LEGAL APPROACHES TO PROMOTE TECHNOLOGICAL SOLUTIONS TO CLIMATE CHANGE

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ABSTRACT

Technological advancement is widely viewed as an essential component to any effective climate change strategy. However, there is no consensus as to the degree to which the law should promote technological innovation and development. This iBrief analyzes government involvement in encouraging such technology and divides the various policies into four categories. On one end are policies that rely mainly on market forces to encourage scientific advancement naturally, requiring minimal government involvement. A second category of policies involves technological development promoted indirectly through laws addressing climate change generally. A third type of policy involves directly offering government funding and financing for technological research and development. These three methods are currently the most popular means of encouraging scientific development in this field. Recently, however, there have been increasing calls for major government action of the scale of such programs as the Apollo Project. This iBrief classifies such proposals as a fourth category of policies encouraging technological solutions to climate change: the creation of institutional structures dedicated to bringing about rapid, radical technological advancements.

INTRODUCTION

¶1 The world faces an imminent climate crisis.[2] Recent reports indicate that climate change is occurring at faster rates than previously

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[2] *E.g.*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY 8–10 (2007) (describing recent scientific findings showing stronger indications of the existence and effects of climate change); NICHOLAS STERN, THE ECONOMICS OF CLIMATE CHANGE: THE STERN REVIEW 2 (2007) ("An overwhelming body of scientific evidence now clearly indicates that climate change is a serious and urgent issue.").

anticipated.[3] Because of this, many experts are calling for a major, government-sponsored scientific effort. Two such proponents, Ted Nordhaus and Michael Schellenberger, are calling for a complete shift in environmental thinking, and suggest framing climate change "as the result of too little clean economic development" rather than as a consequence of overdevelopment and over-industrialization.[4] Driven by the goal of achieving dominance in space within a fixed, short period of time, the Apollo Project was an impressive, government-coordinated initiative that accelerated technological advance and made travel to the moon possible eight years after President Kennedy launched the program.[5]

¶2 In their book, *Apollo's Fire*, Bracken Hendricks and Congressman Jay Inslee argue that the urgency of global warming requires an initiative of the same magnitude as the Apollo Project and the space race of the 1960s.[6] In many ways, Hendricks and Inslee's analogy to climate change is convincing. Cold War security concerns were a major, if not the primary, motivation behind the Apollo Project.[7] National security was also the main driver of a less widely honored, but no less impressive scientific feat: the creation of the atomic bomb through the Manhattan Project.[8] Even the Bush Administration's Department of Defense has warned of the security threats that would result from climate change.[9] Nevertheless, in many respects climate change is a fundamentally different problem.[10] Because of

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[3] *See, e.g.*, James E. Overland & Muyin Wang, *Future Regional Arctic Sea Ice Declines*, 34 GEOPHYSICAL RES. LETTERS L17705, Sept. 8, 2007, at 1; STERN, *supra* note 2, at 8 ("Results from new risk based assessments suggest there is a significant chance that the climate system is more sensitive than was originally thought.").

[4] TED NORDHAUS & MICHAEL SCHELLENBERGER, BREAK THROUGH: FROM THE DEATH OF ENVIRONMENTALISM TO THE POLITICS OF POSSIBILITY 127 (2007) (emphasis removed).

[5] *Id.* at xvii.

[6] JAY INSLEE & BRACKEN HENDRICKS, APOLLO'S FIRE 2–3 (2008).

[7] *See, e.g.*, Roger D. Launius, *Historical Dimensions of the Space Age*, *in* SPACE POLITICS AND POLICY: AN EVOLUTIONARY PERSPECTIVE 3, 16 (Eligar Sadeh ed., 2002).

[8] JEFF HUGHES, THE MANHATTAN PROJECT: BIG SCIENCE AND THE ATOM BOMB 53 (2002).

[9] PETER SCHWARTZ & DOUG RANDALL, AN ABRUPT CLIMATE CHANGE SCENARIO AND ITS IMPLICATIONS FOR UNITED STATES NATIONAL SECURITY 2 (2003) (exploring how "an abrupt climate change scenario could potentially de-stabilize the geo-political environment, leading to skirmishes, battles, and even war due to resource constraints").

[10] *See, e.g.*, Chi-Jen Yang & Michael Oppenheimer, *A "Manhattan Project" for Climate Change?*, 80 CLIMATIC CHANGE 199, 200 (2007) ("Using the Manhattan Project as a rhetorical symbol [in the climate change context] might

this, commentators have argued that dramatic institutional changes and enormous governmental funding may not be the best means of encouraging the development of climate change technology.[11]

¶3 Much of the climate change policy discussions and proposals in recent years have focused on investing in lower risk, more predictable, and steadier methods of technological advancement.[12] However, there are no standard conceptual categories for the types of policies used to encourage such advancement.[13] This iBrief will attempt to categorize technological development relating to climate change as coming from four main sources: (1) market-related incentives that will exist with little to no government interaction, (2) technological progress indirectly resulting from climate change laws, (3) direct government encouragement of private development through financial incentives, and (4) the creation of government institutions charged with ensuring the development of major technological progress.

I. NATURAL MARKET INCENTIVES

¶4 A certain amount of technological progress will inevitably stem from economic incentives to cater to a growing market for environmentally friendly technology.[14] "Perhaps the most powerful force driving today's clean-tech growth is simple economics. As a general trend, clean-energy costs are falling as the costs of fossil fuel energy are going up."[15] With an increasing demand for clean technology, there is a growing opportunity to make money in green industries. To a large degree, pure market forces,

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make sense to create a rallying point for the body politic. But good politics is not equivalent to wise policy.").

[11] *Id.*

[12] *See* JOHN C. ALIC, DAVID C. MOWERY & EDWARD S. RUBIN, U.S. TECHNOLOGY AND INNOVATION POLICIES: LESSONS FOR CLIMATE CHANGE 1 (2003) ("[I]ncremental innovations . . . are more common, have great significance for long-term economic growth, and respond in consistent ways to economic signals and public policies. If only because radical innovations are uncommon and unpredictable, incremental innovations are the most appropriate policy targets."). *See also infra* Parts II and III (explaining that the majority of proposed climate change legislation has focused on developing more predictable, less revolutionary technology).

[13] *See* ALIC, MOWERY & RUBIN, *supra* note 12, at 15 ("Although many types of policies affect innovation, no universally accepted nomenclature or taxonomy summarizes or describes them.").

[14] *See, e.g.*, LAWRENCE H. GOULDER, INDUCED TECHNOLOGICAL CHANGE AND CLIMATE POLICY 3 (Pew Ctr. on Global Climate Change 2004) ("The free enterprise system encourages technological change by offering significant rewards to inventions that yield a competitive advantage in the marketplace.").

[15] RON PERNICK & CLINT WILDER, THE CLEAN TECH REVOLUTION 6 (2007).

existing without any government prodding, will encourage natural technological advancement.

¶5 One clear example of market-driven advances in clean technology is the development of solar energy.[16] The cost of installing solar panels once far outweighed the financial benefits of using solar energy over fossil fuels.[17] Aware of the potential market, entrepreneurs sought to develop the technology necessary to make solar an affordable energy alternative.[18] Progress, largely attributed to private investment, occurred, and solar has become an increasingly viable energy source.[19] The costs of photovoltaic arrays have decreased markedly.[20] Furthermore, the fact that solar energy is immune from the price fluctuations of fossil fuels (sunlight is free), is a major factor in the financial equation.[21]

¶6 The technological advances made in solar power were derived through private investment and occurred without legal assistance.[22] Nevertheless, the fact that clean technologies are able to develop without government influence does not mean that there is no role for lawmakers.[23] There is substantial evidence indicating that laws designed to induce technological advancements often serve to increase the rate of technological change or reduce the costs of change.[24] Were we to have the luxury of having the time to allow for the natural market-driven development of clean technology, these economic incentives would suffice. Unfortunately, because of the urgency of the situation, some degree of government involvement is necessary.

II. INDIRECT CONSEQUENCES OF CLIMATE CHANGE LAWS

¶7 Pure market forces will only go so far in encouraging technological advancement. One easy way for the government to bolster investment in new clean technologies is to send policy signals indicating the economic value of clean energy. I refer to this category as "indirect consequences" of climate change laws that do not include specific provisions related to

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[16] INSLEE & HENDRICKS, *supra* note 6, at 68, 73. *But see* NORDHAUS & SHELLENBERGER, *supra* note 4, at 122 (crediting the initial stimulus for solar development to government-sponsored incentives).
[17] INSLEE & HENDRICKS, *supra* note 6, at 68, 73.
[18] *Id.* at 68.
[19] *Id.*
[20] *Id.*
[21] PERNICK & WILDER, *supra* note 15, at 7.
[22] *See* GOULDER, *supra* note 14, at 9.
[23] *Id.*
[24] *See id.* at 13–16 (describing technical studies concluding that "induced technological change" works and often has more efficient results than technological change occurring in the absence of public policy).

technological improvement.[25] Under this method, the government "pulls" technological advance rather than "pushes" it through more direct means.[26]

¶8 Climate change laws can indirectly spur technological advancement in two major ways. First, by signaling the value of clean energy, laws can encourage private investment in research and development specifically aimed at creating new technology.[27] Second, the simple increase in frequency of clean technology use will lead to technological advance as there become greater opportunities for innovation.[28]

¶9 Carbon cap-and-trade and carbon taxing are two examples of such indirect policies.[29] These policies can signal the economic value of developing clean technologies, encouraging private investors to pump money into research and development.[30] By creating laws that regulate climate change and restrict the ability to emit carbon, the government imposes costs on dirty technologies. Under such policies, the government creates market incentives to develop cheap, carbon-neutral technologies that

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[25] In their analysis of technology policies, Alic, Mowery, and Rubin lay out two separate categories that I essentially collapse into a single "indirect consequences of climate change laws" category. *See* ALIC, MOWERY & RUBIN, *supra* note 12, at 16. One of Alic, Mowery, and Rubin's categories is "a collection of policies that directly or indirectly supports commercialization and adoption, or indirectly supports development." *Id.* The other consists of "policies that foster technology diffusion through information and learning." *Id.* For the purposes of this iBrief, I do not find it necessary to subdivide this category in such a manner.

[26] *See* GOULDER, *supra* note 14, at 3–4 (describing how indirect "pull" policies "stimulate[] technological change by increasing the reward (cost savings) for discovering a process that allows reduced consumption of [dirty] fuels, which [become] more expensive"). "Push" policies are discussed in Parts III and IV, *infra*.

[27] *See* PERNICK & WILDER, *supra* note 15, at 247 (stating that "venture capitalists ranked policy as their number two reason for investing in clean tech in California, and 91% said favorable public policy is a key driver for clean-tech business and investing").

[28] *See* ALIC, MOWERY & RUBIN, *supra* note 12, at 14 ("Incremental improvements come from multiple sources, many of which, such as learning-by-doing and learning-by-using, do not depend on formal R&D.").

[29] Carbon tax policies involve placing a tax on the emission of carbon dioxide. Cap-and-trade policies establish a limit on the total amount of carbon dioxide allowed to be released into the atmosphere and allotting permits to emit based on the limit. Actors who emit less than their permits allow are able to sell their excess allowances to others.

[30] *See, e.g.*, NORDHAUS & SHELLENBERGER, *supra* note 4, at 120–21 (explaining how cap-and-trade "could, if done right, generate billions of dollars in private investment for cleaner sources of energy").

would not be subject to emissions regulations or taxes.[31] The message sent to the business community is that clean technologies are insulated from these external expenses. This method of encouraging technological innovation does not directly entice scientists and engineers to start inventing, but rather indirectly sends the message to investors that clean technology is a promising economic industry.

¶10 Cap-and-trade plans are currently the most popular proposals being offered by politicians. Among 2008 presidential nominees, Barack Obama has plans to auction permits for 100% of the nation's carbon dioxide emissions,[32] and John McCain also supports a cap-and-trade system.[33] Although McCain has been vague on the details of his plan while on the campaign trail,[34] as a senator he has authored numerous cap-and-trade bills.[35]

¶11 Multiple cap-and-trade bills have also been introduced in Congress recently.[36] Although the exact forms of these proposals differ, the common goal is to firmly limit greenhouse gas emissions to create a financial market for the ability to emit. Though not as popular, proposals to place a tax on carbon emissions would have similar results on spurring technological development by increasing the economic costs of releasing greenhouse gases.[37]

¶12 Policies that aim to increase the cost of carbon emissions are likely the most powerful way to indirectly spur technological advance. Nevertheless, other types of laws that address climate change can also have

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[31] For a brief economic explanation of cap-and-trade and carbon tax policies, see Environmental Economics, *Econ 101: Carbon Tax vs. Cap-and-Trade*, http://www.env-econ.net/carbon_tax_vs_capandtrade.html (last visited Oct. 8, 2008).

[32] Barack Obama, *Remarks of Senator Barack Obama: Real Leadership for a Clean Energy Future*, Oct. 8, 2007, http://www.barackobama.com/2007/10/08/remarks_of_senator_barack_obam_28.php (last visited Jan. 16, 2008).

[33] Climate Change, http://www.johnmccain.com/ (follow "Issues" dropdown box to "Climate Change") (last visited Sept. 26, 2008).

[34] *See id.* (merely stating that he "believe[s] "cap and trade" is the best way to manage cost and maximize benefits").

[35] Climate Stewardship and Innovation Act of 2005, S. 1151, 109th Cong. (2005); Climate Stewardship Act of 2005, S. 342, 109th Cong. (2005); The Emission Reductions Incentive Act of 2001, S. 1781, 107th Cong. (2001).

[36] *E.g.*, America's Climate Security Act of 2007, S. 2191, 110th Cong. (2007); Global Warming Reduction Act of 2007, S. 485, 110th Cong. (2007); Climate Stewardship and Innovation Act of 2007, S. 280, 110th Cong. (2007).

[37] *See, e.g.*, Save Our Climate Act of 2007, H.R. 2069, 110th Cong. (2007); America's Energy Security Trust Fund Act of 2007, H.R. 3416, 110th Cong. (2007).

the effect of signaling the value of engaging in technological research. In this regard, many states have taken the lead in implementing innovative policies.[38] California, in particular, has been the most visible in its efforts to tackle climate change.[39] In many ways, California has taken international leadership regarding climate change, often acting more like a nation-state than as a provincial government.[40]

¶13 Although the federal government has not been nearly as active as the states in trying to establish a climate-conscious culture, a number of bills relating to climate change will likely have some impact on the development of new technology. For example, proposals to allow for net metering of homes—allowing individuals to put energy *into* the grid—would likely encourage advancements in solar technology.[41] In addition, bills that focus on energy efficiency would probably have the effect of encouraging the development of better, more efficient technologies.[42] In short, just about any policy that aims to reduce the effects of climate change can indirectly promote the development of green technology. By increasing the value of clean technology and signaling a long-term lucrative market for green industry in the future, climate change laws bolster market incentives to invest in clean technology.

III. DIRECT GOVERNMENT-SPONSORED FINANCIAL INCENTIVES FOR TECHNOLOGICAL DEVELOPMENT

¶14 While market forces occurring both naturally and as a result of indirect government policies will encourage the development of many green

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[38] The Environmental Protection Agency maintains a website detailing state responses to climate change. *See* EPA, Global Warming Actions: State, http://yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsState.html (last visited Jan. 29, 2008).

[39] *See, e.g.*, CAL. PUB. UTIL. CODE §§ 399.11–399.20 (West 2007) (requiring that a certain level of energy production must come from renewable sources).

[40] *See, e.g.*, Press Release, Gov. Schwarzenegger, British Prime Minister Tony Blair Sign Historic Agreement to Collaborate on Climate Change, Clean Energy, July 31, 2006, http://gov.ca.gov/index.php/press-release/2770/ (last visited Jan. 31, 2008).

[41] *See* Solar Opportunity and Local Access Rights Act, H.R. 2848, 110th Cong. (2007) (providing for the establishment of net metering to "promote energy independence and self-sufficiency"); Solar Opportunity and Local Access Rights Act, S. 1016, 110th Cong. (2007) (providing for the establishment of net metering to promote efficiency).

[42] *See, e.g.*, Energy Efficiency Improvement Act, H.R. 3236, 110th Cong. (2007); Smart Grid Facilitation Act of 2007, H.R. 3237, 110th Cong. (2007) (establishing a more energy efficient grid called a "smart grid"); Federal Agency Environmental Responsibility Act, S. 1072, 110th Cong. (2007) (requiring greater efficiency in federal buildings).

technologies that offer low-risk returns, more radical technological advancements are needed to fully address climate change. The previous two methods will not encourage investment in instances in which high initial start-up costs and high risks of low economic return may hinder the development of certain technologies.[43] One method of injecting a bit more inducement to invent would be through direct, government-sponsored financial incentives such as grants and tax benefits.

¶15 The Energy Independence and Security Act of 2007 includes many direct, government-provided financial incentives to engage in scientific research associated with developing technologies to fight climate change.[44] However, the scope of these funds is limited to particular field of research and development. Specifically, the legislation provides funding for research and development in: biofuels,[45] solar energy,[46] geothermal energy,[47] marine and hydrokinetic energy,[48] carbon capture and sequestration,[49] and various other specific, small-scale areas of research.[50]

¶16 Many other bills proposed in 2007 also involve limited availability of research funds. The America's Domestic Fuels Act, for instance, includes a grant to the Secretary of Energy for the specific purpose to study the "use of coal gasification as an energy source in ethanol production."[51]

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[43] See NORDHAUS & SHELLENBERGER, *supra* note 4, at 119 ("But regulation cannot be the sole policy egg in the global warming basket, for without investments to encourage technological breakthroughs, we won't come close to achieving the emissions reductions we need to stabilize the climate.").

[44] Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1492 (2007).

[45] Energy Independence and Security Act of 2007, Pub. L. No. 110-140, §§ 207, 221–34, 121 Stat. 1534–37 (2007).

[46] Solar Energy Research and Advancement Act of 2007, Pub. L. No. 110-140, §§ 601–07, 121 Stat. 1675–78 (2007).

[47] Advanced Geothermal Energy Research and Development Act of 2007, Pub. L. No. 110-140, §§ 611–25, 121 Stat. 1679–85 (2007). Geothermal energy involves the use of "heat energy stored in the Earth's crust that can be accessed for direct use or electric power generation." *Id.* § 612(5).

[48] Marine and Hydrokinetic Renewable Energy Research and Development Act, Pub. L. No. 110-140, §§ 631–36, 121 Stat. 1687–89 (2007). Marine and hydrokinetic energy includes energy derived from waves, tides, currents, free-flowing water, and differentials in ocean temperatures. *Id.* at § 632. It excludes hydroelectric power coming from dams, etc. *Id.*

[49] Department of Energy Carbon Capture and Sequestration Research, Development, and Demonstration Act of 2007, Pub. L. No. 110-140, §§ 701–08 121 Stat. 1704–09 (2007).

[50] *See* Energy Independence and Security Act of 2007, §§ 651–56, 121 Stat. 1696–704 (2007).

[51] America's Domestic Fuels Act, H.R. 931, 110th Cong. § 3(a) (2007).

Other proposals specify grants relating to research in: geothermal energy,[52] clean coal,[53] and ethanol.[54] Some bills take the approach of the Energy Independence and Security Act of 2007 and provide for multiple areas of research.[55] However, those bills limit funding to further advancement of existing technologies rather than encouraging revolutionary development.[56]

¶17 Of the cap-and-trade proposals submitted in 2007, both the Lieberman-Warner[57] and the Bingaman-Specter[58] bills involve a direct investment in technological research. Both plans allocate 28% of available funds to "advanced coal and [carbon dioxide] sequestration,"[59] 7% to "cellulosic biomass ethanol,"[60] and 20% to "advanced technologies vehicle manufacturing."[61] In other words, more than half of available research goes towards advancing existing technologies. For both bills, the remaining 45% is dedicated to support a "zero or low-carbon energy technologies program."[62]

¶18 This results-oriented zero or low-carbon energy technologies program provides financial incentives for those who develop new technologies that either result in zero or low-carbon energy solutions or in high-efficiency products.[63] Programs such as these provide the best opportunity for direct government funds to result in the creation of new technologies. Although funding specifically targeted to the further development of current technologies is certainly necessary, it is important to

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[52] Advanced Geothermal Energy Research and Development Act of 2007, H.R. 2304, 110th Cong. § 4 (2007).
[53] Energy and Water Development and Related Agencies Appropriations Act of 2008, H.R. 2641, 110th Cong. tit. III (2007).
[54] Ethanol Infrastructure Expansion Act of 2007, S. 859, 110th Cong. § 4 (2007) (providing funds for "feasibility studies").
[55] *E.g.*, Renewable Fuels, Consumer Protection, and Energy Efficiency Act of 2007, H.R. 2950, 110th Cong. (2007). This bill grants funding for research in: bioenergy, *id.* § 122; renewable fuel, *id.* § 125; low-carbon fuels, *id.* § 132; lightweight material for vehicles, *id.* § 241; smart grid technology, *id.* § 256; marine and hydrokinetic renewable energy, *id.* § 292; carbon capture and storage, *id.* § 302; and green buildings, *id.* § 435.
[56] *See supra* note 55. Although it provides money for a wide range of research projects, like the Renewable Fuels and Consumer Protection, the Energy Efficiency Act of 2007 does not give funding for advanced research into new solutions. *Id.*
[57] *See* America's Climate Security Act of 2007, S. 2191, 110th Cong. (2007).
[58] *See* Low Carbon Economy Act of 2007, S. 1766, 110th Cong. (2007).
[59] S. 2191 § 4401(2)(A); S. 1766 § 401(a) (1)(B)(i).
[60] S. 2191 § 4401(2)(B); S. 1766 § 401(a)(1)(B)(ii). The Bingaman-Specter bill also includes "municipal solid waste deployment" in this 7% group. *Id.*
[61] S. 2191 § 4401(3); S. 1766 § 401(a)(1)(C).
[62] S. 2191 § 4401(1); S. 1766 § 401(a)(1)(A).
[63] S. 2191 § 4402(b); S. 1766 § 401(b)(2).

keep in mind the importance of encouraging the invention of breakthrough technologies that are essential to adequately deal with the climate crisis. Because revolutionary technologies by their very nature do not yet exist or are in conceptual infancy, their development via the method of direct, government-sponsored financial incentives should provide for flexibility in the scope of research. The zero or low-carbon energy technologies program does this by attaching funding to the end *result* of lowering carbon emission rather than dictating the *means* by which this is to happen.

¶19 Another cap-and-trade bill uses direct government funds with the purpose of promoting new technologies. The McCain-Lieberman Climate Stewardship and Innovation Act of 2007 establishes a "Climate Technology Financing Board."[64] This board is charged with providing financial assistance to those working to create new, innovative solutions to climate change.[65] In determining which projects to fund, the Climate Technology Financing Board is to consider "the extent to which the project represents the construction of the first generation of facilities that use substantially new technology."[66] This provides incentives to invent new technologies. Furthermore, the program aims to speed the development of new technologies by focusing on projects that are in need of financial support beyond what the market will provide. Specifically, the board must consider "the likelihood that assistance . . . would enable the project to proceed at an earlier date than the project would otherwise be able to proceed without such assistance" when selecting projects to fund.[67]

IV. GOVERNMENT INSTITUTIONAL LEADERSHIP

¶20 Some degree of technological advancement is sure to result from any and all of the three methods mentioned previously. However, the big question is whether those advancements will be enough to sufficiently address a problem that can easily turn into a crisis overnight. Because climate change is such a unique problem with potentially catastrophic consequences, many commentators argue that nothing should be left to chance.[68] Therefore, there are increasing calls for major government

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[64] Climate Stewardship and Innovation Act of 2007, S. 280, 110th Cong. § 251 (2007).
[65] *See id.* §§ 251(a), 251(c)(2).
[66] *Id.* § 251(c)(2)(D).
[67] *Id.* § 251(c)(2)(C).
[68] *See, e.g.*, RICHARD A. POSNER, CATASTROPHE: RISK AND RESPONSE 163 (2004); CASS R. SUNSTEIN, WORST CASE SCENARIOS 119 (2007). *But see* BJORN LOMBORG, COOL IT 123–24 (2007) (arguing that it is not worthwhile to plan for a catastrophe caused by climate change).

initiatives—beyond simple lawmaking and regulation—to spur technological development.[69]

¶21 Existing federal law falls far short of establishing the major institutional measures that are called for by those advocating an Apollo-like approach to climate change. For instance, although the principal 2007 energy legislation takes some steps to encourage climate-related technological development, it provides for no major institutional changes.[70] Two cap-and-trade bills—Sanders-Boxer[71] and Kerry-Snowe[72]—include an institutional apparatus that somewhat resembles the type of initiative needed to truly assist in the creation of breakthrough technologies, but falls far short of the ideal institutional structure.[73]

¶22 Perhaps the closest thing to an Apollo proposal to come out of Congress is the establishment of an "Advanced Research Projects Agency – Energy" (ARPA-E)[74] Modeled after the Defense Advanced Research Projects Agency (DARPA), ARPA-E simply aims "to overcome the long-term and high-risk technological barriers in the development of energy technologies."[75] DARPA was created for the purpose of encouraging defense and military-related research and development.[76] DARPA had many successes, including the development of crucial space technologies as well as the creation of the internet.[77] ARPA-E is currently the climate change plan that best matches the type of institutional structure needed to meet Apollo-like standards. However, as the ARPA-E proposal stands, it lacks many crucial characteristics that would be part of a truly effective institution of this category.[78]

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[69] *See supra* note 6 and accompanying text.
[70] *See supra* notes 44–50 and accompanying text.
[71] Global Warming Pollution Reduction Act, S. 309, 110th Cong. (2007).
[72] Global Warming Reduction Act of 2007, S. 485, 110th Cong. (2007).
[73] Specifically, the R&D institution mentioned in these bills would be subsidiary to existing organizations and would be charged mainly with advancing existing technologies rather than encouraging revolutionary inventions. S. 309 § 711; S. 485 § 705.
[74] America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act, S. 761, 110th Cong. § 2005 (2007).
[75] *Id.* § 2005(b).
[76] Defense Advanced Research Projects Agency, DARPA Over the Years, http://www.darpa.mil/body/overtheyears.html (last visited Mar. 5, 2008).
[77] DARPA, DARPA's 50th Anniversary, History, http://www.darpa.mil/DARPA50thevent/history.html (last visited Mar. 5, 2008).
[78] To truly be effective, a climate change equivalent to Apollo must be as expansive, goal-driven, and fully supported as the Kennedy-initiated lunar mission. This will require a massive initiative involving the creation of a government climate institution analogous to NASA. As with Apollo, it will also require strategic coordination with the private sector, academic institutions, and

¶23 California has established an institutional structure that comes close to fitting within this fourth category of climate change technology policies. The California Global Warming Solutions Act of 2006 mandated the establishment of the Global Warming Economic and Technology Advancement Advisory Committee (ETAAC), a branch of the California Air Resources Board.[79] The ETAAC is given the responsibility to:

> advise [the Air Resources Board] on activities that will facilitate investment in and implementation of technological research and development opportunities including, but not limited to, identifying new technologies, research, demonstration projects, funding opportunities, developing state, national, and international partnerships and technology transfer opportunities, and identifying and assessing research and advanced technology investment and incentive opportunities that will assist in the reduction of greenhouse gas emissions.[80]

The members of this committee have varied backgrounds and expertise.[81] They are appointed "based on their knowledge and expertise in fields of business, technology research and development, climate change, and economics."[82]

¶24 The United States has a long history of investing enormously in scientific progress as a means of tackling crises. For instance, faced with World War II security concerns, the U.S. initiated the Manhattan Project, a government-sponsored program charged with developing advanced nuclear

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think tanks. Under ARPA-E, entities in these sectors can qualify for grants and contracts, but would have little say in the agency itself. H.R. 364, 110th Cong. § 2(d) (2007). Unlike Apollo, the ideal climate change institutional structure will also require cooperation and coordination with actors beyond the U.S. borders. To be most effective, therefore, an Apollo project for climate change must not only involve a massive domestic effort, but must also allow for and encourage strong international collaboration. ARPA-E falls short of this component since it does not explicitly provide for international coordination. *See id.* § 2(f) (providing for coordination among federal entities but not mentioning international coordination).

[79] California Global Warming Solutions Act of 2006, CAL. HEALTH & SAFETY CODE div. 25.5, §§ 38500–99 (West 2007).

[80] *Id.* § 38591.

[81] *See generally* Cal. EPA Air Res. Bd., Economic and Technology Advancement Advisory Committee Members, http://www.arb.ca.gov/cc/etaac/etaac_members.pdf (last visited Feb. 2, 2008) (providing biographical summaries of the members of ETAAC).

[82] Cal. EPA Air Res. Bd., Economic and Technology Advancement Advisory Committee (ETAAC), http://www.arb.ca.gov/cc/etaac/etaac.htm (last visited Feb. 2, 2008).

technology as quickly as possible.[83] The urgency the world currently faces in avoiding an impending climate catastrophe parallels the urgency that the United States felt in the need to secure the capacity to build atomic bombs during World War II.[84] The Manhattan Project was a bold, proactive response to the crisis. The brightest minds were brought together, including thousands of scientists, engineers, and technicians.[85] The project was enormous and "was directed to one overriding goal: the production of nuclear weapons."[86]

¶25 Nevertheless, there are some clear differences between the Manhattan Project and the institutional composition of an analogous climate change program. One major difference is that secrecy was paramount to the success of the Manhattan Project.[87] Since climate change is by its very nature a global problem, there is no need to hide scientific findings and technological progress. In fact, openness and collaboration will likely be beneficial in reaching solutions to the crisis. In addition, the Manhattan Project was driven by a single technological goal, whereas for climate change, it is probably best to encourage the development of countless different types of technologies. A large government apparatus worked for the narrow technological goal of creating an atomic weapon, but may not work as well in this situation. In addition, such a massive government project may not be the most efficient way to accomplish the same results that could be achieved through the three more basic methods of encouraging technological progress.[88]

¶26 Twenty years after the Manhattan Project, the United States government once again took decisive action in assisting in the creation of a technological breakthrough. In 1961, President Kennedy announced a goal to send a man to the moon within a decade.[89] Determined to succeed, the U.S. government established an institutional apparatus that would provide the best environment for the development of space technology. NASA collaborated with private industry and university researchers in a nexus that "enable[d] the large-scale technological development needed for Project

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[83] *See* HUGHES, *supra* note 8, at 53.
[84] *See id.* at 53–55.
[85] *Id.* at 9.
[86] *Id.*
[87] *Id.* at 53.
[88] *See* Yang & Oppenheimer, *supra* note 10, at 200.
[89] President John F. Kennedy, Special Message to the Congress on Urgent National Needs 4 (May 26, 1961), *available at* http://www.jfklibrary.org/Historical+Resources/Archives/Reference+Desk/Speeches/JFK/Urgent+National+Needs+Page+4.htm ("I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth.").

Apollo."[90] On July 20, 1969, Apollo XI landed on the moon, accomplishing Kennedy's mission two years early.[91]

¶27 As referenced earlier in this iBrief, the Apollo Program is a popular source of inspiration for climate change proposals.[92] Despite this, most Apollo-like proposals appear to have only superficial similarities with the original Apollo Program. For instance, the original Apollo was effective in part because it involved strategic coordination with the private sector, academic institutions, and think tanks. Under ARPA-E, however, entities in these sectors have little say in the agency.[93]

¶28 It is also questionable whether Apollo is actually an appropriate model to follow for climate change. For example, unlike Apollo, the ideal climate change institutional structure will also require cooperation and coordination with actors beyond the U.S. borders. Apollo was born as part of the Cold War space race between two nation-states. It was in essence part of a giant contest between the two superpowers of the time. The climate change crisis is fundamentally different in that the entire world risks impending peril from a global phenomenon. To be most effective, therefore, an Apollo-like project for climate change must not only involve a massive domestic effort, but must also allow for and encourage strong international collaboration. ARPA-E falls short of this component since it does not explicitly provide for international coordination.[94]

¶29 Furthermore, most proposals selling themselves as "Apollo"-like also lack the necessary domestic and international scale and scope.[95] In addition, the Apollo Program shared the Manhattan Project's single-goal mission model. As discussed earlier, climate change is different in that a multiple technologies solution is likely the best option, and it is unclear as to whether creating a massive government institution is the most effective way to accomplish this. Moreover, it is questionable as to whether a government-controlled institution is the most efficient investment of resources if the same results can be reached under any of the three less intensive approaches to inducing technological advance.

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[90] Eligar Sadeh, *Public Administration of the Space Program*, *in* SPACE POLITICS AND POLICY, *supra* note 7, at 129, 143.
[91] NASA, The Apollo 11 Mission, http://spaceflight.nasa.gov/history/apollo/apollo11/index.html (last visited Jan. 22, 2008).
[92] *See, e.g.*, HENDRICKS & INSLEE, *supra* note 6, at 2–3.
[93] *See* America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act, S. 761, 110th Cong. § 2005 (2007).
[94] *See id.*
[95] *See, e.g.*, New Apollo Energy Act of 2007, H.R. 2809, 110th Cong. §§ 204, 612 (2007).

CONCLUSION

¶30 Technology is an essential component of any effective climate change solution. The drivers of technological advancement can come from a range of policy methods. The easiest strategy is to simply allow the free market system to work its course. Private investors will continue to naturally be drawn to a growing market for clean technology. As a second alternative, the government can encourage private investment by indirectly signaling the increasing value of clean technology under climate-friendly legal frameworks. If costs are assigned to environmentally unsound practices, incentives will form to create technology that will allow for cheaper compliance to climate-friendly laws. A third approach would be for the government to take a more proactive role in encouraging technological advancement by directly funding research and development. To this point, clean technology has been driven by these three types of tactics.

¶31 Recently, however, there have been calls for a more intensive government-initiated method: establishing a specialized institutional structure to focus on the development of revolutionary technological solutions to climate change. The United States has done this in the past to meet exceptional scientific challenges. Both the Manhattan Project and the Apollo Program were successful in meeting their extraordinary goals. However, comparisons to Manhattan and Apollo only go so far. It is questionable as to whether a similar massive government initiative is the most appropriate way to encourage climate change technological development.

¶32 In short, a wide array of policy options is available to spur the creation of clean technology. Relying solely on market forces will likely be insufficient, and establishing a large-scale Apollo-like project for energy is controversial and has some drawbacks. The best policy option likely involves a blend of all four types of policies, with more of a concentration on the second and third categories—indirect and direct government encouragement of technological development through climate change legislation.