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Exclusive Rights to Saving the Planet: The Patenting of Geoengineering Inventions

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By Anthony E. Chavez[*]

We will not be able to curtail greenhouse-gas emissions quickly enough to avoid significant climate change. Thus, we should anticipate that society will consider implementing climate engineering, either to avert a climate catastrophe or to reduce atmospheric carbon. Although geoengineering research is still in its infancy, in recent years the number of geoengineering patents and patent applications has increased dramatically. Because of the importance of these technologies to society's future, the United States needs to ensure that these patents do not deter innovation or prevent these technologies from being available for implementation. Specifically, the United States should develop unique procedures to approve these applications and form a geoengineering patent pool that will facilitate both innovation and accessibility.

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[*] Associate Professor, Chase College of Law, Northern Kentucky University. The author is grateful for the advice and contributions of Jon Garon and the participants of the Vermont Colloquium on Environmental Scholarship, for the research assistance of Jennifer Mart-Rice, and especially for the tireless efforts of Blaine Burgess, without whose efforts this Article would not have been possible.

I. INTRODUCTION

¶1 The Fifth Assessment Report of the United Nations' Intergovernmental Panel on Climate Change warns that the planet is rapidly reaching a dangerous level of warming.[1] Furthermore, it reports that much of the carbon dioxide causing this warming will remain in the atmosphere for a millennium.[2] Many scientists have urged studying geoengineering as a means to avert a climate emergency or to reduce the level of CO_2 in the atmosphere. Some have begun researching climate-engineering methods and have patented their inventions.

¶2 Over the past five years, the number of climate-engineering patents has skyrocketed. The patent system, however, may not be ready for the implications of this wave of new applications and may in fact hinder the development of these technologies. Already, one company has cancelled testing of a geoengineering method because of a dispute over a patent.[3] One leading advocate of climate engineering argues for a categorical ban of geoengineering patents altogether.[4]

¶3 This Article explores the patenting of geoengineering inventions and its potential impact. To place this issue in its appropriate context, Section II reviews the current and future state of the global climate and discusses the basics of geoengineering. Section III explores the current trends in geoengineering patents. Section IV reviews methods used previously to ameliorate problems with the patent system. Finally, Section V proposes an approach to address the concerns raised by geoengineering patents.

II. UNAVOIDABLE AND LONG-LASTING CLIMATE CHANGE WILL NECESSITATE CONSIDERATION FOR CLIMATE ENGINEERING

¶4 Dangerous climate change is unavoidable. Structural barriers will prevent a quick reduction in greenhouse emissions. The resulting delay will ensure that warming will have severe consequences. Even worse, the long lifespan of atmospheric carbon will keep

[1] Todd Sanford et al., *The Climate Policy Narrative for a Dangerously Warming World*, 4 NATURE CLIMATE CHANGE 164, 164 (2014). Present emissions exceed the Fifth Assessment Report's highest Representative Concentration Pathway, in which total emissions exceed the 2°C budget by mid-century. *Id.* The 2°C rise had been the level at which avoiding dangerous climate change could be avoided, but many now believe that level should be set at 1.5°C. *Id.*

[2] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 472 (2013) [hereinafter IPCC].

[3] Daniel Cressey, *Cancelled Project Spurs Debate over Geoengineering Patents*, 485 NATURE 429, 429 (2012).

[4] Anne C. Mulkern, *Researcher: Ban Patents on Geoengineering Technology*, SCI. AM. (Apr. 18, 2012), http://www.scientificamerican.com/article/researcher-ban-patents-on-geoengineering-technology/.

the global temperature at its new level for a millennium. Mitigation alone cannot avert these consequences. As a result, we need to consider climate-engineering methods to reduce the level of carbon in the atmosphere to avoid a climate catastrophe.

A. *Significant Climate Change Is Becoming Unavoidable*

¶5 The global scientific community agrees that we must hold global warming below 2°C to avoid "dangerous climate change."[5] This goal, however, is now "patently unrealistic."[6] Even more troubling, scientists now project the effects of a 2°C rise to be worse than anticipated, identifying such an increase as "dangerous" or "extremely dangerous" climate change.[7]

¶6 Indeed, the National Research Council (NRC) recently reported that the earth is warming so quickly that abrupt and unpredictable consequences are foreseeable in a few decades, or worse, maybe just a few years.[8] In its December 2013 report, the NRC analyzed the likelihood of "abrupt climate changes" occurring in the near future.[9] The report concluded that the effects of climate change have already begun,[10] and that more can be anticipated.[11] Furthermore, the risk of reaching various "tipping points"[12] has increased markedly.[13] Indeed, months later, two groups of scientists concluded that a large portion of the West Antarctic ice sheet has begun an irreversible collapse,[14] which will eventually raise global sea levels by several feet.[15]

B. *The Rise in the Planet's Temperature Will Continue and Last for Centuries*

¶7 Although we can already project that global temperatures will reach dangerous levels, we can also anticipate that, regardless of what steps we take now, warming will continue in the near term. Furthermore, global temperatures will remain at their new

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[5] Wil Burns, *Introduction: Climate Change Geoengineering*, 7 CARBON & CLIMATE L. REV. 87, 87 (2013) (internal citations omitted).

[6] *Id*. Indeed, a United Nations report notes that current emission trends and commitments project warming reaching 3.5°C to 5°C by 2100. WORLD BANK, TURN DOWN THE HEAT 1 (2013).

[7] Kevin Anderson & Alice Bows, *Beyond "Dangerous" Climate Change: Emission Scenarios for a New World*, 369 PHIL. TRANSACTIONS ROYAL SOC'Y A 20, 23 (2011).

[8] Tony Barboza, *Studies Warn of Abrupt Environmental Effects of Warming*, L.A. TIMES (Dec. 3, 2013), http://articles.latimes.com/2013/dec/03/local/la-me-climate-urgency-20131204 (citing NAT'L RESEARCH COUNCIL, ABRUPT IMPACTS OF CLIMATE CHANGE: ANTICIPATING SURPRISES (2013), *available at* http://www.nap.edu/catalog.php?record_id=18373).

[9] NAT'L RESEARCH COUNCIL, *supra* note 8, at 21. The report identifies "abrupt climate changes" as "abrupt changes in the physical climate system."*Id.* at 2.

[10] *Id*. at 3. These changes include the disappearance of late-summer Arctic sea ice and increases in extinction rates. *Id*.

[11] *Id*. at 14–17 (identifying the following as abrupt changes with a moderate likelihood of occurring this century: decrease in ocean oxygen, increase in heat waves, increase in precipitation events, and rapid changes in ecosystems and species habitats).

[12] "Tipping points" are thresholds beyond which major and rapid changes occur when crossed. *Id.* at vii.

[13] Barboza, *supra* note 8.

[14] Ian Joughlin, Benjamin E. Smith & Brooke Medley, *Marine Ice Sheet Collapse Potentially Under Way for the Thwaites Glacier Basin, West Antarctica*, SCIENCE, May 16, 2014, at 735, 738.

[15] E. Rignot et al., *Widespread, Rapid Grounding Line Retreat of Pine Island, Thwaites, Smith, and Kohler Glaciers, West Antarctica, from 1992 to 2011*, 41 GEOPHYSICAL RES. LETTERS 3502, 3502 (2014).

levels for centuries. This will occur for a number of reasons, including both an inability to reduce emissions rapidly and the long atmospheric life of carbon.

¶8 As noted previously, current commitments to reduce greenhouse-gas emissions contemplate continued emissions.[16] Scientists have concluded, however, that the eventual increase in peak warming is equivalent to the increase in total emissions. For instance, an annual increase in cumulative CO_2 emissions of 0.5% will lead to a comparable increase in peak-committed warming of approximately 0.5%.[17] Consequently, if society delays reducing emissions for ten years, such a delay would cause peak warming to be 5% higher than it might have been otherwise.[18] A longer delay in emissions reductions will result in a commensurately higher peak warming.

¶9 Delays in emissions reductions will also render certain peak-warming targets unattainable. Assuming that society eventually achieves a zero-emissions rate (neither a net increase in carbon emissions nor a net extraction of atmospheric carbon), the total amount of emitted carbon determines the lowest peak warming.[19] As a result, by 2012, the 1.5°C peak-warming target became unachievable. The 2°C peak-warming target will become similarly unachievable by 2027.[20]

¶10 We can also anticipate that by the time we commit to reducing carbon emissions, our ability to do so will be limited. Historically, society has required fifty to sixty years to switch to a new energy source for half of global energy needs.[21] This delay results from the level of investment and infrastructural change that a transition to a new energy source requires.[22] Unfortunately, postponing this shift to renewables results in "carbon lock-in"—referring to the continued construction of fossil-fuel infrastructure. As society invests more in carbon infrastructure, fewer options to reduce emissions remain and the commitment to fossil fuels becomes more expensive to abandon.[23]

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[16] WORLD BANK, *supra* note 6, at 1.

[17] Myles R. Allen & Thomas F. Stocker, *Impact of Delay in Reducing Carbon Dioxide Emissions*, 4 NATURE CLIMATE CHANGE 23, 24 (2014). Allen and Stocker use an increase of 2% in their calculation. However, the mean annual increase of atmospheric carbon has averaged 0.57% since 2005. *See Annual Data: Atmospheric CO_2*, CO_2NOW.ORG, http://co2now.org/current-co2/co2-now/annual-co2.html (last visited Sept. 14, 2014). Accordingly, this Article uses 0.50% to better approximate the actual increase of atmospheric carbon.

[18] Allen & Stocker, *supra* note 17, at 24.

[19] Thomas F. Stockey, *The Closing Door of Climate Targets*, SCIENCE, Jan. 18, 2013, at 280, 281.

[20] *Id*.

[21] Vaclav Smil, *The Long Slow Rise of Solar and Wind*, SCI. AM., Jan. 2014, at 52, 54. For instance, the transition from wood to coal as the primary energy source took sixty years. *Id*. at 55. Subsequent transitions, however, have taken longer. Oil, after nearly ninety years of use, provides only 40% of world energy. Similarly, the transition from oil to natural gas is occurring at an even slower rate. *Id*. Indeed, natural gas has required fifty-five years to supply 25% of the world energy market. By comparison, oil required only forty years and coal required only thirty-five years. *Id*. at 56. The transition to renewable energy is proceeding even more slowly. After twenty years of subsidized development, "new" renewables (wind, solar, modern biofuels) provide less than 5% of global energy. *Id*. at 54–55.

[22] *Id*. at 56. Globally, the investment in energy infrastructure—including coal mines, oil wells, gas pipelines, refineries, and filling stations—is worth at least $20 trillion. *Id*. at 57. Furthermore, power plants have average lives of twenty-five to fifty years, and some have operational lives of up to 100 years. Consequently, only 2%–4% of existing sources require replacement in a given year. Gert Jan Kramer & Martin Haigh, *No Quick Switch to Low-Carbon Energy*, 462 NATURE 568, 568 (2009).

[23] UNITED NATIONS ENVIRONMENT PROGRAMME, THE EMISSIONS GAP REPORT 21 (2013).

¶11 Finally, delays in emissions cuts necessitate much larger reductions in future emissions.[24] Delay causes the atmospheric CO_2 to peak higher and later, which requires much sharper cuts to attain a particular level.[25] Unfortunately, economic models indicate that our ability to reduce emissions may not surpass 5% per year.[26] We can thus foresee that regardless of our future commitment to cut emissions, several structural barriers will limit the rate at which this reduction can occur.

¶12 Besides these structural barriers to reducing carbon emissions, scientists calculate that once we eliminate carbon emissions, planetary warming will continue for decades, with eventual global temperatures remaining at these new levels for centuries. Even with rapid mitigation of carbon emissions, radiative forcing will continue to increase for nearly ten years,[27] while the thermal inertia of the ocean will delay the full magnitude of warming. Initially, the ocean absorbs heat, but then it radiates this heat for hundreds of years.[28] Thus, taking into account these different factors, even after carbon emissions cease, the global temperature will continue to increase significantly,[29] and will then remain at its new level for what many believe to be at least 1,000 years.[30] In sum, merely *cutting* emissions will not suffice—a true solution requires *reducing* atmospheric carbon.[31]

C. Climate Engineering: What It Is and How It Can Help

¶13 The science underlying climate change demonstrates two key considerations. First, significant climate disruption is inevitable, regardless of future emission levels. Second, mitigation alone cannot return the planet to its preindustrial state. To avoid severe climate disruption, we will need to explore a broad range of options. One of these options is climate engineering.

¶14 Climate engineering[32] identifies a broad range of methods and technologies intended to alter the earth's climate system, counteracting climate change and the effects

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[24] Bryan K. Mignone et al., *Atmospheric Stabilization and the Timing of Carbon Mitigation*, 88 CLIMATIC CHANGE 251, 253 (2008).

[25] *Id*. at 255.

[26] *See* Stockey, *supra* note 19, at 281.

[27] *See* Detlef P. van Vuuren & Elke Stehfest, *If Climate Action Becomes Urgent: The Importance of Response Times for Various Climate Strategies*, 121 CLIMATIC CHANGE 473, 480 (2013).

[28] *See* JEFF GOODELL, HOW TO COOL THE PLANET 10 (2010).

[29] H. Damon Matthews & Ken Caldeira, *Stabilizing Climate Requires Near-Zero Emissions*, 35 GEOPHYSICAL RES. LETTERS 1, 1 (2008). The IPCC estimates that if the composition of the atmosphere were to be held constant, the global temperature would still rise by up to 0.9°C by the end of the 21st Century. IPCC, *supra* note 2, at 822.

[30] *See* Susan Solomon et al., *Irreversible Climate Change Due to Carbon Dioxide Emissions*, 106 PROC. NAT'L ACAD. SCI. U.S. 1704, 1704 (2009).

[31] As one of the authors of the IPCC's Fifth Assessment Report describes the situation, "A large fraction of climate change is thus irreversible on a human timescale, except if net anthropogenic CO_2 emissions were strongly negative over a sustained period." Fred Pearce, *World Won't Cool Without Geoengineering, Warns Report*, NEW SCIENTIST (Sept. 25, 2013, 11:40 AM), http://www.newscientist.com/article/dn24261-world-wont-cool-without-geoengineering-warns-report.html#.U11Md1cvBfS.

[32] Numerous terms besides "climate engineering" have been used to refer to these efforts, including "geoengineering," which appears most frequently. Although "climate engineering" may more accurately describe the processes, here it will be used interchangeably with "geoengineering." BART GORDON, H.R. COMM. ON SCI. & TECH., 111TH CONG., ENGINEERING THE CLIMATE: RESEARCH NEEDS AND STRATEGIES FOR INTERNATIONAL COORDINATION 39 (2010).

thereof.[33] Geoengineering is set apart from other acts that alter planetary systems in two ways: it involves deliberate efforts and requires global cooperation.[34]

¶15 Climate engineering techniques fall into two broad categories.[35] The first, solar radiation management (SRM), would increase the reflection of sunlight to cool the planet.[36] The second, carbon dioxide removal (CDR), would remove CO_2 from the atmosphere.

¶16 SRM techniques reflect a small percentage of inbound light and heat from the sun back into space.[37] They cover a range of methods and costs; some are simplistic while others are technologically complex and potentially prohibitively expensive.[38] These techniques also vary as to the part of the environment they affect, such as the earth's surface, its atmosphere, or outer space. Surface-based techniques include painting roofs white, planting more reflective crops, and covering desert or ocean surfaces with reflective materials.[39] Atmospheric methods would increase the reflectivity of clouds (by adding sea salt or other materials to whiten clouds) or inject aerosol particles into the atmosphere. The latter would mimic the temporary global cooling following the ejection of sulfur particles from volcanoes.[40] A major advantage of some SRM techniques is that they may be the only means to reduce the global temperature almost immediately, should that become necessary to avert a climate emergency or to buy time to more fully implement mitigation procedures.[41]

¶17 In contrast to SRM, CDR removes CO_2 directly from the atmosphere. CDR techniques involve methods that store CO_2 in the ocean or ground. Ocean-based methods include ocean fertilization, which promotes the growth of carbon-consuming phytoplankton, and enhanced upwelling/downwelling, which alters ocean circulation to increase the availability of nutrients to enhance phytoplankton growth (upwelling) while accelerating the return of CO_2-concentrated surface water to the deep sea (downwelling).[42] Land-based techniques include direct air capture and sequestration, the use of biomass and sequestration, and afforestation.[43]

[33] IPCC, *supra* note 2, at 23, Annex I.

[34] *See* ROYAL SOC'Y, GEOENGINEERING THE CLIMATE: SCIENCE, GOVERNANCE AND UNCERTAINTY ix (2009).

[35] The Royal Society, the United Kingdom's national academy of sciences, produced a seminal analysis of geoengineering that utilized this distinction. *Id.* at 1. Subsequent reports, including those prepared by a House subcommittee, the National Regulatory Commission, the Government Accountability Office, and the IPCC, have followed this dichotomy. *See supra* notes 2, 8, 32, and *infra* note 40.

[36] IPCC, *supra* note 2, at 91.

[37] ROYAL SOC'Y, *supra* note 34, at 23.

[38] Space-based reflective mirrors, for instance, could require several decades and trillions of dollars to put into place. Roger Angel, *Feasibility of Cooling the Earth with a Cloud of Small Spacecraft near the Inner Lagrange Point (L1)*, 103 PROC. NAT'L ACAD. SCI. U.S. 17184, 17189 (2006).

[39] Peter J. Irvine, Andy Ridgwell, & Daniel J. Lunt, *Climatic Effects of Surface Albedo Geoengineering*, 116 J. GEOPHYSICAL RES. 2 (2011).

[40] U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-10-903, CLIMATE CHANGE: A COORDINATED STRATEGY COULD FOCUS FEDERAL GEOENGINEERING RESEARCH AND INFORM GOVERNANCE EFFORTS 10 (2010) [hereinafter GAO CLIMATE CHANGE REPORT]. Aerosol methods are modeled after the global cooling effect produced when volcanoes emit sulfur into the atmosphere. For instance, when Mount Pinatubo erupted in 1991, it cooled the globe by approximately 0.5°C in less than one year. David W. Keith, Edward Parson & M. Granger Morgan, *Research on Global Sun Block Needed Now*, 463 NATURE 426, 426 (2010).

[41] IPCC, *supra* note 2, at 91, 96.

[42] GAO CLIMATE CHANGE REPORT, *supra* note 40, at 7.

[43] *Id*. at 8. "Afforestation" refers to the establishment of trees on non-treed land. INTERGOVERNMENTAL

¶18 CDR removes CO_2 directly from the atmosphere by either increasing natural-carbon sinks or using chemical engineering to remove CO_2.[44] CDR can thus reverse planetary warming by reducing the atmosphere's CO_2 content. However, it requires the reduction of a significant fraction of CO_2 before it can alter the atmospheric balance. CDR may therefore require several decades to have a discernible effect on the environment. On the other hand, its ability to lower the CO_2 content of the atmosphere may become critical if significant mitigation efforts come too late to prevent CO_2 from reaching levels causing dangerous warming.[45] And in contrast to SRM methods, CDR involves fewer environmental risks. By removing CO_2 from the atmosphere, CDR simply returns the atmosphere to its preindustrial state. This differs from SRM, which, notwithstanding several possible adverse consequences, would only create an artificial and approximate balance between increased atmospheric-gas concentrations and sunlight levels.[46]

III. THE INFANCY OF CLIMATE-ENGINEERING RESEARCH AND THE IMPACT OF PATENTS ON FUTURE DEVELOPMENT

¶19 Concerted geoengineering research remains in its infancy. Nevertheless, the patenting of related inventions has grown substantially over the past five years. A number of these patents' characteristics, however, suggest that they might deter access to this technology, potentially stymieing future climate-engineering innovation.

A. Patent Law Basics

¶20 The power to award patents derives from the Constitution. Article I provides that, "Congress shall have Power . . . To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries."[47] Through the Patent Act of 1790, Congress established the first patent system for the United States.[48] Congress passed five subsequent Patent Acts.[49] The 2011 America Invents Act (AIA) was the first major

PANEL ON CLIMATE CHANGE, LAND USE, LAND-USE CHANGE AND FORESTRY (2000), *available at* http://www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=47.

[44] IPCC, *supra* note 2, at 9.

[45] For instance, in its emissions report, the United Nations Environment Programme (UNEP) calculates that scenarios with a "likely" chance of meeting the 2°C target have net negative total greenhouse emissions. To achieve this result, these scenarios assume utilization of carbon capture and storage, a CDR technology. UNITED NATIONS ENVIRONMENT PROGRAMME, THE EMISSIONS GAP REPORT 3 (2012).

[46] GAO CLIMATE CHANGE REPORT, *supra* note 40, at 4.

[47] U.S. CONST. art. I, § 8, cl. 8.

[48] Benjamin K. Sovacool, *Placing a Glove on the Invisible Hand: How Intellectual Property Rights May Impede Innovation in Energy Research and Development (R&D)*, 18 ALB. L.J. SCI. & TECH. 381, 385 (2008). Under the Patent Act, a board consisting of the Secretaries of State and War and the Attorney General would consider all patent applications. *Id*.

[49] Jesse S. Chui, *To What Extent Can Congress Change the Patent Right Without Effecting a Taking?*, 34 HASTINGS CONST. L.Q. 447, 448 (2007).

reform in patent law since 1952.[50] As discussed later, the AIA provides a process for prioritized examination of patent applications.[51]

¶21 An inventor commences the patent process by submitting an application to the United States Patent and Trademark Office (USPTO).[52] The USPTO assigns the application to an examiner who specializes in that field.[53] The examiner then searches previous patents and patent applications, referred to as "prior art," to determine if the new application involves a novel, useful, and nonobvious invention.[54] The application may proceed through several rounds of internal evaluation, interviews of the applicant, and possibly even appeals before the agency grants the patent.[55]

¶22 The patent application process can be both long and expensive. Processing an application often requires multiple years,[56] with an average pendency of 29.8 months.[57] Applicants typically spend tens of thousands of dollars on, among other things, attorneys' fees, pre-filing searches, drawing fees, and filing fees before receiving their patents.[58] Patents involving environment-oriented inventions tend to be more complicated, and consequently, usually require longer processing times and higher costs.[59]

¶23 The grant of a patent provides one primary benefit: the patent owner may exclude others from using the invention. Specifically, the patentee can exclude another from making, using, or selling any patented invention,[60] retaining this right for twenty years.[61] In exchange for this right, the patentee discloses her invention to the public in the manner required by statute.[62] The patentee may receive royalties by licensing the invention during the period of the patent.[63]

¶24 The patent system provides several other benefits. The exclusivity provided by patents grants monopoly powers, which foster innovation by enabling inventors to profit from their work.[64] For twenty years, inventors can choose to use their inventions, license them to others, or keep them off the market. This enables inventors to recover research

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[50] Caitlin E. Lanning, *Mapping Our Future: The Impact of Gene Patents on Scientific Research and Health Care in the United States*, 26 J.L. & HEALTH 375, 397 (2013).

[51] *Id.* at 401.

[52] 35 U.S.C. § 111(a)(1) (2012).

[53] Michael A. Carrier, *Post-Grant Opposition: A Proposal and a Comparison to the America Invents Act*, 45 U.C. DAVIS L. REV. 103, 106 (2011).

[54] *Id*.

[55] Gregory N. Mandel, *Promoting Environmental Innovation with Intellectual Property Innovation: A New Basis for Patent Rewards*, 24 TEMP. ENVTL. L. & TECH. J. 51, 61 (2005).

[56] *Patent Time Frame: How Long Does It Take to Get a Patent?,* UNIV. CAL. SANTA BARBARA OFFICE OF TECH. & INDUS. ALLIANCES, http://tia.ucsb.edu/faculty/information-resources/patent-basics/ (last visited Sept. 14, 2014).

[57] *Data Visualization Center*, USPTO, http://www.uspto.gov/dashboards/patents/main.dashxml (last visited July 28, 2013).

[58] *See* Emilie Winckel, *Hardly a Black-and-White Matter: Analyzing the Validity and Protection of Single-Color Trademarks Within the Fashion Industry*, 66 VAND. L. REV. 1015, 1018 n.13 (2013).

[59] Mandel, *supra* note 55, at 61.

[60] 35 U.S.C. § 271(a) (2012).

[61] 35 U.S.C. § 154(a)(2) (2012) (stating that the term of the patent lasts from the date on which the patent issues to twenty years after the date on which the inventor filed the application).

[62] 35 U.S.C. § 112(a) (2012).

[63] *See* Nicholas G. Smith, Medimmune v. Genentech*: A Game-Theoretic Analysis of the Supreme Court's Continued Assault on the Patentee*, 15 MARQ. INTELL. PROP. L. REV. 503, 516 (2011).

[64] Scott Taylor, *Where Are the Green Machines?: Using the Patent System to Encourage Green Invention and Technology Transfer*, 23 GEO. INT'L ENVTL. L. REV. 577, 583 (2011).

and development costs and prevents free riding.[65] It also provides inventors with several competitive advantages, especially the ability to attract venture capital and the opportunity to develop related products.[66] And importantly, this system promotes full disclosure of inventions. Early disclosure avoids the wasting of resources in unnecessary experimentation[67] and facilitates the development of successive inventions, thereby fostering technological advancement.[68]

¶25 Despite these benefits, the patent system imposes various costs. For instance, the effective monopoly power provided to inventors raises the invention's price, thus decreasing its overall availability to society during the patent period.[69] In addition, multiple inventors may waste resources by duplicating inventions that have limited availability.[70] Among others, these costs must be weighed against the likely benefits of any potential modification of the patent system.

B. Dramatic Increase in Climate-Engineering Patents and Recent Issues

¶26 Despite the relative infancy of climate-engineering technologies, various entities are currently confronting issues that will drastically influence their development. The USPTO has already received hundreds of applications for patents on these technologies. Furthermore, the number of geoengineering patents granted by the agency has risen dramatically. But a review of these patents illustrates several disturbing trends—specifically, how the breadth of some of these patents could block future developments. Moreover, original inventors are reassigning these patents at an alarming pace, concentrating these patents in the hands of a limited number of patent holders.

¶27 This author directed a review of USPTO records to determine trends in applications for and granting of patents involving climate-engineering technologies. The review searched the USPTO database using words describing the most common SRM and CDR methods.[71] The review included only patents related to one of these two categories, excluding patents pertaining to short-term weather modification. As described below, this review focused on both patent applications[72] and patents awarded.

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[65] Niels J. Melius, *Trolling for Standards: How Courts and the Administrative State Can Help Deter Patent Holdup and Promote Innovation*, 15 VAND. J. ENT. & TECH. L. 161, 169 (2012).

[66] Sarah Tran, *Prioritizing Innovation*, 30 WIS. INT'L L.J. 499, 520 (2012).

[67] *Cf.* Michael S. Mireles, *An Examination of Patents, Licensing, Research Tools, and the Tragedy of the Anticommons in Biotechnology Innovation*, 38 U. MICH. J.L. REFORM 141, 153 (2004).

[68] *See* Taylor, *supra* note 64, at 583. Commentators recognize an additional benefit known as the "prospect theory." This refers to the notion that the patent holder can encourage successive inventors to share information and avoid duplicative research. Mireles, *supra* note 67, at 155.

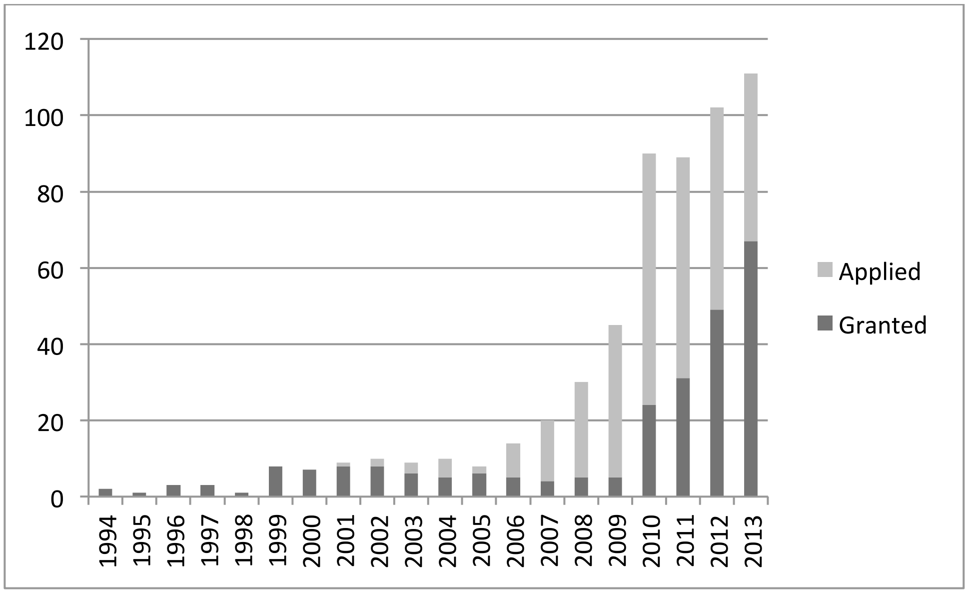
[69] MICHELE BOLDRIN & DAVID K. LEVINE, THE CASE AGAINST PATENTS 5–6 (2012).

[70] *See* Joseph A. Yosick, *Compulsory Patent Licensing for Efficient Use of Inventions*, 2001 U. ILL. L. REV. 1275, 1292 (2001).

[71] Search results on file with author [hereinafter Geoengineering Patent Search]. The search used a number of terms associated with climate engineering, including "aerosols," "albedo," "biochar," "carbon," "capture," "climate," "cloud," "geoengineering," "global warming," "inject," "phytoplankton," "pyrolysis," "radiation," "sequestration," "solar," "storage," and "stratospheric." Then, the search results were reviewed for relevance.

[72] In this discussion, "applications" refers to applications submitted to the USPTO but not yet granted. The USPTO, however, does not report information regarding patent applications received before 2001. *See* *Finding Pre-2001 Applied Not Granted Applications*, STACKEXCHANGE, http://patents.stackexchange.com/questions/3368/finding-pre-2001-applied-not-granted-applications (last visited Sept. 14, 2014). Accordingly, this discussion does not incorporate application data from before that year.

¶28 The number of climate-engineering patent applications and patents granted has risen dramatically over the past five years. The following chart reflects the number of geoengineering applications and patents since 1994:



¶29 As the chart demonstrates, before 2008, the combined number of patent applications and patents granted for geoengineering technologies did not exceed twenty in a single year. However, the total exceeded forty in 2009, and eventually increased to more than one hundred in 2013. Moreover, the rate at which the USPTO has granted these patents has similarly increased. For instance, the USPTO never granted more than ten such patents annually before 2010. Four years later, the annual number of geoengineering patents granted increased nearly tenfold. In sum, both the number of patents granted and applications filed illustrate startling growth over the past four years.[73]

¶30 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.[74] Particle-dispersion (4%) and solar-ray-reflection (2%) patents

[73] A recently published review of climate-engineering patents found both similar and inconsistent results to those found in our Geoengineering Patent Search. *See* Oldham et al., *Mapping the Landscape of Climate Engineering*, 372 PHIL. TRANSACTIONS ROYAL SOC'Y A, Nov. 17, 2014, at 1–20, *available at* http://rsta.royalsocietypublishing.org/content/372/2031/20140065. They used fewer search terms, but they performed their search over more databases (those of the USPTO, the European Patent Office, and the Patent Cooperation Treaty). *Id*. at 3–4. They found that geoengineering patents peaked in 2007, but they acknowledge that this may reflect a lack of data availability in some databases for recent years. *Id*. at 11. These results conflict with their own findings regarding publications concerning geoengineering, which they found "accelerated" after the publication of a seminal article by Paul Crutzen in 2006. *Id*. at 5 (citing Paul J. Crutzen, *Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?*, 77 CLIMATIC CHANGE 211, 211–12 (2006)); *see infra* note 89 (discussing the impact of the Crutzen article).

[74] Geoengineering Patent Search, *supra* note 71. Some patents, which this author categorized as carbon sequestration, clearly identified inventions that involved burial, application, or use of captured carbon. Other patents identified inventions that both captured carbon from a source and *then* provided for its sequestration, which this author treated as carbon-capture patents. *See id*.

commonly recur, with patents involving other various methods making up the difference (3%).[75]

¶31 A review of these patents further reveals that many of these inventions are assigned to only a few patent holders. Consequently, the future development of these technologies is concentrated in the hands of a few.[76] Only three inventors (or groups of inventors) are credited with inventing five or more climate-engineering patents.[77] Combined, these parties have invented twenty-five (10%) of the patented technologies. However, many geoengineering patents have been assigned to other parties, with 200 original patent holders transferring ownership to 122 assignees.[78] Eight of these assignees received five or more patents. In total, these eight large patent holders were assigned fifty-six (23%) recent geoengineering patents.[79] And of these fifty-six assignments, only eight were transferred to a non-corporate entity—the U.S. Department of Energy.

¶32 Although these assignments have resulted in concentrated ownership, they remain spread across a number of different industries. A review of some of the largest patent holders and the industries in which they operate shows the following industry distribution for holders of 110 of these patents:

Renewable Energy	35
Universities	29
Manufacturing	13
Government	13
Oil	12
Chemical	8

¶33 Additionally, a characteristic that typifies many of these patents is the breadth of their terms. For example, Patent 6,056,919 states:

> A method of sequestering carbon dioxide in a deep open ocean comprising the following steps:
>
> > (1) testing an area of the surface of a deep open ocean, in order to confirm that at least a first nutrient is missing to a significant extent from said area, and to identify said first missing nutrient, and

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[75] *Id*. The findings of the Oldham et al. search corroborated these general patterns. In their search, they found that approximately 80% of geoengineering patents involved CDR. Oldham et al., *supra* note 73, at 11.

[76] Common ownership of patents provides a useful indication of patent concentration, but more meaningful approaches may be available. Daniel R. Cahoy notes that just counting patents fails to account for the importance of foundational patents or integrated patent portfolios. No standard methodology exists, however, for such analysis. Daniel R. Cahoy, *Inverse Enclosure: Abdicating the Green Technology Landscape*, 49 AM. BUS. L.J. 805, 846–47 (2012).

[77] Geoengineering Patent Search, *supra* note 71; *see* Oldham et al., *supra* note 73, at 14 (finding geoengineering patents to be held by small networks of inventors associated with particular companies and also by a number of individuals).

[78] Geoengineering Patent Search, *supra* note 71.

[79] Another eight patents were assigned equally between Schlumberger Technology Corporation's Massachusetts and Texas affiliates. If they are treated as one entity, then nine parties control sixty-four (26%) of the patents. Geoengineering Patent Search, *supra* note 71.

> (2) applying to said area a first fertilizer which comprises said first missing nutrient, to fertilize said area with an appropriate amount of said first missing nutrient whereby carbon dioxide is sequestered,
>
> (3) limiting zooplankton and fish growth in said area by applying said first fertilizer in pulses; and
>
> (4) measuring the amount of sequestered carbon dioxide that results from said fertilization of said area.[80]

Conceivably, the terms of this patent are broad enough to cover numerous processes.[81] For instance, the patent claim does not identify the applicable testing procedures, the extent of the area to be tested, the sought-after nutrients, the type of "fertilizer" used, or the "pulses" that the procedure contemplates for applying the "fertilizer." In fact, such a broadly stated patent encompasses most ocean-fertilization methods while excluding few. Similarly, granted in 2013, Patent 8,603,424 states in part:

> Before the invention is described in greater detail, it is to be understood that the invention is not limited to particular embodiments described herein as such embodiments may vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting, since the scope of the invention will be limited only by the appended claims.[82]

Thus, the USPTO granted a patent which by its own language specifically rejects any limitations upon its terms. Discussed *infra*, overly broad patents create myriad issues.

¶34 A review of these patents also highlights the delay inherent to the application process. On average, the USPTO has required nearly thirty-two months to approve a climate-engineering patent.[83] However, this average masks a wide range in processing time. On the short end, the USPTO has awarded a patent within six months of the application's receipt.[84] At the other extreme, the USPTO has required more than eighty months on two separate occasions.[85]

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[80] U.S. Patent No. 6,056,919 (filed May 4, 1999).

[81] *See* Shobita Parthasarathy et al., *A Public Good? Geoengineering and Intellectual Property* 5 (Sci. Tech. & Pub. Policy Program, Working Paper No. 10-1, 2010), *available at* http://www.umt.edu/ethics/ethicsgeoengineering/Workshop/articles1/Chris%20Avery.pdf.

[82] U.S. Patent No. 8,603,424 (filed Oct. 11, 2012); *see also* Oldham et al., *supra* note 73, at 10 (noting that geoengineering-patent claims "are often deliberately constructed in a broad way . . . to capture the maximum range of possible uses of a claimed invention").

[83] Geoengineering Patent Search, *supra* note 71.

[84] The inventor submitted his application (for using satellites to reflect solar energy to modify the earth's atmosphere) on October 8, 1999, and the USPTO granted it as Patent 6,045,089 on April 4, 2000. U.S. Patent No. 6,045,089 (filed Oct. 8, 1999).

[85] In the first instance, the inventors submitted their application (for a lime-based sorbent to capture CO_2) on November 14, 2003, and the USPTO granted it as Patent 7,879,139 on February 1, 2011. U.S. Patent No. 7,879,139 (filed Nov. 14, 2003). In the second case, the inventor submitted his application (for a process for removing CO_2 from gaseous streams) on March 4, 2004, and the USPTO granted it as Patent 7,901,487 on March 8, 2011. U.S. Patent No. 7,901,487 (filed Mar. 4, 2004).

C. The Current Patent System Exacerbates Geoengineering-Patent Issues

¶35 As the number of climate-engineering patents has accelerated, the risk that they will impede access and future innovation has similarly increased. The granting of a large number of broad, fundamental patents can create substantial barriers to subsequent innovators.

¶36 While the number of patent applications and granted patents has increased significantly in recent years,[86] the corresponding rate of increase for geoengineering patents has risen even more drastically. Indeed, climate engineering appears to be undergoing a "patent land-grab." This occurs when a lack of clarity in 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.[87] 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. Indeed, geoengineering is one of the few new fields (along with nanotechnology) in nearly a century to experience substantial patenting at the outset.[88]

¶37 In light of the early stage of climate-engineering research, this patent land-grab is particularly pernicious. First, knowledge about geoengineering is in its infancy. Scientists have contemplated climate engineering as a response to climate change for less than one decade.[89] Unsurprisingly, significant research into these methods has yet to commence.[90] Second, and in part because of the novelty inherent to this technology, a number of climate-engineering patents are poorly defined or overly broad.[91] Consequently, holders of some of these early geoengineering patents may control broad swaths of these methods. This is normally a cause for concern because of the immense control patent holders have over future inventions.[92] Here, this disparity is especially troublesome

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[86] *U.S. Patent Statistics Summary Table, Calendar Years 1963 to 2012*, USPTO, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm (last modified July 24, 2014, 6:22 PM).

[87] Brian H. Lawrence, *Clarifying Patent Law's Role in Financial Service: Time to Settle the "Bill"ski?*, 22 FED. CIR. B.J. 319, 341 n.180 (2012).

[88] Mark A. Lemley, *Patenting Nanotechnology*, 58 STAN. L. REV. 601, 606 (2005). Professor Lemley notes that the building blocks of several recent industries, such as computer hardware, software, the Internet, and biotechnology, were "either unpatented, through mistake or because they were created by government or university scientists with no interest in patents, or the patents presented no obstacle because the government compelled licensing of the patents, or they were ultimately invalidated." *Id*. In other fields, including lasers, semiconductors, and polymer chemistry, "basic building-block patents did issue, but they were delayed so long in interference proceedings that the industry developed in the absence of enforceable patents." *Id*. at 606–07.

[89] *See* Wylie A. Carr et al., *Public Engagement on Solar Radiation Management and Why It Needs to Happen Now*, 121 CLIMATIC CHANGE 567, 568 (2013). Although the concept of intentionally altering the climate had been discussed previously, a 2006 article by Paul J. Crutzen, a Nobel Laureate, is credited with triggering serious consideration of climate engineering as a response to climate change. *Id.*; *see* Crutzen, *supra* note 73, at 211–12.

[90] *See* Anthony E. Chavez, *A Napoleonic Approach to Climate Change: The Geoengineering Branch*, 5 WASH. & LEE J. CLIMATE & ENV'T 93, 123 (2014).

[91] Parthasarathy et al., *supra* note 81, at 5.

[92] *See* 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, 561–62 (2012).

because it both deters future innovation and bestows control over technology with potentially immeasurable societal value to only a few.[93]

¶38 The timing of patent land-grabs also creates unique problems. By their nature, land grabs occur early in the development of a field. Because of this, applications often seek building-block patents, which cover fundamental products and processes. Building-block patents are therefore distinct "from incremental improvement patents, which have a much narrower claim scope."[94]

¶39 Awarding building-block patents, especially early in an industry's development, can frustrate the field's growth. Patents for building-block technologies do not always possess any marketable value of their own, but the inventions they cover can be crucial to downstream development. Thus, patenting these inventions can slow industry innovation.[95] Moreover, overly broad patents exacerbate this problem. Broad patents commonly arise at the confluence of several circumstances: a field is novel, standardized terminology has not developed, patent examiners lack experience with and expertise in the new technology, and applicants seek "to capture the largest possible grant of IP protection with the claims of a single patent, leading applicants to draft claims that reach too far."[96] As discussed previously, geoengineering patents share most of these characteristics.

¶40 Making these adverse effects worse, the patent review process is inherently biased, favoring approval of broad, building-block patents. When applications in new industries are involved, an examiner may not be able to find an embodiment of the claimed invention in prior art. In such circumstances, USPTO policy requires that the claim be allowed, even if stated broadly.[97] This is the case even where the examiner believes, but cannot establish, that the claim exceeds the area actually explored.[98]

¶41 Broad initial patents can lock up technologies or retard development in a number of ways.[99] Overly broad patents prevent potential subsequent inventors from developing new inventions derived from the original patent.[100] Furthermore, they allow patent holders to deny licenses, charge exorbitant royalties, or engage in delaying tactics, most notably litigation.[101] A related issue surfaces when patents are so broad that they overlap. This widespread distribution of broad, overlapping patents causes various problems, such as those stemming from "patent thickets" or "anticommons."[102]

[93] *See* Cressey, *supra* note 3.

[94] John C. Miller & Drew L. Harris, *The Carbon Nanotube Patent Landscape*, 3 NANOTECHNOLOGY L. & BUS. 427, 435 (2006).

[95] *See* Stiles, *supra* note 92, at 561–62.

[96] *Id*. at 563.

[97] *See* Amit Makker, *The Nanotechnology Patent Thicket and the Path to Commercialization*, 84 S. CAL. L. REV. 1163, 1182 (2011).

[98] *Id.*

[99] *See* Lemley, *supra* note 88, at 618–19.

[100] *See* Samuel Reger, *It's Not So Obvious: How the Manifestly Evident Standard Affects Litigation Costs by Reducing the Need for Claim Construction*, 1 TEX. A&M L. REV. 729, 732 (2014).

[101] *See* Nikola L. Datzov, *The Machine-or-Transformation Patentability Test: The Reinvention of Innovation*, 33 HAMLINE L. REV. 281, 292 (2010) (explaining that innovators may avoid the market because of fears of litigation).

[102] Lemley, *supra* note 88, at 620.

¶42 A patent thicket arises when patent rights extend more broadly than the actual products claimed in a given field.[103] A "dense web of overlapping intellectual property rights" develops,[104] and the resulting thicket "choke[s] out an industry."[105] A geoengineering patent thicket may be especially dense because geoengineering end-products likely incorporate components from many different patentable inventions. For instance, an aerosol method might involve patents for the specific method (e.g., balloons, hoses, etc.), the materials,[106] the aerosol injector, and other aspects. Thus, each facet may require different inventions patented by different inventors, further complicating the thicket.[107]

¶43 A patent thicket can impede invention in a number of ways. Specifically, it usually requires an inventor to incur additional costs to avoid infringement. While all hopeful inventors must research whether their inventions infringe upon existing patents, and if so, negotiate licenses[108]—the attendant costs of this process drastically increase when numerous overlapping patents are involved.[109] In this context, patents impede rather than promote innovation.[110]

¶44 A related problem is that of a patent anticommons. The "tragedy of the anticommons" is the mirror image of its better-known cousin.[111] The problem of a commons arises when too few exclusionary property rights result in exhaustion of a resource.[112] In the alternative, an anticommons occurs when too many persons have been awarded exclusionary rights, causing a resource not to be fully utilized.[113] Thus, the anticommons involves "fragmented property rights, the aggregation of which is necessary to make effective use of the property."[114] But the rights are not just fragmented; they are

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[103] Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1614 (2003).

[104] Dana Beldiman, *Patent Choke Points in the Influenza-Related Medicines Industry: Can Patent Pools Provide Balanced Access?*, 15 TUL. J. TECH. & INTELL. PROP. 31, 46 (2012) (footnote omitted) (internal quotation marks omitted).

[105] Burk & Lemley, *supra* note 103, at 1627.

[106] Although the material commonly mentioned is sulfur, scientists are exploring alternative materials, such as titanium dioxide, which has high reflectivity, well-researched safety, and significant availability. Peter Davidson, Chris Burgoyne, Hugh Hunt & Matt Causier, *Lifting Options for Stratospheric Aerosol Geoengineering: Advantages of Tethered Balloon Systems*, 370 PHIL. TRANSACTIONS ROYAL SOC'Y A 4263, 4266 (2012).

[107] Burk & Lemley, *supra* note 103, at 1628 (discussing patent thickets and the semiconductor industry). Burk and Lemley and others point to semiconductors as an example of an end-product consisting of different components covered by overlapping patents. They also involve cumulative technologies. For semiconductors, cross licensing avoids patent interference. By contrast, in the chemical and pharmaceutical industries, cross licensing primarily enables the exchange of technologies. DAVID J. TEECE, ESSAYS IN TECHNOLOGY MANAGEMENT AND POLICY: SELECTED PAPERS OF DAVID J. TEECE 206 (2003).

[108] Makker, *supra* note 97, at 1175.

[109] *See* Stiles, *supra* note 92, at 559 (noting that overlapping building-block patents have deterred many prospective inventors from proceeding with innovation plans).

[110] *See* Burk & Lemley, *supra* note 103, at 1629.

[111] D. Theodore Rave, *Governing the Anticommons in Aggregate Litigation*, 66 VAND. L. REV. 1183, 1190 (2013).

[112] *See* Harry First, *Controlling the Intellectual Property Grab: Protect Innovation, Not Innovators*, 38 RUTGERS L.J. 365, 382–83 (2007).

[113] *Id*. at 382; Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, SCIENCE, May 1, 1998, at 698.

[114] Burk & Lemley, *supra* note 103, at 1611.

dispersed among multiple owners. "Once an anticommons emerges, collecting rights into usable private property is often brutal and slow."[115]

¶45 Because of the diffusion of these rights, downstream inventors need to incur greater costs to acquire licenses. These costs will include higher search fees, and more time and money spent negotiating license fees.[116] Furthermore, because innovators typically cannot know in advance which rights will become necessary to produce their inventions, they often must acquire more licenses than they actually need.[117] Such expenses essentially serve as a tax on further innovation.[118] Consequently, in contrast to a commons problem, the anticommons results in the underutilization of the property.[119] Specifically, innovators are unable or unwilling (because of costs) to assemble the assorted inventions to produce an innovative product.

¶46 Thickets and anticommons are similar yet distinct. Thickets involve horizontally overlapping patents.[120] Anticommons arise either horizontally with "different companies hold[ing] rights at the same level of distribution," or vertically with the final product combining upstream and downstream components.[121] Unlike a thicket, which results from the distribution of broad patent rights, an anticommons requires the aggregation of a multiplicity of patents controlled by numerous owners.[122] Both, however, derive from the excessive granting of patent rights. Moreover, an industry can suffer from both problems concurrently.[123]

¶47 One last issue foretells problems for geoengineering innovation: delays in processing patent applications. Timing, both at the beginning and end of the patent system, can impair the development of geoengineering inventions. Delays in processing patent applications slow the rate of innovation.[124] On average, patent applications require more than two years to process, extending up to six years in many instances.[125] The USPTO has required an even longer period to grant geoengineering patents.[126] Since the twenty-year exclusion period usually commences upon the filing of the patent

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[115] Heller & Eisenberg, *supra* note 113, at 698. In *eBay Inc. v. MercExchange L.L.C.*, the Supreme Court held that a plaintiff in a patent enforcement action must establish that monetary damages would not be adequate to compensate for its injury before receiving the relief of a permanent injunction. 547 U.S. 388, 391–92 (2006). Nevertheless, decisions of the Federal Circuit may limit the ability of this decision to prevent patent holdups. DAN L. BURK & MARK A. LEMLEY, THE PATENT CRISIS AND HOW THE COURTS CAN SOLVE IT 30 (2009) (noting that a Federal Circuit decision allowing patentees to obtain up to fifty-times actual damages may effectively serve as an injunction).

[116] *See* Heller & Eisenberg, *supra* note 113, at 700.

[117] *See* First, *supra* note 112, at 382.

[118] *Id*. This assumes that these negotiations proceed relatively smoothly. In some instances, patent owners refuse to license their inventions, *id*., or become holdouts, agreeing to license only if they receive excessive licenses. Burk & Lemley, *supra* note 103, at 1611.

[119] Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting*, 1 INNOVATION POL'Y & ECON. 119, 124 (2000).

[120] Burk & Lemley, *supra* note 103, at 1614.

[121] *Id*. at 1612–13.

[122] *See id*. at 1613.

[123] *See* Beldiman, *supra* note 104, at 47 (noting the presence of both thickets and anticommons in the influenza-related medicines market).

[124] "Patent backlogs hinder the deployment of innovation and have clear adverse effects on the global economy." *USPTO and UKIPO Announce Action Plan to Reduce Global Patent Backlogs*, USPTO (Mar. 10, 2010), http://www.uspto.gov/news/pr/2010/10_09.jsp.

[125] *See Patent Time Frame: How Long Does It Take to Get a Patent?*, *supra* note 56.

[126] *See* Winckel, *supra* note 58, at 1018 n.13.

application, a processing delay reduces both the value of the patent to the inventor and the availability of the invention to innovators.[127]

¶48 At the back end, the twenty-year exclusion period also impedes the development of climate-engineering inventions. Climate-engineering systems remain in their infancy, with scientists having conducted only limited research on these methods.[128] Consequently, most methods will likely require a decade or more of computer analysis and field-testing before they are ready for implementation.[129] Limiting access to geoengineering technologies only further delays the development of the underlying methodologies.[130]

IV. Several Approaches Might Help Reduce the Problems Caused by the Patenting of Geoengineering Inventions

¶49 Despite the various issues arising from the patenting of climate-engineering inventions, several possible solutions—or combinations of solutions—can help minimize these concerns. This section reviews and analyzes prior approaches and considers their appropriateness for climate-engineering patents. Before exploring these strategies, however, this section identifies some aspects of geoengineering that policymakers must consider when modifying the patent system to address these inventions.

A. Several Considerations Apply Uniquely to Geoengineering Patents

¶50 While geoengineering patents are new, many of the aforementioned issues are anything but. Previous problems inspire solutions that are useful here, but no single approach provides a perfect or complete answer. Thus, to best place these approaches in their appropriate context, proper analysis must begin with the considerations that apply uniquely to climate-engineering patents.

¶51 First, time is essential. With the planet's climate approaching a tipping point,[131] and the vast amount of time required to develop and implement geoengineering methods,[132] one could argue that humankind is already out of time. Certainly, any further delay will make research, development, and implementation even more urgent.

¶52 Second, the eventual end-user is likely to be a governmental body, such as the U.S. government or a similar multinational entity.[133] This has several implications for the

[127] *See* Tran, *supra* note 66, at 520.

[128] Royal Soc'y, *supra* note 34, at 52.

[129] *See* Timothy A. Fox & Lee Chapman, *Review: Engineering Geo-Engineering*, 18 Meteorological Applications 1, 6 (2011).

[130] *See* Joshua D. Sarnoff, *The Patent System and Climate Change*, 16 Va. J.L. & Tech. 301, 338 (2011) (noting that patent protection may delay climate-change-related discoveries and their development).

[131] Based upon the IPCC's Fifth Assessment Report, a tipping point may be only twenty-five years away. Barboza, *supra* note 8. Holding global warming to an increase of less than 2°C, on the other hand, may soon be impossible within half of that time. Stockey, *supra* note 19, at 281.

[132] *See* Fox & Chapman, *supra* note 129, at 6.

[133] Because of the global consequences of implementing geoengineering, we can anticipate that international agreements will eventually govern its implementation, if not also its testing. Kelsi Bracmort & Richard K. Lattanzio, Geoengineering: Governance and Technology Policy 29 (2013). Moreover, such agreements are likely to impose moratoriums on implementation absent international consent. For instance, the parties to the Convention on Biological Diversity have already imposed such a moratorium. Chavez, *supra* note 90, at 146–47. Thus, because of these considerations, the "consumer" of

patent system. For instance, if necessary, the U.S. government will be more likely to use whatever means required to break any patent logjams, which it has done previously, most notably during World War I.[134] Active governmental involvement is foreseeable if patent holders unreasonably withhold access to essential patents. Additionally, with a government as the primary consumer, regular market forces will exercise less force.

¶53 In sum, geoengineering is in its infancy. Most of these methods are still at the conceptual or research stages,[135] and few field-tests have been proposed.[136] The development of new methods, the involvement of new players, and the invention of new devices are likely to cause drastic change in the geoengineering field. Accordingly, flexibility will be an important component of any application review process.

B. *The USPTO Can Reduce the Number or Limit the Scope of Climate-Engineering Patents Already Granted*

¶54 Patent thickets and anticommons both result from over-patenting. The USPTO has several tools at its disposal to address these problems. For instance, it can limit the number or scope of certain patents or simply block overly broad patent applications. At the extreme end of the spectrum, the USPTO could independently deny all climate-engineering patent applications, or alternatively, Congress could prohibit the patenting of these inventions, both achieving the same result. And concerning patents already awarded, the USPTO can exercise its reexamination power, possibly limiting or revoking such patents where appropriate. Nevertheless, as an industry develops, one assumes the USPTO imposes stricter standards, perhaps even limiting the number of patents annually awarded in a newly established field.[137] If recent trends are indicative,[138] however, the USPTO's permissive practices might endure longer than expected.

¶55 Alternatively, Congress could force a resolution by prohibiting patents of climate-engineering inventions. While this approach might seem drastic, the U.S. government has taken similar measures before to protect the public interest. For instance, federal law currently prohibits patents for inventions relating to national security[139] or atomic energy.[140] Pursuant to these statutes, if the Commissioner of Patents concludes that an

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climate-engineering products will likely be an intergovernmental agency. *See also* Paul Nightingale & Rose Cairns, *The Security Implications of Geoengineering: Blame, Imposed Agreement and the Security of Critical Infrastructure* 9–10 (CGG Working Papers, Paper No. 18, 2014), *available at* http://www.climate-engineering.eu/single/items/nightingale-paul-cairns-rose-c-2014-the-security-implications-of-geoengineering-blame-imposed-agreement-and-the-security-of-crit.html (arguing that, because of security concerns, SRM technologies would likely be operated by the military).

[134] *See* Mfrs. Aircraft Ass'n, Inc. v. United States, 77 Ct. Cl. 481, 488 (Ct. Cl. 1933) (noting that the U.S. government threatened to condemn aviation patents to facilitate airplane manufacturing).

[135] BRACMORT & LATTANZIO, *supra* note 133, at i.

[136] The recent Stratospheric Particle Injection for Climate Engineering (SPICE) Project was "one of the first large SRM research projects anywhere in the world, and the first to propose an outdoor experiment." Jack Stilgoe, Matthew Watson & Kirsty Kuo, *Public Engagement with Biotechnologies Offers Lessons for the Governance of Geoengineering Research and Beyond*, PLOS BIOLOGY, Nov. 2013, at 1, 2. The experimenters cancelled the field-test over a patent dispute. Cressey, *supra* note 3, at 429.

[137] *See* Burk & Lemley, *supra* note 103, at 1613.

[138] *See U.S. Patent Statistics Chart, Calendar Years 1963–2012*, USPTO, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm (last visited Sept. 14, 2014).

[139] 35 U.S.C. § 181 (2012).

[140] 42 U.S.C. § 2181 (2012).

application might involve such technologies, then she must submit the application to the appropriate agency for review.[141] If the agency concludes that the application implicates these concerns, then the USPTO withholds the patent.[142] The applicant, however, is entitled to reasonable compensation,[143] determined by the Patent Compensation Board.[144] The Atomic Energy Act similarly bars patents for inventions that are "useful solely in the utilization of special nuclear material or atomic energy in an atomic weapon."[145]

¶56 Climate change has national security implications.[146] Because of the risks inherent in several geoengineering methods,[147] many are unlikely to be used *except* in the event of a climate emergency. Thus, premising a reduction or even prohibition of climate-engineering patents upon national security concerns could be justified. Furthermore, by definition, a prohibition on such patents would prevent the problems of thickets and anticommons from worsening, and remove barriers to future inventions.[148]

¶57 Nevertheless, the disadvantages of such a ban outweigh its benefits. The outright prohibition of patents and their corresponding exclusivity rights would likely discourage research and investment in a fledgling field.[149] And given that these inventions will likely have geoengineering and non-geoengineering uses,[150] an inventor may circumvent this limitation by seeking patent protection for its other uses, while keeping silent about the climate-engineering aspects of the invention. Furthermore, prohibiting or denying patents for future inventions will not resolve the problems associated with current patents, specifically the difficulty of identifying and tracking geoengineering inventions and securing rights to the use thereof.

¶58 Congress adopted a slightly different approach for inventions related to the space program. Inventions pertaining to space activities developed during employment or under contract for the U.S. government became the exclusive property of the United States,[151] ensuring that such inventions were available for this national purpose. Climate

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[141] *See* 35 U.S.C. § 181. Specifically, the Commissioner shall provide the patent to the Atomic Energy Commission, the Secretary of Defense, and the chief officer of any other department or agency designated by the President as a defense agency of the United States. *Id*.

[142] S. Scott Pershern, *Taking Inventors' Lunch Money: Provide Incentives for Sensitive Technology Research Under the Patriot Act*, 29 HOUS. J. INT'L L. 697, 702 (2007).

[143] 35 U.S.C. § 183 (2012).

[144] 42 U.S.C. § 2187.

[145] 42 U.S.C. § 2181(a).

[146] *See* CNA CORP., NATIONAL SECURITY AND THE THREAT OF CLIMATE CHANGE 6 (2007). Among these concerns are food and water security, famine and food scarcity, health security, disruptive migration events, political instability, and international conflict. NAT'L RESEARCH COUNCIL, ABRUPT IMPACTS OF CLIMATE CHANGE: ANTICIPATING SURPRISES 146 (2013).

[147] For instance, most aerosol-based SRM methods would alter the globe's precipitation patterns. John Latham et al., *Marine Cloud Brightening*, 370 PHIL. TRANSACTIONS ROYAL SOC'Y A 4217, 4223 (2012). If SRM does cool the planet, the system could be turned off but only at a price—scientists have determined that the climate would return to its pre-cooled temperature, but the temperature would rise at such a rapid rate that it might endanger many species. Kelly E. McCusker et al., *Rapid and Extensive Warming Following Cessation of Solar Radiation Management*, 9 ENVTL. RES. LETTERS 24005, 24005 (2014). Similarly, CDR methods also involve risk. For example, stored carbon could escape and reenter the atmosphere. Bob van der Zwaan & Koen Smekens, *CO2 Capture and Storage with Leakage in an Energy-Climate Model,* 14 ENV'T MODEL ASSESS. 135, 135 (2009).

[148] *See* Beldiman, *supra* note 104, at 49.

[149] *See also id*.

[150] *See infra* Part V.B.

[151] 42 U.S.C. § 2457(a) (2006) (repealed 2010).

engineering not only shares many parallels with the space program, such as governmental involvement and national (indeed, global) benefit,[152] but also is more urgent. Thus, a comparable provision asserting exclusive government control of such inventions, joined with broad or open licensing practices, could help eliminate the problems of thickets and anticommons. While this might be helpful, in light of the wide range of private industries currently involved in geoengineering research,[153] this restriction would likely have limited impact.

¶59 Alternatively, the USPTO could reexamine and, where appropriate, revoke or narrow previously issued patents. The Patent Statute authorizes any person at any time to file a request to reexamine any patent on the basis of prior art.[154] Further, the America Invents Act (AIA) provides two new procedures for third parties to request patent review.[155] The first procedure—post-grant review—enables a third party to challenge a patent on any ground of patentability within nine months of the granting of the patent.[156] After this nine-month period (or resolution of a post-grant review), the second procedure, called *inter partes* examination, allows anyone to request that one or more claims of a patent be deemed unpatentable.[157] But despite these improvements, the new procedures likely provide inadequate remedies because filing for a patent reexamination is labor intensive and expensive.[158] Simply stated, relying upon prospective inventors to reduce the thicket in this manner seems both misplaced and unrealistic.

¶60 Perhaps more promising, the USPTO Director also possesses the power to initiate reexamination of a patent, either after request or upon the Director's own initiative.[159] A Director, however, rarely issues an order to commence reexamination.[160] That said, one of the few instances of director-initiated reexamination addressed an analogous trend of granting overly broad patents in a fledgling and complex field. For an entire decade, the USPTO had denied all software patent applications. But in 1981, in *Diamond v. Diehr*, the Supreme Court held that software was patentable.[161] As a result, and in part because of a lack of examiners possessing the necessary expertise, the USPTO began granting excessively broad software patents. After receiving much criticism for these broad patents, the Director initiated a reexamination, and ultimately, the agency rescinded dozens of these patents.[162]

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[152] *See* BRACMORT & LATTANZIO, *supra* note 133, at 36 (noting that because engineering the climate system is a global activity with trans-boundary effects, some suggest that only a multilateral body is appropriate in addressing it).

[153] Geoengineering Patent Search, *supra* note 71.

[154] 35 U.S.C. § 302 (2012).

[155] Lanning, *supra* note 50, at 403.

[156] *Id.*

[157] 35 U.S.C. § 311(b) (2012).

[158] *See* Stiles, *supra* note 92, at 570. While one analysis found reexamination costs total approximately one-tenth of the cost of litigation, they still could range as high as $100,000. Additional drawbacks are a limited role for the challenger during the reexamination process and probable juror bias against a party whose reexamination request failed. Stuart J. H. Graham et al., *Patent Quality Control: A Comparison of U.S. Patent Reexaminations and European Patent Oppositions, in* PATENTS IN THE KNOWLEDGE-BASED ECONOMY: PROCEEDINGS OF THE SCIENCE, TECHNOLOGY AND ECONOMIC POLICY BOARD 8 (Wesley M. Cohen & Stephen A. Merrill eds., 2003), *available at* http://www.nber.org/papers/w8807.

[159] 35 U.S.C. § 303(a) (2012).

[160] *See* 37 C.F.R. § 1.520 (2012).

[161] 450 U.S. 175, 185–86 (1981).

[162] *See* Lori B. Andrews, *Genes and Patent Policy: Rethinking Intellectual Property Rights*, 3 NATURE

¶61 Finally, and serving as the most extreme alternative procedure, Congress can simply revoke all geoengineering patents, as it did when enacting the Atomic Energy Act (AEA). Congress passed the AEA to provide for government control of the possession, use, and production of atomic energy and special nuclear material, and to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes.[163] To these ends, the law "revoked all existing patents useful exclusively in the production of fissionable materials."[164] While revocation, or "patent breaking," would help reduce the number and breadth of climate-engineering patents, most commentators consider it an unpalatable option used only in dire circumstances.[165] For this reason, compensation is available for any patent revoked under these provisions.[166] In view of these considerations, namely the significant resources required and limited deterrent value for future patent applications, patent breaking probably provides only a remedy of last resort for dealing with these issues.

C. Compulsory Licenses Can Ensure Access to These Inventions

¶62 A similar yet less extreme option often suggested by commentators to improve access to patents is compulsory licensing. A compulsory license "compels a patent owner to allow certain others to practice the invention otherwise protected by a patent."[167] The government effectively steps into the shoes of the patent holder to grant a license to a government agency or third party. Usually, the patentee receives compensation for the compelled license.[168]

¶63 The primary benefit of compulsory licenses is that they allow widespread access to inventions to facilitate further innovation.[169] Specifically, compulsory licensing can be critical when the market has failed to disseminate inventions. This occurs when the patent owner exercises its monopoly power but chooses not to practice the invention or charges unreasonable prices for a license.[170] Therefore, many argue that compulsory licensing may mitigate patent thickets[171] and anticommons,[172] both of which impair future inventors' attempts to acquire the necessary licenses to continue innovation. Given that

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REVS. GENETICS 803, 805 (2002).

[163] 42 U.S.C. § 2013 (2012). The legislative history of the Atomic Energy Act indicates that Congress concluded that the processing and use of fissionable material must be regulated to promote the national interest and to protect public health and safety. Michael Moulton, *Effecting the Impossible: An Argument Against Tax Strategy Patents*, 81 S. CAL. L. REV. 631, 665 (2008).

[164] N.V. Philips' Gloeilampenfabrieken v. Atomic Energy Comm'n, 316 F.2d 401, 405 (D.C. Cir. 1963).

[165] *See* Andrew W. Torrance, *Patents to the Rescue: Disasters and Patent Law*, 10 DEPAUL J. HEALTH CARE L. 309, 341 (2007) [hereinafter Torrance, *Patents to the Rescue*].

[166] *Id.*

[167] *Id.* at 336.

[168] *Id.*

[169] *See* Simone A. Rose, *On Purple Pills, Stem Cells, and Other Market Failures: A Case for a Limited Compulsory Licensing Scheme for Patent Property*, 48 HOW. L.J. 579, 619 (2005).

[170] *See* Mandel, *supra* note 55, at 59.

[171] *See, e.g.,* Richard Bis, *Financing Innovation: A Project Finance Approach to Funding Patentable Innovation*, 21 INTELL. PROP. & TECH. L.J. 14, 20 (2009).

[172] *See, e.g.,* Richard Li-dar Wang, *Biomedical Upstream Patenting and Scientific Research: The Case for Compulsory Licenses Bearing Reach-Through Royalties*, 10 YALE J.L. & TECH. 251 (2008).

these licenses are especially appropriate when the underlying invention has significant social value, at first blush, compulsory licensing appears to offer a possible solution.[173]

¶64 Yet the U.S. patent system generally disfavors compulsory licenses. As the Supreme Court recognized, "Compulsory licensing is a rarity in our patent system."[174] A broad grant of compulsory licenses has generally received a frigid reception from domestic parties, with U.S. courts and many commentators often "hostile to the very concept of compulsory licensing."[175] And although courts recognize compulsory licensing as a solution for antitrust violations,[176] it is considered a remedy of last resort.[177]

¶65 On only a few occasions, and none recently, courts have imposed compulsory licenses.[178] In one case, the Second Circuit found a compulsory license appropriate primarily because the patent owner was not using the license to manufacture a product.[179] Subsequent decisions of the Federal Circuit, however, indicate that it is unlikely to award compulsory licenses in the future.[180] Indeed, the Federal Circuit consistently posits that broad protection of patent rights conforms to public policy.[181]

¶66 Despite this resistance, the use of compulsory licenses to resolve legal disputes has spawned some significant successes; the most prominent examples of which occurred over a half-century ago. In 1956, the United States entered into consent decrees with American Telegraph & Telephone (AT&T) and International Business Machines (IBM) concerning their patents. The agreement with AT&T required that it license at reasonable royalties all patents controlled by a subsidiary, Bell Systems.[182] Similarly, the IBM decree required that it grant nonexclusive, nontransferable licenses for all of its patents to any applicant at reasonable royalties. Accordingly, the applicant was obligated to cross license its patents to IBM on similar terms.[183] While some originally opposed this government involvement, in hindsight, the combined licensing of these patent portfolios is widely recognized for fostering the rapid growth of the semiconductor industry.[184]

¶67 Nevertheless, Congress has repeatedly rejected invitations to enact a broad compulsory license statute. While the Patent Act does not contain a general compulsory

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[173] Rose, *supra* note 169, at 621–22.

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

[175] Kimberly M. Thomas, *Protecting Academic and Non-Profit Research: Creating a Compulsory Licensing Provision in the Absence of an Experimental Use Exception*, 23 SANTA CLARA COMPUTER & HIGH TECH. L.J. 347, 356 (2007). Indeed, a congressional representative once charged that compulsory licenses are both unconstitutional and un-American. Stefan A. Risenfeld, *Compulsory Licenses and United States Industrial and Artistic Property Law*, 47 CAL. L. REV. 51, 51–52 (1959).

[176] *See* United States v. Glaxo Grp. Ltd., 410 U.S. 52, 71 n.5 (1973) (Rehnquist, J., dissenting).

[177] *See* Carol M. Nielsen & Michael R. Samardzjia, *Compulsory Patent Licensing: Is It a Viable Solution in the United States?*, 13 MICH. TELECOMM. & TECH. L. REV. 509, 535–36 (2007).

[178] *See* Yosick, *supra* note 70, at 1281.

[179] Foster v. Am. Mach. & Foundry Co., 492 F.2d 1317, 1324 (2d Cir. 1974).

[180] *See* Yosick, *supra* note 70, at 1281.

[181] *See* Smith Int'l., Inc. v. Hughes Tool Co., 718 F.2d 1573, 1581 (Fed. Cir. 1983) (granting a preliminary injunction against infringement as consistent with the public policy underlying the patent laws).

[182] TEECE, *supra* note 107, at 209.

[183] *Id*. at 211.

[184] *See id*. at 212–13. IBM noted that this relatively open licensing helped accelerate the pace of innovation because it facilitated the work of others and access to their results. In fact, IBM considered access to others' patents to be more valuable than the royalties it could have earned on the licensing of its 9,000 patents. *Id*. at 212.

licensing provision,[185] during its 1952 revision of U.S. patent law, Congress considered incorporating a compulsory licensing provision. However, after vehement opposition, it excluded this provision from the final bill.[186] A few years later, Congress reconsidered adding the provision, but again rejected it.[187] Subsequent efforts to amend the Patent Act to allow compulsory licensing for public health purposes or special circumstances have also failed.[188] With opposition still salient, the United States remains one of the few countries without a general compulsory license provision.[189]

¶68 Nevertheless, in certain limited circumstances, inapplicable to the vast majority of patents,[190] Congress has provided for the imposition of compulsory licenses.[191] The most noteworthy examples, touched on before and discussed below, are the Atomic Energy Act and Clean Air Act. Other instances of limited compulsory licensing are found in the Tennessee Valley Authority Act (granting compulsory licenses for inventions related to fertilizer or hydroelectric power),[192] the Plant Protection Act (granting compulsory licenses when necessary to provide an adequate supply of fiber, food, or feed),[193] and the Semiconductor Chip Protection Act (granting innocent purchaser of an infringing chip the right to pay a reasonable royalty).[194]

¶69 The Atomic Energy Act (AEA) provides a form of compulsory license. Upon receipt of an application to practice a license, the Atomic Energy Commission will conduct a hearing to determine whether the patent implicates the public interest.[195] That is, the public interest must be of primary importance to the utilization of fissionable material to effectuate the purposes of the AEA.[196] Where the public-interest inquiry has been satisfied, the Commission may grant a nonexclusive license[197] to either the government or a person seeking a license.[198] If a person applies for a license, the applicant must demonstrate that he cannot receive a license from the patent holder for a

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[185] Chui, *supra* note 49, at 462.

[186] *See* Dawson Chem. Co. v. Rohm & Haas Co., 448 U.S. 176, 215 n.21 (1980).

[187] Andrew W. Torrance, *Patent Law, Hippo, and the Biodiversity Crisis*, 9 J. MARSHALL REV. INTELL. PROP. L. 624, 648 (2010).

[188] Rose, *supra* note 169, at 621. Congress rejected compulsory license provisions in other legislation, including the 1973 Hart Bill and the 1999 Affordable Prescription Drugs Act. Yosick, *supra* note 70, at 1278. The Hart Bill would have permitted compulsory licenses of patents related to "public health, safety, or protection of the environment" or for patents that are unused. *Id*. The Affordable Prescription Drugs Act would have required compulsory licenses of patents relating to human health under certain circumstances. *Id*.

[189] *See* Kenneth J. Nunnenkamp, *Compulsory Licensing of Critical Patents Under CERCLA?*, 9 J. NAT. RES. & ENVTL. L. 397, 404 (1994).

[190] *See id.*

[191] Despite their relative rarity in U.S. patent law, compulsory licenses are actually commonplace under U.S. copyright law. *See* Jorge L. Contreras, *Standards, Patents, and the National Smart Grid*, 32 PACE L. REV. 641, 672 (2012).

[192] 16 U.S.C. § 831 (2012).

[193] 7 U.S.C. § 2404 (2012).

[194] 17 U.S.C. § 901(a) (2012).

[195] 42 U.S.C. § 2183(d) (2012).

[196] 42 U.S.C. § 2183(a).

[197] 42 U.S.C. § 2183(b).

[198] *Id*.

reasonable amount.[199] The AEA correspondingly mandates that patent owners receive reasonable royalties from licensees.[200]

¶70 Congress similarly included a compulsory license provision in the Clean Air Act (CAA), which places the primary responsibility for air-pollution prevention and control on the states.[201] The CAA seeks to improve air quality through the implementation of a regulatory scheme designed to stimulate private development of air-pollution-control technology.[202] Because of the importance of access to these technologies, Congress included a means for states to acquire compulsory licenses to technologies necessary to achieve federally mandated air-quality standards.[203] If the state can satisfy a set of requirements,[204] then the U.S. Attorney General certifies the application to a district court, which may order the patentee to license the invention upon reasonable terms.[205] While states have yet to employ this provision, one commentator suggests that its presence may have persuaded parties to negotiate agreements they might not otherwise have reached.[206]

¶71 The U.S. government has also reserved the right to a compulsory license for any U.S. patent.[207] When the United States uses or manufactures (or contracts with a party to do so) an invention protected by a U.S. patent, it acts not as an ordinary infringer but as a compulsory, nonexclusive licensee.[208] Congress enacted this law to enable the federal government to purchase goods necessary to its performance without the threat of having the supplier enjoined from selling patented goods to the U.S. government.[209] The United States' right to compel a license applies broadly, and the federal government exercises this right frequently.[210]

¶72 Additionally, although Congress has not approved a general compulsory license provision, it did provide the federal government broad licensing rights for government-funded inventions. In 1980, Congress passed the Bayh-Dole Act (BDA), which amended the patent code.[211] Prior to the passage of the BDA, the USPTO received very few applications for federally funded inventions, the majority of which remained in the hands

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[199] 42 U.S.C. § 2183(e)(4).

[200] 42 U.S.C. § 2183(g).

[201] 42 U.S.C. § 7401(a)(3) (2012).

[202] *See* Warren F. Schwartz, *Mandatory Patent Licensing of Air Pollution Control Technology*, 57 VA. L. REV. 719, 719 (1971).

[203] Torrance, *supra* note 187, at 648–49.

[204] The Clean Air Act requires a party to satisfy three requirements to obtain a license. First, the patented technology is not "reasonably available" yet "necessary" to comply with an air-quality standard; second, "no reasonable alternative methods" exist; and third, the unavailability of such technology may cause a "substantial lessening of competition." 42 U.S.C. § 7608 (2012).

[205] *Id*. Congress approved § 7608 with little controversy in 1970, Nunnenkamp, *supra* note 189, at 405–06, but an effort arose subsequently to repeal the provision. *Id*. at 406 n.39. Nevertheless, by 1977, when Congress "completely revised" the Clean Air Act, the provision remained. *Id*. at 406.

[206] Yosick, *supra* note 70, at 1279.

[207] *See* 28 U.S.C. § 1498(a) (2012).

[208] *See* Motorola, Inc. v. United States., 729 F.2d 765, 768 (Fed. Cir. 1984). The statute entitles the patent holder to a reasonable royalty. 28 U.S.C. § 1498(a). Because the government has the right to use patented inventions for the public good, infringement by the government is treated as an exercise of eminent domain, rather than tortious conduct, as would be the case with private litigants. B.E. Meyers & Co. v. United States, 47 Fed. Cl. 375, 380 (2000).

[209] *See* Coakwell v. United States, 372 F.2d 508, 511 (Ct. Cl. 1967).

[210] *See* Nunnenkamp, *supra* note 189, at 403.

[211] Thomas, *supra* note 175, at 365.

of educational institutions.[212] Congress approved the BDA to promote the utilization of inventions arising from federally funded research, to encourage small businesses' participation in federally funded research, and to foster the collaboration of profit and nonprofit interests, especially universities.[213] The BDA accomplished these goals by allowing universities to retain title to federally funded inventions.[214]

¶73 This transfer of rights had a profound effect. Since 1980, the number of patents generated by domestic universities has increased tenfold.[215] Additionally, university income from licensing increased from $7.3 million in 1981 to $3.4 billion in 2008.[216] Yet universities were not the only benefactors. In exchange for allowing universities to retain title to their inventions, the BDA establishes "march-in rights" for federal agencies that fund these patented inventions. And because march-in rights allow funding agencies to grant licenses to qualified third parties,[217] the private sector benefits as well. In essence, the BDA establishes compulsory licenses for those inventions that arise from federal funding.[218]

¶74 Further, the U.S. government may exercise its march-in rights, *inter alia*, to alleviate health or safety needs.[219] These rights, however, appear not to have been exercised in the three decades since Congress passed the law.[220] Joshua Sarnoff suggests that the refusal to exercise these rights demonstrates their highly controversial nature, specifically in that they function as "*ex post* regulatory compulsory license[s]."[221] Again, American antipathy to compulsory licensing proves persistent.

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[212] Terry K. Tullis, Comment, *Application of the Government License Defense to Federally Funded Nanotechnology Research: The Case for a Limited Patent Compulsory Licensing Regime*, 53 UCLA L. REV. 279, 303–04 (2005). At the time, the government funded 60% of all academic research. *Innovation's Golden Goose*, ECONOMIST (Dec. 12, 2002), http://www.economist.com/node/1476653. Despite this investment, only 5% of federally funded inventions led to commercial applications. Tullis, *supra* at 304 n.97.

[213] *See* 35 U.S.C. § 200 (2012).

[214] 35 U.S.C. § 202(a) (2012). The United States also retains a royalty-free license for it or any of its contractors to practice the invention. *Id*. § 202(c)(4).

[215] *Id*. § 202(a).

[216] *See* Vicki Loise & Ashley J. Stevens, *The Bayh-Dole Act Turns 30*, 45 LES NOUVELLES 185, 188 (2010).

[217] 35 U.S.C. § 203(a) (2012).

[218] Thomas, *supra* note 175, at 366.

[219] 35 U.S.C. § 203(a)(2). Additional circumstances include overcoming a failure to apply the invention, § 203(a)(1), meeting requirements of federal regulations for public use, § 203(a)(3), or addressing a breach of the agreement, § 203(a)(4). Administrative and federal court appeals processes further restrict these rights for adversely affected inventors and licensees. § 203(b).

[220] As of 1997, the United States had never utilized its march-in rights. Mary Eberle, *March-In Rights Under the Bayh-Dole Act: Public Access to Federally Funded Research*, 3 MARQ. INTELL. PROP. L. REV. 155, 160 n.38 (1999). For instance, as of 2012, the National Institutes of Health (NIH) had yet to grant a petition for a license. Kevin E. Noonan, *Groups Petition for NIH Exercise of March-In Rights over Abbott Laboratories' Norvir®,* PATENT DOCS (Oct. 31, 2012), http://www.patentdocs.org/2012/11/groups-petition-for-nih-exercise-of-march-in-rights-over-abbott-laboratories-norvir.html.

[221] Sarnoff, *supra* note 130, at 355. Mr. Sarnoff believes that this resistance could be alleviated through greater clarity concerning the criteria and circumstances giving rise to the exercise of march-in rights. *Id*. A related approach that might better encourage the extension of licenses comes from California. In 2004, the Golden State's voters approved the California Stem Cell Research and Cures Initiative. Andrew T. Serafini & Gene H. Yee, *IP Provisions and ROI for State-Funded Stem-Cell-Based Products and Technologies in California*, 24 INTELL. PROP. & TECH. L.J. 3, 3 (2012). It requires grantee organizations to negotiate non-exclusive licenses of funded inventions "whenever possible." CAL. CODE REGS. tit. 17, § 100306(b) (2014).

¶75 International agreements and laws, on the other hand, typically support compulsory licenses dating back to the 1873 Vienna Congress.[222] Currently, for example, the Trade-Related Aspects of Intellectual Property Rights Agreement (TRIPS) identifies several grounds for granting compulsory licenses, such as in response to national emergencies, anticompetitive practices, or unavailable necessary medicine.[223] Further, both the Paris Convention and the North American Free Trade Agreement (NAFTA) also provide for the exercise of such licenses.[224] Many nations have enacted compulsory license laws as well. For instance, when the World Intellectual Property Organization (WIPO) surveyed its member states concerning their compulsory licensing provisions, twenty-two countries responded that they allow compulsory licenses for national or public interests,[225] while twelve countries responded that they provide such licenses for public health reasons.[226]

¶76 However, even countries with compulsory licensing provisions rarely implement them.[227] More commonly, governments threaten to utilize their licenses, thus coercing patent holders to either grant licenses or make the products available at substantially lower prices. For instance, in 2001, Brazil announced its intent to grant a compulsory license to produce Nelfinavir, a retroviral drug used in the treatment of AIDS.[228] Brazil planned to act under the "national emergency" provision of its patent law, which mirrors Article 31 of TRIPS.[229] Less than two weeks after Brazil's announcement, Hoffman-La Roche reduced the price of the drug by 40%.[230] Thus, the true benefit of compulsory licenses may stem from the threat of potential licensing rather than the actual grant thereof, inspiring patent holders and potential licensees to negotiate agreements.[231] While governments have used compulsory licensing infrequently, many proponents identify the coercive nonuse of compulsory licensing as its primary benefit. Referred to as a "wings effect,"[232] the mere ability of the government to compel licenses can encourage patent holders and inventors to negotiate acceptable terms rather than risk governmental intervention.[233]

¶77 Yet notwithstanding their realistically benign influence, critics attack compulsory licenses on several grounds.[234] The primary criticism has been that these licenses reduce

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[222] Thomas, *supra* note 175, at 359.

[223] *Id*.

[224] Torrance, *supra* note 187, at 648.

[225] Included within this category are national security, national defense, considerable public interests, protection of natural environment, etc. WORLD INTELLECTUAL PROP. ORG., SURVEY ON COMPULSORY LICENSES GRANTED BY WIPO MEMBER STATES TO ADDRESS ANTI-COMPETITIVE USES OF INTELLECTUAL PROPERTY RIGHTS 7 (2011). The twenty-two countries were Algeria, Azerbaijan, Belgium, the Czech Republic, Finland, Ireland, Japan, Kenya, Mexico, Lithuania, Nicaragua, Norway, Oman, Panama, Poland, Spain, Sweden, Trinidad and Tobago, the United Kingdom, Ukraine, Uruguay, and Uzbekistan. *Id.*

[226] *Id*. These countries are Belgium, France, Hungary, Kenya, Mexico, Lithuania, Oman, Panama, Poland, Trinidad and Tobago, and Ukraine. *Id.*

[227] *See* Yosick, *supra* note 70, at 1294.

[228] *See* Jason D. Ferrone, *Compulsory Licensing During Public Health Crises: Bioterrorism's Mark on Global Pharmaceutical Patent Protection*, 26 SUFFOLK TRANSNAT'L L. REV. 385, 402 (2003).

[229] *Id*. at 402–03.

[230] Alex Bellos, *Roche Bows to Brazil on AIDS Drug*, THE GUARDIAN, Sept. 1, 2001.

[231] Thomas, *supra* note 175, at 357–58.

[232] Rose, *supra* note 169, at 622.

[233] *Id*.

[234] At one extreme, critics charge that compulsory licenses represent "socialism in disguise." Rose, *supra* note 169, at 623.

incentives to invent because they diminish the value of inventions by eliminating inventors' opportunities to exercise monopoly pricing. The resulting lower return lessens the main incentive to invent.[235] Moreover, fearing this potential loss of value, many inventors might avoid patenting their inventions, thus inhibiting the beneficial disclosure that an application requires.[236] Finally, the reduced prices resulting from compulsory licenses would discourage research investment, further hindering opportunities for innovation.[237] In other words, critics argue that compulsory licenses could undermine the primary objectives of the patent system.[238]

¶78 Critics also charge that compulsory licenses reduce competition.[239] Although theoretically possible, the actual use of these licenses has avoided this consequence. As noted previously, the U.S. government tends to use compulsory licenses sparingly, if at all.[240] Further, some commentators suggest that compulsory licenses should only be used in circumstances where the patent owner is either not licensing the invention entirely or only in a limited manner.[241] Thus, under current practices, any anticompetitive impact would likely be minimal.

¶79 Compulsory licenses certainly could help address the problems developing with geoengineering patents. The general resistance to their use, however, favors relying primarily upon less disruptive measures. Perhaps, compulsory licenses might be most useful as sticks to encourage voluntary participation in a less severe manner. Patent pools provide precisely such a method.

D. Patent Pools Allow the Retention of Rights and Provide Broader Access

¶80 The conditions for a patent pool arise when two or more patent holders control related patents, but at least some manufacturers of the end-product do not possess licenses.[242] Stated simply, a patent pool is an agreement between two or more patent holders to license their patent rights. The patent holders usually convey their rights to a single entity, such as a limited liability partnership or corporation, allowing persons interested in the patents to purchase licenses to the entity's entire portfolio.[243] Then, the pool allocates the license fees to the patent owners pursuant to a predetermined formula.[244] Patent pools are typically voluntary organizations.[245]

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[235] Mandel, *supra* note 55, at 60.

[236] Thomas, *supra* note 175, at 357. To avoid such concerns, Katherine Strandburg suggests that, after a patent is granted, a moratorium be imposed before a compulsory license can be exercised. Katherine J. Strandburg, *What Does the Public Get?: Experimental Use and the Patent Bargain*, 2004 WIS. L. REV. 81, 143 (2004).

[237] *See* Nunnenkamp, *supra* note 189, at 416–17.

[238] *See* Yosick, *supra* note 70, at 1292.

[239] *See, e.g.*, Thomas, *supra* note 175, at 357.

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

[241] *See* Mandel, *supra* note 55, at 59.

[242] Sovacool, *supra* note 48, at 433.

[243] Nielsen & Samardzjia, *supra* note 177, at 530. This structure is typical, especially of some of the more prominent patent pools discussed *infra*. In some instances, however, the patent owners merely license their patents to one another. Different forms may reflect the different goals of the pool, such as upstream research and development or downstream access. Krista L. Cox, *The Medicines Patent Pool: Promoting Access and Innovation for Life-Saving Medicines Through Voluntary Licenses*, 4 HASTINGS SCI. & TECH. L. J. 291, 294–95 (2012).

[244] Cox, *supra* note 243, at 295.

¶81 Patent pools are especially helpful in addressing patent thickets, where separate patent holders own patents for individual, related components.[246] Patent pools can also be effective in remedying patent anticommons.[247] Broadly stated, a patent pool solves both the thicket and anticommons problems because it facilitates innovation by expanding the number of persons who can utilize patented subject matter.[248]

¶82 One of the most prominent examples of a patent pool involved the early American aviation industry. Following their historic invention, the Wright brothers sought and received a broadly defined airplane patent.[249] Subsequently, the founders of flight attempted to block nearly all airplanes as infringements upon their patent.[250] Further exacerbating "a chaotic situation concerning the validity and ownership of important aeronautical patents," various aircraft companies threatened competitors with patent infringement suits.[251] Because of the years of protracted litigation, at the start of the First World War, the U.S. aviation industry had produced a fraction of the number of planes produced by either France or Germany.[252]

¶83 Upon the United States' entry into the war, the federal government chose to intervene, in part through the efforts of then-Assistant Secretary of the Navy Franklin D. Roosevelt.[253] The U.S. government faced difficulty fulfilling plane orders and, as the principal purchaser of aircraft, greatly suffered from increased prices. Airplanes required components covered by a number of patents, and manufacturers were afraid of possible infringement suits.[254] To resolve this problem, the Manufacturers Aircraft Association (MAA) incorporated in 1917.[255] Manufacturers of aircraft and related parts purchased a share of the association,[256] enabling them to exercise licenses on key patents shared in the pool.[257] This arrangement was so successful that, upon its expiration after the war, the War and Navy Departments negotiated a new agreement with the MAA.[258] By the end of the 1920's, the aviation industry, which had produced only 100 planes preceding the war, was manufacturing 7,500 planes annually.[259]

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245 *See* Contreras, *supra* note 191, at 674–75.

246 *Id.* at 655.

247 *See* JEANNE CLARK ET AL., USPTO, PATENT POOLS: A SOLUTION TO THE PROBLEM OF ACCESS IN BIOTECHNOLOGY PATENTS? 4 (2000), *available at* www.uspto.gov/web/offices/pac/dapp/opla/patentpool.pdf.

248 Lanning, *supra* note 50, at 412. Other recognized benefits include reducing licensing costs (including litigation) and managing and administering the agreement and parties. Cox, *supra* note 243, at 295.

249 LAWRENCE GOLDSTONE, BIRDMEN 86–87 (2014).

250 MATTHEW ALBRIGHT, PROFITS PENDING: HOW LIFE PATENTS REPRESENT THE BIGGEST SWINDLE OF THE 21ST CENTURY 145 (2004).

251 Mfrs. Aircraft Ass'n, Inc. v. United States, 77 Ct. Cl. 481, 483 (Ct. Cl. 1933).

252 ALBRIGHT, *supra* note 250. At the commencement of hostilities, France had manufactured 2,000 airplanes, Germany 1,000, and the United States fewer than 100. *Id*.

253 Contreras, *supra* note 191, at 675 n.137.

254 *Mfrs. Aircraft Ass'n, Inc.,* 77 Ct. Cl. at 483.

255 *Id.* at 486. Its founders modeled the MAA after a similar entity formed at the beginning of the century to address comparable issues concerning patents related to automobiles. ALBRIGHT, *supra* note 250, at 146.

256 *Mfrs. Aircraft Ass'n, Inc.,* 77 Ct. Cl. at 486.

257 ALBRIGHT, *supra* note 250, at 146. The MAA enabled the Navy to avoid spending an appropriation of $1 million to purchase or condemn basic aeronautic patents. *Mfrs. Aircraft Ass'n, Inc.,* 77 Ct. Cl. at 488.

258 *Mfrs. Aircraft Ass'n, Inc.,* 77 Ct. Cl. at 502.

259 ALBRIGHT, *supra* note 250, at 146.

¶84 Providing a more recent example, in 2009, UNITAID formed the Medicines Patent Pool (MPP) using the MAA as a model.[260] Several countries established UNITAID to develop a financing mechanism providing regular, sustainable, and predictable long-term financing for drugs and diagnostics used to treat AIDS, tuberculosis, and malaria in developing countries.[261] But while UNITAID created the MPP using the MAA as its guiding framework,[262] the arrangements differ in significant ways. Most obviously, participation in the MPP is voluntary, whereas the MAA was not.[263] Further, the MPP negotiates with generic-drug manufacturers for non-exclusive licenses,[264] which extend to multiple uses (e.g., a drug typically used for HIV can also be produced to treat hepatitis B), but not to new uses.[265] Finally, employing modern technology to its advantage, the MPP publishes on its website the names of relevant pharmaceutical companies that have or have not joined the pool.[266]

¶85 Thus, while UNITAID used the MAA as a blueprint, the MPP's structure was uniquely tailored not only to a specific field, but also to modern realities. These distinctions illustrate the utility and flexibility of patent pools in cultivating innovation though cooperation. From the consolidation of sewing-machine inventions in the mid-19th century[267] to the standardization of modern radio and television,[268] the past two centuries are replete with examples of patent pools enabling the development of critical technologies.[269]

¶86 Patent pools provide myriad advantages. For instance, they help resolve problems arising from building-block patents. Typically, patent pools do this by providing economic incentives for holders of building-block or component patents to cooperate when developing end-products.[270] This is what essentially transpired in the aviation industry during World War I.[271] Patents on fundamental inventions coupled with a general unwillingness to license the inventions at reasonable rates paralyzed the aviation

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[260] Cox, *supra* note 243, at 296.

[261] Jorge Bermudez & Ellen 't Hoen, *The UNITAID Patent Pool Initiative: Bringing Patents Together for the Common Good*, 4 OPEN AIDS J. 37, 37 (2010). The MPP receives its financing from a tax on airline tickets established by the participating member countries. *Id*.

[262] *See id*. at 38.

[263] Cox, *supra* note 243, at 296.

[264] *Id*. at 296–97.

[265] *Id*. at 303–04.

[266] *See* JACQUES DE WERRA, RESEARCH HANDBOOK ON INTELLECTUAL PROPERTY LICENSING 233 (2013).

[267] *See* DAVID SERAFINO, SURVEY OF PATENT POOLS DEMONSTRATES VARIETY OF PURPOSES AND MANAGEMENT STRUCTURES 3 (2007).

[268] Mireles, *supra* note 67, at 220–21. The Radio Corporation of America (RCA), which combined several companies' technologies, led to the standardizing of radio and television parts and transmissions. Prior to the formation of RCA, a number of separate entities held important patents, enabling them to block one another. Moreover, radio systems required several technologies, each of which involved multiple patents. Accordingly, the industry was deadlocked. Once again, the parties resolved their differences after prompting from the Navy Department. *See* TEECE, *supra* note 107, at 207.

[269] Contreras, *supra* note 191, at 674–75. Recent examples include patent pools formed for CDs, DVDs, Bluetooth, and MPEG. *Id.*

[270] Stiles, *supra* note 92, at 576.

[271] Although the MAA was technically a voluntary patent pool, many commentators consider it to have been a *de facto* mandatory patent pool. *See* Contreras, *supra* note 191, at 675 n.137. If necessary, the United States had contemplated exercising its eminent domain powers to acquire the necessary patents. SERAFINO, *supra* note 267, at 16.

industry. Establishing a patent pool through the MAA provided manufacturers with access to these inventions, enabling the production of airplanes at a greatly enhanced pace.[272]

¶87 Another key advantage is that patent pools help reduce licensing-transaction costs. Patent pools minimize or avoid many costs of acquiring licenses. These avoided costs include patent searches and possible litigation expenses related to patent infringement actions.[273] Pools also help minimize the effort required to address questionable patents, such as those that are either invalid or excessively vague.[274] They provide even greater efficiencies when patents on complementary technologies are available through the pool.[275] Patent pools can thus provide an efficient, "one-stop" shopping means for acquiring access to patents that are essential for a given technology.[276]

¶88 Patent pools also have benefits over involuntary licenses and the effects thereof, such as those resulting from compulsory licensing schemes or litigation. Pools, unlike involuntary measures, derive their valuations and royalty prices from the consensus of persons involved in the industry. This increases the likelihood that they fairly reflect their market value.[277]

¶89 The most common criticism of patent pools stems from their potentially anticompetitive impact. In the past, some have used patent pools to collude and fix prices.[278] Consequently, federal regulators and courts historically have viewed patent pools with skepticism. In recent years, however, these critics have more readily acknowledged a patent pool's ability to encourage innovation.[279] Indeed, the joint guidelines of the Federal Trade Commission and the Department of Justice recognize that patent pools provide procompetitive benefits.[280] Many commentators note that careful scrutiny of the pooling arrangement can minimize anticompetitive tendencies.[281]

¶90 Patent pools can help address the thickets and anticommons developing with climate-engineering patents. Furthermore, a geoengineering pool is likely to avoid the resistance that more disruptive approaches, such as patent breaking or compulsory licenses, would engender. Similar to how patent pools played critical roles in making radio and airplane inventions available, patent pools can again help provide access to inventions that may play a crucial role in society's future.

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[272] CLARK ET AL., *supra* note 247, at 8.
[273] *Id*.
[274] Nielsen & Samardzjia, *supra* note 177, at 530.
[275] Stiles, *supra* note 92, at 587.
[276] CLARK ET AL., *supra* note 247, at 9. Patent pools also reduce the likelihood that, after licenses have been acquired on all but a few patents for a technology, the remaining patent holders can hold out to force above-market rates for their patents. *Id*.
[277] *See* Mireles, *supra* note 67, at 220.
[278] Nielsen & Samardzjia, *supra* note 177, at 530–31.
[279] Mireles, *supra* note 67, at 218.
[280] *See id*. at 219.
[281] *See* CLARK ET AL., *supra* note 247, at 10. They also note that some commentators have argued that patent pools can be used to shield invalid patents, thereby allowing the charging of royalties on patents that should be in the public domain. The authors also believe that this also should be avoidable through careful review of the pooling arrangement. *Id*.

V. The United States Should Implement Changes to the Patent System to Address Climate Engineering

¶91 Because of the rapid acceleration in geoengineering patents and the growing urgency of climate change, the United States needs to modify its patent system to facilitate these inventions. First, it should establish a separate process for consideration of these applications, including a process for expedited review. Second, to facilitate access to these patents, the U.S. government should encourage the establishment of a patent pool, which would provide limited licenses for climate-engineering innovation. The government should also be empowered to ensure that all essential patents join the pool.

A. The United States Needs a Unique Patent Process for Climate-Engineering Inventions

¶92 A patent system tailored for geoengineering patents must provide for quick review. Not only will this require an expedited-review mechanism, but it should also include separate application and review procedures for climate engineering. Specifically, the USPTO should establish a separate application process staffed by examiners specializing in geoengineering patents. Experience indicates that such procedures accelerate review.[282] In addition, a separate process will help the USPTO develop sufficient expertise to analyze and resolve these applications. This is especially important because, unlike most industries, the geoengineering field resembles an umbrella, incorporating a number of diverse technologies under a common goal.[283] Furthermore, future methods may be unforeseeable. Thus, the establishment of a separate office with a dedicated staff would facilitate the approval of related inventions and enable the staff to stay abreast of recent developments in the field. Finally, as examiners develop greater expertise, they are less likely to approve broadly defined patents, which would help mitigate problems associated with thickets and anticommons at their source.

¶93 A separate process will also centralize information about geoengineering patents. Currently, applications do not need to identify their inventions as related to climate engineering. Consequently, searching for related patents is unduly time consuming.[284] Identifying geoengineering patent applications separately will facilitate both the examination process by the USPTO and their subsequent identification by third parties, such as future inventors and manufacturers.

¶94 Recent evidence further supports the conclusion that, by establishing a separate application process, the USPTO can review applications more easily and expeditiously.

[282] *See* Deborah Behles, *The New Race: Speeding up Climate Change Innovation*, 11 N.C. J. L. & Tech. 1, 41 (2009). Ms. Behles points to the experience under the Orphan Drug Act. The Food and Drug Administration established the Office of Orphan Products Development to review applications and award orphan designations. Office of Inspector Gen., The Orphan Drug Act: Implementation and Impact 4 (2001), *available at* oig.hhs.gov/oei/reports/oei-09-00-00380.pdf. The office has reduced the time required to designate a product by 40%. *Id*. at 10–11.

[283] Included under this heading are methods such as carbon capture and sequestration, ocean fertilization, aerosol injection, enhanced ocean circulation, cloud whitening, enhanced surface albedo, space mirrors, and others. Bracmort & Lattanzio, *supra* note 133, at 10–19.

[284] *See* Oldham et al., *supra* note 73, at 9. They reported that their search terms "generated unexpected noise" and the results were "diffuse." *Id*.

In 2009, the USPTO initiated its Green Technology Pilot Program (GTPP).[285] The program provided a means for green-technology patent applications to receive preferential consideration without needing to satisfy all of the accelerated-examination program's requirements.[286] While the GTPP ended in March 2012,[287] subsequent analysis determined that the separate process used for that program did in fact facilitate expedited review.[288] Accelerated consideration is critical for geoengineering patents because of the prolonged time required to research and test these technologies,[289] especially given that climate change is already surpassing tipping points.[290] For these reasons, geoengineering patents provide a more compelling case for expedited consideration than do patents in most other fields.

¶95 As did the GTPP, this new climate-engineering program should attempt to limit burdens placed upon applicants. Analysis suggests that added burdens—such as prior-art searches—deter applicants from using the accelerated-examination procedures.[291] Unlike the GTPP, however, this new program needs to provide expedited review throughout the application process. Stahl and Beshore found this approach to mesh successfully with the USPTO's accelerated-examination process.[292]

¶96 Additionally, a separate process would enable the USPTO to develop a public database of climate-engineering patents. Such a database could reduce transaction costs resulting from preparing applications and prior-art searches.[293] It would also help other inventors, researchers, and the public stay informed of developments concerning these technologies. For instance, a similar database, GenBank, exists for genetic sequences.[294] The National Institutes of Health designed GenBank to provide the scientific community access to the most up-to-date DNA-sequence information.[295] Similarly, a geoengineering database can facilitate access to information about climate-engineering patents.

B. *The United States Should Establish a Geoengineering Patent Pool to Facilitate Access to These Patents*

¶97 Besides modifying the application process, the United States needs to ensure access to climate-engineering inventions to spur innovation. To this end, it should facilitate the establishment of a patent pool, and encourage or compel inventors to join. Furthermore,

[285] Tran, *supra* note 66, at 526. The implementation of the GTPP followed the adoption of similar programs in Australia, Japan, South Korea, and the United Kingdom. *Id.* at 525–26.

[286] Pilot Program for Green Techs Including Greenhouse Gas Reduction, 74 Fed. Reg. 64,666, 64,666 (Dep't of Commerce Dec. 8, 2009). Most importantly, the GTPP did not require the applicant to conduct a pre-examination search for prior art. Jay Hickey, *Green Technology: An Alternative Path to Accelerated Patent Examination*, 62 SYRACUSE L. REV. 145, 151 (2012).

[287] Tran, *supra* note 66, at 529–30.

[288] *Id.* at 530.

[289] *See* Mandel, *supra* note 55, at 61.

[290] *See, e.g.,* Joughlin, Smith & Medley, *supra* note 14, at 738.

[291] *See* Tran, *supra* note 66, at 522–23.

[292] Lawrence A. Stahl & Seth E. Boeshore, *Accelerating the Acquisition of an Enforceable Patent: Bypassing the PTO's Backlog*, 23 INTELL. PROP. & TECH. L.J. 3, 5 (2011).

[293] Mireles, *supra* note 67, at 231.

[294] Lanning, *supra* note 50, at 410.

[295] *Id.*

the United States should structure licenses for the pool's patents to minimize costs to innovators.

¶98 The patent system needs to provide inventors sufficient access to climate-engineering patents. Following a model previously established to address the urgent need for patent-barrier elimination, the U.S. government can achieve this goal. Nearly one century ago, the United States used the urgency of a World War and the threat of compulsory licensing to break two patent logjams. This prodding resulted in the establishment of the MAA and RCA.[296] Similarly, the United States should encourage the creation of a climate-engineering patent pool, which, for simplicity, this Article will refer to as "GeoPool."

¶99 GeoPool would present significant advantages over the current patent model and the various alternatives. Pools have previously helped break through barriers created by overlapping and diffuse patent distributions.[297] The "one-stop shopping" opportunity that pools provide to innovators enables efficient and inexpensive access to patents,[298] which facilitates fair licensing rates[299] and spurs investment.[300] Thus, by improving access and minimizing costs, pools can foster innovation[301] and centralize information related to climate engineering and inventions. To accomplish this, GeoPool will need an administrator to determine which patents to include in the pool.[302] This is especially important because of the breadth of technologies falling under the heading of climate engineering that continue to evolve,[303] thus requiring the parameters of the pool to be interpreted flexibly.[304]

¶100 Because of the likely variety of inventions included in this pool, measures should be included to minimize the royalties that prospective licensees must pay for access to only some of the pool's patents. Specifically, GeoPool should utilize provisions that limit licensees' costs. For instance, severable or unbundled licenses allow a party to obtain licenses to fewer than all of the patents in the pool.[305] This is important since innovators rarely know in advance which rights will be essential in developing an invention.[306] In addition, the inclusion of termination rights would allow pool members to terminate a license on one or more patents while retaining their rights to other licenses.[307] Such rights help reduce licensing costs for technologies that become dead ends. In other words,

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[296] Mfrs. Aircraft Ass'n, Inc. v. United States, 77 Ct. Cl. 481, 488 (Ct. Cl. 1933).

[297] *See* Contreras, *supra* note 191, at 674–75.

[298] CLARK ET AL., *supra* note 247, at 9.

[299] Beldiman, *supra* note 104, at 59.

[300] *See id*. at 57–58 (noting that the establishment of a pool concerning severe acute respiratory syndrome (SARS) helped to remove barriers that were discouraging investment).

[301] *Id*. at 59.

[302] Shanshan Zhang, *Proposing Resolutions to the Insufficient Gene Patent System*, 20 SANTA CLARA COMPUTER & HIGH TECH. L.J. 1139, 1167–68 (2004). Besides determining the inventory in the pool's portfolio, an administrator would also collect and distribute royalties and enforce and terminate licenses. *Id*. at 1168.

[303] *See* BRACMORT & LATTANZIO, *supra* note 133, at 10–19.

[304] *See* Beldiman, *supra* note 104, at 56 (noting that although electronics-industry pools narrowed membership to "essential" patents, such a limitation in a younger field may be counterproductive because relations among patents may still be undefined).

[305] Cox, *supra* note 243, at 309–10.

[306] First, *supra* note 112, at 382.

[307] Cox, *supra* note 243, at 310.

termination rights allow innovators to limit their investment in licenses that prove to be unproductive, thus encouraging innovator participation in the pool.

¶101 In this same vein, GeoPool should require that participants provide only a field-of-use license limited to geoengineering uses.[308] This limited license would allow pool members to utilize the patent for climate-engineering purposes while enabling original patent holders to retain patent rights over non-geoengineering uses. Thus, original patent holders could still benefit from the ability to license and receive royalties for these other uses. Since many climate-engineering inventions may have other applications,[309] this significantly eases the blow of losing royalties from geoengineering uses.

¶102 Finally, following previous frameworks, the federal government should utilize a combination of "carrots" and "sticks" to ensure inclusion of essential patents. As with prior patent pools, membership in GeoPool should be voluntary, if possible. Hopefully, the access that membership in the pool allows to other technologies, much as IBM gained by licensing its patents, will provide a sufficient "carrot" to incentivize widespread membership.[310] But just as the United States was one century ago, it must be willing to utilize some "sticks" to prod patent holders into joining GeoPool. For instance, for geoengineering patents that do not join the pool, the USPTO can reexamine the patent to determine whether to narrow or break it. Although patent breaking is an extreme, rarely utilized solution,[311] as discussed previously, it is one of several tools available for the U.S. government to compel licenses, along with exercising its march-in rights for federally funded inventions.[312]

¶103 Yet the most palatable "stick" in this scenario lies in compulsory licensing. Although the United States lacks a general compulsory license provision,[313] the exercise of such a provision would be consistent with international agreements like TRIPS[314] and NAFTA.[315] These agreements allow compulsory licenses to be granted during national emergencies, or in the alternative, for public, noncommercial uses.[316] However, in circumstances requiring urgent and coordinated action such as this, adding a provision to the Patent Act that allows private parties to practice a license in the public interest would be most beneficial, perhaps mirroring a similar provision in the Atomic Energy Act.[317] Ideally, the legislation would provide an expedited process whereby the USPTO could

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308 A "field-of-use" license permits licensees to use a patent but only for certain purposes. Mark R. Patterson, *Must Licenses Be Contracts?: Consent and Notice in Intellectual Property*, 40 FLA. ST. U. L. REV. 105, 105 (2012). The Federal Circuit upheld such conditions of patent grants. Mallinckrodt, Inc. v. Medipart, Inc., 976 F.2d 700, 708 (Fed. Cir. 1992).

309 The following provide a few examples: Patent 8,603,424 pertains to the development of formed building materials composed of sequestered carbon which can be used in construction processes; Patent 8,507,253 provides for the development of photosynthetic organisms to be used in bioreactors both to sequester carbon and to generate fuel; Patent 6,045,089 pertains to a solar-powered airplane, one application of which is intended to be weather modification.

310 *See* TEECE, *supra* note 107, at 212.

311 Torrance, *Patents to the Rescue*, *supra* note 165, at 342.

312 35 U.S.C. § 203(a) (2012).

313 Nunnenkamp, *supra* note 189, at 404.

314 Thomas, *supra* note 175, at 359.

315 Torrance, *supra* note 187, at 648.

316 Thomas, *supra* note 175, at 359.

317 *See* Nielsen & Samardzjia, *supra* note 177, at 538 (recommending that compulsory licenses be granted not as a matter of course but where public interest factors outweigh the patent holder's property interest).

rule upon pertinent requests.[318] Of course, should actual implementation of a method become necessary, the United States' right to exercise a compulsory license over any patent it has authorized ensures that it can guarantee access to essential inventions.[319]

VI. CONCLUSION

¶104 The geoengineering-patent land-grab has already begun. These technologies, however, may become critical to society's response to climate change. Because of the importance of these technologies, the United States needs to ensure that these patents do not deter innovation or prevent these technologies from being available for implementation. Specifically, it should develop unique procedures to approve these applications and form a geoengineering patent pool that will facilitate both innovation and accessibility.

[318] In other contexts, commentators have suggested modifying the terms of patents to encourage or facilitate joining pools. For instance, Caitlin Lanning proposes conditioning the awarding of gene patents upon joining a gene patent pool. Lanning, *supra* note 50, at 413. Dana Beldiman, on the other hand, suggests imposing a default trigger that would impose a fixed royalty upon a patented invention for failure to join a pool for influenza medicines. Beldiman, *supra* note 104, at 59. While the Lanning proposal may be more drastic than would be necessary, the Beldiman default trigger may suggest an approach that is worthy of further consideration. Lanning also proposes shortening the exclusivity period for certain patents. Lanning, *supra* note 50, at 409–10. While Lanning's proposal might be helpful, the establishment of a geoengineering patent pool should obviate the need for such a remedy.

[319] 28 U.S.C. § 1498(a) (2012).