light back into space” (Yusoff, 5). Michael Le page, in his newspaper article, “The pros and cons of geoengineering”, states that the method of seeding sulphate particles in the clouds and the stratosphere is a successful technological advancement because it is very much similar to how the volcanic eruptions cool the planet. Yusoff also states the other methods of geoengineering which are weathering, or rather enhancing of rocks. With increasing technology and advance resources, some geoengineers have proposed to exponentially speed up the complex natural and chemical process by distributing pre-weathered rocks and stones out in several locations. Rather than relying on the natural weathering process that take millions of years, this boosted method could absorb carbon out of the atmosphere very efficiently (Yusoff 6). Though, this form of geoengineering is very specific to location and region, it has no further consequent effect on the biodiversity and is also cost efficient. The final and the third form of geoengineering that is proposed in Yusof’s research article is ocean fertilization. According to the *IPCC Fourth Assessment Report*, “Climate Change 2007”, “The method of ocean fertilization encompasses boosting the number of phytoplankton’s in the oceans by adding iron rick nutrients to the water.” As states above, the added planktons in the ocean will not only reduce the carbon

footprints in the environment by burying it on the ocean sea floor, but will also minimize the rate of ocean acidification and enhance the ocean biodiversity (Yusoff 8). A study, “The Physical Science Basis”, published in The Cambridge University Press by T.F Stocker, verifies that the practice of ocean fertilization will actually be efficient in moderating the rate of sea-level rise. As discussed, these methods are quite sustainable and efficient. However, the common man will have to face several hurdles and bumps in order to incorporate these practices and methods in their daily routines.

There have been many discussions and debates over the approach and methodology of geoengineering that have been concentrated on the evaluations of risk, cost efficiency and technical feasibility. These debates include several questions about the threat of side effects and the risk of failure involved in the geoengineering practice. Chapter three, “Social, Economic, and Ethical Concepts and Methods”, in the 2014 IPCC report, Mitigation of Climate Change, by Charles Kolstad and Kevin Urama, discusses about the current debate over the method of geoengineering and examines the possible judicial, ethical, and social values related to the practice. The main problem that is discussed in the above stated report is that the improbability of the climate change does not allow the measure of risk involved. Keith in his article states that the possible risk of harmful consequence on the environment, the risk of losing infrastructure and investment and the risk of failure is uncertain and cannot be determined with the method of geoengineering. However, there have been a number of articles and research studies that elucidate on the fact that the effects and risks of all the geoengineered activities are somewhat similar to the natural processes, and thereby, should not result in a greater danger than the nature poses for itself (Keith 2). The amount of sulfate released into the stratosphere as part of a geoengineering scheme will be comparable to the amount released by a large volcanic eruption (Keith, Geoengineering). Keith, in his article, argues that this notion can be corresponded to approximate the magnitude of the loss of the stratospheric ozone. However, the execution of the practices seems far fetched without strong ethical and political support.

The most essential factors that can help the homo sapiens to save themselves are, collaboration and unity. Other conflicts that may arise because of geoengineering can be the incapability of the countries to control the international global norms. “Whether or not they were actually responsible, the operators of a geoengineering project could be blamed for harmful climatic events that could plausibly be attributed—by an aggrieved party—to the geoengineering” (Keith 6). In addition to this, there have also been debates about the ethical aspects associated with the intervention by the mankind in the Earth’s natural biodiversity. In one of her interviews, Ken Caldeira (a climate scientist at The Stanford University) asserted that, “I think it's going to be easier and cheaper to avoid making a mess than it will be to make a mess and then try to clean it up later.” The above statement by Caldeira showcases the prime unethical concern of geoengineers and

elevates the question of whether the common man should intentionally manipulate the natural biodiversity. Keith states a similar worry as 'The slippery slope argument.' He contends that the intervention in the Earth's natural processes in order to fight human induced climate change would open further doors for the future generation to systematically alter global environment to fulfill human wants and desires (6). In his paper, Kieth also states, "Rather than attacking the problems caused by fossil fuel combustion at their source, geoengineering aims to add new technology to counter their side-effects." Keith's statement asserts to the view that the approach of geoengineering will open future gates for the common man to be nonchalant towards the biodiversity and will not make any precautions efforts in their daily lives to reduce the impact of global warming. It is crystal clear that the mankind guides the environment is a number of ways everyday, from practicing agriculture using fertilizers to diverting water according to his needs and wants, or to utilize wind and solar radiations for energy. The main question that arises here is, "Can we not move a step forward to these local management techniques to the natural processes itself, by doing this, are we actually crossing the moral line?" The explanations and the answers to this question is on us to decide, whether we want to define it morally correct to intervene in the natural processes and the natural biodiversity and actually make a difference in our living, or whether we want to stick to the old dated ways of fighting temperature change and seek happiness in the minutest of the visible changes that occur.

Paul Falkowski, a professor at The Rutgers University, said in one of the conference conducted by the National Academy of Sciences on geoengineering, "technology can, and often has, changed overnight. The time between the drilling of the first oil well and an America with cars and airplanes was only about 60 years, which suggests we're capable of remaking our energy system again in the next 60 years." Over the past several years, technological advancements have had revolutionary effects, or rather a blessing to the mankind, across the globe. Elon Musk, CEO of Tesla Motors, being one of the greatest examples, who would have thought that he would come up with an innovative idea of cars that work on electricity, therefore, minimizing the carbon footprints in the atmosphere and leading a way to promote the practice sustainable development. The need of the hour today is to stay below the 2°C climate change, and at the pace we are progressing, the goal can only be achieved using several technological inventions. Through geoengineering, as a practice, has various disadvantages and flaws, but it is the only viable option we have for now that could help us in dealing with the problem of global warming and climate change. Therefore, the only way to survive and improve the current temperature conditions is to take a different approach and combat the problem is a completely unnatural way i.e. intrude in the natural processes and the natural biodiversity using technological advancements.

WORK CITED

Avery, William H., Wu, Chih. "Renewable Energy from the Ocean," Oxford University Press, New York. 1994.

Change, Intergovernmental Panel On Climate. "Social, Economic, and Ethical Concepts and Methods." *Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Climate Change 2014 Mitigation of Climate Change* (n.d.): 207-82. Inter Governmental Panel on Climate Change. Web.

Chew, Jonathan. "2016 Is Going To Be The Hottest Year Ever." *Fortune 2016 Is Going To Be The Hottest Year Ever Comments*. The Fortune, 19 Apr. 2016. Web. 03 June 2016.

Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Denchak, Melissa. "How You Can Stop Global Warming." *NRDC*. N.p., 11 Mar. 2016. Web. 29 May 2016.

Finney, Karen Anne. *Finney. Ocean Thermal Energy Conversion. Guelph Engineering Journal, (1), 17 - 23. ISSN: 1916-1107. ©2008.* (n.d.): n. pag. Web.

"Summary for Policymakers." - *AR4 WGI*. Intergovernmental Panel on Climate Change, n.d. Web. 29 May 2016.

Keith, David W. *Geoengineering Climate*. Dordrecht: Springer, 2006. July 1998. Web.

Kunzig, Robert. "Climate Milestone: Earth's CO2 Level Nears 400 Ppm." *National Geographic*. National Geographic Society, 12 May 2013. Web. 29 May 2016. *Launch*. N.p., 14 Dec. 2014. Web. 29 May 2016.

Lombardo, Crystal. "Ocean Thermal Energy Conversion Pros and Cons - Vision Launch." *Vision* N.p., 19 Jan. 2013. Web. 29 May 2016.

Newitz, Annalee. "10 Ways Geoengineering Could Save the World." *Io9*. N.p., 09 Nov. 2012. Web. 29 May 2016.

Nuccitelli, Dana. "Global Warming Is Being Caused by Humans, Not the Sun, and Is Highly Page, Michael Le. "The Pros and Cons of Geoengineering." *New Scientist*. New Scientist, 20 Sept. 2012. Web. 29 May 2016.

Santer, B. D., and M. F. Wehner. "Contributions of Anthropogenic and Natural Forcing to Recent Tropopause Height Changes." *The Science*, n.d. Web.

Schneider S.H. (2008) Geoengineering: could we or should we make it work? *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 366, 3843–3862. doi: 10.1098/rsta.2008.0145, ISSN: 1364-503X, 1471–2962.

Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.) (2013). *Climate Change 2013: The Physical Science Basis. Summary for Policy Makers.* (PDF) (Report). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. p. 29. Retrieved 2015-08-30.

Takahashi, Patrick, Trenka, Andrew. "Ocean Thermal Energy Conversion," John Wiley & Sons, Chichester, 1996.

U.S. Energy Information Administration (2016). *Electricity Explained - Basics.*
"11.2.2 Ocean Fertilization and Other Geo-Engineering Options." - *AR4 WGIII Chapter 11: Mitigation from a Cross-sectoral Perspective.* Intergovernmental Panel on Climate Change, n.d. Web. 29 May 2016.

"Causes of Global Warming: The Human Impact." *Global Warming Facts*. N.p., n.d. Web. 29 May 2016.

"Helping Developing Countries Tackle Climate Change - United Nations Partnerships for SDGs Platform." *Helping Developing Countries Tackle Climate Change - United Nations Partnerships for SDGs Platform.* United Nations, n.d. Web. 29 May 2016. (1), 17 - 23. ISSN: 1916-1107. ©2008. (n.d.): n. pag. Web.

"Scientific Consensus: Earth's Climate Is Warming." *Climate Change: Vital Signs of the Planet.* The National Aeronautics and Space Administration, n.d. Web. 03 June 2016.