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Eyes on a Climate Prize: Rewarding Energy Innovation to Achieve Climate Stabilization

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Introduction

The scope, complexity, and potential costs of global climate change are daunting. Without concerted efforts by nearly all nations to drastically reduce net greenhouse gas (GHG) emissions, atmospheric concentrations will likely double pre-industrial levels before century's end.[1] President Barack Obama and congressional leaders have endorsed an ambitious target for greenhouse gas emission reductions of 80% by the year 2050.[2] Meeting this goal would require that the United States emit less carbon dioxide than at any point in nearly a hundred years—while accommodating a much larger and much wealthier population. This will be exceedingly difficult to do, both practically and politically.

If the United States is to come anywhere close to the "80 by 50" target, substantial innovation in energy and climate related technologies is necessary.[3] And yet there is doubt whether such innovation is something dominant innovation policy tools can deliver. Neither traditional federal support for research and development of new technologies nor command-and-control regulations are likely to spur sufficient innovation. Nor is there reason to believe a proposed cap-and-trade system will do the trick. Such tools have not shown themselves capable of affecting dramatic technological innovation.

In the climate change context, traditional policy tools such as grants, regulatory controls, and intellectual property are likely insufficient to generate desired levels of invention, innovation, and diffusion.[4] Presently, there are no meaningful economic incentives to develop technologies that reduce GHG emissions or remove carbon from the atmosphere.

Meeting the climate policy challenge will require policymakers to expand their policy toolkit. Specifically, the federal government should shift a substantial portion of climate-related research and development funding from grants to prizes. Instead of doling out billions to researchers in the hope they will invent something that will help solve the global warming challenge, the government should offer substantial rewards to those who invent or develop technologies that solve particular climate-related problems. While no policy guarantees technological innovation, greater reliance on inducement prizes would increase the likelihood of developing and deploying needed technologies in time to alter the world's climate future.

I. The Climate Policy Challenge

Atmospheric stabilization requires global action. Yet climate change presents the ultimate commons problem on a planetary scale. No country has much incentive to reduce its emissions without assurance that other nations will follow. Those countries most essential to controlling global emissions—the United States and China in particular—have the least incentive to act.[5] Furthermore, so long as reducing greenhouse gas emissions is costly, most nations are unlikely to undertake meaningful emission reduction efforts.[6]

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1. *See* Intergovernmental Panel on Climate Change (IPCC), Climate Change 2007: Synthesis Report; Fourth Assessment Report of the Intergovernmental Panel on Climate Change 45 (2007).
2. *See The Obama-Biden Plan Agenda, Energy & Environment*, Change.gov, http://change.gov/agenda/energy_and_environment_agenda.
3. *See infra* Part I.
4. *See* Adam B. Jaffe, Richard G. Newell & Robert N. Stavins, *Technological Change and the Environment*, *in* 1 Handbook of Environmental Economics, 464-65 (Karl-Göran Maler & Jeffery R. Vincent eds., 2003) (distinguishing between invention, "the first development of a scientifically or technically new product or process," innovation, "when the new product or process is commercialized" or "made available on the market," and diffusion, when an innovation becomes "widely available for use in relevant applications through adoption by firms or individuals").
5. *See* Cass R. Sunstein, *The World vs. the United States and China? The Complex Climate Change Incentives of the Leading Greenhouse Gas Emitters*, 55 UCLA L. Rev. 1675, 1678-90 (2008); *see also* Robert W. Hahn, *Climate Policy: Separating Fact From Fantasy*, 33 Harv. Envtl. L. Rev. 557, 566 (2009).
6. *See* Roger Pielke Jr., The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming 46 (2010).

Technological innovation is necessary to make climate stabilization achievable and affordable. The price tag associated with greenhouse gas emission limits has discouraged the adoption and enforcement of emission limits. Developing nations, in particular, have made clear they will not adopt climate policies that hamper economic growth.

The level of technological innovation necessary to make atmospheric stabilization an affordable—and therefore politically viable—proposition is unlikely to happen without government intervention. The competitive pressures of a market economy provide substantial incentives for firms to increase efficiency, but not to reduce GHG emissions, as such. Because GHGs are emitted into the atmospheric commons, there is no direct economic incentive to reduce such emissions, and little market for GHG-limiting innovations. This is the problem technology inducement prizes could solve.

II. Innovation-Inducing Prizes

The idea behind technology inducement prizes is simple: incentives matter. If the goal is greater effort toward solving a particular problem, then one way to achieve that goal is to provide economic incentives for individuals to act accordingly. Inducement prizes do this by offering rewards for pre-specified scientific or technological achievements, such as the solution to a mathematical problem, a device or method to perform a particular function within given parameters, or the completion of a particular task.[7] Like patents, prizes offer the promise of a greater economic return than that which would be obtained in a competitive market.[8] With a patent, the increased return is provided by the monopoly right. With a prize, the increased return comes from the value of the prize itself.

One virtue of the patent system that prizes simulate is decentralization.[9] Because technological innovation is unpredictable, can arise from unexpected directions, and may involve a degree of serendipity, prizes have a distinct advantage over centrally allocated research grants insofar as they do not preclude potentially promising directions for innovation.[10] Decentralized systems are also more able to draw from a wider pool of ideas and potential innovators.[11] By offering a potential award to all comers, prizes encourage diverse research and innovation strategies, and allow for the success of outliers.[12] Inducement prizes allow the government to establish a goal without being prescriptive as to how that goal should be met or who is the best position to meet it.[13] Further, with a prize there is no need to apply for a government grant, comply with complex eligibility requirements, or ingratiate oneself with grant-making authorities.[14]

Prizes have the capacity to stimulate increased investment in a given technological problem from a wide range of sources. Because the prize is a competition, multiple innovators may invest in trying to obtain the prize.[15] Competitors may also be motivated by prestige and publicity.[16] As a consequence, prizes "can stimulate philanthropic and private-sector investment that is greater than the value of the prize."[17] One value of the patent system that prize systems do not duplicate is the added incentive for commercialization of an innovation.[18] A prize winner, however, may receive the prize simply for the invention itself. In order to avoid this potential problem, prize specifications can include criteria to ensure potential marketability.

Prizes can also be particularly important to spur investment in technological innovations that would be of primary benefit to low-income consumers and people in developing nations. Few profit-seeking firms are likely to make significant investments in serving such markets. Few firms see massive profit opportunities in developing low-carbon energy options for developing nations. Yet, the welfare benefits from improved energy efficiency and a less carbon-intensive development path in much of the world could be quite substantial.

Technology inducement prizes are particularly well suited for climate change policy. Climate change policy depends less upon additional basic research than the development and deployment of practical technological innovations, and the utility of such innovations can be readily evaluated. While there are substantial market incentives encouraging the development of environmentally friendly technologies in other contexts, the commons nature of the climate problem and lack of a price on carbon emissions discourages optimal private investment in climate-related innovation.

III. Prize History

Prizes for scientific and technological innovation used to be common. Prizes were awarded for basic science just as for technical advance, from mathematics to food preservation, alkali production to air travel. Among the most famous

7. *See generally* Brian D. Wright, *The Economics of Invention Incentives: Patents, Prizes and Research Contracts*, 73 Am. Econ. Rev. 691 (1983).
8. *See* Kenneth W. Dam, *The Economic Underpinnings of Patent Law*, 23 J. Legal Stud. 247, 250 (1994).
9. *See* Peter S. Menell & Suzanne Scotchmer, *Intellectual Property Law*, *in* Handbook of Law & Economics 1473, 1477 (A. Mitchell Polinsky & Steven Shavell eds., 2007).
10. According to William Baumol, "the independent innovator and the independent entrepreneur have tended to account for most of the true, fundamentally novel innovations." William J. Baumol, *Education for Innovation: Entrepreneurial Breakthroughs vs. Corporate Incremental Improvements* 5 (Nat'l Bureau of Econ. Research, Working Paper No. 10578, 2004).
11. *Id.*; *see also* Nat'l Acad. of Sci., Innovation Inducement Prizes at the National Science Foundation 13 (2007) ("[C]ompared with grant programs, prize programs may be expected to attract more individuals, informal teams, and for-profit firms of various sizes and perhaps not as many academic institutions.").
12. *See* Thomas Kalil, *Prizes for Technological Innovation*, Hamilton Discussion Paper 2006-08, The Brookings Institution, at 5 (Dec. 2006).
13. *See Id.*
14. *See* Suzanne Scotchmer, Innovation and Incentives 41-42 (2004).
15. *See* John F. Duffy, *Rethinking the Prospect Theory of Patents*, 71 U. Chi. L. Rev. 439 (2004).
16. *See* McKinsey & Company, "And the Winner Is . . .": Capturing the Promise of Philanthropic Prizes 19, 26 (2009).
17. *See* Kalil, *supra* note 12, at 7.
18. *See generally* F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 Minn. L. Rev. 697 (2001).

prizes was the British government's longitude prize, which led to the development of a revolutionary clock that aided navigation.[19] Despite the success of prizes in the 18th and 19th centuries, they gradually went out of favor. However, the 1990s saw a "renaissance" of prize awards, largely funded by private philanthropists.[20] The X-Prize Foundation created the "Ansari X-Prize," an award of $10 million for the private development of a reusable, manned spacecraft. In 2004, a team bankrolled by Microsoft co-founder Paul Allen claimed the prize for their SpaceShipOne, which managed to make two suborbital flights in less than two weeks. Although only $10 million was awarded, the prize spurred over $100 million in privately funded research.[21]

The federal government has also showed a renewed interest in prizes. In 2005, Congress directed the National Science Foundation (NSF) to begin utilizing "innovation inducement prizes" with portions of its annual appropriations.[22] The NSF arranged for a study on how it could administer prizes to "achieve novel solutions to specified social or research needs or capitalize on recognized research opportunities."[23] The resulting report, published in 2007, concluded there are "many possibilities for employing innovation inducement prizes to overcome technical and scientific challenges in low-carbon energy supply, demand, and storage technologies."[24] The Obama Administration has also shown interest in the use of prizes.[25]

IV. Prizes Versus Grants

Additional funding of energy-related research and development will be necessary to spur the technological innovation necessary to reduce GHG emissions.[26] However, both public and private investment in such R&D has declined over the past few decades,[27] as has the number of patents issued for energy-related technologies.[28] Energy R&D accounted for approximately 25% of nondefense federal R&D spending in the 1970s, but was only 7% in 2008.[29] The question is less whether there should be more R&D funding, but the form such funding should take.[30]

Traditional grant-driven funding for R&D has several limitations.[31] First, decisions about projects or efforts to fund are centralized, limiting the range of promising ventures that receive funding while increasing the risk that research funding will not result in useful technological innovations. Second, with ex ante grants, the government pays for R&D whether or not the R&D produces anything of value. Third, grant funding is more subject to political pressure and may create negative incentives among researchers.

Prizes, like patents, impose the R&D costs of the invention on the inventors. Prize sponsors only pay for an inventor's work if she is ultimately successful.[32] Unsuccessful innovators, and their sponsors, are left to bear their R&D costs themselves. This has clear fiscal benefits for the government, and taxpayers.[33] If R&D is funded ex ante, there is no assurance that the investment will produce any benefits to the funder at all.[34] With prizes the financial payment is conditional upon the prize conditions being fulfilled. Provided the prize is properly designed—and a would-be innovator succeeds—the funder gets its money's worth.

The same characteristics that make innovation prizes effective discourage their use by politicians. Grant programs empower government officials to dole out funds to favored constituencies and institutional insiders. Even where efforts are made to insulate the decision-making process, grant-making officials are influenced by knowledge of who will receive grant support, and the grants go out whether or not a grant recipient delivers or a problem is solved. Prize money is only paid out if someone fulfills the preset conditions and is available to all comers, irrespective of their political influence or institutional connections.

Prizes are not without their drawbacks. Setting the appropriate level for a prize can be difficult, particularly if the prize is expected to substitute for patent protection.[35] A prize that is too small will fail to stimulate sufficient investment, but a prize that is too high will waste resources.[36] Additionally, prize systems require researchers

19. *See* Dava Sobel, Longitude (1995).
20. *See* Scotchmer, *supra* note 14, at 44. *See also* McKinsey, *supra* note 16, at 16 (noting "prizes are booming once again" and citing increase in prizes since 2000). In 1972, President Richard Nixon proposed the use of prizes to "foster useful innovation," but Congress did not act upon his proposal. *See* Harry Goldsmith, *An Olympiad of Science*, 177 Sci. 35, 35 (July 7, 1972).
21. *See* McKinsey, *supra* note 16, at 25.
22. Science, State, Justice, Commerce, and Related Agencies Appropriations Act, Pub. L. No. 109-108, 119 Stat. 2290, 2318 (2006).
23. *See* Nat'l Acad. of Sci., *supra* note 11, at vii.
24. *See id.* at 42.
25. For example, in 2010, the White House Office of Management and Budget issued guidance to federal agencies on the use of prizes to spur technological innovation. *See* Memorandum from Jeffrey D. Zienst, Deputy Director for Management, Office of Management and Budget, to the Heads of Executive Departments and Agencies (Mar. 8, 2010).
26. *See* Gwyn Prins & Steve Rayner, *Time to Ditch Kyoto*, 449 Nature 973, 974 (2007).
27. Gregory F. Nemet & Daniel M. Kammen, *U.S. Energy Research and Development: Declining Investment, Increasing Need, and the Feasibility of Expansion*, 35 Energy Pol'y 746, 746 (2007). Of note, energy R&D funding has declined, while overall R&D funding has increased. *Id.* at 747.
28. *Id.* at 749-50; *see also* John Alic et al., *A New Strategy for Energy Innovation*, 466 Nature 316, 316 (2010).
29. *See* Richard G. Newell, *The Energy Innovation System: A Historical Perspective*, *in* Accelerating Innovation in Energy: Insights From Multiple Sectors (Rebecca Henderson & Richard Newell eds., forthcoming) (manuscript at 13). *See also* Nat'l Acad. of Sci, Limiting the Future Magnitude of Climate Change 120 (2010) (noting decline in energy R&D as percentage of non-defense federal spending from 1980 to 2008).
30. *See* Newell, *supra* note 29.
31. *See* Alic et al., *supra* note 28, at 316.
32. In the case of patents, on the other hand, the costs of developing successful innovations are passed through to consumers.
33. As Scotchmer notes, "When innovations are funded out of general revenue, there is no guarantee that the benefits received by any individual taxpayer outweigh that taxpayer's share of the costs," if, that is, the funding generates any innovation benefits at all. *See* Scotchmer, *supra* note 14, at 38.
34. Contrary to some claims, it is unclear how much government science and R&D funding directly contribute to economic growth. *See* Julia Lane, *Assessing the Impact of Science Funding*, 324 Sci. 1273, 1273 (2009).
35. *See* Michael Abramowicz, *Perfecting Patent Prizes*, 56 Vand. L. Rev. 115, 121 (2003).
36. Marlynn Wei, *Should Prizes Replace Patents? A Critique of the Medical Innovation Prize Act of 2005*, 13 B.U. J. Sci. & Tech. 25, 32 (2007) ("If the prize is too low, then the system will inadequately stimulate R&D investment. If the prize is too high, then costs such as resource duplication and the problem of favoritism will be exacerbated.").

to obtain funding for their research up front. For some types of research, particularly where expensive equipment is required, this can create a significant obstacle. Prizes are not well suited to situations in which the funding authority cannot articulate clear criteria upon which the prize would be awarded. For this reason, prizes are not likely well suited for the funding of basic research. In the climate change context, however, there is a need for practical innovations that are commercially viable. This makes prizes particularly well-suited for the climate policy challenge.

V. Innovation and Regulation

Using traditional regulatory tools to drive technological innovation requires detailed knowledge about the desired course of technological change and what sorts of innovations are likely or foreseeable. Yet, government regulators rarely have the necessary information or foresight to drive innovation this way.[37] Even if regulators were able to identify a proper target initially, the regulatory process changes so slowly that regulatory standards would be unlikely to keep up with technological change or account for new information.

Regulatory measures often have compliance periods that are too short to induce large-scale innovation or significant technological breakthroughs.[38] The regulatory environment can also generate uncertainty that discourages investments in technological innovation.[39] Insofar as governmental commitments to future levels of regulation are of "questionable credibility," this diminishes the incentives for innovation that environmental regulations could otherwise provide.[40]

Technology-based standards, in particular, can "play a key role in discouraging innovation," as they can result in the locking-in of an administratively anointed technology, discouraging efforts to develop more advanced alternatives.[41] As a consequence, "technology-based standards provide the weakest incentives for both abatement technology and output technology innovation."[42] Yet, even performance-based standards can discourage innovation as such standards may be based upon established reference technologies in order to facilitate implementation and enforcement. In such cases, companies and regulators are likely to prefer reference technologies they are confident will meet standards, rather than innovative approaches that are less certain.[43]

Market-based regulatory approaches are likely to be more effective in encouraging technological innovation than command-and-control regulations. Yet, there is little evidence that even market-oriented instruments can produce more than incremental improvements. The Clean Air Act's acid rain program, for instance, is widely credited with achieving substantial pollution reductions at a relatively low cost, yet it does not appear to have spurred much innovation.[44]

VI. A Prize Proposal

Richard Branson and other private individuals may continue to offer technological inducement prizes for climate-related innovations. These prize awards could be important, but they are unlikely to produce the degree of technological innovation necessary to achieve current climate policy goals in a cost-effective manner. Encouraging the desired level of innovation will require far more. Thomas Kalil believes that the federal government should offer $100-200 million annually in prize awards for the innovations in zero-energy building design, reductions in urban greenhouse gas emissions, and increased development of fuel-efficient vehicles.[45] Yet, even this could be insufficient. If one uses the potential social benefits of averting climate change as the benchmark, the investment in technological innovation should be far greater.

The federal government currently spends approximately $3 billion annually on research and development of climate-related technologies. The U.S. Climate Change Technology Program (USCCTP) funds research efforts into technological improvements that could potentially be achieved in the near, medium, and long term.[46] Projects range from vehicle and building design to fuel cell technology, agricultural methods, and carbon sequestration technologies.[47]

Assuming current funding levels continue, the federal government will spend approximately $30 billion on

37. *See* Hahn, *supra* note 5, at 580 ("The regulator typically lacks the kind of information needed to set standards appropriately for forcing innovation."); Gary E. Marchant, *Sustainable Energy Technologies: Ten Lessons From the History of Technology Regulation*, 18 Widener L.J. 831, 836 (2009) ("[I]t is difficult to predict the ingenious and creative innovations" scientists and inventors might develop.).
38. *See* Kenneth J. Arrow et al., *A Statement on the Appropriate Role for Research and Development in Climate Policy*, Economists' Voice 3, Feb. 2009.
39. *See* Newell, *The Energy Innovation System*, *supra* note 29, at 15-16 (noting research showing that changing regulatory conditions and uncertainty can dampen private-sector investment in technological innovation).
40. *See* Marchant, *supra* note 37, at 848.
41. *See* Environmental Law Institute, Barriers to Environmental Technology Innovation and Use 7 (Envtl. L. Inst., 1998). This report further explains, "Emission limits or discharge standards based on a single best technology create practical barriers to innovation by limiting permissible technologies to available ones that meet the standard. This requirement precludes the normal development and refinement processes most technologies need to achieve their best performance and, in many cases, can limit permissible technologies to a single one." *Id. See also* Adam Jaffe, Richard G. Newell, and Robert N. Stavins, *Environmental Policy and Technological Change*, Envtl. & Resource Econ. 41, 50 (2002).
42. Wesley A. Magat, *The Effects of Environmental Regulation on Innovation*, 43 Law & Contemp. Problems 4, 21 (1979).
43. *See* U.S. Office of Tech. Assessment (OTA), Innovation and Commercialization of Emerging Technologies 87 (1995).
44. *See* David M. Driesen, *An Environmental Competition Statute*, *in* Beyond Environmental Law: Policy Propsoals for a Better Environmental Future 175-76 (Alyson C. Flournoy & David M. Driesen eds., 2010).
45. *See* Kalil, *supra* note 12, at 9.
46. The U.S. Climate Change Technology Program (USCCTP) defines "near-term" as less than 20 years, "mid-term" as 20-40 years, and "long-term" as more than 40 years. USCCTP, U.S. Dep't of Energy, U.S. Climate Change Technology Program, Strategic Plan 211 (Sept. 2006), *available at* http://www.climatetechnology.gov/stratplan/final/index.htm.
47. *Id.*

climate-related technologies over the next decade. If the federal government committed one-third of USCCTP funding—either reallocating it from traditional R&D or augmenting it with a new revenue source—it would have sufficient resources to endow a series of substantial climate prizes. With $10 billion over 10 years, the USCCTP, or another agency such as ARPA-E, could endow prizes across the range of technologies the USCCTP has identified as priorities for climate change policy. This amount is significantly less than the estimated potential social welfare losses of climate change, and yet would substantially increase the incentives for needed technological innovation.

Due to the potential for prize awards to spur greater levels of private research, as what occurred with the Ansari X-Prize, reallocation of USCCTP funding in this way would produce a substantial increase in overall investment into climate-friendly technologies.[48] Equally important, the announcement of prizes of this magnitude would draw additional attention to the need for climate-related research and increase the prestige of developing climate-related technologies. A high-profile government investment in prizes would underscore the importance of climate-friendly technological innovation.[49]

Developing specific prize criteria is particularly important.[50] The USCCTP's matrix of technological goals and projected time frames for development could serve as the basis for prize specifications, but would need to be refined if used for prizes instead of traditional R&D. Either the USCCTP or some other entity, such as the National Academy of Sciences or National Academy of Engineering, could assemble an expert panel of researchers, scientists and engineers to identify which technological goals are most suited to the use of prizes. Such a panel would also have to devote considerable time to developing prize specifications with sufficient detail to ensure that winning innovations would be worth the public investment, but with enough flexibility so as not to preclude new ways of solving existing problems.[51] It is also important that prize criteria are clear and objectively measurable.[52] The panel would also have to determine the size of prize awards, and whether there would be multiple or shared awards in any given area. In some cases, structuring prizes to divide awards proportionately may increase entry rates and generate additional innovation.[53]

The recent NAS report on the prospective use of innovation inducement prizes by the National Science Foundation reviewed many of the prospective implementation questions for government administered prize program.[54] Among other things, the NAS stressed the need to design prizes around objectively measurable outcomes and endorsed "first past the post" prizes with set time limits.[55] The NAS also recommended that the federal government should not seek to own, control or influence the disposition of intellectual property resulting from a prize competition, unless the winner does not seek to commercialize resulting innovations within a reasonable time period.[56] The NAS suggested the possibility that prize awards include a stipulation requiring good faith efforts to commercialize resulting innovations or even forced licensing, but urged against requiring that such intellectual property be made available at no cost or on concessional terms.[57]

It would also be important to examine whether additional incentives would need to be created to encourage diffusion of the relevant technology. One possibility would be for prizes to include advance market commitments, through which a government commits in advance to purchase of a given quantity of an innovation that meets predetermined characteristics.[58] So, for instance, the federal government could commit to purchase a given number of automobiles that meet or exceed a given fuel efficiency or emissions-per-mile standard, creating additional incentives to translate new inventions in to commercially viable products. The potential for government procurement appears to enhance the incentives for defense-related technologies.

As the Office of Management and Budget noted in 2010, federal agencies, including the Department of Energy, already have some ability to fund technology inducement prizes out of existing appropriations. It would be a mistake to leave prizes to the administrative process, however. The same political pressures that can distort traditional R&D funding are likely to discourage the diversion of funds from R&D grant programs to prizes. Without a direct statutory mandate, agencies are more likely to talk about prize competitions than they are to implement them.[59]

Congress should mandate that specific agencies develop prizes and specify the minimum degree of funding such prizes should receive out of agency appropriations. Congress should also identify, in broad terms, the purposes for which prizes should be used, as well as to require the appointment of outside expert panels to assist in the prize

48. It is also possible that the creation of prizes would not require an equal offset of existing USCCTP funding, as prize awards would not be paid out unless and until the necessary innovations were developed and proven.
49. *See* McKinsey, *supra* note 16, at 21 (discussing potential for prizes to change public perception); *id.* at 22 (discussing ability of prizes to focus a community's efforts on a specific problem).
50. X-Prize Foundation Chairman and CEO Peter Diamandis testified before Congress that "writing the rules is more than 80 percent of the battle." *NASA Contests and Prizes: How Can They Help Advance Space Exploration?: Hearing Before the Subcomm. on Space and Aeronautics of the H. Comm. on Sci.*, 108th Cong. 29 (2004) (statement of Dr. Peter H. Diamandis, Chairman & CEO, X-Prize Foundation).
51. *See* McKinsey, *supra* note 16, at 39-45 (discussing the goal setting process for prize competitions).
52. *See* McKinsey, *supra* note 16, at 54 (noting "objectivity and simplicity are the biggest challenges" in drafting prize criteria).
53. *See* Timothy N. Cason, William A. Masters, and Roman M. Sheremeta, *Entry Into Winner-Take-All and Proportional Prize Contests: An Experimental Study*, 94 J. Pub. Econ. 604 (2010).
54. *See* Nat'l Acad. of Sci., *supra* note 11, at 18-39.
55. *Id.* at 21.
56. *Id.* at 33.
57. *Id.*
58. *See* Kalil, *supra* note 12, at 5.
59. Although the NAE recommended consideration of prizes in 1999, the NSF did not even consider using prizes until required to by federal statute many years later. *See* Nat'l Acad. of Sci., *supra* note 11.

development process. Directed statutory authorization of this sort could ensure that agencies pursue the potential of prizes to assist with the climate change challenge. It would also further underscore that climate-friendly technological innovation is a national priority.

Conclusion

Prizes are no panacea.[60] Indeed, barring some serendipitous discovery, there is no panacea for the climate policy challenge. Yet, technology inducement prizes offer a relatively low cost way to encourage greater innovation than traditional grant-based R&D funding. Prizes alone will not solve the problem. Indeed, in order to encourage greater levels of technological innovation it would also be desirable to reduce existing regulatory barriers to the development and deployment of alternative technologies as well as to place a price on carbon, ideally with a simple and straight-forward carbon tax. Combined with prizes, such measures could create a more favorable environment for climate-friendly innovation. But without prizes, or some other enhanced incentive for technological innovation, the necessary technological breakthroughs are much less likely to materialize.

Prizes have a peculiar virtue of imposing costs only to the extent they produce results, so there is room to be ambitious. Assuming the worst climate policy scenarios only strengthens the case for large climate policy prizes. Rather than funding 10 who will try, the government needs to incentivize hundreds and reward the one who succeeds. As the patent system demonstrates, the hope of a large financial windfall is a powerful inducement for innovation. There has been lots of talk about prizes in recent years, but not much action. Now, it is time to up the ante for climate innovation with federally funded climate prizes.

60. *See* David C. Mowery, Richard R. Nelson, & Ben R. Martin, *Technology Policy and Global Warming: Why New Policy Models Are Needed (or Why Putting New Wine in Old Bottles Won't Work)*, 39 Res. Pol'y 1011, 1021 (2010) (noting potential drawbacks of inducement prizes in the energy context).