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Past the Tipping Point, but With Hope of Return: How Creating a Geoengineering Compulsory Licensing Scheme Can Incentivize Innovation

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Past the Tipping Point, but With Hope of Return: How Creating a Geoengineering Compulsory Licensing Scheme Can Incentivize Innovation

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Abstract

This Note explores the patenting of geoengineering technologies and issues arising from the early stages of this high-risk, high-reward technology. This Note focuses on one possible solution to solving the issues surrounding the patenting of geoengineering technology: Creating a specialized compulsory licensing scheme.

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I. Introduction

As of February 2021, the Keutsch Research Group at Harvard University is on track to launch one of the biggest outdoor tests of stratospheric aerosol injection.[1] The project is called Stratospheric Controlled Perturbation Experiment (SCoPEx) and will simulate the cloaking effect of a volcano eruption.[2] A high-altitude balloon will lift an instrument package approximately twenty kilometers into the atmosphere and release a very small amount of material to create a perturbed air mass roughly one kilometer long and one

1. *See* Jonathan Watts, *US and Saudi Arabia blocking regulation of geoengineering, sources say*, THE GUARDIAN (Mar. 18, 2019 2:00 AM), https://www.theguardian.com/environment/2019/mar/18/us-and-saudi-arabia-blocking-regulation-of-geoengineering-sources-say ("US academics at Harvard are also poised to conduct the biggest outdoor test of stratospheric aerosol injection, which simulates the cloaking effect of a volcano eruption.") [https://perma.cc/B6RC-HDNW]; *see also* Keutsch Research Group, *SCoPEx*, HARV. U., https://projects.iq.harvard.edu/keutschgroup/scopex (last visited Feb. 20, 2021) (describing a proposed platform test in Sweden in June 2021) [hereinafter SCoPEx] [perma.cc/6Q8H-2XDY].

2. *See* Watts, *supra* note 1 (identifying the Harvard experiment).

hundred meters in diameter.[3] The purpose of the experiment is to observe how particles interact with one another; to measure changes such as aerosol density, atmospheric chemistry, and light scattering; and to test whether it is possible to find aerosols that can reduce or eliminate ozone loss without increasing other physical risks.[4] This project has the potential to improve knowledge relevant to estimating the overall effectiveness and risks of solar geoengineering.[5]

The Keutsch Group's project is monumental in several ways. A successful test could spark the development of more geoengineering technology, large-scale schemes designed and aimed at reducing the effects of climate change.[6] Once deployed, SCoPEx would be one of the first experiments to collect real data and compare those results to existing computer generated models.[7] If successful, SCoPEx could "create a template for how geoengineering research is conducted going forward, and perhaps pave the way for more experiments to follow."[8] Further, SCoPEx illuminates that private businesses, institutions, and inventors are driving the new wave of geoengineering and climate engineering technology, and SCoPEx illuminates the role intellectual property plays in developing geoengineering technology.[9]

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3. *See* SCoPEx, *supra* note 1 (answering general questions about the purpose and objectives of the experiment).

4. *See id.* (explaining the purpose and highlighting the concerns regarding the project).

5. *See id.* (answering the question of whether SCoPEx will test geoengineering itself).

6. *See id.* (explaining that the group hopes to learn more about stratospheric aerosol physics and chemistry to improve large-scale models).

7. *See id.* ("Computer modeling and laboratory work tell us some very useful things about solar geoengineering, but as with all other aspects of environmental science, computer models ultimately rest on observations of the real environment.").

8. James Temple, *Geoengineering is very controversial. How can you do experiments? Harvard has some ideas.*, MIT TECH. R. (July 29, 2019), https://www.technologyreview.com/s/614025/geoengineering-experiment-harvard-creates-governance-committee-climate-change/ [perma.cc/2RBN-9L27].

9. *See id.* (observing that there is not "any public oversight body set up to weigh the particularly complex questions surrounding such a proposal"); *see also* SCoPEx, *supra* note 1 (explaining how the intellectual property from the SCoPEx project is being managed).

Throughout history, developments in technology have been imperative to solving societal problems.[10] Today, one of the most pressing threats to society is climate change where "the most extreme risks of climate change can't be ruled out—including the collapse of human civilization."[11] Geoengineering technology provides a possible solution to slowing and mitigating the effects of climate change.[12] With the lack of government oversight, private actors and intellectual property will have a substantial role in the research, development, and potential implementation of geoengineering technologies.[13] Yet, issues have developed and are continuing to develop with patenting geoengineering (also commonly referred to as climate-engineering) technologies.[14] The challenge becomes how to safely incentivize innovation in a field of technology that could have profound local and global effects.

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10. *See e.g.*, Claudia Flavell-While, *Fritz Haber and Carl Bosch–Feed the World*, THE CHEM. ENG'R (Mar. 1, 2010), https://www.thechemicalengineer.com/features/cewctw-fritz-haber-and-carl-bosch-feed-the-world/ ("[The Haber-Bosch process] made it possible for the first time to produce synthetic fertilisers and produce sufficient food for the Earth's growing population.") [perma.cc/5NAF-A3YM]; *see also* Howard Markel, *The real story behind penicillin*, PBS NEWSHOUR (Sept. 27, 2013), https://www.pbs.org/newshour/health/the-real-story-behind-the-worlds-first-antibiotic ("The discovery of penicillin, one of the world's first antibiotics, marks a true turning point in human history—when doctors finally had a tool that could completely cure their patients of deadly infectious diseases.") [perma.cc/UWN4-KU32].

11. Katia Dmitrieva, *JPMorgan Warns of Climate as a Threat to 'Human Life as We Know It'*, BLOOMBERG GREEN (Feb. 21, 2020, 2:44 PM), https://www.bloomberg.com/news/articles/2020-02-21/jpmorgan-warns-of-climate-threat-to-human-life-as-we-know-it [perma.cc/WH3F-M5NL].

12. *See* Rima Sabina Aouf, *Five Geoengineering Solutions Proposed to Fight Climate Change*, DEZEEN (Oct. 18, 2018), https://www.dezeen.com/2018/10/18/five-geoengineering-solutions-climate-change-un-ipcc-technology/ ("The United Nations' Intergovernmental Panel on Climate Change (IPCC) report highlighted geoengineering as a necessary Plan B if temperature rises can't be capped at a manageable level.") [perma.cc/NP8B-YZDU].

13. *See* Jesse L. Reynolds, Jorge L. Contreras, & Joshua D. Sarnoff, *Intellectual Property Policies for Solar Geoengineering*, WILEY 1, 2, https://onlinelibrary.wiley.com/doi/epdf/10.1002/wcc.512 (last updated Dec. 12, 2017) (explaining the lack of governance will lead to intellectual property and private actors to play a growing role) [perma.cc/MS7D-J3VA].

14. *See* Anthony E. Chavez, *Exclusive Rights to Saving the Planet: The Patenting of Geoengineering Inventions*, 13 N.W. J. TECH. & INTELL. PROP. 1, 9–17 (2015) (describing the development and issues of patenting geoengineering technology).

This Note explores one possible solution to the issues involved in patenting geoengineering technology. Part II provides context for the growing threat of climate change and how geoengineering technologies are defined. Part III describes the current status of geoengineering patents, the unique issues pertaining to patenting Carbon Dioxide Removal (CDR) and Solar Radiation Management (SRM) technology, and the recommendations that have been previously provided in the literature. Part IV proposes an approach to address issues with patenting geoengineering technology and how to continue to safely promote innovation.

II. Background

A. The Growing Threat of Climate Change

Global climate change has become an increasing threat to the United States and the world.[15] In 1990, in response to President Reagan's proposal for a U.S. Global Change Research Program (USGCRP), Congress passed the United States Global Change Research Act (GCRA) with the goal of "improv[ing] understanding of global change."[16] The federal program coordinates federal research and invests in understanding the "forces shaping the

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15. *See* U.S. GLOBAL CHANGE RESEARCH PROGRAM, THIRD NATIONAL CLIMATE ASSESSMENT: CLIMATE CHANGE IMPACTS IN THE UNITED STATES 11 (Jerry M. Melillo et al. eds., 2014) (identifying the observed and projected climate change impacts for specific regions across the United States) [hereinafter THIRD NATIONAL CLIMATE ASSESSMENT]; *see also Climate Change,* UNITED NATIONS, https://www.un.org/en/sections/issues-depth/climate-change/ (last visited Oct. 25, 2019) ("Climate Change is the defining issue of our time and we are at a defining moment.") [perma.cc/S7M8-MLXN].

16. 15 U.S.C. § 2933 (2018); *see* John P. Holdren, Tamara Dickinson, Mike Kuperberg, & Afua Bruce, *Celebrating the 25th Anniversary of the U.S. Global Change Research Program*, THE WHITE HOUSE PRESIDENT BARACK OBAMA (Nov. 16, 2015 9:50 AM), https://obamawhitehouse.archives.gov/blog/2015/11/16/celebrating-25th-anniversary-us-global-change-research-program ("Twenty-five years ago today, the landmark Global Change Research Act (GCRA) was signed into law by President George H.W. Bush, formally mandating the U.S. Global Change Research Program (USGCRP) that had been proposed in President Reagan's final budget.") [perma.cc/G9JN-R92X].

global environment, both human and natural, and their impacts on society."[17]

In 2014, the USGCRP released the Third National Climate Assessment: *Climate Change Impacts in the United States*.[18] The report illustrated that over the last fifty years, the atmospheric concentration of heat-trapping gases, such as carbon dioxide, methane, and nitrous oxide, has skyrocketed, resulting in an increase in the global annual average temperature.[19] Weather patterns, incidents of extreme weather, and amount of precipitation are predicted to change and increase.[20] Along with these physical effects, climate change will have drastic societal, health, and economic effects, which will disproportionately affect certain people and communities including children, the sick, the poor, and some communities of Color.[21] Particularly climate-related hazards will exacerbate other stressors.[22]

In 2014, the Intergovernmental Panel on Climate Change (IPCC) released the Fifth Assessment Report, which evaluated the shifting patterns of risk and potential benefits since the last assessment in 2007.[23] The report explained that there was a very

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17. *About USGCRP*, U.S. GLOBAL CHANGE RES. GRP., GLOBALCHANGE.GOV, https://www.globalchange.gov/about [hereinafter *About USGCRP*] [perma.cc/L3E7-43XW].

18. *See generally* THIRD NATIONAL CLIMATE ASSESSMENT, *supra* note 15 (discussing the impact and future impact climate change will have on the United States).

19. *See id.* at 23 ("The majority of the warming at the global scale over the past 50 years can only be explained by the effects of human influences . . . [t]he emissions from human influences that are affecting the climate include heat trapping gases . . . .").

20. *See id.* at 25–49 (explaining the current and predicted consequences of climate change including increased annual temperatures, changes in average annual precipitation, lengthening of the frost-free season, more frequent heavy downpours and extreme weather events, more intense and frequent hurricanes, rising sea levels, decreased ice volume, and increases in ocean acidification).

21. *See id.* at 221 (explaining how climate change threatens human health and identifying groups specifically vulnerable).

22. *See* Lennart Olsson, *Livelihoods and Poverty, in* CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY. PART A: GLOBAL AND SECTORAL ASPECTS. CONTRIBUTION OF WORKING GROUP II TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 796 (C.B. Field et al. eds., Cambridge University Press 2014) ("Climate-related hazards exacerbate other stressors, often with negative outcomes for livelihoods, especially for people living in poverty (*high confidence*).").

23. *See generally id.* (summarizing the changes that have occurred since

high likelihood, based on robust evidence and high agreement, that "climate change and climate variability worsen existing poverty, exacerbate inequalities, and trigger both new vulnerabilities and some opportunities for individuals and communities."[24] While people may have economic disadvantages due to different circumstances and are not equally affected, "[c]limate change interacts with non-climatic stressors and entrenched structural inequalities to shape vulnerabilities."[25]

Projections about the pattern of poverty across the globe vary substantially.[26] Yet, there has been a shift in distribution of global poverty, which has challenged the view that the world's poorest people live in the poorest countries.[27] These trends suggest "that substantial pockets of poverty persist in countries with higher levels of average per capita income."[28] Additionally since 2005, between-country inequality has been decreasing, but within-country inequality fluctuates based on geographic location.[29] Within-country inequality is rising in Asia, falling in Latin America, and difficult to discern in sub-Saharan Africa.[30] These two factors—poverty and persistent inequality—are the "most salient of the conditions that shape climate-related vulnerability."[31]

When poor and marginalized people face a climate hazard, even a modest one, they usually have the least buffer to face, the fewest assets to liquidate in times of hardship or crisis, and suffer

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2007 because of climate change).

24. *Id.*

25. *Id.*

26. *See id.* at 801 (advising caution when requiring poverty projections due to the different means these projections use and the diverse conceptions of poverty itself).

27. *See id.* (explaining the shift in global poverty toward middle income countries and an increase in relative poverty in high income countries).

28. *Id.*

29. *See id.* at 802 (explaining the trends for between-country and within-country inequality between 2005 and 2014).

30. *See id.* ("However, within-country inequality is rising in Asia, especially [C]hina, albeit from relatively low levels, and is falling in Latin America, albeit from very high levels, while trends in sub-Saharan Africa are difficult to discern regionally . . . .").

31. *Id.*

the most from successive events with limited recovery time.[32] Climate change, climate variability, and extreme events affect several aspects of a person's life.[33] They can negatively affect natural assets (such as lakes and rivers where certain livelihoods depend directly), damage physical assets (including homes and farms), erode financial assets (losses of farms and jobs and increased costs of living due to expenses like funerals), result in damage to human assets (food insecurity, undernourishment, spikes in food prices, anxiety, depression), and erode social and cultural assets (disrupting social networks which prevent the mobilization of labor and reciprocal gifts).[34] Overall, these can have the effect of keeping poor people in a poverty trap.[35] It is projected that climate change will slow economic growth and poverty reduction and create new poverty pockets between 2014 and 2100, in developing and developed countries.[36]

Additionally, developing countries may experience disproportionate and unequal impacts of climate change.[37] Developing countries that have set to achieve the United Nation's Sustainable Development Goals, are being severely hampered by the adverse effects of climate change.[38] Statements taken from

32. *See id.* ("People who are poor and marginalized usually have the least buffer to face even modest climate hazards and suffer the most from successive events with little time for recovery.").

33. *See id.* at 803 ("Climate change, climate variability, and extreme events interact with numerous aspects of people's livelihoods.").

34. *See id.* (describing the different aspects of one's life climate change affects).

35. *See id.* at 806 ("Poverty traps arise when climate change, variability, and extreme events keep poor people poor and make some poor even poorer.").

36. *See id.* at 796–97 (describing how "[c]limate change will create new poor between now and 2100, in developing and developed countries, and jeopardize sustainable development").

37. *See Climate Change and the Developing World: A Disproportionate Impact*, U.S. GLOB. LEADERSHIP COAL. (March 2020), https://www.usglc.org/blog/climate-change-and-the-developing-world-a-disproportionate-impact/ (last visited Feb. 27, 2021) ("While global leadership on climate change will require multi-faceted policy solutions, there is consensus that extreme weather and disruption from drought, flooding, and conflicts over natural resources disproportionately affect the developing world, particularly the poor and most vulnerable including women and children.") [perma.cc/464D-HC94].

38. *See Unprecedented Impacts of Climate Change Disproportionately Burdening Developing Countries, Delegate Stresses, as Second Committee Concludes General Debate*, UNITED NATIONS (Oct. 8, 2019),

delegates from over a dozen countries at the United Nations' General Assembly Second Committee meeting highlighted the vast ways which climate change was affecting each country and the pressing need to address these issues.[39] While the issues voiced at the assembly were tailored to each country, there was an overall sense of urgency and hope for a unified global initiative.[40]

Further, there is a sense that the globe may have surpassed a threshold for a cascade of inter-related tipping points.[41] The concentration of carbon dioxide in the atmosphere has increased by over forty percent since 1750.[42] While the planet is capable of adapting and absorbing changes to its atmosphere, the rate at which it has had to do so to keep constant is unsustainable.[43] Additionally, as more carbon dioxide is displaced into the atmosphere, the temperature will rise, resulting in less effective carbon sinks—reservoirs, typically natural, that absorb more carbon dioxide from the atmosphere than they release.[44] This can create a "'feedback loop'—a cyclical process triggered by environmental change that leads back to more change."[45] For example, scientists had once assumed that oceans would absorb carbon dioxide and slow global warming.[46] However, due to

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https://www.un.org/press/en/2019/gaef3516.doc.htm (explaining Botswana's concerns and observations of the effects of climate change on their country's efforts to reach their sustainability goals) [hereinafter *Unprecedented Impacts of Climate Change*] [perma.cc/JD6U-K2GJ].

39. *See id.* (summarizing the statements from delegates of many nations).

40. *See id.* (describing the statements from delegates and where many concluded that drastic measures need to be taken).

41. *See* Fred Pearce, *As Climate Change Worsens, A Cascade of Tipping Points Looms*, YALE ENV'T 360 (Dec. 5, 2019), https://e360.yale.edu/features/as-climate-changes-worsens-a-cascade-of-tipping-points-looms (quoting researchers who are studying the earth's climate and consider several different "tipping points" to be interrelated) [perma.cc/WX2Q-8L4Y].

42. *See* DAVID HUNTER, DURWOOD ZAELKE, & JAMES SALZMAN, INTERNATIONAL ENVIRONMENTAL LAW AND POLICY 4 (5th ed. 2015) ("Due to the burning of fossil fuels, such as coal and oil, and the destruction of forests, the atmospheric concentration CO2 has increased by nearly 40%, from 280 parts per million (ppm) to 395 ppm between 1750 and 2013, ...").

43. *See id.* at 28–29 (describing how regular carbon sinks may not be able to keep up).

44. *See id.* (describing one scenario where a rising temperature will further reduce the oceans ability to absorb carbon dioxide).

45. *Id.* at 29.

46. *See id.* (explaining how increased temperatures will decrease the ocean's

increased global temperatures, the currents that carry carbon dioxide from the ocean surface and into the depths have slowed, and the ocean's "ability to absorb [carbon dioxide] may be reduced by as much as 50%."[47]

Climate change presents global issues that will affect all peoples, but more significant those who are socioeconomically disadvantaged.[48] While conventional actions must be taken to reduce emissions and rein in consumption, technology will be crucial in reducing emission levels, minimizing the effects of climate change, and addressing issues that arise once climate crises have begun.

B. What Is Geoengineering?

When geoengineering and climate engineering are referenced today, the terms typically refer to large-scale schemes designed and aimed at reducing the effects of climate change.[49] Unlike the historic impact humankind has had on the environment, "the climate effects of geoengineering are not considered incidental side effects, but instead constitute intended results."[50] These projects may range from schemes designed to remove carbon dioxide from

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ability to absorb carbon dioxide).

47. *Id.*

48. *See the Facts: How Climate Change Affects People Living in Poverty*, MERCY CORPS (Nov. 15, 2019), https://www.mercycorps.org/blog/climate-change-poverty#:~:text=Climate%20change%20threatens%20the%20cleanliness,and%20pushes%20people%20into%20poverty ("And it's people living in poverty who have the most to lose [due to impacts of climate change]. For those on the frontlines of the crisis, the struggle to earn a living, feed their families and create safe and stable homes is made more difficult every day.") [perma.cc/4TR3-8CF3].

49. *See What is geoengineering?*, THE GUARDIAN (Feb. 18, 2011, 05:48 AM), https://www.theguardian.com/environment/2011/feb/18/geo-engineering ("Geoengineering schemes are projects designed to tackle the effects of climate change directly . . . .") [perma.cc/X54G-RQNL]; *see also What is Geoengineering?*, GEOENGINEERING MONITOR, http://www.geoengineeringmonitor.org/what-is-geoengineering/ (last visited Oct. 25, 2019) ("Climate geoengineering refers to large-scale schemes for intervention in the earth's oceans, soils and atmosphere with the aim of reducing the effects of climate change, usually temporarily.") [perma.cc/HY3H-2MJF].

50. Gerd Winter, *Climate Engineering and International Law: Last Resort or the End of Humanity?*, 20 RECIEL 277, 297 (2011).

the air, commonly referred to as Carbon Dioxide Removal (CDR)[51], to schemes designed to reduce the amount of sunlight reaching the Earth, commonly referred to as Solar Radiation Management (SRM).[52] Despite the wide variety in schemes, "the prominent new trait of climate engineering is its enormous depth of intervention into the natural course of the biosphere."[53]

Yet, there are important differences between certain types of CDR and SRM technologies.[54] Some technologies, such as technology for direct air capture of carbon dioxide that filters the air and removes carbon dioxide, can be considered clean technology.[55] This type of technology typically creates a local impact that can be measured reasonably accurately.[56] Existing regulations on similar industries like power plants, paper mills, and chemical plants may also be more easily applied to a carbon sequestration plant using this type of technology.[57] Whereas solar geoengineering, such as stratospheric aerosols, attempts to alter the entire climate by reflecting back light from the sun into the

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51. *See id.* at 278 ("Large-scale afforestation, BECS biochar, enhanced weathering, CO2 air capture, ocean fertilization and CCS are all described as 'Carbon Dioxide Removal' (CDR) . . . .").

52. *See What is geoengineering?*, *supra* note 49 ("Geoengineering schemes are projects designed to tackle the effects of climate change directly, usually by removing CO2 from the air or limiting the amount of sunlight reaching the planet's surface."); Winter, *supra* note 50, at 279 ("[W]hereas increasing surface and cloud albedo, the methods of injecting stratospheric aerosols and installing space reflectors are known as 'Solar Radiation Management' (SRM).").

53. Winter, *supra* note 50, at 279.

54. *See* David Keith, *Why I Am Proud to Commercialize Direct Air Capture while I Oppose Any Commercial Work on Solar Geoengineering*, HARV. U. (June 4, 2018), https://keith.seas.harvard.edu/blog/why-i-am-proud-commercialize-direct-air-capture-while-i-oppose-any-commercial-work-solar (discussing the differences between direct air capture and solar geoengineering technology) [perma.cc/Q9K4-2YFL]; *see also* Albert C. Lin, *Does Geoengineering Present a Moral Hazard?*, 40 ECOLOGY L. Q. 676–77 (2013) (highlighting the issues particularly with ocean fertilization, a type of CDR, and stratospheric aerosol deployment, a type of SRM).

55. *See* Keith, *supra* note 54 (explaining why direct air capture technology is similar to clean energy technology).

56. *See id.* ("When Carbon Engineering succeeds and large-scale air capture plants are built, it will be very easy for outside entities such as governments, third-parties, or citizen groups to monitor the net flows of energy and materials in and out of the plant . . . .").

57. *See id.* (stating that there are applicable regulations already in place).

atmosphere.[58] "Solar geoengineering is large-scale climate modification which inherently has global consequences that are difficult to quantify even after deployment."[59] Therefore, as different forms of geoengineering technology have different potential consequences and implications, different mechanisms should be in place to regulate and commercialize these technologies.[60]

While new geoengineering technology is being developed today for climate change, the concept of geoengineering and use of this technology is not novel.[61] In October of 1966, the United States conducted the test phase for "Project Popeye," a weather modification experiment.[62] During the test phase, the U.S. government conducted over fifty cloud seeding experiments where 82% of the seeded clouds produced rain.[63] The purpose of the project was to increase normal rainfall in North Vietnam to "inhibit overland vehicular movement and to reinforce the bottlenecks already created at stream crossings . . . ."[64] In 1976, the United Nations General Assembly condemned "Project Popeye."[65] Major countries such as the United States and Russia, created and ratified the Environmental Modification Convention (ENMOD) treaty, which prohibited nations from deliberately altering weather for *hostile* purposes.[66] From 1976 to 2010, there were no substantial developments within the United States

58. *See id.* ("Solar geoengineering is not cleantech . . . . It's a set of technologies that might allow humanity to alter the entire climate.").

59. *Id.*

60. *See id.* (arguing that solar geoengineering should not be commercialized).

61. *See* Mollie Bloudoff-Indelicato, *Controlling the Controllers: A Timeline of Geoengineering Rules and Regulations Worldwide*, SCI. AM. (Oct. 25, 2012), https://www.scientificamerican.com/article/geoengineering-worldwide-rules-regulations-timeline/ (last visited Feb. 27, 2021) (providing a timeline of the history of geoengineering in the United States) [perma.cc/ZNY6-FGAN].

62. *See 274. Memorandum From the Deputy Under Secretary of State for Political Affairs (Kohler) to Secretary of State Rusk*, OFF. OF THE HISTORIAN, DEP'T. OF STATE (Jan. 13, 1967), https://history.state.gov/historicaldocuments/frus1964-68v28/d274 (describing and requesting permission for Project Popeye) [hereinafter "Project Popeye"] [perma.cc/K9L8-RVQZ].

63. *See id.* (describing the test phase).

64. *Id.*

65. *See* Bloudoff-Indelicato, *supra* note 61 (summarizing the United States' history with geoengineering).

66. *See id.* (summarizing the United States' history with geoengineering).

regarding their policy or role in geoengineering.[67] However, in 2010, a 193-member U.N. Convention on Biodiversity agreed to ban climate-related geoengineering activities.[68] The Convention aimed to ban geoengineering on the grounds of "unknown environmental impacts" that could benefit one country but destroy another.[69] Noticeably, the United States refused to sign the document.[70]

1. Concerns about Geoengineering Technology

From the point of view of geoengineering critics, there are two overarching concerns regarding climate change: (1) That it may present a moral hazard to invest in climate altering technology rather than focusing on initiatives to reduce emissions and (2) that there is a lack of oversight and international agreement on how to regulate geoengineering.[71]

The moral hazard concern highlights the tensions between geoengineering research and deployment as well as the relationship between geoengineering and other methods of responding to climate change.[72] Critics of geoengineering generally argue that the development of this technology "gives political leaders a false but enticing way to avoid confronting the carbon giants . . . and avoid addressing the root causes of climate chaos."[73] Geoengineering endeavors could "undermine mainstream efforts to combat climate change."[74]

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67. *Id.*

68. *Id.*

69. *Id.*

70. *Id.*

71. *See e.g.*, Lin, *supra* note 54, at 677 (discussing the moral hazard concern); *see also* Watts, *supra* note 1 (highlighting the lack of governmental oversight and regulations for geoengineering technology).

72. *See id.* ("The moral hazard concern highlights relationships between geoengineering research and geoengineering deployment, and more broadly between geoengineering and other methods of responding to climate change.").

73. *Open Letter to SCoPEx Advisory Committee*, GEOENGINEERING MONITOR (Aug. 21, 2019), http://www.geoengineeringmonitor.org/2019/08/open-letter-scopex/ (last visited Feb. 27, 2021) [perma.cc/DK3B-XPB3].

74. Lin, *supra* note 54, at 674.

Critics are also concerned about the lack of international agreement.[75] The lack of international agreement could allow "an individual nation or even a private actor to undertake full-scale deployment of geoengineering unilaterally, potentially precipitating international conflict."[76] Efforts to internationally discuss and come to a resolution regarding geoengineering have been starkly opposed.[77] United Nations member states have been reluctant to discuss or reach any consensus for economic or other reasons.[78] As an example within the past year, member nations of the United Nations tried to discuss the importance of establishing an international, uniform policy towards geoengineering, or at least trying to discuss the dangers of geoengineering technology.[79] However, the United States and Saudi Arabia, "the world's two biggest oil producers," opposed plans to examine the risks of climate altering technology.[80]

While the moral hazard and lack of international agreement may be troubling, there are compelling reasons why the United States, in particular, has chosen not to participate in international discussions about geoengineering technology. For the United States, climate-engineering technology has the potential to lessen the severity of the harms of climate change and allow for more gradual greenhouse gas controls, which would lessen the economic burden of imposing carbon reduction regulations.[81] At this time,

75. *See International Regulatory Framework for Geoengineering*, ECOLOGIC (Aug. 2011), https://www.ecologic.eu/4168 ("There are no international rules or institutions specifically on geoengineering.") [perma.cc/89S7-NTCC].

76. Lin, *supra* note 54, at 677.

77. *See* Watts, *supra* note 1 (reporting that the initiative for the United Nations to discuss geoengineering "was block, initially by the US and Saudi Arabia, then by Japan and other countries").

78. *See id.* (implying that the United States' and Saudi Arabia's opposition to discuss geoengineering is because of their economies' dependence on oil).

79. *See id*. ("Deeper analysis of the risks had been proposed by Switzerland and 12 other countries as a first step towards stronger oversight of potentially world-altering experiments that would have implications for food supply, biodiversity, global inequality and security.").

80. *See id.* ("But sources involved with the talks said the initiative was blocked, initially by the US and Saudi Arabia, then by Japan and other countries.").

81. *See* Lee Lane*, U.S. National Interest, Climate Engineering, and International Law*, HUDSON INST. 1, 2 (2011) ("For the United States, having a viable CE option would confer two kinds of potential benefits. First, CE might

more information is needed to effectively govern geoengineering technology as it continues to develop.[82] Geoengineering technology is in the relatively early stages of development, and the costs of climate engineering are not entirely predictable.[83] Also, geoengineering technology has unknown risks, which makes it more difficult to predict the potential side effects of deploying climate-engineering technologies, and the cost of those effects.[84]

The concerns about geoengineering are substantial and must be addressed; however, these concerns may be unnecessarily preemptive at this time.[85] The technology that could have global effects is still in its very early stages.[86] Instead, more needs to be done to incentivize and create innovation, so when the time comes for this technology to be deployed, the best technologies are available for governments and the public to consider.[87]

III. Intellectual Property–Patents

A. The Balance Between Encouraging Innovation and the Social Cost to the Public

The fundamental purpose of intellectual property law, specifically patent law is, "to Promote the Progress of Science and

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avoid harm from climate change; second, CE might allow more gradual, and, hence, less costly, GHG controls and adaptation measures.").

82. *See id.* at 4 ("In the face of such great uncertainty, rules must either be hopelessly vague, or risk distorting future research and policy choices.").

83. *See* SCoPEx, *supra* note 1 (describing SCoPEx as an experiment and not a test as a test would "make sense late in the development of an engineering system"); Lane, *supra* note 81, at 2–3 (estimating the net economic benefits from climate engineering technology to exceed one trillion dollars).

84. *See* Lane, *supra* note 81, at 3 ("U.S. policy makers must weigh the risk that CE might trigger costly side effects.").

85. *See id.* at 4–5 (explaining reasons why the United States may wish to preserve its freedom of action on climate engineering).

86. *See id.* ("Such means do not exist with regard to the early stages of developing and testing CE . . . .").

87. *See id.* ("If the United States . . . someday, decides that it wishes to deploy [climate engineering], affairs would alter. Any state or states seeking to deploy CE, or even to test it at large scale, would have a motive for trying to reconcile all bona fide world powers to its actions.").

useful Arts."[88] "The principle objective of much of intellectual property law is the promotion of new and improved works—either technological or expressive."[89] To accomplish this objective, patent law is incentive based.[90] A patent allows its owner to hold a monopoly for a limited duration.[91] Yet, this comes at a cost.[92] The promise that one will have twenty years to exclusively use and profit from patented invention, incentivizes individuals to invest in innovation and creation.[93] "[F]ewer people will acquire the work than if it were distributed on a competitive basis, and they will pay more for access."[94] Additionally, this may result in a less efficient allocation of resources.[95]

B. The Status of Geoengineering Patents Today

Geoengineering technology is a growing industry that appears to be in its beginning phase.[96] Prior to 2008, the combined number of patent applications and patents granted for geoengineering technologies did not exceed twenty in a single year.[97] Between 2008

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88. U.S. CONST. art. I, § 8, cl. 8.

89. PETER S. MENELL, MARK A. LEMLEY, & ROBERT P. MERGES, INTELLECTUAL PROPERTY IN THE NEW TECHNOLOGICAL AGE: 2019, 16 (Clause 8 Publishing, ed. 2019) (2019).

90. *See id.* at 16 ("Both the United States Constitution and judicial decisions emphasize incentive theory in justifying intellectual property.").

91. *See id.* at 19 (describing how intellectual property rights give IP owners temporary monopolies).

92. *See id.* (describing intellectual property rights as imposing a social cost on the public).

93. *See id.* at 18 ("Instead, the government has created time-limited intellectual property rights over technological inventions and expressive creativity to encourage inventors and authors to invest in the development of new ideas and works of authorship.").

94. *Id.*

95. *Id.* at 19.

96. *See* Fred Pearce, *Geoengineer the Planet? More Scientists Now Say It Must Be an Option*, YALEENVIRONMENT360 (May 29, 2019), https://e360.yale.edu/features/geoengineer-the-planet-more-scientists-now-say-it-must-be-an-option ("A spate of dire scientific warnings that the world community can no longer delay major cuts in carbon emissions . . . has left a growing number of scientists saying that it's time to give the controversial technologies a serious look.") [perma.cc/K9YJ-SNY4].

97. *See* Chavez, *supra* note 14, at 10 ("As the chart demonstrates, before 2008, the combined number of patent applications and patents granted for

and 2013, the number of patent applications for geoengineering technology increased five-fold.[98]

> CDR methods have dominated this recent growth, constituting more than 90% of the geoengineering patents approved by the USPTO. Specifically, of the patents granted, more than half (54%) concern carbon capture, and more than one-third (37%) involve carbon sequestration. Particle-dispersion (4%) and solar-ray reflection (2%) patents commonly recur, with patents involving other various methods making up the difference (3%).[99]

Between 2001 and 2010, the number of "exotic" geoengineering patent applications increased from two to thirty-one—a 1550% increase.[100] Given the early stages of geoengineering technology and lack of established governance framework, intellectual property will likely have a profound impact on the development and use of this type of technology.[101]

The private sector can and should play a vital role in geoengineering research, subsequent development, and possible implementation because the private sector is the primary source for research, development, production, and services.[102] However, within the current scheme of geoengineering technology patents, there are emerging issues.[103] Some issues extend to cover all

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geoengineering technologies did not exceed twenty in a single year.").

98. *See id.* (describing the increase and rate of increase in patent applications for geoengineering technologies).

99. *Id.* at 10–11.

100. Shobita Parthasarathy, *A Public Good?* 5 (UNIV. OF MICH. GERALD R. FORD SCH. OF PUB. POL'Y, Working Paper No. STPP 10-1) http://jreynolds.org/wp-content/uploads/2019/03/Parthasarathy-2010-A-Public-Good.pdf (describing the recent rise in geoengineering patent applications) [perma.cc/9EJR-VCFJ].

101. P. Oldham et al., *Mapping the Landscape of Climate Engineering* 2, ROYAL SOC'Y PUBL'G (Dec. 28, 2014), https://royalsocietypublishing.org/doi/pdf/10.1098/rsta.2014.0065 ("In the absence of an established governance framework, the practices of scientific research and intellectual property tend to shape the field and set trajectories for future development.") [perma.cc/4TUE-SQN6].

102. *See* Reynolds, *supra* note 13, at 2 (explaining that it is likely that the private sector will drive innovation in this field and highlighting that many times states do not take on the endeavor themselves but rely on the private sector for innovation).

103. *See e.g.*, Parthasarathy, *supra* note 100, at 10 (describing the high risks of geoengineering technologies and how the current patent system cannot adequately address these characteristics); Chavez, *supra* note 14, at 9–17

geoengineering patents, while others appear to apply only to specific areas of geoengineering, such as SRM and CDR technologies.

The majority of geoengineering patents are assigned to the same patent holders, thus concentrating the potential for this technology in the hands of a few.[104] Original patent holders tend to transfer their ownership to many of the same assignees, some of which are non-practicing entities.[105] This could allow a few owners to dictate how the field of geoengineering develops.[106] Scholars have cautioned against keeping the status quo and allowing the geoengineering industry to develop in the same manner as the biotechnology industry developed.[107] One academic speaking on the topic stated:

> If we continue to deal with geoengineering patents as we did in biotechnology, we would create problems that are similar—or perhaps even worse—because of the high risk, high reward nature of the technology. The patent holders will control whether and how geoengineering technology will be researched and used.[108]

In the biotechnology industry, the concentration of patent ownership among a few entities incentivized the limited grant of exclusive licenses, incentivized patent owners to charge incredibly high prices, and allowed these patent holders to dictate the development of the industry.[109]

(warning that the development of geoengineering IP was resulting in anti-commons and patent thickets); Reynolds, *supra* note 13, at 3 (describing emerging issues with SRM technologies).

104. *See* Chavez, *supra* note 14, at 11 ("A review of these patents further reveals that many of these inventions are assigned to only a few patent holders.").

105. *See id.* ("Consequently, the future development of these technologies is concentrated in the hands of a few."); Parthasarathy, *supra* note 100, at 5 ("Non-practicing entities . . . and commercial ventures, in particular, have filed applications for a number of variants on one technology, often resulting in one or a handful of innovators controlling a significant proportion of the patents in a particular method of geoengineering.").

106. *See* Parthasarathy, *supra* note 100, at 6 ("While this may just be a result of the small number of applications to date, it could allow a relatively small number of owners to control innovation in a particular area of geoengineering.").

107. *See id.* at 7–8 (describing the biotechnology industry as a cautionary tale).

108. *Id.* at 8.

109. *See id.* at 7–8 (using Myriad Genetics' patents on the BRCA genes as an

The critiques of the development of the biotechnology industry parallel many of the global concerns about the distribution of not only geoengineering technology, but more broadly "green" technology.[110] "Concerns over patent system and climate change have already caused serious political tensions."[111] Geographic imbalances in patenting behaviors and problems with the costs of technology acquisition for developing countries will "further exacerbate existing intellectual property trade, and scientific differences and [will] generate political tensions along the North-South divide."[112]

There are also specific problems tied to the development of CDR technologies.[113] Many of these issues arise from the novelty of the field, lack of development of standardized technology, patent examiners' lack of expertise in the new technology, and applicants' desires to capture the largest possible grant of protection.[114] In this area of geoengineering technology, extremely broad patents are being granted, and there appears to be a "land grab" taking place.[115] A land grab "occurs when a lack in clarity of future technologies encourages speculators to seek patents in developing fields, which in turn causes actual inventors to file patent applications to avoid a competitive disadvantage."[116] An example of an extremely broad patent is Patent No. 8,603,424, "CO_2-sequestering formed building materials," which in its own

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example of this phenomena).

110. *See* Joshua D. Sarnoff, *The Patent System and Climate Change*, 16 VA. J. L. & TECH. 301, 320 (2011) (explaining the concerns about the patent system's role in promoting climate change technology development and dissemination given the unbalanced nature of worldwide innovation, patenting, and ownership).

111. *Id.* at 306.

112. *Id.* at 320.

113. *See* Chavez, *supra* note 14, at 13–17 (describing how the current patent system exacerbates geoengineering patent-issues).

114. *Id.* at 14 (citing Amber Rose Stiles, *Hacking Through the Thicket: A Proposed Patent Pooling Solution to the Nanotechnology "Building Block" Patent Thicket Problem*, 4 DREXEL L. REV. 555, 563 (2012)).

115. *See id.* at 13 ("Indeed, climate engineering appears to be undergoing a 'patent land-grab.'").

116. *Id.*

language specifically rejects any limitations upon its terms.[117] This patent is not set to expire until November 8, 2029.[118]

There are three main reasons why a "land grab" and patents, such as No. 8,603,424, are troubling in this space.[119] First, geoengineering is in its infancy; scientists have contemplated using technology to combat climate change for fewer than fifteen years.[120] Second, many of the granted patents are overly broad and poorly defined.[121] Early owners could own huge swaths of the field, thus "deter[ring] future innovation and bestow[ing] control over technology with potentially immeasurable societal value to only a few."[122] Third, granted geoengineering patents tend to be the "building-block patents," on which later inventions must rely.[123] Building-block patents are distinct from "incremental improvement patents, which have a much narrower claim scope."[124] While building-block patents may not be very profitable, they can be crucial for downstream development.[125] Conversely, too many building-block patents can "lock up technologies" and slow development. [126] "[T]hey allow patent holders to deny licenses,

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117. *See CO2-Sequestering Formed Building Materials*, GOOGLE PATENTS, https://patents.google.com/patent/US8603424B2/en (last visited Feb. 19, 2020) (listing the basic information for Patent No. US 8,603,424) [perma.cc/8Z8Z-FC37]; *see also* Chavez, *supra* note 97, at 12 (using this patent as an example of an over-broad patent).

118. *See CO2-Sequestering Formed Building Materials*, *supra* note 117 (listing the adjusted expiration as Nov. 8, 2029).

119. *See* Chavez, *supra* note 97, at 13–14 (explaining why a patent land-grab is particularly pernicious in this space).

120. *See id.* at 13 ("Scientists have contemplated climate engineering as a response to climate change for less than one decade.").

121. *See id.* (describing the types of patents that have been issued for geoengineering technologies).

122. *Id.* at 14.

123. *See id.* at 13 ("Because of this [early in the development of the field], applications often seek building-block patents, which cover fundamental products and processes.").

124. *Id.* at 14 (quoting John C. Miller & Drew L. Harris, *The Carbon Nanotube Patent Landscape*, 3 NANOTECH L. & BUS. 427, 435 (2006)).

125. *See* Mark A. Lemley, *Patenting Nanotechnology*, 58 STAN. L. REV. 601, 611–12 (2005) ("But largely because they were funded by the federal government before the passage of the Bayh-Dole Act, they granted nonexclusive licenses to all comers, meaning that their patents raised the cost of practicing biotechnology but did not prevent anyone from entering the downstream market.").

126. *See* Chavez, *supra* note 14, at 13 ("Awarding building-block patents,

charge exorbitant royalties, or engage in delaying tactics, most notably litigation."[127] The combination of inventors' filing applications early on to avoid a competitive disadvantage and the lack of existing geoengineering research make the climate-engineering environment ripe for opportunistic exploitation.[128]

The development of SRM technology has taken a slightly different course than CDR technology and appears to be proceeding in a publicly oriented manner.[129] As of 2020, many of these solar geoengineering patent families have been abandoned and very few remain.[130] In part, that is due to the unique nature of SRM technology.[131] SRM technologies most likely will be transnational.[132] Solar geoengineering research, development, and implementation would be public goods in the sense that they would provide nonexcludable and non-rivalrous benefits of expected lessened climate change.[133] There also appears to be an emerging culture and practice among SRM researchers of sharing data freely, and there is little evidence that researchers are keeping the data to themselves or taking protective measures to maintain trade secrecy in the know-how.[134]

especially early in an industry's development, can frustrate the field's growth.").

127. *Id.*

128. *See id.* ("Coupled with the increasing number of patent applications for related technologies, the lack of geoengineering research makes the climate-engineering environment ripe for opportunistic exploitation.").

129. *See* Reynolds, *supra* note 13, at 3 (describing the indications that solar geoengineering is proceeding in a publicly oriented manner).

130. *See id.* at 2 ("Of these [patents and patent application families], 13 had been abandoned, 5 had expired, and 17 were related to space- and surface-based techniques, which are generally regarded as prohibitively expensive, of limited capacity, and/or otherwise infeasible.").

131. *See id* at 2–3 (detailing the unique characteristics of solar geoengineering).

132. *See id.* at 3 ("First, any implementation would inherently have transnational effects.").

133. *See id.* at 2 ("After all, solar geoengineering research, development, and implementation would be public goods, not necessarily in a normative sense but in the economic sense of providing the nonexcludable and nonrivalrous benefits of expected lessened climate change.").

134. *See id.* (explaining the present culture and practice among solar geoengineering researchers).

Additionally, the market for SRM technology will be quite different.[135] One author predicts that the field of SRM technology will become a monopsony (or oligopsony) procurement structure, like there is in the national defense and transportation industries.[136] Monopsony and oligopsony are market conditions where there is only one buyer or a small number of buyers, respectively.[137] Estimates predict that the direct financial cost of global solar geoengineering deployment will be approximately $25 to $50 billion with additional annual spending in monitoring and related activities.[138] There likely will be a substantial opportunity for private companies to profit from these technologies.[139]

The two largest issues facing the development of SRM technology and intellectual property are: (1) That any implementation would inherently have transnational effects, and (2) that it is difficult to distinguish purely SRM research and innovation from non-SRM research and innovation.[140] SRM technology would have global effects.[141] Given its global effects, collaboration and transfer of know-how will be essential for research and innovation in this field.[142] Additionally, there are few patents that will strictly be "SRM" patents.[143] Many of the

135. *See id.* at 3 (predicting the market structure for solar geoengineering technologies).

136. *See id.* ("We believe that large-scale research, development, and potential implementation of solar geoengineering are most likely to assume a monopsony (or oligopsony) procurement structure, as it has in the national defense and transportation sectors.").

137. *See* Julie Young, *Monopsony*, INVESTOPEDIA (Feb. 3, 2020), https://www.investopedia.com/terms/m/monopsony.asp (defining monopsony and oligopsony) [perma.cc/9JU5-EYZ7].

138. *See* Reynolds, *supra* note 13, at 3 ("Looking toward possible implementation, estimates of the direct financial cost of global solar geoengineering deployment are approximately US $25 to 50 billion annually.").

139. *See id.* ("This implies that providing technology, materials, and services could be a moderately sized industry generating significant profits.").

140. *See id.* (explaining the two challenges of solar geoengineering patents).

141. *See id.* (explaining how the transnational effects of climate change create an interesting dilemma where control to data access law remain within national jurisdictions yet governmental legislators and regulators are reluctant to tackle the issue).

142. *See id.* ("[B]ut we also expect research and innovation to be collaborative and to transfer know-how and technologies across borders.").

143. *See id.* (explaining that there is not a clear line between non-SRM and strictly SRM technology).

components necessary for successful SRM technology will come from devices and technology successful in other industries.[144] For example, the developers of inkjet printers are involved in research to create a nozzle to spray fine salt water mist without clogging that could be used for marine cloud brightening.[145] Identifying "SRM" technology is difficult as many inventions will have dual-use, uses applicable in multiple fields.[146]

C. Solutions That Have Already Been Provided

In response to these emerging issues, multiple scholars have offered possible solutions and suggestions about how the patent system should adapt or change for geoengineering technology.[147] Several scholars have advocated for a separate entity within the United States Patent and Trademark Office (USPTO) to review geoengineering patent applications more closely and with additional scrutiny.[148] Others advocate for creating patent pools, and either additionally or as an alternative, create a research commons.[149] Many have touched upon whether march-in rights or implementing compulsory licenses is another appropriate response to the developing system.[150] However, due to the limited cases

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144. *See id.* ("Likewise, inventions developed in contexts outside of solar geoengineering would have applications therein, and those that seem exclusive to solar geoengineering would have uses elsewhere.").

145. *See id.* (providing an example of how developers of inkjet printers are involved in creating a nozzle that can spray an extremely fine mist of salt water without clogging).

146. *See id.* ("A second difficulty for IP and data access policies is that there is no clear line between, on the one hand, research and innovation within solar geoengineering and, on the other, activities outside of the field.").

147. *See* Reynolds, *supra* note 13, at 5–6 (proposing four recommendations regarding IP for solar geoengineering); Parthasarathy, *supra* note 100, at 11–12 (proposing four recommendations for geoengineering patent development); Chavez, *supra* note 97, at 31–35 (advocating for the United States to establish a patent pool).

148. *See e.g.*, Parthasarathy, *supra* note 100, at 11–12 (proposing recommendations for a *sui generis* patent system).

149. *See e.g.*, Chavez*, supra* note 14, at 31–35 (advising that the US develop unique procedures to approve these patent applications and form a geoengineering patent pool to facilitate innovation and accessibility).

150. *See e.g.*, *id.* at 21–27 (discussing the viability of compulsory licensing for geoengineering patents); *see also* Reynolds, *supra* note 14, at 4 (dismissing

discussing march-in rights (none have been granted) and compulsory licenses, scholars have urged the government to clarify the conditions under which it would exercise march-in rights, compulsory licenses, or other mechanisms to grant licenses.[151]

D. Different Mechanisms Through Which the United States Government Interferes in the Patent System to Grant Licenses

1. The Bayh-Dole Act and Origin of March-In Rights

The federal government plays a large role in the development of U.S. technologies in the private sector through financial assistance and funding.[152] Yet, the aid of federal funding brings questions about who owns the rights to the invention once patented.[153] What interest does the U.S. government retain when it plays a purely financial role in the development of the patented invention?

In the 1960s, the Kennedy administration implemented the "Government Patent Policy."[154] Under the policy, the United States was the default owner of the rights to inventions developed through government contracts and government funding.[155] Yet, there were specific circumstances where the contractor could

march-in rights or compulsory licenses as a potential solution because only very rare circumstances trigger their use).

151. *See e.g.*, Reynolds, *supra* note 13, at 6 ("The fourth and final proposal is for governments to clarify the conditions under which they would: exercise march-in rights . . . .").

152. *See* Oldham, *supra* note 101, at 7 (stating that the "climate engineering research funding is dominated by the US National Science Foundation (NSF), the UK Natural Environment Research Council (NERC), the European Commission, the US Department of Energy and NASA with the National Natural Science Foundation of China appearing seventh in the rankings.").

153. *See* JOHN R. THOMAS, CONG. RSCH. SERV., R44597, MARCH-IN RIGHTS UNDER THE BAYH-DOLE ACT, 1, 5–6 (2016) (discussing the history of how the federal government considered the implications of public funding in intellectual property research and development).

154. *See id.* at 5 (explaining the early beginnings of granting rights for intellectual property made with public funding to government contractors).

155. *See id.* ("This early 'Government Patent Policy' generally allowed the U.S. government to retain rights to inventions developed through government contracts.").

obtain title to the patent.[156] If a contractor obtained title, the patent was still "subject to the government acquiring at least an irrevocable non-exclusive royalty free license throughout the world for governmental purposes."[157] Further, the 1963 policy contained an additional policy, which became the prelude to today's march-in rights:

> Where the principal or exclusive (except as against the government) rights to an invention are acquired by the contractor, the government shall have the right to require the granting of a license to an applicant royalty free or on terms that are reasonable in the circumstances to the extent that the invention is required for public use by governmental regulations or as may be necessary to fulfill health needs, or for other public purposes stipulated in the contract.[158]

However, Congress became increasingly concerned that the United States was falling behind the pace of technological advancement.[159] Congress accepted the proposition that, "the lack of patent title discouraged private enterprise from advancing early-stage technologies into the marketplace."[160] In 1980, Congress enacted the Bayh-Dole Act, which allowed non-profits, universities, and small businesses to elect to retain title to any invention that was made under federally funded research and development.[161] In February 1983, through an executive order, President Reagan extended the Bayh-Dole Act to apply to all parties that contract with the United States, regardless of their

156. *See id.* ("However, the contractor could obtain title in specified circumstances.").

157. Statement of Government Patent Policy, 28 Fed. Reg. 10943, 10945 (Oct. 10, 1963).

158. *See* Thomas, *supra* note 153, at 5 (quoting Statement of Government Patent Policy, 28 Fed. Reg. 10943, 10945 (Oct. 10, 1963)).

159. *See* Titus Galama & James Hosek, *Is the United States Losing Its Edge in Science and Technology?*, RAND CORP. (2008), https://www.rand.org/content/dam/rand/pubs/research_briefs/2008/RAND_RB9347.pdf ("In the mid-2000s, numerous public and private sector reports argued that the United States is falling behind, and Capitol Hill responded with a wave of policy initiatives.") [perma.cc/5P6G-K8DG].

160. Thomas, *supra* note 153, at 5.

161. *See id.* at 6 ("Under the Bayh-Dole Act, each nonprofit organization (including universities) or small business is permitted to elect within a reasonable time to retain title to any 'subject invention' made under federally funded R&D.").

size.[162] The executive order has been upheld and maintained since it went into place.[163]

While the Bayh-Dole Act gave contractors the rights to inventions, the act also provided that the United States government had march-in rights.[164] "March-in rights allow the government, in specified circumstances, to require the contractor or successors in title to the patent to grant a 'nonexclusive, partially exclusive, or exclusive license' to a 'responsible applicant or applicants.'"[165] In essence, the government could "march in" and grant licenses for patents that were the product of publicly funded research and development.[166] If the patent owner refused to grant a license, the government can grant the license itself.[167] Exercising march-in rights does not invalidate the patent; rather, it grants permission for an enterprise, identified by the government, to practice the patented invention.[168] To invoke march-in rights, one of four circumstances must be met:

> (1) action is necessary because the contractor or assignee has not taken, or is not expected to take within a reasonable time, effective steps to achieve practical application of the subject invention in such field of use;
>
> (2) action is necessary to alleviate health or safety needs which are not reasonably satisfied by the contractor, assignee, or their licensees;
>
> (3) action is necessary to meet requirements for public use specified by Federal regulations and such requirements are not reasonably satisfied by the contractor, assignee, or licensees; or
>
> (4) action is necessary because the agreement required by

162. *See id.* ("[T]hen-President Ronald Reagan ordered all agencies to treat, as allowable by law, all contractors within the Bayh-Dole Act framework regardless of their size.").

163. *Id.*

164. *See id.* at 7 (explaining the mechanics of march-in rights under the Bayh-Dole Act).

165. *Id.*

166. *See id.* ("The Bayh-Dole Act provides the government with the ability to 'march in' and grant licenses for patents that resulted from publicly funded R&D.").

167. *See id.* ("If the patent owner refuses to do so, the government may grant the license itself.").

168. *See id.* (explaining how march-in rights affects the patent and assignee's rights).

> section 204 [generally requiring that patented products be manufactured substantially in the United States unless domestic manufacture is not commercially feasible] has not been obtained or waived or because a license of the exclusive right to use or sell any subject invention in the United States is in breach of its agreement obtained pursuant to section 204. [169]

"Practical application" under subsection one is further defined as,

> [T]o manufacture in the case of a composition or product, to practice in the case of a process or method, or to operate in the case of a machine or system; and, in each case, under such conditions as to establish that the invention is being utilized and that its benefits are to the extent permitted by law or Government regulations available to the public on reasonable terms.[170]

Following enactment of the Bayh-Dole Act, however, march-in rights have not been exercised.[171] The National Institute of Health (NIH) has received six petitions for the NIH to "'march in' with respect to a particular pharmaceutical."[172] Yet, each petition has been denied.[173] Petitioners filed for march-in rights for several reasons mainly focusing on the drug's price.[174] NIH has declined to exercise march-in rights for high drug prices, because this type of scenario does not fit into any of the four statutory provisions[175] and

169. 35 U.S.C. § 203(a).

170. Thomas, *supra* note 153, at 7 (citing 35 U.S.C. § 201(f)).

171. *See id.* at 8 ("March-in rights have never been exercised during the 35-year history of the Bayh-Dole Act.").

172. *Id.*

173. *See Policies and Reports*, NAT'L INSTS. OF HEALTH OFF. OF INTRAMURAL RSCH. & OFF. OF TECH. TRANSFER, https://www.ott.nih.gov/policy/policies-reports (listing the National Institute of Health's march-in responses) [perma.cc/Q9GC-ZXW2]; *see also* Thomas, *supra* note 153, at 8 ("Each petition was denied.").

174. *See e.g.*, *NIH Decision on Xtandi March-In Request*, DEP'T OF HEALTH & HUM. SERVS., NAT'L INST. OF HEALTH (June 7, 2016 & June 20, 2016), https://www.ott.nih.gov/sites/default/files/documents/policy/pdfs/Final_Response_Goldman_6.20.2016.pdf (responding to concerns that the price of Xtandi® is too high) [perma.cc/25KE-57RZ]; *see also March-In Position Paper in the Case of Xalatan*, DEP'T OF HEALTH & HUM. SERVS., NAT'L INST. OF HEALTH (Sept. 17, 2004), https://www.ott.nih.gov/sites/default/files/documents/policy/March-in-xalatan.pdf (responding to concerns that the price of Xalatan® is too high) [perma.cc/N8AB-Z3YY].

175. *See March-In Determination in the Case of Norvir (November 2013)*, DEP'T OF HEALTH & HUM. SERVS., NAT'L INST. OF HEALTH (Nov. 1, 2013), https://www.ott.nih.gov/sites/default/files/documents/policy/March-In-

discrepancies between drug prices in the United States and other countries are "appropriately left for Congress to address legislatively."[176]

The requests to initiate march-in rights to combat rising drug prices and the government's lack of action to exercise of march-in rights has led to a renewed debate about the pros and cons of march-in rights.[177] Some proponents of march-in rights in this context believe that "U.S. taxpayers should be protected from what they view as excessive profiteering on technologies developed with public funding."[178] Other proponents assert that the Bayh-Dole Act "has had a powerful price-control clause since its enactment in 1980 that mandates that inventions resulting from federally funded research must be sold at reasonable prices."[179] Therefore, the solution to high drug prices can be solved within the Act as it is already written, through the unused, unenforced march-in provision of the Act.[180]

The proponents' argument rests on the "reasonable terms" within the definition of "practical application."[181] Several courts, including the Courts of Appeals for the Fifth and Sixth Circuits and district courts have interpreted "reasonable terms" in similar contexts to include price.[182] "The terms required by the Bayh-Dole

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Norvir2013.pdf (addressing each of petitioners' claims in light of the statute's text) [perma.cc/2PM7-F24T].

176. *March-In Position Paper in the Case of Xalatan*, *supra* note 174, at 6.

177. *See e.g.*, Joseph Allen, '*The Washington Post*' *Misses the Mark on March-In Rights*, IP WATCHDOG (Apr. 22, 2019), https://www.ipwatchdog.com/2019/04/22/washington-post-misses-mark-march-rights/id=108499/ (explaining why under the Bayh-Dole Act the NIH was correct in denying petitioners' requests for the federal government to march-in due to high drug prices) [perma.cc/B5LD-LP2R].

178. Thomas, *supra* note 153, at 1–2.

179. Peter S. Arno & Michael H. Davis, *Why Don't We Enforce Existing Drug Price Controls? The Unrecognized and Unenforced Reasonable Pricing Requirements Imposed Upon Patents Deriving in Whole or in Part from Federally Funded Research*, 75 TUL. L. REV. 631, 631 (2001).

180. *See id.* (concluding that "the solution to high drug prices does not involve new legislation but already exists in the unused, unenforced march-in provision of the Bayh-Dole Act").

181. *See id.* at 649 (explaining the importance of the phrase "available to the public on reasonable terms" within 35 U.S.C. § 201(f) (1994)).

182. *See id.* at 650 (explaining the courts' history of interpreting the phrase "reasonable terms").

Act include, but are not limited to, reasonable prices."[183] A price is unreasonable if the unit price is "too high or if its use over the long term makes it too costly with respect to the investment, costs, and profits of the manufacturer."[184] "The requirement for 'practical application' seems clearly to authorize the federal government to review the prices of drugs developed with public funding under Bayh-Dole terms and to mandate march-in when prices exceed a reasonable level."[185]

Opponents of using march-in rights to combat rising drug prices include the two primary sponsors of the law.[186] Senators Birch Bayh and Robert Dole responded with an editorial in the *Washington Post*, which plainly stated, "Bayh-Dole did not intent that government set prices on resulting products . . . . The law instructs the government to revoke such licenses only when the private industry collaborator has not successfully commercialized the invention as the product."[187] Additionally, Norman Latker, the former NIH patent counsel, and Howard Bremer, with the Wisconsin Alumni Research Foundation, sent statements to NIH opposing the proposed misuse of march-in rights as "contrary to the law."[188]

In their statements, opponents of granting march-in rights in this context also highlighted the benefits of the current, unaltered scheme.[189] Their statements explained that the Act has created new companies, new jobs, and contributes enormously to the U.S. economy.[190] Companies that have developed some of the most

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183. *Id.* at 651.

184. *Id.*

185. *Id.*

186. *See* Allen, *supra* note 177 (quoting Senator Bayh and stating that Senators Bayh and Dole reject the argument that under the Act the federal government can use march-in rights to combat rising drug prices).

187. Birch Bayh and Robert Dole, *Our Law Helps Patients Get New Drugs Sooner*, WASH. POST (Apr. 11, 2002) at A28.

188. Allen, *supra* note 177.

189. *See generally NIH Public Meeting on Norvi / Ritonavir March-in Request*, NAT'L INST. OF HEALTH & HUM. SERVS. (May 25, 2004), https://www.ott.nih.gov/sites/default/files/documents/2004NorvirMtg/2004NorvirMtg.pdf (compiling the statements of those who opposed granting march-in rights) [perma.cc/Y3UB-LGAX].

190. *See id.* at 5 ("The Economist estimated that Bayh-Dole created 2,000 new companies, 260,000 new jobs, and now contributes $40 billion annually to the U.S.

valuable drugs for curing human diseases were created because of the funding boost the federal government provided.[191] Further, a change in march-in policy could undermine the ability of universities to make their federally funded technologies available for public benefit and the incentive for the private sector to invest in federally funded discoveries.[192] While this debate was centered around rising drug prices, the debate illustrates the underlying tension and concerns about invoking march-in rights, and therefore their limited applicability and use.

2. US Government's Eminent Domain–Like Power Under 28 U.S.C. § 1498

Another mechanism that can be used by the United States government to grant licenses to U.S. patents is through 28 U.S.C. § 1498.[193] Section 1498 of the United States Code provides the United States government and its contractors with the ability to use or manufacture an invention described in and covered by a United States patent.[194] The patent owner's remedy is to bring an action against the United States in the US Court of Federal Claims "for the recovery of his reasonable and entire compensation for such use and manufacture."[195] The patent owner may not enjoin the United States from using their invention.[196]

Section 1498(a) of the United States Code operates separately from the Bayh-Dole Act, and there are three significant distinctions from march-in rights.[197] First, unlike march-in rights,

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economy.").

191. *See id.* at 30 ("The award of the NCDDG-AIDS grant gave the HIV project a much-needed funding boost. In my opinion, it catalyzed the development of the antiviral program.").

192. *See id.* at 36 ("The ability of universities to make their federally funded technologies available for public benefit would be undermined, and the incentive for the private sector to invest in federally funded discoveries would be removed.").

193. *See* 28 U.S.C. § 1498 (2018) (discussing licenses with patents).

194. *Id.* § 1498(a).

195. *Id.*

196. *Id.* § 1498.

197. *See* Thomas, *supra* note 153, at 8 ("Three significant distinctions exist between march-in rights under the Bayh-Dole Act and 28 U.S.C. § 1498(a).").

the scope of 28 U.S.C. § 1498 is not limited to only patented inventions that were developed with the support of federal funds; the provision applies to every U.S. patent.[198] Second, the provision applies when the federal government or its contractors practice the patented invention, whereas with march-in rights, private enterprises may initiate requesting march-in rights from the government.[199] Third, the scheme for compensation is different.[200] Under 28 U.S.C. § 1498(a) the patent owner, "commences litigation and may be awarded damages to compensate for the use of the government or its contractors."[201] Whereas under the Bayh-Dole Act, recipients of march-in rights are awarded licenses and presumably pay royalties to the owner of the patent.[202]

3. Compulsory Licensing

A third mechanism the U.S. government may use to interfere with the United States patent system is to grant compulsory licenses.[203] Compulsory licensing provides that the government has the ability to require that an owner of a patent license the use of their rights.[204] In the United States, unlike many other countries, there is not a general compulsory licensing scheme.[205] Rather, Congress in a few circumstances has created limited compulsory licensing statutes, such as the Atomic Energy Act of

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198. *See id.* (contrasting march-in rights and 28 U.S.C. § 1498).

199. *See id.* (contrasting march-in rights and 28 U.S.C. § 1498).

200. *See id.* (contrasting march-in rights and 28 U.S.C. § 1498).

201. *Id.*

202. *See id.* (contrasting march-in rights and 28 U.S.C. § 1498).

203. *See Compulsory Licensing of Pharmaceuticals and TRIPS*, WORLD TRADE ORG. (Mar. 2018), https://www.wto.org/english/tratop_e/trips_e/public_health_faq_e.htm ("Compulsory licensing is when a government allows someone else to produce a patented product or process without the consent of the patent owner . . . .") [perma.cc/4ZV6-PSHT].

204. *See id*. (explaining compulsory licensing).

205. *See* Mark W. Lauroesch, *General Compulsory Patent Licensing in the United States: Good in Theory, but not Necessary in Practice*, 6 SANTA CLARA HIGH TECH. L. J. 41, 41 (1990) ("Unlike a number of foreign countries, no 'general' compulsory licensing statute, applicable to all patents that have not been practiced or have been used for anticompetitive purposes, exists in this country [the United States].").

1954 and the Clean Air Act of 1970.[206] Although there is not a general compulsory licensing scheme in the United States, the Constitution permits limited compulsory licensing statutes as well as a potential general licensing statute.[207]

Article I, section 8, clause 8 of the Constitution is the primary source of Congress' authority to enact laws concerning patents and intellectual property broadly.[208] Some authors have expressed that the term "exclusive rights" within clause 8 prevents the government from constitutionally granting a nonexclusive patent, which would be the result with compulsory licensing.[209] Additionally, some authors argue the government's power to take patents is limited to takings for the public benefit and that "compulsory licensing results in the confiscation of private property only for the benefit of a private citizen, the licensee."[210]

However, both of these arguments fail. The purpose of compulsory licensing would be for the public's benefit.[211] Compulsory licensing is used to, "ensure that the public receives the benefit of an innovation as soon as possible rather than only after [twenty] years."[212] Additionally, the term "exclusive rights" should not be interpreted as establishing the only rights that Congress can grant, but to indicate that "exclusive rights" was the maximum that Congress could grant.[213] Further, in *Sony Corporation of America v. Universal City Studios, Inc.*,[214] the

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206. *See id.* at 46 ("Provisions permitting compulsory licenses have been included in the Atomic Energy Act of 1954, the Plant Variety Protection Act, the Clean Air Act of 1970, and the Copyright Act of 1976.").

207. *See id.* at 44–47 (explaining why the U.S. Constitution would permit a general compulsory licensing statute).

208. *See id.* at 44 (stating the source of Congress' power to enact patent laws).

209. *See id.* (explaining some of the constitutional arguments against compulsory licensing).

210. *Id.* at 44–45.

211. *See id.* at 45 ("The granting of a general compulsory license under a working requirement would, however, be in the public interest.").

212. *Id.*

213. *See id.* ("Moreover, the word 'exclusive' in clause 8 should not be interpreted as establishing the only type of intellectual property right that Congress may grant, but instead only as emphasizing the greatest extent of the rights it may grant.").

214. Sony Corp. of Am. V. Univ. Cty. Studios, Inc., 464 U.S. 417, 429 (1984) (holding that Sony's sale of video tape recorders to the general public does not constitute contributory infringement of copyrights).

Supreme Court stated that, "[a]s the text of the Constitution makes plain, it is Congress that has been assigned the task of defining the scope of the limited monopoly that should be granted to authors or to inventors in order to give the public appropriate access to their work product."[215] Therefore, Congress has the flexibility to determine the balance and incentives to disclose inventions, encourage innovation, and ensure that patents are practiced for the public's benefit.[216]

Opponents of compulsory licensing also tend to highlight that "those who believe they are attacking the abuses of the [patent] system may inadvertently damage the patent system itself."[217] Compulsory licensing could destroy research incentives, which is an integral component of the patent system.[218] This could occur if the royalties provided for under a compulsory licensing scheme are not comparable to royalties that would be received under a voluntary licensing scheme.[219] The royalties under a compulsory licensing scheme may not allow the patent holder to fully recoup research and development costs.[220] Inventors and companies may be less willing to invest time and money in research and development, if there is a possibility that they will not be able to reap the financial benefits of a patented technology.[221]

215. *Id*. at 429.

216. *See* Lauroesch, *supra* note 205, at 45 (concluding that "the framers' intent has been interpreted not merely to ensure disclosure of inventions, but also to encourage innovation so that society can enjoy and benefit from the disclosure of inventions").

217. *Id.* at 53 (quoting Fortas, *The Patent System in Distress*, 53 J. PAT. OFF. SOC'Y 810, 820 (1971)).

218. *See id.* ("Similarly, opponents of compulsory licensing argue that such licensing provisions would destroy the research incentive that is so integral to the patent system.").

219. *See id.* ("This position would appear to be most valid if the royalties granted under a compulsory licensing system were not comparable to those that would be obtained under voluntary licensing.").

220. *See id.* (explaining that an investor or inventor devotes time and money not only to patentable inventions but also all the prior unsuccessful experiments and inventions that came before it).

221. *See id.* (explaining that an investor or inventor is motivated in part to devote their time and money because of the expectation that they are going to recoup their investment or make more of a profit).

Further, the notion of implementing compulsory licenses within the United States patent system is generally disfavored.[222] Because of this hesitancy to use the compulsory licensing provisions within specific statutes, such as the Clean Air and Atomic Energy Acts, the courts have expressed resistance to awarding compulsory licenses.[223] The Supreme Court has stated, "Compulsory licensing is a rarity in our patent system,"[224] and it is typically considered a last resort.[225]

However, despite the potential problems of compulsory licensing there can be significant benefits.[226] Advocates for a general compulsory licensing scheme have highlighted four main potential benefits.[227] "[G]eneral compulsory licensing could help put unused or unmarketed patented products in the consumers' hands when patentees have not made efforts to practice their inventions."[228] Also, compulsory licensing could combat patent suppression.[229] Patent suppression occurs when other patent holders have no intention to practice or license an improvement patent, but they use their patent simply to block competitors.[230] Further, compulsory licensing could also reduce wasted energy on "invent around" products, which consume significant amounts of time and effort to create imitation products that circumvent the

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222. *See* Chavez, *supra* note 14, at 22 ("Yet, the U.S. patent system generally disfavors compulsory licensing.").

223. *See id.* (explaining that only on a few occasions has the court imposed compulsory licensing).

224. Dawson Chem. Co. v. Rohm & Haas Co., 448 U.S. 176, 215 (1980).

225. *See* Chavez, *supra* note 14, at 22 ("And although courts recognize compulsory licensing as a solution for antitrust violations, it is considered a remedy of last resort.").

226. *See* Laureosch, *supra* note 205, at 42 ("Although some people support compulsory licensing purely out of distaste for the patent system, there appears to be a number of positive effects that could potentially result from compulsory licensing.").

227. *See id.* at 42–44 (describing four benefits of a general compulsory licensing scheme).

228. *Id.* at 42.

229. *See id.* at 43 ("A second potential benefit of compulsory licensing is it might combat patent suppression.").

230. *See id.* (explaining the detriment patent suppression can have on consumers).

actual patent.[231] Lastly, compulsory licensing "could be used as a remedy for patent misuse and antitrust violations."[232]

IV. Proposing a Solution to Geoengineering Patenting Issues

The complexities and early-stage development of geoengineering technologies warrant the creation and use of a specialized compulsory licensing scheme.[233] There is a growing and immediate need for technologies that can help mitigate and slow the effects of climate change.[234] Without the use of CDR and SRM technologies, it is almost certain that human and wildlife populations will be affected, and that poorer and marginalized communities will be disproportionately affected.[235]

Additionally, geoengineering technologies that will be deployed, need to be high quality and thoroughly tested.[236] Geoengineering technologies, particularly solar-radiation management technologies, will have transnational effects.[237] Geoengineering technologies are "high risk technologies with the potential for a high reward; their impacts, positive and negative, are global in scope and if [the technology] does damage, it is likely to be irreversible."[238] Also, predictions about the effects of geoengineering technology are based, in large part, on computer

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231. *See id.* (explaining that "[s]ignificant amounts of time and efforts are expended to create imitation products by inventing around patents").

232. *Id.* at 44.

233. *See supra* Part III.D. 3. Compulsory Licensing (discussing compulsory licensing).

234. *See e.g.*, Pearce, *supra* note 41 (warning that the globe may have surpassed a threshold for a cascade of inter-related tipping points); *see also* HUNTER, *supra* note 42 (explaining that the rise in global temperatures affects remaining carbon sinks and diminishes their ability to absorb carbon dioxide further exacerbating the effects of climate change).

235. *See* OLSSON, *supra* note 22, at 802 (explaining that because people who are poor and marginalized usually have the least buffer to face modest climate hazards they tend to suffer most).

236. *See* Parthasarathy, *supra* note 100, at 10 (describing the high risks of geoengineering technologies).

237. *See* Reynolds, *supra* note 13, at 3 (describing SRM technology as transnational and providing a public good).

238. Parthasarathy, *supra* note 100, at 10.

modeling.[239] Computer modeling is only as good as the data that is put into the system.[240] The input of multiple inventors and research groups will be required to adequately assess the benefits and problems with certain geoengineering technologies.[241]

Further, there is a risk that allowing one patent holder of a broad, foundational patent could allow that patent rights holder to single handedly control the development of that technology.[242] Without multiple parties working to invent better technologies, a monopoly of the industry, or a particular swath of that industry, for twenty years could result in sub-par technology.[243] Competition in an industry promotes innovation, and given the transnational effects of geoengineering inventions, patent holders and countries should be exercising the utmost caution with deploying technology that may not be the best equipped or most advanced.[244]

A. Determining Which U.S. Government Action Would Best Promote Innovation Given the Unique Features of Geoengineering Technology

The purpose of involving the United States federal government in this space would be to ensure that owners of broad, building block patents license these patents to other parties that can work towards creating improvement patents.[245] Based on the

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239. *See* SCoPEx*, supra* note 1 (stating that one of the purposes of the SCoPEx project is "to improve the fidelity of simulations (computer models)").

240. *See id.* ("Analyzing these experiments will improve our knowledge beyond what is currently available within computer models is measurable with confidence under laboratory conditions.").

241. *See id.* (explaining the benefit of inputting updated and real data into computer modeling programs).

242. *See* Chavez, *supra* note 14, at 13 ("This is normally a cause of concern because of the immense control patent holders have over future inventions.").

243. *See* Parthasarathy, *supra* note 102, at 7–8 (discussing how the lack of a robust research environment in the space of genetic tests led to less accurate and most expensive methods for gene testing such as in the case for the BRCA genes).

244. *See* Reynolds, *supra* note 13, at 3 (stressing the global effect of climate engineering technologies); *see also* Parthasarathy, *supra* note 100, at 10 (describing the high risks of geoengineering technologies).

245. *See* Chavez, *supra* note 14, at 14 (explaining how building blocks, while not always possessing any marketable value on their own, can be crucial to downstream development and the ability to create "incremental improvement patents").

three mechanisms that the United States government may employ when interfering in the patent system, it appears that creating a specialized compulsory licensing scheme is most appropriate.[246]

The Bayh-Dole Act provides that the government can compel patent rights holders that received federal funding to grant licenses to the government to use their technology or to entities which the government deems best to use to use the patented technology.[247] There is evidence that many CDR and SRM technologies are invented with the aid of federal funding.[248] However, march-in rights have never been exercised.[249] And, the specific requirements that must be met in order for the government to exercise the march-in rights provision have been narrowly construed making it even more difficult to satisfy these requirements .[250]

Perhaps, the government could exercise march-in rights under the Bayh-Dole Act's third provision, which permits the government to exercise march-in rights when it "is necessary to meet requirements for public use by Federal regulations . . . ."[251] But, as of February 2020, there are no regulations defining what "public use" would look like in this context.[252] Further, even if "public use" could be defined in this context, march-in rights would only be applicable to inventions that used federal funding in their research

246. *See supra* Part II.D (describing the three mechanisms through which the federal government can interfere with the patent system to license patented inventions).

247. *See* Thomas, *supra* note 153, at 7 (explaining that the Bayh-Dole Act preserves the United States' ability to "march-in").

248. *See* Oldham, *supra* note 101, at 7–8 (listing the U.S. National Science Foundation, U.S. Department of Energy, and NASA among the entities that are dominating climate engineering research funding).

249. *See* Thomas, *supra* note 153, at 1 ("Members of Congress have recently taken note of the fact that march-in rights have never been exercised during the 35-year history of the Bayh-Dole Act.").

250. *See id.* at 7–10 (stating the four scenarios where march-in rights can be used and describing the six failed petitions to institute march-in rights).

251. 35 U.S.C. § 203(a).

252. *See* James Temple, *Geoengineering is very controversial. How can you do experiments? Harvard has some ideas.*, MIT TECH. REV. (July 29, 2019), https://www.technologyreview.com/s/614025/geoengineering-experiment-harvard-creates-governance-committee-climate-change/ (highlighting that there is not a US-government-funded research program in this area, or any public oversight body set up to weigh the particularly complex questions surrounding solar geoengineering) [perma.cc/P8Q9-WLT9].

and development.[253] Using march-in rights could allow private entities to escape the possibility of mandatory licensing.[254] Broad, foundational patents invented without the use of federal funding would still be able to take up large swaths of the geoengineering field and prevent other inventors from building off of that foundational patent to create incremental, "improvement" patents.[255]

The government's exercise of its eminent domain-like power under 28 U.S.C. § 1498 would also be inadequate to fully address the issues developing within the geoengineering patent space.[256] Under Section 1498(a) of the U.S. Code, the federal government has the ability to condemn any patent; however, the government may only then allow the government or one of its contractors to practice the invention.[257] In the geoengineering space, the private sector, without direct affiliation with the federal government, can and should play a crucial role in the development of CDR and SRM technologies.[258] Limiting the potential licensees of this technology to only the government and governmental contractors would not solve the underlying issues within the geoengineering technology space.

A specific compulsory licensing scheme, as was created with the Atomic Energy and Clean Air Acts, would be the best option

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253. *See* Thomas, *supra* note 153, at 7 ("The Bayh-Dole Act provides the government with the ability to 'march-in' and grant licenses for patents that resulted from publicly funded R&D.").

254. *See id.* (stating that the Bayh-Dole Act only applies to inventions that received some federal funding).

255. *See* Chavez, *supra* note 14, at 14 (explaining the implications of awarding building-blocks early in an industry's development).

256. *See* Thomas, *supra* note 153, at 8 (listing the similarities and differences between march-in rights and 28 U.S.C. § 1498).

257. *See* 28 U.S.C. § 1498(a) ("[T]he use or manufacture of an invention described in and covered by a patent of the United States by a contractor, a subcontractor, or any person, firm, or corporation for the Government . . . shall be construed as use or manufacture for the United States.").

258. *See* Reynolds, *supra* note 13, at 2

> Furthermore, the private sector arguably should play a role in solar geoengineering research and any subsequent development and possible implementation, as the private sector is the primary source of valuable innovations in many devices, materials, techniques, and services that might be necessary or useful for any development and implementation of solar geoengineering.

for addressing the concerns with SRM and CDR technologies.[259] Like the Atomic Energy Act, a compulsory licensing scheme for geoengineering technology could address concerns about the national and international implications of this technology while also promoting development within the industry.[260] For countries that have compulsory licensing provisions in other fields, the benefits of having these provisions is not implementing the scheme, but rather using the scheme as a threat.[261] The threat of implementing the compulsory licensing scheme can coerce patent holders to grant licenses to third parties, and perhaps on terms that may be more favorable to the patent holders than if the compulsory licensing scheme were implemented.[262]

Additionally, there is evidence that the industry is already taking steps on its own to fix the emerging technology issues.[263] By providing a clear mechanism through which patent holders understand when they would be compelled to license their patents, a specific compulsory licensing scheme could serve as further encouragement to ensure that the industry develops in a manner that does not lock up technologies.[264]

259. *See* 42 U.S.C. § 2011 (2018) (discussing the way that atomic energy can "contribute to the general welfare").

260. *See* Parthasarathy, *supra* note 102, at 9 ("It [Congress] created these rules as part of the Atomic Energy Act in order to address concerns about national security implications of atomic energy development while still promoting development in this industry.").

261. *See* Chavez, *supra* note 97, at 26 (describing the prevalence of compulsory licensing schemes in international agreements and laws and that in practice, countries rarely implement the schemes).

262. *See id.* ("More commonly, governments threaten to utilize their licenses, thus coercing patent holders to either grant licenses or make the product available at substantially lower prices.").

263. *See e.g.*, David Keith & John Dykema, *Why We Chose Not to Patent Solar Geoengineering Technologies*, THE KEITH GRP. (May 3, 2018), https://keith.seas.harvard.edu/blog/why-we-chose-not-patent-solar-geoengineering-technologies (advocating that inventors and organizations should not patent SRM technology) [perma.cc/9MSS-LDCx]; *see also* Reynolds, *supra* note 13, at 2 ("[W]e also found that there presently is a culture and practice among solar geoengineering researchers of sharing data freely, and little evidence that these researchers kept data or know how to themselves or took protective measures to maintain trade secrecy in the data and know-how.").

264. *See* Thomas, *supra* note 153, at 10–12 (describing the on-going debate and uncertainty as to when march-in rights should be exercised); *see also* Chavez, *supra* note 14, at 27 ("Compulsory licenses certainly could help address the problems developing with geoengineering patents.").

B. Defining the Scope of a Geoengineering Compulsory Licensing Scheme

While some authors advocate for the federal government to compel licensing or exercise march-in rights to all green technology, there are significant benefits to limiting the scope of technologies susceptible to a compulsory licensing scheme to only geoengineering technologies.[265] Opponents of compulsory licensing in general, highlight that compulsory licensing could deter and stifle innovation.[266] Therefore, limiting a compulsory licensing scheme to only geoengineering technologies balances the concerns of granting compulsory licensing generally with the concerns about the unique, transnational, and high-risk nature of this technology.

Unlike atomic energy, there is a wide breadth of geoengineering technologies with few common and easily definable characteristics.[267] Yet, the Atomic Energy Act's definition of technology susceptible to the act as, "to the extent that an invention is useful in atomic energy" provides useful guidance.[268] Patents and technologies subject to a potential compulsory scheme should be limited to the extent that a technology is useful in significantly altering the climate through climate engineering.[269] Within CDR technologies, this would include ocean fertilization and direct air capture; however, it would exclude the development of more fuel-efficient car engines.[270] Within SRM technologies, this

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265. *See e.g.*, Teneille R. Brown, *The Eminence of Imminence and the Myopia of Markets*, 9 J. MARSHALL REV. INTELL. PROP. L. 674, 690–91 (2010) (advocating for the use of compulsory licensing for all "clean tech"); *see also* Deborah Behles, *The New Race: Speeding Up Climate Change Innovation*, 11 N.C. J.L. & TECH. 1, 26–31, 34–40 (2009) (discussing solutions to promote "green technology" including creating a new patent system with compulsory licensing).

266. *See* Lauroesch, *supra* note 205, at 53 ("Similarly, opponents of compulsory licensing argue that such licensing provisions would destroy the research incentive that is so integral to the patent system.").

267. *See* Parthasarathy, *supra* note 102, at 10 (contrasting geoengineering, which "includes a wide range of technologies, from stratospheric sulfate aerosols to mirrors to be built in space," with atomic energy which was defined as "fissionable material").

268. *See id.* at 11 ("The precedent of patentability *to the extent that* an invention is useful in atomic energy is therefore highly applicable to and useful in [the] case of geoengineering.").

269. *See supra* Part III.D. 3. Compulsory Licensing (discussing compulsory licensing).

270. *See supra* Part IV.A. Determining Which U.S. Government Action Would

would encompass grand schemes for cloud brightening but also include the smaller inventions, such as the jet stream, necessary to conduct and deploy large-scale SRM technologies. This definition of technology susceptible to a potential licensing scheme thereby defines the scope of the specialized compulsory licensing scheme to encompass pertinent geoengineering technology inventions, but also exclude tangentially related inventions that are not crucial for geoengineering technology.

V. Conclusion

Climate change is one of the biggest problems of our generation, and we may have passed the critical tipping point. Geoengineering technology may be the only way to substantially slow climate change and its effects. However, the current development and granting of geoengineering patents raises concerns about how the patent system has and will continue to incentivize innovation. Creating a compulsory licensing scheme for geoengineering technologies—technologies that are useful in significantly altering the climate through climate engineering—is a viable solution. Not only would this continue to encourage licensing practices, but it would also reinforce the national and international commitment to developing accurate technology built upon robust research and innovative, collaborative thinking.

Best Promote Innovation Given the Unique Features of Geoengineering Technology (discussing compulsory licensing with geoengineering).