REORIENTING STATE CLIMATE CHANGE POLICIES TO INDUCE TECHNOLOGICAL CHANGE

David E. Adelman* & Kirsten H. Engel**

This Article challenges the prevailing view that state action on climate change is misconceived because it cannot meaningfully impact greenhouse gas emissions. We argue that inducing technological change provides an independent ground for state programs; one can think globally and still act locally. Technological innovation is essential to successful climate policy and subject to a distinct market failure—technology spillovers that undermine investment incentives. State action can significantly enhance technological change, as promoting innovation is less dependent on large-scale government action and its inherent uncertainties favor the diversity sustained by multiple state programs. These observations suggest a two-tiered strategy: primary federal responsibility for reducing greenhouse gas emissions while state policies focus on promoting technological change. This Article concludes by proposing measures designed to support this complementary federal-state framework.

INTRODUCTION

After years of inaction, the federal government is now poised to address climate change. As of late January 2008, seven major bills to regulate greenhouse gas (GHG) emissions were pending before various committees of Congress.[1] Most significantly, in December 2007, the Senate Environment and Public Works Committee voted in favor of broad climate change legislation calling for U.S.

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** Professor of Law, University of Arizona James E. Rogers College of Law.

1. Pew Ctr. on Global Climate Change, Economy-wide Cap and Trade Proposals in the 110th Congress (Jan. 2008), available at http://www.pewclimate.org/federal/analysis/congress/110/cap-trade-bills.

GHG emissions to be cut 70% from 2005 levels by the year 2050.[2] Even the U.S. Supreme Court has joined the fray with a 2007 ruling that the Clean Air Act could be applied to GHGs.[3]

The prospect of federal action on climate change follows a period of rapid policy development by state and local governments. In the absence of strong federal leadership, a growing number of states have filled the void in climate policy with a broad array of programs, including regulation of GHG emissions from vehicles and power plants, renewable energy mandates, GHG emissions registries, and energy-efficiency initiatives.[4] This diversity in policies is matched by the variation in program development across the states and the stringency of state commitments.[5]

The question addressed in this Article is whether state climate change initiatives can be justified independently of their capacity to influence federal policy. We focus particular attention on identifying strategies for state programs in the event that the federal government enacts significant legislation to reduce GHG emissions. Our approach complements and goes beyond existing justifications for state action (e.g., promoting policy innovation, facilitating capacity building, prompting federal action).[6] Anticipating the current groundswell of industry interest in federal legislation,[7] the most prominent of these theories holds that

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2. John M. Broder, *Senate Panel Passes Bill to Limit Greenhouse Gases*, N.Y. TIMES, Dec. 6, 2007, at A39.

3. Massachusetts v. EPA, 127 S. Ct. 1438, 1462 (2007) (holding that "[i]f EPA makes a finding of endangerment, the Clean Air Act requires the agency to regulate emissions of the deleterious pollutant from new motor vehicles").

4. *See generally* Pew Ctr. for Global Climate Change, What's Being Done in the States, *available at* http://www.pewclimate.org/what_s_being_done/ in_the_states (last visited Sept. 6, 2008); Barry G. Rabe, STATEHOUSE AND GREENHOUSE: THE EMERGING POLITICS OF AMERICAN CLIMATE CHANGE POLICY (2004) [hereinafter STATEHOUSE]; Linda Adams, *California Leading the Fight Against Global Warming*, 23 ECO STATES 14, 14–16 (summer 2006); Kirsten H. Engel, *Mitigating Global Climate Change in the United States: A Regional Approach*, 14 N.Y.U. ENVTL. L.J. 54, 60–61 (2005); Barry G. Rabe, *Environmental Policy and the Bush Era: The Collision Between the Administrative Presidency and State Experimentation*, 37 PUBLIUS 413 (2007) [hereinafter *Bush Era*].

5. *See* Kirsten H. Engel & Barak Y. Orbach, *Micro-Motives and State and Local Climate Change Initiatives*, 2 HARV. L. & POL'Y REV. 119, 122–27 (2008), *available at* http://www.hlponline.com/Engel_Orbach_HLPR.pdf.

6. *See* ROBERT W. HAHN, THE ECONOMICS AND POLITICS OF CLIMATE CHANGE 44–54 (1998) (highlighting the importance of policy experiments and institutional capacity building); J.R. DeShazo & Jody Freeman, *Timing and Form of Federal Regulation: The Case of Climate Change*, 155 U. PA. L. REV. 1499, 1533 (2007) (arguing that states have managed to hit the federal regulatory "sweet spot" for stimulating federal regulation); Kirsten H. Engel, *Harmonizing Regulatory and Litigation Approaches to Climate Change Mitigation: Incorporating Tradable Emissions Offsets into Common Law Remedies*, 155 U. PA. L. REV. 1563, 1570 (2007) (discussing the "domino effect" created when states adopt differing environmental standards).

7. The potential for federal preemption appears to be a major factor in the recent switch by several major industries from opposing federal climate legislation to supporting it. Steven Mufson & Juliet Eilperin, *Energy Firms Come to Terms with Climate Change*, WASH. POST, Nov. 25, 2006, at A1 (According to the President of Shell Oil, "We

costly state policies can trigger federal action by motivating powerful multi-state firms to seek uniform national standards.[8] A notable qualification of this, and the other, rationales is that they treat state programs as derivative of federal action.[9]

We will show that inducing technological change provides an independent ground for state action on climate change—one can think globally and still act locally. Under this view, innovation is a distinct regulatory end that is subject to a market failure, technology spillovers, that is unrelated to the negative externalities that have traditionally justified environmental regulation.[10] It also provides its own rewards. Many states, for example, are motivated by the direct economic advantages (e.g., new jobs, energy security) of fostering green innovation[11] and the prospect of gaining a "first mover" advantage by cultivating a critical mass of green industries in their jurisdictions.[12] At the same time, the high uncertainties associated with technological innovation argue against centralization in the federal government,[13] as a diverse range of independent strategies is more likely to succeed over a monolithic approach.[14]

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cannot deal with 50 different policies. . . . We need a national approach to greenhouse gases."); Felicity Barringer, *A Coalition for Firm Limit on Emissions*, N.Y. TIMES, Jan. 19, 2007, at C1 (coalition of industry leaders, including GE, Alcoa, BP, and Lehman Brothers are asking Congress to pass climate legislation and expressing concern about state regulation).

8. *See* E. Donald Elliott et al., *Toward a Theory of Statutory Evolution: The Federalization of Environmental Law*, 1 J.L. ECON. & ORG. 313, 332–33 (1985).

9. Of course, federal legislation does not preclude states from playing a critical role in implementing and enforcing environmental laws, as demonstrated by the major environmental statutes that embrace cooperative federalism. William Buzbee attributes this to the benefits parallel enforcement regimes provide to both industry and to state environmental regulators. William W. Buzbee, *Brownfields, Environmental Federalism, and Institutional Determinism*, 21 WM. & MARY ENVTL. L. & POL'Y REV. 1, 52–53 (1997).

10. Adam Jaffe et al., *A Tale of Two Market Failures: Technology and Environmental Policy*, 54 ECOL. ECON. 164, 168–69 (2005) [hereinafter Jaffe et al., *Tale*] (highlighting the importance of innovation policies "as distinct from environmental policies [designed to] internaliz[e] environmental externalities.").

11. Rabe, STATEHOUSE, *supra* note 4, at 29, 424–25 (emphasizing the economic and other environmental benefits driving state climate change policies); PEW CTR. ON GLOBAL CLIMATE CHANGE, LEARNING FROM STATE ACTION ON CLIMATE CHANGE 2 (Dec. 2007) [hereinafter PEW]. *available at* http://www.pewclimate.org/docUploads/ States%20Brief%20Template%20_ November%202007_.pdf ("Many states, however, are looking at policies that address climate change as economic opportunities"); EPA, EPA CLEAN ENERGY-ENVIRONMENT GUIDE TO ACTION ES-3 (2006) *available at* http://www.epa.gov/cleanenergy/ documents/gta/executivesummary.pdf.

12. *See, e.g.*, Matt Richtel & John Markoff, *A Green Energy Industry Takes Root in California*, N.Y. TIMES, Feb. 1, 2008, at C1; Maryann Feldman & Roger Martin, *Constructing Jurisdictional Advantage*, 34 RESEARCH POL'Y 1235, 1236–37 (2005) (describing the competitive advantages of being a first-mover jurisdiction).

13. Adam B. Jaffe et al., *Technological Change and the Environment*, *in* 1 HANDBOOK OF ENVIRONMENTAL ECONOMICS 461, 485 (Karl-Goran Maler & Jeffrey R. Vincent eds., 2003) [hereinafter Jaffe et al., *Change*] (observing that optimization is very hard with the large uncertainties surrounding research and development outcomes).

14. Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 873 (1990) (observing that for technological

Promoting technological change is a so far unrecognized rationale for state action on climate change, even in the wake of a federal climate regulatory program. Intuitively one might wonder what is left for the states once the federal government acts or whether state climate change regulation on its own is misguided. Climate change is a global problem and individual states cannot meaningfully impact global GHG emissions. Even Texas, which has by far the largest carbon dioxide emissions of any state, emits just 11% of U.S. emissions and only about 2.8% of global emissions.[15] The existing rationales for state climate programs reflect these limits insofar as they view them primarily as a means of prompting federal action or promoting new policy development.[16]

Two core economic doctrines reinforce this skepticism about state climate programs: the "matching principle," which states that efficient regulation is possible only when a regulating entity fully internalizes the costs and benefits of its policies;[17] and its complement, which holds that devolving regulation to the state and local levels is presumptively superior to one-size-fits-all regulation at the federal (or higher) level because it enables regulations to be optimized to local conditions.[18] Together these principles imply that federal (or international) regulation is warranted only when jurisdictional spillovers of environmental externalities offset the benefits of optimizing environmental regulations around local conditions.[19] When applied to climate change, which is as pure a global problem as one is likely to find,[20] they call for global-level regulation.

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innovation, "The only way to find out what works and what does not is to let a variety of minds try."); Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1640–41 (2003).

15. James Bushnell et al., *Local Solutions to Global Problems: Climate Change Policies and Regulatory Jurisdiction*, 0 REV. ENVTL. ECON. & POL'Y 1, 17 (2008), *available at* http://reep.oxfordjournals.org/cgi/reprint/ren007v1. (observing that the projected GHG reductions from California policies are "less than 200 MMT of carbon equivalent economy-wide, while China's emissions of CO_2 alone are forecasted to rise by several *thousand* MMT by 2015."); Jonathan B. Wiener, *Think Globally, Act Globally: The Limits of Local Climate Policies*, 155 U. PA. L. REV. 1961, 1972–73 (2007); Lawrence H. Goulder, *California's Bold New Climate Policy*, ECONOMIST'S VOICE 1, 1, Sept. 2007 (observing that state-level action to address climate change "can be regarded as a demonstration project that (if successful) will speed up the arrival of a broader, national program").

16. *See, e.g.*, HAHN, *supra* note 6, at 44–54; Kirsten H. Engel & Scott R. Saleska, *Subglobal Regulation of the Global Commons: The Case of Climate Change*, 32 ECOLOGY L.Q. 183, 223–26 (2005) (describing how state-level regulation can have a "domino effect" that prompts federal action).

17. Lawrence H. Goulder & William A. Pizer, *The Economics of Climate Change in* THE NEW PALGRAVE DICTIONARY OF ECONOMICS, 10 (Steven Durlauf & Lawrence Blume eds., 2d ed. 2006) ("[E]conomic efficiency calls for making market-based systems as geographically broad as possible.").

18. . Dallas Burtraw & Paul R. Portney, *Environmental Policy in the United States*, *in* ECONOMIC POLICY TOWARDS THE ENVIRONMENT 289 (Dieter Helm ed., 1991) ("This 'principle' thus establishes a general presumption in favor of decentralized decisions where the benefits and costs are limited primarily to a particular jurisdiction or locality.").

19. *Id.* at 311–13.

20. William D. Nordhaus, *To Tax or Not to Tax: Alternative Approaches to Slowing Global Warming*, 1 REV. ENVIRO. ECON & POL'Y 26, 27–28 (2007). More

These principles inform the prevailing view, endorsed most prominently by the current Bush Administration,[21] that climate change regulation should be set at the international level, leaving only secondary roles for federal or state policies.[22] Federal or limited multinational regulation, under these principles, is viewed skeptically and state policies even more so.[23] Critics also base their objections on countervailing market dynamics. They argue that reductions in GHG emissions will be eroded through "emissions leakage," which refers to competitive market conditions that cause GHG reductions in regulated jurisdictions to be offset by corresponding increases in emissions from unregulated territories.[24]

None of these arguments undermines the capacity of state policies to promote technological change.[25] As we have seen, government policies have the potential to address two distinct factors relevant to mitigating climate change: (1) GHG emissions levels, and (2) technological change that aids in cutting GHG emissions. Yet, despite these twin objectives, critiques of state regulation have focused almost exclusively on reducing GHG emissions.[26] Consequently, while critics have convincingly demonstrated the degree to which state efforts to reduce GHG emissions are undermined or insignificant, their analyses are incomplete.[27]

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concretely, state or local governments should regulate small-scale problems (e.g., drinking water, contaminated properties), the federal government should regulate where interstate spillovers are significant (e.g., acid rain), and international regimes should be established to address global problems (e.g., stratospheric ozone depletion). *See id.*

21. This view is at the root of the Administration's decisions denying a state role in climate change regulation, as exemplified by the U.S. Environmental Protection Agency's recent rejection of California's greenhouse gas emission standards for automobiles. *See* U.S. Environmental Protection Agency, California State Motor Vehicle Pollution Control Standards: Notice of Decision Denying a Waiver of Clean Air Act Preemption for California's 2009 and Subsequent Model Year Greenhouse Gas Emission Standards for New Motor Vehicles, 73 Fed. Reg. 12,156, 12,156–57 (March 6, 2008).

22. Daniel C. Esty, *Toward Optimal Environmental Governance*, 74 N.Y.U. L. REV. 1495, 1555 (1999) ("At least from a theoretical viewpoint, inherently global problems demand concerted worldwide action."); Robert N. Stavins, *Policy Instruments for Climate Change: How Can National Governments Address a Global Problem?*, 1997 U. CHI. LEGAL F. 293, 323 (arguing that "On the domestic level, even the most cost-effective greenhouse policy instrument will be desirable only if the national target it seeks to achieve is part of an accepted set of international mandates."); Wiener, *supra* note 15, at 1972–73 (2007).

23. Wiener, *supra* note 15, at 1962–63. *But see* Goulder & Pizer, *supra* note 17, at 9 (observing that "International coordination is both crucial and exceptionally difficult"); Nordhaus, *supra* note 20, at 28.

24. Bushnell et al., *supra* note 15, at 7; Wiener, *supra* note 15, at 1968–69.

25. Lawrence H. Goulder & Stephen H. Schneider, *Induced Technological Change and the Attractiveness of CO_2 Abatement Policies*, 21 RESOURCE & ENERGY ECON. 211, 240 (1999) (finding that "[induced technological change] generally makes climate policies more attractive.").

26. *See* sources cited *supra* note 22.

27. To the extent that innovation has been considered, the focus has been on determining which policy instruments (i.e., market-based versus command-and-control) induce innovation most effectively. *See, e.g.*, David M. Driesen, *Design, Trading, and Innovation*, *in* MOVING TO MARKETS IN ENVIRONMENTAL PROTECTION: LESSONS AFTER 20 YEARS OF EXPERIENCE 436, 436 (Jody Freeman & Charles D. Kolstad eds., 2007)

This one-sided focus is counterproductive given the importance of new technologies to climate change mitigation.[28] It is also out of step with the growing economic literature on the capacity of government policies to induce technological change.[29] As a number of economists have recognized, "[t]he effect of environmental policies on the development and spread of new technologies may, in the long run be among the most important determinants of success or failure in environmental protection."[30] Nor is this a naïve brand of technological optimism; strong evidence exists that widespread adoption of *existing* technologies could "solve the carbon and climate problem for the next half century."[31] The current debate over federalism and climate change is therefore not only incomplete, but overlooking an essential element of climate change policy.

This Article is divided into two parts. Part I analyzes the two types of market failure—environmental and technological—relevant to climate change policy. It then explores several avenues for states to induce technological change, whether through new innovations or adoption of existing technologies. The market dynamics differ according to whether state policies are adopted in the shadow of federal legislation versus whether states act in the absence of federal laws, such as to fill gaps in national policies. Each of these scenarios is examined separately.

Part II uses the insights from Part I to evaluate prominent state climate programs and to identify promising opportunities for state action in the federal system. These insights suggest a two-tiered strategy: regulation of aggregate GHG emissions at the federal level, perhaps based on an international agreement, complemented by state (as well as federal) policies designed to promote

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(challenging the view that market-based regulations are more effective at stimulating innovation); Jaffe et al., *Tale*, *supra* note 10, at 165 (claiming that "very little dispute [exists] among economists that flexible, incentive-oriented polic[ies] are [preferable]").

28. *See, e.g.*, Martin I. Hoffert et al., *Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet*, 298 SCIENCE 981, 981 (2002) (arguing that "the most effective way to reduce CO_2 emissions . . . is to develop revolutionary changes in the technology"); Richard G. Newell et al., *The Effects of Economic and Policy Incentives on Carbon Mitigation Technologies*, 28 ENERGY ECON. 563, 563–64 (2006) ("Technological improvements . . . have therefore been the principal means discussed for addressing climate change.") [hereinafter Newell et al., *Effects of Economics*]; S. Pacala & R. Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, 305 SCIENCE 968, 968 (2004) ("Humanity can solve the carbon and climate problem in the first half of this century simply by scaling up what we already know how to do.") [hereinafter Pacala & Socolow, *Stabilization Wedges*]; Alistair Ulph & David Ulph, *Climate Change—Environmental and Technological Policies in a Strategic Context*, 37 ENVTL. RES. ECON. 159, 160 (2007) ("It is now widely recognized . . . that tackling climate change will require a mix of both environmental policies and technology policies.").

29. Jaffe et al., *Change*, *supra* note 13, at 476. It is also a major shortcoming of the debate over climate change policy. Goulder & Schneider, *supra* note 25, at 212–13 (commenting on the neglect of induced technology change in most climate policy); Monica Prasad, *On Carbon, Tax and Don't Spend*, N.Y. TIMES, Mar. 25, 2008, at A27 (arguing that facilitating technology shifting is essential to reducing control carbon emissions).

30. Jaffe et al., *Change*, *supra* note 13, at 476. This claim is bolstered by the fact that assumptions about rates of technological change are often "the single largest source" of uncertainty on cost estimates for climate policies. *Id.* at 463.

31. Pacala & Socolow, *Stabilization Wedges*, *supra* note 28, at 968.

innovation and adoption of GHG mitigating technologies. The Article concludes with a series of policy recommendations for reorienting state climate change programs, paying particular attention to when, and the degree to which, federal preemption can be justified.

I. TWO DISTINCT MARKET FAILURES IMPLICATED BY CLIMATE CHANGE POLICY

According to the standard economic theory, environmental regulation is justified when the failure of businesses and consumers fail to internalize the negative environmental impacts of their actions.[32] Environmental policy is not limited, however, to deterring or restricting behavior with bad environmental consequences; it also seeks to promote development of new technologies that reduce abatement costs and enable more aggressive action. This latter objective is difficult to meet because it occurs "at the nexus of two distinct and important market failures": traditional negative environmental externalities and the positive externalities associated with uncompensated technology spillovers.[33]

Efforts to regulate climate change are particularly susceptible to these forms of market failure. The negative impacts of GHG-emitting activities are diffused globally, although risks from climate change are by no means distributed uniformly.[34] For similar reasons, technology spillovers are likely to be large because of the global importance of environmental technologies relevant to mitigating climate change, and the modest protections for and volatile politics surrounding intellectual property rights in many countries.[35] A third, less-prominent form of market failure also exists that directly undermines incentives for governments to act. Here, the heightened costs of being a regulatory first-mover can encourage delay, especially as there is no means for governments to recoup the value of the institutional knowledge they generate. All three can inhibit efforts to address climate change, but the focus in this Article will be on the first two forms of market failure—negative environmental and positive technology externalities.

Sections A and B below examine the capacities of federal and state climate change policies to address these externalities. While state regulation is clearly inferior to national (or coordinated international) regulation in achieving GHG emissions reductions, we show that it has significant potential to complement federal policies, and has certain advantages over them, in promoting technological change.[36] Section C concludes Part I by analyzing how the federal system can accommodate the respective strengths of national and state policies,

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32. Jaffe et al., *Tale*, *supra* note 10, at 168–69.

33. *Id.* at 168.

34. Goulder & Pizer, *supra* note 17, at 9.

35. Wiener, *supra* note 15, at 1963–65; David E. Sanger, *Bush Will Continue to Oppose Kyoto Pact on Global Warming*, N.Y. TIMES, June 12, 2001, at A1.

36. Jaffe et al., *Change, supra* note 13, at 476. *See also* Allen V. Kneese & Charles L. Schultze, POLLUTION, PRICES, AND PUBLIC POLICY (1975); Goulder & Schneider, *supra* note 25, at 240.

and discussing the implications of our approach for cases in which states operate in the shadow of a federal regime.

A. Traditional Environmental Externalities and the Limits of State Climate Change Regulation

Climate change produces a classic form of pollution externality: industrial producers and consumers alike reap the benefits of activities that generate GHGs while imposing the costs of the emissions upon the world as a whole. Because polluters internalize only a fraction of these costs, their incentives to reduce them are only a fraction of what would be economically efficient.[37] Moreover, no single source emits a globally significant quantity of GHGs, which further undermines the incentives of individual emitters to reduce their contribution of GHGs. Econmic efficiency as a consequence requires that the regulating entity fully internalize the costs and benefits of its policies. The global scale of climate change implies that only international regulation can meet this requirement.[38]

The dominance of state climate change initiatives in the United States runs contrary to these economic principles, and thus has inspired extensive debate over state initiatives involving direct regulation of GHG emissions. Opposition to state programs rests on two primary arguments: (1) state-level programs, by virtue of their small geographic scope, will be too small to have a meaningful impact on global GHG emissions, and (2) state climate regulation is vulnerable to emissions leakage, which involves market responses that can offset emissions reductions in a regulated jurisdiction.[39]

Regulation of GHG emissions from electric power plants illustrates the limited scale of state and regional action. Even when the results of aggressive state programs are aggregated, the volume of emissions reduced constitutes just a small fraction of total emissions in the United States. A useful benchmark here is the group of states committed to or considering involvement in the Regional Greenhouse Gas Initiative (RGGI)—eleven states and the District of Columbia in all.[40] The impact of RGGI will be minimal because carbon dioxide emissions from power plants (its exclusive focus) in the eight committed states constitute only 2% of U.S. emissions from this sector; this rises to 4.5% for all eleven states and the

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37. R. K. Turner, D. Pearce, & I. Bateman, ENVIRONMENTAL ECONOMICS: AN ELEMENTARY INTRODUCTION (1993).

38. *See* Robert N. Stavins, *Policy Instruments for Climate Change: How Can National Governments Address a Global Problem?*, 1997 U. CHI. LEGAL F. 293, 293 (1997).

39. Bushnell et al., *supra* note 15, at 7. More recently, scholars have raised an even more troubling variant of leakage, under which "reshuffling" of production sources occurs with minimal costs and effectively eliminates any net GHG emissions reductions. *Id.* at 8.

40. Reg'l Greenhouse Gas Initiate, About RGGI, http://www.rggi.org/about.htm. The committed states include Connecticut, Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, and Vermont. The District of Columbia and three states, Massachusetts, Rhode Island, and Pennsylvania, are currently monitoring the program and seriously considering joining it. *Id.*

District of Columbia.[41] Even if California joined RGGI, the total carbon dioxide emissions at stake would amount to only 5.3% of U.S. emissions.[42] These percentages reveal that state-level standards would have to be approximately twenty times more stringent than a federal standard to achieve a comparable reduction in GHG emissions. Accordingly, even a weak national program would achieve greater GHG emissions reductions than the current (or expected) patchwork of state regulatory efforts.

The vulnerability of state programs to emissions leakage is pervasive. Even if a state program constituted a significant fraction of U.S. GHG emissions, its emissions reductions could be substantially eroded or nullified by leakage to other jurisdictions. Economists have identified three sources of emissions leakage—one driven by falling fuel prices, the second by reductions in production levels, and the third by relocation of industries to unregulated jurisdictions.[43] Each of these displays the pneumatic character of the underlying market dynamics.[44]

The first two leakage scenarios follow from standard supply-and-demand economics. The logic is simple: insofar as state regulation diminishes demand for carbon-based fuels, it will trigger a drop in fuel prices that, in turn, will cause offsetting increases in fuel consumption in unregulated areas.[45] The degree to which emissions reductions within a regulated territory are offset will depend on the sensitivity of demand to price in unregulated areas; the more price sensitive it is, the more complete the offsetting emissions will be.

The second scenario is a variation of the first, but it involves reductions in the production of goods within a regulatory territory that are driven by increases in costs of production caused by regulation (i.e., higher energy costs).[46] Similar to the first scenario, a reduction in production levels within a regulated territory will lead to compensating production increases in unregulated areas. Here, reductions in supply lead to increases in product prices, which motivate producers outside a regulated jurisdiction to expand their production levels. Furthermore, if relatively

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41. *See* EPA, STATE CO2 EMISSIONS FROM FOSSIL FUEL COMBUSTION, 1990–2005, *available at* http://www.epa.gov/climatechange/emissions/downloads/CO2FFC_2005.pdf (last visited Sept. 6, 2008). Total carbon dioxide emissions from these states is somewhat larger, with the committed states contributing 9% of U.S. carbon dioxide emissions and eleven states and the District of Columbia constituting 15%. *Id.* Similarly, if one considers all the "blue" states in the United States that voted for John Kerry in the 2004 presidential race and Ohio (twenty states in all), their total carbon dioxide emissions (i.e., from all sources) constituted about 32% of U.S. carbon dioxide emissions. This is likely an upper bound on the states that might participate in aggressive regulation of GHG emissions, and yet there is still a factor of three differential in the base level of emissions subject to regulation.

42. *Id.* By contrast, in 2006 the ten U.S. states with the highest carbon dioxide emissions from electric utilities constituted almost 50% of total U.S. carbon dioxide emissions from these sources.

43. Wiener, *supra* note 15, at 1967–68.

44. *Id.* at 1965.

45. *Id.* at 1967–69.

46. *Id.*

efficient production in a regulated area is replaced by production with higher per-unit GHG emissions, the net result could be greater overall GHG emissions.[47]

The significance of price- and supply-based leakage is dependent upon the magnitude of actual reductions and market dynamics.[48] If reductions in carbon-fuel demand or product supply are minimal, the effects will be nominal unless price or supply is extraordinarily sensitive (elastic) to demand or price, respectively.[49] Because leakage rises with impacts on price or supply, the small scale of state programs makes them less vulnerable to price and supply leakage than federal ones.[50] Consistent with this reasoning, the states currently slated to regulate electrical utilities constitute a small share of the market demand for carbon-based fuels and thus have a low risk of significant leakage.[51]

The third form of leakage arises when production facilities are relocated outside of a regulated area.[52] For industries that are sensitive to energy prices, differentials in energy prices between regulated and unregulated jurisdictions may justify incurring short-term relocation expenses.[53] Consequently, instead of reducing GHG emissions, a regulating state would merely prompt companies to relocate outside of its borders and continue to emit GHGs at similar (or possibly even greater) levels.[54]

The existing empirical studies support claims that leakage can undermine efforts to regulate GHG emissions at the regional (e.g., all OECD countries) or

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47. *Id.*; Bushnell et al., *supra* note 15, at 6–8.

48. Bushnell et al., *supra* note 15, at 6–8.

49. *Id.*

50. This is somewhat of a perverse advantage, however, as it is entirely contingent on the effect of state-level regulation being trivial; that is, leakage is insignificant to the extent that the impact of state-level regulation on GHG emissions is insignificant.

51. According to EPA's numbers, *see supra* note 41, states are likely to comprise a relatively larger share of the market of natural gas. Yet, if their measures cause a drop in natural gas prices because of reduced demand, which is unlikely, it could have a net positive effect by shifting production away from more carbon-intensive fuels like oil or coal. Accordingly, a multistate cap that reduced emissions to 50% of current levels would constitute about a 2.5% drop in U.S. demand (assuming conservatively that electrical utilities dominate the market for fuels), suggesting that offsetting price-induced demand is also likely to be modest.

52. In the case of electricity production, movement of production facilities may not be necessary. Instead, the courses of production can simply be "reshuffled," thereby essentially eliminating any relocation costs. Bushnell et al., *supra* note 15, at 1 (describing reshuffling as the "ability of firms to source their production outside of the reach of the local regulation" or contractual reshuffling that just changes the "matching between specific products and consumers").

53. Again, electrical utilities represent an extreme example of this dynamic. California's efforts to limit GHG emissions from electrical utilities illustrate this problem perfectly, as there are "ample resources outside of California that comply with this emissions standard. California utilities can comply with the standard by buying from the existing low-carbon sources, and leaving new or old 'dirty' sources to meet the demand from other states." *Id.* at 11.

54. Mustafa H. Babiker, *Climate Change Policy, Market Structure, and Carbon Leakage*, 65 J. INT'L ECON. 421, 441–43 (2004).

national levels. Estimates using standard economic models typically predict leakage rates ranging from about 5–20%, although some investigators have predicted rates as high as 41%.[55] The most dramatic results have all involved undifferentiated goods (i.e., fungible commodities such as electricity and metals) and more complex economic models that take into account the potential for companies to migrate to unregulated jurisdictions.[56] Under these circumstances, leakage rates can range as high as 50–130%, implying that state or regional efforts to reduce GHGs emissions can cause a net *increase* in global emissions.[57]

The potential significance of leakage is therefore highly variable. For industries that produce differentiated goods, the threat of leakage is relatively low, whereas for industries that produce undifferentiated commodities, it can wipe out or even overwhelm GHG emissions reductions from regulatory programs. Similarly, for industries that are not mobile, whether because of the nature of the good, unique geographic production needs, or human capital constraints, the potential magnitude of leakage is unlikely to overwhelm GHG reductions within a regulated territory.[58]

However, not all "leakage" is negative.[59] Technology spillovers can cause it to be positive, that is regulation in one jurisdiction can precipitate reductions of GHG emissions in unregulated areas. Under this scenario, regulation in a jurisdiction promotes diffusion of new technologies that reduce abatement costs. If technologies, for example, increase energy efficiency and the price sensitivity of carbon-based fuels is sufficiently high, it may be profitable for industries in unregulated areas to adopt them, causing a net reduction in GHG emission both inside and outside a regulated jurisdiction.[60]

The potential for positive technological spillovers demonstrates the counterbalancing effects of technological change on GHG emission levels. It is also important to recognize that state policymakers have strong incentives to promote the spread of effective technologies and policy experience to other governments precisely because climate change is a global problem.[61] There is

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55. Corrado Di Maria & Edwin van der Werf, *Carbon Leakage Revisited: Unilateral Climate Policy with Directed Technological Change* 2–3 (Fondazione Eni Enrico Mattei, Working Paper No. 94.2006), *available at* http://ssrn.com/abstract=912461.

56. Babiker, *supra* note 54, at 441–43.

57. *Id.* Significantly, the author found that the disparity between his results and those of previous models were mostly driven by the added effects of industry relocation. *Id.*

58. *Id.*

59. Wiener, *supra* note 15, at 1971.

60. Di Maria & van der Werf, *supra* note 55, at 16. Particularly where there is little or no support for research and development in unregulated regions, economic models find that subglobal caps on GHGs emissions or taxes can lead to net GHG emissions reductions in unregulated areas with relatively carbon-intensive industrial sectors. Rolf Golombek and Michael Hoel, *Unilateral Emission Reductions and Cross-Country Technology Spillovers*, 4 J. ADVANCES ECON. ANAL. POL'Y 1, 18–19 (2004).

61. Rabe, STATEHOUSE, *supra* note 4, at 114–15, 129 (describing how New Jersey "state officials have been unusually attentive to opportunities to build partnerships with other governments, both domestic and international. These partnerships have been intended both to maximize the potential effectiveness of New Jersey's own greenhouse gas

already "abundant" evidence of this occurring.[62] Recent studies suggest that regulatory programs, subsidies, or a combination of the two that induce development and adoption of cost-effective technologies can eliminate leakage.[63] These observations anticipate the important role of technological change for climate change policy discussed in greater detail below.

The preceding discussion highlights several factors that affect the viability of state climate change regulation. First, the small scale of state programs severely limits their capacity to meaningfully impact global GHG emission levels. Second, leakage may overwhelm regulatory programs, particularly larger ones, that involve mobile industries manufacturing undifferentiated goods—the textbook case being electric utilities. Third, leakage will be minimal, and certainly will not nullify state-level GHG reductions if the regulated industries cannot easily relocate or if they produce differentiated goods. Taken together, these factors indicate that the net effect will often be neutral or modest, implying that the impacts on GHG emissions will not undermine other grounds for state action. Further, if a federal law, such as a cap-and-trade regime, were promulgated that covered the relevant sources, it would further mitigate, if not eliminate, emissions leakage between states, although leakage outside of the United States could still occur in the absence of an international agreement.

B. Establishing Technological Change as a Primary Objective of State Climate Change Policies

Innovation will be an essential element of efforts to mitigate climate change,[64] as well as critical to controlling the costs of climate change policies.[65]

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reduction efforts and to build a larger base to establish inter-jurisdictional cooperation on these issues."). The federal government is further spurring policy diffusion through interstate grants and technical assistance programs. *Id.* at 170.

62. Professor Barry Rabe, who studies state climate change programs extensively, has observed that "[t]he diffusion of policy innovations from one state to others has abundant precedent and has been thoroughly studied . . . . States are clearly moving into an accelerated phase of interstate policy diffusion concerning climate change." *Id.* at 169. The adoption of Renewable Portfolio standards in twenty-four states across the country is one of the best examples of accelerating policy diffusion. *Id.* at 151. Diffusion of climate change policies and knowledge is also occurring across national borders through organizations such as the International Carbon Action Partnership, which "provides a forum for members to share experiences, research, and best practices on the design of trading schemes." PEW, *supra* note 11, at 6.

63. The rates of technology diffusion will, however, be contingent on relatively low adoption costs (e.g., low information and technology licensing barriers). *Id.* These findings also highlight the need for much more information on actual rates of technological diffusion. *Id.*

64. Jaffe et al., *Tale*, *supra* note 10, at 168–69 ("[W]here environmental externalities have not been fully internalized it is likely that the rate of investment in such technology is below the socially optimal level. And it is unlikely that environmental policy alone creates sufficient incentives. Hence the optimal set of public policies likely also includes instruments designed explicitly to foster innovation and possible technology diffusion, as distinct from environmental policies that stimulate new technology as a side effect of internalizing environmental externalities."); Ulph & Ulph, *supra* note 28, at 160.

Yet, technological change continues to be overshadowed by policymakers and public interest in direct commitments to reducing GHG emissions.[66] This bias is clearly evident in debates over the merits of state programs for mitigating climate change. To date, the focus has been on measures to reduce GHG emissions, such as cap-and-trade programs and environmental taxes, with little consideration of the potential for state- or national-level policies to induce technological change.[67] In this section, we aim to correct this oversight and to examine the potential for state policies to facilitate the technological transformations that will be essential to mitigating climate change.

Technological change for our purposes encompasses research and development that produces *new* technologies and adoption (or diffusion) of *existing* technologies,[68] which can itself produce innovation through "learning by doing" as experience is gained with the use and production of a technology.[69] Both forms of technological change are critical to the success of climate change policies. This section will highlight the significant potential of prosaic technology adoption and learning by doing.[70]

One of the most prominent studies on climate change mitigation identifies a collection of fifteen technology-specific "stabilization wedges" that can be used to stabilize carbon emissions over the next fifty years.[71] While acknowledging the importance of new, ground-breaking technologies, the authors show that *existing*

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65. Economists, in particular, have highlighted the sensitivity of policy cost estimates to assumed rates of technological change. Jaffe et al., *Change, supra* note 13, at 463; Newell et al., *Effects of Economics, supra* note 28, at 564 ("[T]he rate and direction of innovation is affected both by *exogenous* 'technological opportunity' and by the *endogenous* expected rate of return to particular innovations."). Janet Yellen, former Chair of Council of Economic Advisors, made the following observation in the 1990s with regard to economic analyses of the Kyoto Protocol: "One area in which the uncertainty is particularly large is the pace of technological progress—including diffusion of existing energy-efficient technologies, as well as research and development of new technologies—and the extent to which the pace will accelerate in response to government programs." *Id.*

66. Goulder & Schneider, *supra* note 25, 212–13.

67. Wiener, *supra* note 15, at 1973 (commenting that "national GHG emissions limitation policies might promote technological change—and foster diffusion of those low-cost, emissions-reducing technologies to other countries—such that the leakage effects could be reduced or even, possibly, outweighed. But it may be difficult or impossible for one U.S. state, even a state as large as California, to succeed with this strategy").

68. Many federal environmental statutes incorporate this distinction, but focus mostly on promoting technology adoption, as reflected in requirements for using the "best system of emission reduction" that has been "adequately demonstrated" considering costs and other relevant factors. 42 U.S.C. § 7411(a)(1) (2006) ("standard of performance").

69. Newell et al., *Effects of Economics, supra* note 28, at 564–66. It can also simply cause reduced energy consumption for a given existing stock of equipment, presumably through refinements of it. *Id.* A typical example of learning by doing is experience-driven innovation that increases the quality of goods or reduces the costs of producing them. Jaffe et al., *Change, supra* note 13, at 490.

70. Robert H. Socolow & Stephen W. Pacala, *A Plan to Keep Carbon in Check*, SCI. AM., Sept. 2006 at 50, 53. *See generally* Pacala & Socolow, *Stabilization Wedges, supra* note 28.

71. Pacala & Socolow, *Stabilization Wedges, supra* note 28, at 968–89.

technologies—assuming efficient technology adoption—are more than adequate for meeting standard stabilization goals through about 2050.[72] These findings provide a strong basis for the importance of technology adoption to climate change mitigation.[73] They also demonstrate that calls for technological change are not based on mere speculation and technological optimism; many of the technologies already exist.

Learning by doing is derivative of technology adoption. It originates from observations that the attributes and production of existing technologies improve and evolve as experience is gained with them. Technology assessments, such as the stabilization-wedges analysis, incorporate assumptions about innovation rates from learning by doing.[74] Significant gaps remain, however, concerning actual rates of innovation from learning by doing. Data for the energy sector, for example, suggest that learning rates are significant and that the corresponding cost savings when integrated over time are in the billions of dollars.[75] Some data also exist on standard equipment, such as tractors, that reveal significant decreases in the costs of production and increases in quality as production experience is gained over time.[76] As these limited examples suggest, the existing studies are far from comprehensive, though, and often fragmentary.

Not everyone is convinced by the available data and theories, including some prominent commentators who have challenged the significance of innovation from learning by doing for climate change mitigation.[77] We expect that innovation

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72. *Id.* (the standard scenario referred to here is stabilization at atmospheric concentration of CO_2 of approximately 500 ppm).

73. *Id.* This point is particularly important because adoption of new technologies is subject to inefficient forms of risk aversion and countervailing network effects that favor existing technologies even when they are less cost effective or efficient. Monica Prasad, Taxation as a Regulatory Tool: Lessons from Environmental Taxes in Europe 4–5, http://www.sociology.northwestern.edu/faculty/prasad/Taxation_3_25_08 (describing the sources of risk aversion and network effects that impede adoption of new, superior technologies) (last visited Sept. 6, 2008).

74. Pacala & Socolow, *Stabilization Wedges*, *supra* note 28, at para. 11; *see also* JOHN CREYTS ET AL., REDUCING U.S. GREENHOUSE GAS EMISSIONS: HOW MUCH AND AT WHAT COST? 63 (Dec. 2007), *available at* http://www.mckinsey.com/clientservice/ccsi/pdf/US_ghg_final_report.pdf.

75. Alan McDonald & Leo Schrattenholzer, *Learning Rates for Energy Technologies*, 29 ENERGY POL. 255, 256 (2001) (illustrating the importance of these rates with a representative hypothetical example in which "decreasing the learning rate from 20 to 10% would increase technology maturing costs from $2 billion to $16 billion").

76. Newell et al., *Effects of Economics*, *supra* note 28, at 568 (describing a study on tractor production, which found strong evidence of learning by doing, as "a 10% increase in cumulative production was associated with about a 7% decrease in quality-adjusted product cost").

77. W. David Montgomery & Anne E. Smith, *Price, Quantity, and Technological Strategies for Climate Change Policy*, *in* HUMAN-INDUCED CLIMATE CHANGE: AN INTERDISCIPLINARY ASSESSMENT 332 (M. Schlesinger et al. eds., 2005) (arguing that it is often firm specific, that it occurs principally within a single generation of a technology, and that it rarely translates into cumulative technological advancements); *see also id.* (arguing that energy-related technologies, such as gas turbine combined-cycle

from learning by doing will be significant for many technologies relevant to mitigating climate change (e.g., solar power, energy-saving technologies), but given the value of just adopting existing technologies our argument is not dependent on it.

The first subsection below analyzes the market failures that are characteristic of technological change. The second subsection evaluates the merits of different policies for inducing technological change paying particular attention to the circumstances relevant to state action. One of most important findings here is that environmental regulations are most effective in spurring adoption of existing technologies, as opposed to promoting research and development that produces entirely new ones. The third subsection assesses the relative value of state programs to induce technological change in the federal system. Drawing on this analysis, we conclude by advocating a portfolio approach that integrates environmental regulation and technology policies.

1. Sources of Technology Market Failure

Economists have long recognized that technological innovation is subject to market failure stemming from inventors' inability to appropriate the full social value of their work.[78] This lost value leads to under-investment in research and development.[79] Technology adoption and the innovation from learning by doing that it promotes are impeded for similar reasons. Early adopters of new technologies, for example, absorb the costs of working through the kinks in early versions of a technology.[80] This learning process produces valuable knowledge and refinements, which firms adopting the technology later benefit from without having to incur any of the costs. These knowledge spillovers, which early adopters cannot fully internalize, cause investment in learning by doing to be socially suboptimal.[81]

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generators, are mature technologies for which learning by doing has at best nominal value, but ignoring altogether renewable technologies such as wind and solar power).

78. Jaffe et al., *Change*, *supra* note 13, at 471 ("The combination of great uncertainty and intangible outcomes makes financing of research through capital market mechanisms much more difficult than for traditional investment. The difficulty of securing financing for research from outside sources may lead to under-investment in research . . . .").

79. *Id.* at 472 (observing "laissez-faire levels of investment in innovation will be too low from a social perspective"). Moreover, while competition for rents on innovation could lead to over-investment in research and development, the empirical evidence suggests that positive externalities dominate and that under-investment will be the norm. *Id.* at 473.

80. Jaffe et al., *Tale*, *supra* note 10, at 166.

81. *Id.* More generally, "the cost or value of a new technology to one user may depend on how many other users have adopted the technology. . . . Dynamic increasing returns can be generated by learning-by-using (early adopters), learning by doing (reduced production costs and improvements), or network externalities (value of technology increases with the number of users"). *Id.* at 167. For example, a recent study has shown that volume of products produced can be key to the cost of more energy efficient products. In this example, a 10% increase in cumulative productions was associated with a 7% decrease in quality-adjusted product cost. Newell et al., *Effects of Economics*, *supra* note 28, at 568.

Government regulation has the potential to correct technology market failures because "the rate and direction of innovation are likely to respond to changes in relative prices."[82] Under this theory, governments can induce technological change either directly, through subsidies, or indirectly, through increasing potential market payoffs.[83] Accordingly, government policies that increase the costs of polluting activities or improve the economics of innovative work can potentially stimulate innovation that lowers pollution abatement costs and, in doing so, enhance collective capacities to reduce GHG emissions.[84]

Policies will differ, however, according to whether they are designed to promote adoption of existing technologies or development of new ones. For companies considering whether to invest in developing new technologies, the key factors will be research and development costs, expected revenues, projected market share, and any likely royalties.[85] The potential market size for a technology is often of particular importance in such investment decisions.[86] By contrast, purchasers of new technologies will typically focus on factors such as capital and operating costs, product characteristics, and the environmental benefits of a product.[87] Because none of these factors is sensitive to market size, this suggests that inducing technology adoption can occur at any level of government.

These differences prove critical to preserving a role for state-level policies. Because companies developing new technologies will often be different from those adopting them, the market factors that affect technology diffusion, as well as learning by doing, will be distinct from those relevant to promoting research and development. Further, while market size will limit the capacity of environmental policies to spur investments in research and development—the larger a regulated market, the larger the effective incentive—it is irrelevant to states' capacities to induce technology adoption.[88]

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82. Jaffe et al., *Change*, *supra* note 13, at 469–70.

83. *Id.* at 490 (making the point that "both theory and empirical evidence are clear that technology diffusion rates depend on the strength of economic incentives for technology adoption"); Jaffe et al., *Tale*, *supra* note 10, at 173; Montgomery & Smith, *supra* note 77, at 328.

84. Government policy options fall into three basic categories: (1) reducing research and development costs through tax incentives, direct subsidies, or research grants; (2) improving the market for a new technology through government purchasing, subsidies for purchase or installation, or disincentives for adopting competing technologies; and (3) enhancing the ability of inventors to appropriate the value of their technology through patent systems, employment relations, and antitrust/competition policies. Jaffe et al., *Change*, *supra* note 13, at 474.

85. *Id.* at 490.

86. *Id.* (observing that "market size tends to be an important determinant of R&D effort and innovative activity").

87. Newell et al., *Effects of Economics*, *supra* note 28, at 566 tbl. 1.

88. See *supra* Part I.A. This assertion ignores the benefits of economies of scale or network effects that can precipitate technology adoption beyond the regulatory minimum. Our point here, however, is that state-level regulation will not have a meaningful impact on investments in research and development unless they can create a market of sufficient size to warrant it. By contrast, they can compel technology adoption directly, such as through renewable portfolio standards, or subsidize it, neither of which are dependent of the size of

State-level policies also have certain advantages over their federal counterparts. While a federal standard can reach a much greater number of potential technology adopters, multiple state-level measures can mitigate problems with tunnel vision, pork barrel politics, and picking the wrong technology that can compromise technology programs.[89] For instance, the rise in federal support for biofuels, particularly ethanol produced from corn, is the most glaring example of interest-group politics overtaking sound policy.[90] Despite the enthusiasm among legislators, the benefits of biofuels are shockingly small.[91]

State programs can generate a diversity of approaches by virtue of their multiplicity and differing mixes of socioeconomic, environmental, and political factors.[92] For example, within the field of renewable energy, some states require that solar power constitute a specific share of an electricity provider's portfolio, while others emphasize wind or geothermal resources.[93] Similarly, states such as West Virginia and Ohio, both of which have large supplies of coal, are supporting innovation directed at clean coal technology,[94] whereas Texas, with its abundant wind resources, has focused on developing power wind turbines.[95] Other states, such as New Jersey, have been driven by a mix of the potential threats and adopted

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their local markets for the technology. The presence of economies of scale or network effects merely allows states to leverage the regulatory power that they already possess.

89. Bushnell et al., *supra* note 15, at 6 (observing that the "information required needed to pick the 'right' technologies is daunting").

90. Alexei Barrionuevo, *Boom in Ethanol Reshapes Economy of Heartland*, N.Y. TIMES, June 25, 2006, at A1; L. Leon Geyer, *Ethanol, Biomass, Biofuels and Energy: A Profile and Overview*, 12 DRAKE J. AGRIC. L. 61, 64–69 (2007).

91. For example, corn-based ethanol provides a meager 12% reduction in GHG emissions over oil-based gasoline and has a marginal capacity to meet gasoline demand in the United States (i.e., less than 10%). Jason Hill et al., *Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels*, 103 PROC. NAT'L ACAD. SCI. 11,206, 11,206 (2006). The estimated reductions in GHG emissions can be lower, and even negative, when the effects of land conversation (e.g., from boreal forest to farmland) are taken into account. Joseph Fargione et al., *Land Clearing and the Biofuel Carbon Debt*, 319 SCIENCE 1235, 1235 (2008), *available at* http://www.sciencemag.org/cgi/reprint/319/5867/1235.pdf.

92. Rabe, STATEHOUSE, *supra* note 4, at 22–23 (observing that state policies are driven by both the threat of climate change and "are also coupled with efforts to design policy that 'fits' the economic and political realities of a particular state," as opposed to the "moralistic rhetoric" that has polarized the national debate); Wallace E. Oates & Paul R. Portney, *The Political Economy of Environmental Policy*, *in* 1 HANDBOOK OF ENVIRONMENTAL ECONOMICS 325, 339 (K.G. Maler & J.R. Vincent eds, 2003) ("[B]ut one theme does emerge in nearly all these studies—namely, that actual environmental measures bear the imprint in various ways of the interest groups that have taken part in the debate and design of these measures.").

93. *See generally* Database of State Incentives for Renewables and Energy Efficiency, DSIRE Home, http://www.dsireusa.org (last visited Sept. 6, 2008) [hereinafter Database of State Incentives].

94. PEW, *supra* note 11, at 9 (observing that West Virginia and Ohio "are supporting a pilot project to sequester carbon in a deep underground rock formation on the border between the two states").

95. Rabe, STATEHOUSE, *supra* note 4, at 60–61 (describing the leadership and large scale of the Texas wind energy program).

a more integrated strategy.[96] The constellation of state-level programs thus reflects the diversity of conditions present in the states.[97]

The case for state action on climate is bolstered further by the diseconomies of scale endemic to technological change. In particular, whereas meaningful reductions in GHG emissions require coordinated large-scale action, technological change occurs most readily at small geographic scales.[98] Broad consensus exists that innovation is enhanced in geographic clusters (e.g., the Silicon Valley phenomenon) because spatial concentrations allow inventors to access knowledge externalities that reduce the costs of research, development, and commercialization.[99] These externalities are dominated by "tacit knowledge," which is "vague, difficult to codify and often only serendipitously recognized," and thus by definition cannot be formalized or written down.[100] These characteristics, the Internet notwithstanding, limit the spread of tacit knowledge to the kinds of frequent face-to-face interactions that occur most efficiently in small geographic areas.[101]

States clearly have a role to play in promoting technological change. To the extent that market size matters, state programs will be inferior to federal regulation. However, while state-level regulation may provide weaker overall incentives, its compensating virtue is the diversity of approaches and experimentation that are a hallmark of state policies. Moreover, where innovation is subject to substantial uncertainties, diversity is often more important than the coordination and large scale found in federal programs.[102] These competing factors reveal important tradeoffs between federal and state programs, particularly as they apply to research and development. By contrast, inducing technology adoption, which is insensitive to the size of the market being regulated, is less constrained by these tradeoffs. Finally, states are arguably in a better position to establish geographically concentrated centers of innovation that can boost development of new technologies.

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96. *Id.* at 110–11.

97. PEW, *supra* note 11, at 9; Rabe, STATEHOUSE, *supra* note 4, at 21 (noting the "enormous state-by-state variation in response" to climate change).

98. Rabe, STATEHOUSE, *supra* note 4, at 26. Economists have also found that "diversity across complementary economic activities sharing a common science base is more conducive to innovation than is specialization." *Id.* at 17.

99. Feldman & Martin, *supra* note 12, at 1236–37.

100. David B. Audretsch & Maryann P. Feldman, *Knowledge Spillovers and the Geography of Innovation*, *in* 4 THE HANDBOOK OF URBAN AND REGION ECONOMICS 2713, 2718 (J. Vernon Henderson & Jaques-Francois Thisse eds., 2004).

101. *Id.* at 2719. One common indicator used to demonstrate these innovation clusters is that patent citations (i.e., cites on one patent to another patent) are highly geographically localized, that is, it is much more likely for the inventors of a patent cited by another patent to live in close proximity to the inventors of the cited patent. *Id.* at 2721–22.

102. Merges & Nelson, *supra* note 14, at 873 (arguing that a diversity of approaches is more important than coordination in the context of cutting-edge innovation).

2. *Research & Development: The Temporal Schism in Technology Forcing*

Limited empirical support exists for the effectiveness of environmental regulation in inducing research and development at any level of government.[103] Two recent studies have identified correlations between pollution abatement costs and either patenting rates in related technological areas or levels of research and development.[104] More extensive studies exist for research and development related to energy-efficient technologies.[105] Researchers have, for example, observed "significant amounts of innovation" in response to both increases in energy prices and changes in energy-efficiency standards.[106]

None of these studies provides compelling evidence that environmental regulation offers a powerful means of stimulating research and development.[107] This is not to suggest that regulations can never be effective in this respect. To the contrary, the 1970 Clean Air Act successfully spurred significant research and development.[108] But even this example is subject to qualification, as the extended grace period the statute provided and fortuitous timing of the new technology were critical to the success of the regulations.

The equivocal empirical data may reflect deeper problems. The degree to which environmental regulations can promote technological innovation is hampered by the political economy of the regulatory process itself.[109] This critique turns on the realization that incentives to conduct research and development, because of the long lag time between conducting research and sale of a product, are tied to the stringency of regulations in place when a commercially viable

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103. Jaffe et al., *Change*, *supra* note 13, at 481 ("[E]xceptionally little empirical analysis of the effects of alternative policy instruments on technology innovation in pollution abatement, principally because of the paucity of available data").

104. Adam B. Jaffe & Karen Palmer, *Environmental Regulation and Innovation: A Panel Data Study*, 79 REV. ECON. & STATS. 610, 611–12 (1997); Jean Olson Lanjouw & Ashoka Mody, *Innovation and the International Diffusion of Environmentally Responsive Technology*, 25 RES. POL'Y 549, 550–51 (1996).

105. Jaffe et al., *Change*, *supra* note 13, at 475–76, 481–83.

106. *Id.* at 475. The studies also found that the rates of patenting in energy-related fields rise with increases in energy prices. *Id.*

107. *Id.* at 476.

108. *See* NAT'L RESEARCH COUNCIL, COMM. ON STATE PRACTICES IN SETTING MOBILE SOURCE EMISSIONS STANDARDS, STATE AND FEDERAL STANDARDS FOR MOBILE-SOURCE EMISSIONS 116 (2006) [hereinafter NRC, MOBILE SOURCE-STANDARDS] (the statute mandated a 90% reduction in the emissions of three pollutants from new vehicles by 1975). *See also* Thomas O. McGarity, *Radical Technology-Forcing in Environmental Regulation*, 27 LOY. L.A. L. REV. 943 (1994) (giving additional examples and evaluating the technology-forcing approach in environmental law).

109. Some commentators have argued that these problems can undermine the capacity of environmental regulations to have any effect at all. Montgomery & Smith, *supra* note 77, at 328 (arguing that neither command-and-control nor market-based regulations can "provide credible incentives for the technological change needed to enable stabilizing atmospheric concentrations of greenhouse gases").

product is produced.[110] Consequently, it is the credible threat of stringent regulation in the future—not policies currently in place—that is most relevant to spurring investments in research and development.[111]

The extended lag between investment decisions and the relevant regulatory policies creates uncertainties that erode regulatory incentives. These uncertainties stem from the disparities "between what governments will announce as a *future policy* and what governments will *subsequently* be motivated to adopt as policy."[112] In fact, the optimal policy today—permit levels that reflect the costs of adoption *and* invention—will not be the politically expedient or economically optimal policy in the future when regulatory standards matter.[113] Moreover, these uncertainties will be compounded by those associated with the projected magnitude and timing of climate change and corresponding societal impacts.[114]

The questionable credibility of government commitments to future levels of regulation diminishes the capacity of environmental regulations to induce companies to invest in long-term research and development.[115] This temporal

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110. Ulph & Ulph, *supra* note 28, at 161 (observing that "environmental policies provide an important incentive for firms to undertake R&D. But . . . what matters for firms is not current environmental policies, but the future environmental policies that might be in place when R&D bears fruit").

111. Montgomery & Smith, *supra* note 77, at 7–8 ("Thus the incentive for R&D has to take the form of a credible threat to impose a high future cost of control, which will provide economic returns to the innovator . . . ."). Only future regulations can enhance the market for a new technology, and they will bind the price at which a new technology can be sold and the total revenues from it. *Id.* at 16–17; Jean-Jacques Laffont & Jean Tirole, *Pollution Permits and Environmental Innovation*, 62 J. PUB. ECON. 127, 128–29 (1996).

112. Montgomery & Smith, *supra* note 77, at 1. This problem is analogous to the dubious status, and poor track record, of international agreements that do not incorporate adequate mechanisms for enforcing participation or compliance. *See* Thomas C. Schelling, *What Makes Greenhouse Sense?*, 81 FOREIGN AFF. 2, 2 (2002).

113. Montgomery & Smith, *supra* note 77, at 27. Once a technology is available, the government will be under immense pressure to ensure that it is adopted as readily and cheaply as possible (e.g., permit prices set at the lowest level that ensures efficient adoption). *Id.* at 7–8 (arguing that "permit prices will not reflect the full cost of R&D, but only forward costs of installing and operating the new technology"); Carolyn Fischer & Richard G. Newell, *Environmental and Technology Policies for Climate Mitigation*, 55 J. ENVTL. ECON. MGMT. 142, 144 (2008) (observing that "an emissions price high enough to induce the needed innovation cannot be credibly implemented"); Laffont & Tirole, *supra* note 111, at 128 ("Widespread diffusion of [an] innovation often lowers the innovator's payoff and accordingly reduces the incentive to innovate.").

114. Jaffe et al., *Tale*, *supra* note 10, at 168 ("[T]he huge uncertainties surrounding the future impacts of climate change, the magnitude of the policy response, and thus the likely returns to research and development investment, would seem to exacerbate [under-investment in environmental technology] further.").

115. LAWRENCE H. GOULDER, PEW CTR. ON GLOBAL CLIMATE CHANGE, INDUCED TECHNOLOGICAL CHANGE AND CLIMATE POLICY, 26 (2004), *available at* http://www.pewclimate.org/global-warming-in-depth/all_reports/itc (observing that "producers are likely to have less than 100% confidence that a prior policy pledge (particularly one that is made many years in advance) will actually be fulfilled. To the extent that producers question the credibility of the [regulatory] announcement, the impacts on near-term

paradox has led some observers to conclude that environmental regulation has little or no capacity to induce innovation relevant to mitigating climate change.[116] For them, the benefits of environmental regulations rest solely on their capacity to "minimize the costs of technology adoption for *existing* technologies" or to stimulate short-term innovation with "immediate implications for cost savings."[117]

These arguments expose the pitfalls of ignoring the political (and economic) realities of environmental regulation at any level of government. One must be careful, however, not to take this argument too far. For one, this critique runs contrary to those studies and examples suggesting that environmental regulation can influence research and development. More fundamentally, the critique rests on a narrow conception of economic rationality that does not necessarily match common understanding of political decision-making processes.[118] Little doubt nevertheless exists that the politics of regulation and uncertainties in climate change science diminish the incentives that environmental regulation—whether state or federal—can provide for investment in extended research and development.[119] One admittedly modest way to mitigate these uncertainties is to include phase-in provisions that match the expected time (often decades) for new technologies to be developed.

3. Adoption of Existing Technologies: A More Promising Role for the States

Significant empirical support exists for the benefits of using environmental regulations to induce technology adoption. Examples include studies of prominent regulations under the Clean Air Act and the Clean Water Act.[120] Positive correlations have also been found between energy prices and

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behavior will be muted and associated cost savings will be reduced.") [hereinafter GOULDER, INDUCED TECHNOLOGICAL].

116. Montgomery & Smith, *supra* note 77, at 1–2 (concluding that "[t]he only role for near-term greenhouse gas caps or taxes would be to achieve emissions reductions that are justifiable immediately.").

117. *Id.* at 6–7. An important implication of this view is that environmental regulation should be calibrated to existing technologies, not to the levels needed to promote research and development on new ones. *Id.* at 11.

118. *Id.* at 24–29. Contrary to this simple model, the absence of a temporally stable equilibrium price for GHG permits (or taxes) does not preclude governments from making a pragmatic judgment that balances interests over time. In fact, if this argument were generally valid, any policies subject to significant variance over time (i.e., most of them) would present the same dilemma, and regulating with future changes in mind would be impossible.

119. Some researchers have argued for more creative approaches to bridging this temporal divide. For example, Professors Jean-Jacques Laffont and Jean Tirole suggested the issuance of advanced allowances can mitigate these uncertainties if government commits to a fixed number of allowances in the future. Laffont & Tirole, *supra* note 111, at 129. Perhaps more interestingly, they have also suggested allowing permit buyers to trade in allowances at pre-specified prices or, better yet, to sell options to purchase future allowances at a specified price. *Id.*

120. Jaffe et al., *Change*, *supra* note 13, at 502 (describing one study finding significant price sensitivity to adoption of scrubbers, as opposed to higher-cost low-sulfur

adoption rates of energy-efficient products.[121] The most compelling evidence is associated with Corporate Average Fuel Economy (CAFE) standards, which have been found to be substantially more effective than increases in fuel prices.[122] Consistent with these findings, researchers have found that "technology adoption decisions are more sensitive to up-front costs than to longer-term operating expenses."[123]

One potential reason for these robust results is the absence of a temporal schism between the timing of regulation and investments in technology adoption. Both technology adoption and learning by doing are responsive to incentives created by *current* environmental policies. This dramatically reduces the uncertainties that undermine regulatory incentives for innovation, although they are by no means eliminated because the policies themselves are, of course, subject to change by state (or federal) governments. On the other hand, competing companies must comply with a regulation, implying that no one is potentially at a competitive disadvantage by adopting an under-utilized technology—even if a state later chooses to relax its regulatory standards—and free rider problems are minimized because learning by doing occurs in parallel.[124]

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coal, in coal-fired power plants, and a second one finding "effluent charges a significant predictor of adoption of biological treatment"); Suzi Kerr & Richard G. Newell, *Policy-Induced Technology Adoption: Evidence from the U.S. Lead Phasedown*, 51 J. IND. ECON. 317, 340–41 (2003) (describing a study of the law that was successful in phasing out lead in gasoline).

121. Richard G. Newell et al., *The Induced Innovation Hypothesis and Energy-Saving Technological Change*, 114 Q.J. ECON. 941, 967–70 (1999); Newell et al., *Effects of Economics*, *supra* note 28, at 567 (finding that "energy efficiency in 1993 would have been about one-quarter to one-half lower in air conditioners and gas water heaters if energy prices had stayed at their 1973 levels").

122. Patricia K. Goldberg, *The Effects of the Corporate Average Fuel Economy Standards in the U.S.*, 46 J. IND. ECON. 1, 2–3 (1998) (determining that fuel costs have had a significant effect on vehicle fuel economy, but that the implied gas tax necessary to achieve the levels of fuel efficiency set by the CAFE standards would have to be "very large"); David L. Greene, *CAFE or Price?: An Analysis of the Effects of Federal Fuel Economy Regulations and Gasoline Price on New Car MPG, 1978–89*, 11 ENERGY J. 37, 55–57 (1990) (finding that CAFE standards had approximately twice the impact on the fuel economy of new cars as fuel prices).

123. Jaffe et al., *Change*, *supra* note 13, at 496 (reporting on a study finding that reductions in up-front costs are three times more effective than energy pricing); *see also* Newell et al., *Effects of Economics*, *supra* note 28, at 571 (describing a study in which "firms [were] about 40% more responsive to investment costs than to energy savings, suggesting that policies to reduce implementation costs may be somewhat more effective than various mechanisms that raise energy prices").

124. Furthermore, insofar as a regulation requires new types or classes of technologies (e.g. renewable portfolio standards that entail constructing new capacity) it is less subject to regulatory leakage problems. The reason for this is that while in the short term it may lead to offsetting increases in energy demand outside a regulated jurisdiction, it creates new renewable capacity that becomes a new source of power that becomes less subject to leakage and demand for power grows—it displaces the need for new dirty power with renewable.

Paradoxically, the successes in using environmental regulations to promote technology adoption may also owe something to the many barriers that impede it. Many studies have shown that adoption of new technologies is slow even when they are clearly superior to existing technologies with respect to cost and performance.[125] Economists, for example, have calculated implicit discount rates for consumers purchasing energy-efficient technologies that far exceed market interest rates (25% and often much higher).[126] As these findings suggest, multiple potential barriers exist including transaction costs, bounded rationality, information deficits, technological and financial risks, and investor–user splits.[127] Unfortunately, the factors that impede adoption of specific technologies are highly variable across different classes of technologies and no unifying theory currently exists to guide policy.[128] Policymakers must therefore be attentive to the specific barriers that may be present (e.g., onerous upfront capital costs) and structure policies accordingly.[129]

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125. Timothy F. Malloy & Peter Sinsheimer, *Innovation, Regulation and the Selection Environment*, 57 RUTGERS L. REV. 183, 189 (2004).

126. Richard B. Howarth and Bo Anderson, *Market Barriers to Energy Efficiency*, 11 ENERGY ECON. 262, 262–63 (1993); Newell et al., *Effects of Economics*, *supra* note 28, at 570–71 (describing a study in which firms sought a one to two year payback, which corresponded to an implicit discount rate of 50–100% for projects lasting ten years or more).

127. Joachim Schleich & Edelgard Gruber, *Beyond Case Studies: Barriers to Energy Efficiency in Commerce and the Services Sector*, 30 ENERGY ECON. 449, 453–55 (2008). Transaction costs include: obtaining relevant information, negotiating contracts, etc.; bounded rationality limits agents' ability to optimize because of lack of time, attention, or capacity; limited access to capital may cause adoption to be unprofitable because capital is so expensive (often true of public sector organizations); the investor/user dilemma arises when, for example, neither a renter nor a landlord has the incentive to invest in energy-saving technologies because they cannot recoup their costs; and technological or financial risks arises when significant uncertainty exists about the potential returns on an investment (e.g., uncertainties about the effectiveness/reliability of the technology, volatility in energy prices). *Id.* Significant opportunity costs may also exist, such as the cost associated with a plant closure to install new technologies. *See, e.g.*, Lori D. Snyder, Nolan H. Miller, & Robert N. Stavins, *The Effects of Environmental Regulations on Technology Diffusion: The Case in Chlorine Manufacturing*, 93 AEA PAPERS PROCEEDINGS 431, 434 (2003) (describing how operational down-time costs impeded adoption of new membrane technology in the chlorine industry and noting that more stringent regulation did not increase likelihood of adoption).

128. Malloy & Sinsheimer, *supra* note 125, at 190–91, 233 ("[T]he types of barriers to innovation vary across sectors, as will the effectiveness of different forms of regulation."); P.A. Geroski, *Models of Technology Diffusion*, 29 RES. POL'Y 603, 621 (2000).

129. Geroski, *supra* note 128, at 621–22 (describing how policies should be oriented depending on the model believed to represent the specific mode of technology adoption; for example, adoptions that follow an epidemic model call for policies that focus on providing information and direct subsidies); Newell et al., *Effects of Economics*, *supra* note 28, at 569 (describing how providing information facilitated the diffusion of high-efficiency lighting in commercial buildings); *Id.* at 571–72 (observing that "policies targeted at increasing the financial attractiveness of [certain energy-efficiency] projects

C. The Merits of a Portfolio Approach to Climate Change Policy

One of the great virtues of federal climate change policies, particularly when linked to an international regime, is that they can overcome the eroding, or even perverse, effects of emissions leakage on GHG reductions. We have shown above how, in the absence of a federal program or where gaps in a federal regime may exist, states can adopt technology-oriented policies that circumvent the limited scale of state programs and their vulnerability to emissions leakage. This strategy sidesteps the challenges of achieving meaningful reductions in GHG emissions by focusing on technological change. In this section, we address the circumstances in which states operate under the backdrop of significant federal legislation, such as a multi-sector cap-and-trade program.

An important potential limitation of our approach is the irreducible uncertainties that may exist foreclosing standard optimization strategies.[130] The efficiency gains, as opposed to benefits alone, of induced technological change have proven difficult to demonstrate.[131] William Nordhaus and other researchers have estimated that "the impact of induced innovation is modest."[132] By contrast, other studies have predicted cost savings from induced innovation of 50%[133] and, where cost functions are convex (i.e., the rate of increase rises with required abatement level) and the abatement standard is stringent, another study has found the benefits of induced innovation to be dramatic.[134] These inconsistencies suggest that the best we may be able to achieve is increases in relative efficiency, often referred to as "satisficing," as opposed to optimization.

(e.g., energy/carbon taxes, or tax breaks/subsidies for implementation) may be needed to further promote energy efficiency").

130. Jaffe et al., *Change*, *supra* note 13, at 484–85 (observing that "considerable ambiguity [remains] regarding the importance of induced innovation for the optimal stringency of environmental policy" and that theory may be able to identify the key factors to consider, "but is unlikely to provide robust prescriptions for policy").

131. For example, where the supply for research and development is inelastic, increasing research and development for environmental technologies will entail losses for other technologies that may offset the welfare gains of induced innovation. *Id.* at 483. Of course, even if the estimates of the welfare benefits of induced innovation are uncertain, the existence of market failures provides independent grounds for government intervention. GOULDER, INDUCED TECHNOLOGICAL, *supra* note 115, at 17.

132. Jaffe et al., *Change*, *supra* note 13, at 484. Other researchers have found that the welfare gains from induced innovation typically to be substantially less than those of direct GHG emissions reductions. Ian W.H. Parry et al., *How Large are the Welfare Gains from Technological Innovation Induced by Environmental Policies?*, 23 J. REG. ECON. 237, 239 (2003) (finding that only in exceptional cases where new technology reduces abatement costs dramatically and quickly (i.e., by about 50% within 10 years) does induced innovation overtakes direct abatement).

133. Hadi Dowlatabadi, *Sensitivity of Climate Change Mitigation Estimates to Assumptions About Technical Change*, 20 ENERGY ECON. 473, 473–74 (1998).

134. GOULDER, INDUCED TECHNOLOGICAL, *supra* note 115, at 14–15. Econometric estimates of the benefits from learning by doing are similar in magnitude, with one study finding that learning by doing reduces the cost of meeting a 550 ppm abatement target by 42% under a high-cost scenario and by 72% under a low-cost scenario. *Id.* Estimates of learning by doing elasticities are significant, with values of about 0.30 generally for renewables such as wind. Fischer & Newell, *supra* note 113, at 154.

The available studies provide solid grounds for identifying state policies that meet this satisficing principle. A recent set of studies evaluates strategies that combine market-based environmental regulations with technology-push policies. The estimated benefits over either type of approach on its own are impressive. As one might expect, given the long lag times and high costs of research and development, a dual approach is far superior (about a factor of ten less costly) to a straight technology policy.[135] While not quite as dramatic, dual approaches that combine a carbon tax with direct innovation subsidies can reduce costs by more than one third over a carbon tax on its own.[136] These studies provide strong support for policies that utilize a portfolio of measures, such as a carbon tax combined with subsidies for innovation and learning by doing.[137] A portfolio approach can also enhance the efficiency of other measures, such as renewable portfolio standards, by implementing them in parallel with, for example, market-based regulations.[138]

By allowing environmental and technology *objectives* to be decoupled, a portfolio approach circumvents the tensions created by these sometimes competing goals.[139] In particular, near-term GHG reductions can be pursued efficiently, if focused on technology adoption, because they are not burdened by the perceived need to implement stringent standards to spur investment in costly research and development.[140] At the same time, by recognizing the limitations of using regulations to stimulate research and development, one can leverage technology policies to subsidize research and development. This strategy has the virtue of ensuring that new technologies will be available in the future while limiting abatement costs and encouraging continual improvements in technologies and their production processes over time.

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135. Stephen H. Schneider & Lawrence H. Goulder, *Achieving Low-Cost Emissions Targets*, 389 NATURE 13, 14 (1997) (finding that costs of achieving a 15% reduction in CO_2 emissions over the interval 1995–2095 is an order of magnitude lower for a combined strategy (carbon tax, R&D subsidy for low-carbon energy) than just the R&D subsidy alone). The elasticity of R&D with respect to production and cost functions is only about 0.15, meaning that a doubling of R&D output leads to a 15% increase in productivity. Fischer & Newell, *supra* note 113, at 154–55.

136. Fischer & Newell, *supra* note 113, at 144 (basing their model on "reductions over the near- to mid-term and incremental improvement of existing technology," the authors projected a 36% drop in cost relative to the emissions-price only approach to meet a 4.8% reduction in CO_2 emissions); *see also* Goulder & Schneider, *supra* note 25, at 240 ("[Induced technological change] generally makes climate policies more attractive. The *net benefits* from a given carbon tax are higher in the presence of ITC, even though the *gross costs* of the tax are raised as well.").

137. Goulder & Schneider, *supra* note 25, at 240.

138. Fischer & Newell, *supra* note 113, at 143 ("[W]hen the ultimate goal is to reduce emissions, policies that create incentives for fossil-fuel generators to reduce emissions intensity, and for consumers to conserve energy, perform better than those that rely on incentives for renewable energy producers alone.").

139. GOULDER, INDUCED TECHNOLOGICAL, *supra* note 115, at iv ("To promote ITC and reduce GHG emissions most cost-effectively, two types of policies are required: policies to reduce emissions and incentives for technological innovation.").

140 Fischer & Newell, *supra* note 113, at 143–44.

The efficiencies gained by combining environmental regulatory measures and technology policies is borne out by a recent comparative study of environmental taxes in Europe targeted at reducing carbon dioxide emissions. The author, Monica Prasad, found that environmental taxes in several Scandinavian countries dating back to the early 1990s have had little discernable effect, except in the case of Denmark.[141] Prasad identified several reasons for Denmark's success including, most importantly for our purposes, that "Danish policy makers made huge investments in renewable energy and subsidized environmental innovation."[142] By ensuring that substitute technologies were readily available, the Danish government overcame the risk aversion of firms, countervailing sunk costs, and network effects that often limit technology adoption.[143] Denmark encouraged technology adoption through direct subsidies, differentially high taxes on coal, and tax benefits to industries that voluntarily agreed to reduce emissions.[144] Prasad concluded that this mix of environmental taxes and technology policies was essential to Denmark's success and ultimately distinguished its system from the failed policies of other European countries.[145]

The existing econometric analyses and Prasad study reveal the benefits of combining traditional environmental regulations with technology policies to address climate change.[146] They also highlight the importance of remaining attentive to the two distinct but related objectives of climate policy—reducing GHG emissions and promoting the technological changes that will be essential to meeting long-term GHG emissions targets.

The preceding sections have explored the strengths and weakness of different regulatory and technology policies in an effort to identify the policies most amenable to state action when a federal regime is in place. This exploration leads to three central conclusions. First, state climate change regulations should not center on reducing GHG emissions. Second, the primary objective of state climate change regulations should be to induce technological change, principally through technology adoption and innovation through learning by doing. Third, a portfolio of regulatory and technology policies should be adopted by states, with particular emphasis on market-based regulations, technology portfolio standards,

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141. Prasad, Taxation as a Regulatory Tool, *supra* note 73, at 1–2; Prasad, *Tax and Don't Spend*, *supra* note 29, at A27.

142. Prasad, *Tax and Don't Spend*, *supra* note 29, at A27.

143. Prasad, Taxation as a Regulatory Tool, *supra* note 73, at 11–12. Denmark has reduced its emissions of carbon dioxide by 15% relative to 1990 levels, and much of this drop occurred through lowering its dependence on coal. *Id.* at 10–11.

144. *Id.* at 11–12.

145. *Id.* at 12–14. Timothy Malloy and Peter Sinsheimer have developed an elegant case study focused on the adoption of a new, cleaner technology in the dry cleaning industry, which demonstrates the limits of "government-initiated financial incentives and information strategies on their own," but they ultimately argue that a gradual phasing out of the existing technology is the most efficient approach. Malloy & Sinsheimer, *supra* note 125, at 188.

146. Goulder & Pizer, *supra* note 17, at 10 (commenting that "there is a particularly strong need for advances in the integration of emissions policy and technology policy . . . .").

and innovation subsidies, while the federal government retains primary responsibility for direct regulation of GHG emissions.

II. A "FEDERAL" RESPONSE TO CLIMATE CHANGE MITIGATION

Some critics disparage subglobal climate change regulation as ineffective if not outright counterproductive.[147] While we agree that state-level policies will have a limited impact upon global GHG concentrations, we disagree with the inference that states have no role in addressing climate change outside influencing federal policy. As the preceding Part shows, states can play a meaningful role in addressing a second market failure implicated in climate change policies—inadequate investment in technological change.

This Part examines the opportunities for reorienting state and local climate change policies to induce technological change and evaluates the implications of these findings for environmental federalism in the United States. The first section focuses on several leading state climate change policies, assessing their current capacity to induce technological change. We conclude that many of these policies—renewable portfolio standards, vehicle and other product standards, subsidies for renewable power and energy efficiency, and green building programs—are well-suited to promoting technological change, while others, such as regional cap-and-trade programs, are poorly suited to this goal. The second section draws on the preceding analysis to derive several recommendations for harmonizing federal and state action on climate change mitigation to avoid federal preemption of state climate initiatives that promote technological change.

In making these recommendations, this Article does not presume that state climate policies will necessarily survive in the wake of federal legislation. The principal goal of this Article is to identify policies that will enable states to contribute meaningfully to mitigating climate change should they choose to do so. That said, state and local climate change programs are almost certain to continue even after the enactment of federal climate legislation.[148] While federal regulation of GHG emissions would trump similar regulations by states, it is clear that GHG reductions alone are not the sole or even the primary objective of state and local action—the plausible reductions in GHG emissions from state programs are simply too small to be supportable on this basis.[149] Similarly, many state programs are

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147. Wiener, *supra* note 15, at 102 (arguing that "subnational state-level action, by itself, is of limited value, and may even yield perverse results"); *see also* sources cited in *supra* note 15.

148. Richard B. Stewart, *States and Cities as Actors in Global Climate Regulation: Unitary v. Plural Architectures*, 50 ARIZ. L. REV. 681, 688 (2008) (arguing that state and local climate mitigation activities may well persist if climate regulatory architecture is designed to accommodate and even encourage them).

149. *See* Engel & Orbach, *supra* note 5, at 128–35 (state and local climate initiatives appear motivated by a desire to reap a host of diverse benefits unrelated to reducing actual concentrations of greenhouse gases and which range from the political boost attributable to the making of symbolic political statements to attracting new businesses in the alternative and renewable energy industry).

inconsistent with a strategy wholly oriented toward triggering federal regulation.[150] State and local governments are therefore unlikely to be deterred by federal intervention and thus, as we have argued above, there is ample opportunity for them to play an important role in climate policy even after the federal government establishes a regulatory program.

Deeper structural reasons reinforce this view. We have come a long way from the 1970s when the federal government dominated environmental regulation nationally. As a practical matter, the states have primary responsibility for implementing federal environmental laws and, of course, have sole responsibility for their own laws. Three quarters of the federal environmental programs that can be delegated to state agencies pursuant to their governing statutes are run by the states.[151] Consistent with this federal-state work ratio, state agencies now pursue 90% of the enforcement actions and collect 95% of the data used by EPA.[152] Much of this shift in responsibility has occurred through the passage of numerous federal rules that have given the states much greater programmatic flexibility and authority.[153]

The sheer magnitude of devolution to the states suggests that a major reversal is unlikely, if not impossible, in the near term. The complexity and scope of regulations and policies necessary to mitigate climate change provide additional grounds to doubt that the federal government will return to its dominant position. Moreover, some states are potentially significant international players in their own right—Texas ranks seventh globally (above Canada, the United Kingdom, and France) in the amount of its GHG emissions and California has the eighth largest economy in the world.[154] Continuing state action is therefore inevitable and should be fashioned in a manner that promises to be effective.

A. Leading State Climate Change Initiatives

States have enacted a panoply of climate programs over the past decade. The earliest programs focused on constructing GHG inventories and using state procurement policies to provide initial markets for energy efficient products.[155] A diverse range of state programs now exist: more than twenty states have created Public Benefits Funds to support technology adoption and innovation;[156] thirty states have joined the Climate Registry, which provides a common system for measuring, tracking, verifying, and reporting GHG emissions;[157] twenty-six states

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150. For instance, many of the initiatives, such as state subsidies for renewable technology, do not impose standards on multistate firms at all. *See infra* text accompanying notes 178–87.

151. ENVTL. COUNCIL OF THE STATES, ANNUAL REPORT AND ALMANAC 16 (2005), *available at* http://www.ecos.org/files/1457_file_2005_Annual_Report_and_Almanac.pdf.

152. Rabe, *Bush Era*, *supra* note 4, at 422.

153. *Id.* (describing how the states have assumed many new duties, including the implementation of more than 250 new rules).

154. Rabe, STATEHOUSE, *supra* note 4, at 5.

155. *Id.* at 20–21.

156. PEW, *supra* note 11, at 7.

157. *Id.* at 5.

have established renewable portfolio standards for electrical power generation;[158] and more than forty states have adopted building codes for energy efficiency.[159] This Article analyzes only the most prominent state programs, as a comprehensive review of state programs is beyond its scope given the number and variety of programs that exist.

1. State- and Regional-level Carbon Emission Caps

Somewhat ironically from our perspective, the most publicized state climate initiatives are directed primarily at reducing GHG emissions. This Article highlights two of the most prominent cap-and-trade programs: the Regional Greenhouse Gas Initiative (RGGI), which as discussed earlier, encompasses New York and nine New England and mid-Atlantic states, and California's 2006 Global Warming Solutions Act (A.B. 32). Two other regional programs, the Western Climate Initiative[160] and the Midwestern Regional Greenhouse Gas Reduction Accord,[161] were established in the last year and are consequently in only preliminary stages of development.

RGGI currently applies only to large electrical generating units. The RGGI states have agreed to cap carbon dioxide emissions at current levels through 2015 and subsequently to reduce them by 10% by 2019.[162] Under A.B. 32, California has mandated that statewide GHG emissions be reduced to 1990 levels by 2020, but unlike RGGI, the law is not limited to specific industries and allows a one-year extension of the target emissions level under extraordinary circumstances.[163] California is currently developing an implementation plan to determine how the regulations will treat different economic sectors.[164]

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158. *Id.* at 7.

159. Rabe, STATEHOUSE, *supra* note 4, at 19. Other policies have included adopting non-binding GHG emissions targets (often in the range of 10–20% below 1990s levels by 2020 and 70–80% by 2050), decoupling utility profits from sales volumes, providing public information on GHG emissions and consumers with the ability to purchase green energy. PEW, *supra* note 11, at 12–13.

160. This consortium of western states and Canadian provinces is also developing a regional cap-and-trade program with a GHG emissions target of 15% below 2005 levels by 2020. PEW, *supra* note 11, at 3; *see also* Western Climate Initiative, http://www.westernclimateinitiative.org (last visited Sept. 6, 2008) (initiative members include Arizona, British Columbia, California, Manitoba, Montana, New Mexico, Oregon, Quebec, Utah, and Washington).

161. The Midwestern Regional Greenhouse Gas Reduction Accord established regional plans for GHG reduction targets, including a long-term target of 60 to 80% below current emissions levels, a multi-tiered cap-and-trade system, and a GHG emissions tracking system. Pew, *supra* note 11, at 3. The participating states include Illinois, Iowa, Kansas, Michigan, Minnesota, Wisconsin, and Manitoba. Indiana, Ohio, and South Dakota have joined as observers. *Id.*

162. Toshi H. Arimura et al., *U.S. Climate Policy Developments*, Resources for the Future Discussion Paper 07-45 18 (Oct. 2007), http://www.rff.org/Documents/RFF-DP-07-45.pdf.

163. CAL. HEALTH & SAFETY CODE § 38560 (Deering 2008) (simply providing that the California Air Resources Board shall adopt rules and regulations to achieve greenhouse gas emissions reductions from "sources or categories of sources"); § 38599(a)

RGGI and A.B. 32 demonstrate the limitations of state and regional emissions caps. The emissions reduction potential for each program is constrained by its limited size and vulnerability to emissions leakage. The limited scope of RGGI, a product of the small fraction of U.S. GHG emissions attributable to the regulated states, was discussed previously.[165] At the same time, estimates of emissions leakage from the RGGI program are quite substantial, ranging from 20 to even 40%.[166] While these estimates are dependent on a host of factors, the impact on the projected RGGI emissions reductions is substantial, even at the low end.[167]

Similar problems exist for the California legislation. GHG emissions in California constitute 6.6% of the U.S. total, but the emissions covered by A.B. 32 are limited to a mere 2.2%.[168] A.B. 32 attempts to prevent emissions leakage by requiring regulators to account for emissions from electrical power imported from out-of-state plants,[169] and to ensure that all power, whether in state or out of state, meets an emissions performance standard.[170] Experts warn, however, that these measures cannot prevent a reshuffling of existing power sources that would nullify

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(providing the governor with the power to extend deadlines in the event of extraordinary circumstances, catastrophic events or threat of significant economic harm).

164. The California Air Resources Board is currently developing a "scoping plan" which will contain the major strategies the State will use to meet the target reductions called for by A.B. 32. *See* CAL. AIR RES. BD., AB 32 SCOPING PLAN, http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm (last visited June 18, 2008).

165. *Supra* text accompanying notes 40–42 (discussing how, even if California were to join RGGI, the total carbon dioxide at stake amounts to only approximately 5.3% of U.S. carbon dioxide emissions).

166. RGGI Emissions Leakage Multi-State Staff Working Group, *Potential Emissions Leakage and the Regional Greenhouse Gas Initiative (RGGI): Evaluating Market Dynamics, Monitoring Options, and Possible Mitigation Mechanisms* 9 (2007) (estimating leakage will range from 18-27% through 2015); Dallas Burtraw et al., *Allocation of CO_2 Emission Allowances in the Regional Greenhouse Gas Cap and Trade Program*, Resources for the Future Discussion Paper 05-25 (2005) (30% leakage the most likely outcome).

167. RGGI Emissions Leakage Multi-State Staff Working Group, *supra* note 166, at 4 (the factors include the cost differential of generation inside and outside RGGI, physical transmission capabilities, and the market impacts of transferring power into the RGGI region).

168. California Global Warming Solutions Act of 2006 (A.B. 32), CAL. HEALTH & SAFETY CODE § 38500 (West 2008).

169. *Id.*

170. California legislators enacted A.B. 1368, companion legislation to A.B. 32 that limits load-serving entities (investor-owned utilities, energy service providers, community choice aggregators) from building new plants or from entering into a long-term financial commitment for base-load generation that does not comply with a California emissions performance standard. According to the Act, that standard cannot be any higher than the greenhouse gas emissions rate from a baseload combined-cycle natural gas-fired plant. On January 25, 2007, the California Public Utilities Commission adopted an interim GHG emissions performance standard putting into effect the statutory standard and defining it in terms of pounds of CO_2 per megawatt hour. *See* Seth Hilton, *The Impact of California's Global Warming Legislation on the Electric Utility Industry*, 19 ELECTRICITY J. 10, 10 (2006).

California's efforts.[171] They argue that reshuffling is inevitable because existing supplies of clean power in California and neighboring states are sufficient to meet California's projected clean-energy needs under A.B. 32.[172]

The effect of these programs on technological change is no better. As discussed previously, emission caps and taxes do not effectively compel new investments in research and development because the standards adopted are usually too weak and the compliance period too short.[173] RGGI and A.B. 32 exhibit both of these shortcomings because they focus on the short term and neither program requires dramatic emissions reductions.[174] RGGI compounds these weaknesses by allowing for many avenues of compliance that do not involve new technologies.[175] A.B. 32 and RGGI's weak caps also limit their capacities to promote technology adoption, such that their influence will depend on the specific barriers to adoption and the existence of complementary programs that might mitigate them. On their own, these state and regional cap-and-trade programs are not structured to achieve significant reductions in GHG emissions or technological change.

2. Promotion of Clean Technologies

Unlike efforts to reduce GHG emissions, technological change has a significant local component that shrinks the scale at which success is measured. Innovation, whether through research and development or learning by doing, is enhanced by knowledge externalities captured only in geographically localized communities.[176] Similarly, the trajectory of technology adoption typically follows an "S-curve"—rising gradually at first, then steeply increasing, and finally leveling

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171. Bushnell et al., *supra* note 15, at 10. Recall that reshuffling occurs when electricity suppliers relinquish their rights to purchase power from dirtier sources of power (e.g., coal) and replace this supply with new contracts for clean power. If the dirty power relinquished by the California suppliers is then purchased by out-of-state suppliers, net GHG emissions in the region will remain the same. *Id.* One way to preclude reshuffling is by requiring firms to be considered responsible for the emissions of their past electricity purchases rather than their current purchases, but such an approach may be legally vulnerable. *Id.* at 14.

172. *Id.* at 14–15.

173. *See supra* text accompanying notes 109–19.

174. RGGI, for example, requires only a modest decrease in emissions below business as usual. In the absence of a regulatory program, carbon dioxide emissions are expected to grow by 7% with in the RGGI states. When this 7% is added to the requirement that emissions in 2019 be 10% below 2009 levels, RGGI should effect a 17% decrease in emissions from affected sources. N.H. Dep't of Envtl. Scis., Regional Greenhouse Gases Initiative (RGGI) Frequently Asked Questions on the Economic Analysis 1 (Jan. 10, 2008), http://www.des.state.nh.us/ard/climatechange/pdf/economic_FAQs.pdf.

175. Sources are permitted to comply not only through the retirement of carbon allowances equal to their emissions, but through the use of "offsets" representing emissions reductions from sources other than electricity generators. While a source's use of offsets is capped at 3.3% of their emissions, While a source's use of offsets is capped at 3.3% of its emissions, should the average allowanceprice rise above $7 or $10 respectively, RGGI provides that a source may use offsets to make 5-10% of its emissions. *See* http://www.rggi.org/docs/program_summary_10_07.pdf.

176. *See supra* notes 98–101 and accompanying text.

off—such that success is marked by achieving levels of adoption that trigger a shift to rapid diffusion (the steep part of the adoption curve).[177] In the discussion that follows, these dynamics prove critical to the success of state programs for promoting technological change.

a. State Renewable Portfolio Standards

Renewable portfolio standards (RPS) are arguably the most popular program for promoting low-GHG electrical generation capacity. Under an RPS, electricity suppliers are required to have a minimum percentage of renewable energy in their portfolio of electricity generators.[178] An RPS is a type of subsidy insofar as the guaranteed renewable share of the electricity market is subsidized by non-renewable generators. It differs from most subsidies, however, by encompassing many types of renewable technologies, thereby avoiding the pitfalls of direct subsidies to specific technologies. The most important of these arises when a less-than-optimal technology, say corn-based ethanol, is selected for political or other non-environmental reasons. RPSs avoid this problem by fostering competition among multiple qualifying technologies for the market share that is guaranteed to them as a group.[179]

The number of states that have adopted RPS programs has grown rapidly since the early 1990s.[180] Today RPS programs exist in twenty-six states and the District of Columbia,[181] and they apply to more than 40% of the electrical generating capacity in the United States.[182] Most state standards range from 15–20% and are phased in over the 2010–2020 time period. A few states, such as California,[183] Minnesota,[184] and Maine,[185] require even higher percentages, while others, often because they apply only to newly constructed renewable generators,

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177. Geroski, *supra* note 128, at 604.

178. BARRY G. RABE, RACE TO THE TOP: THE EXPANDING ROLE OF U.S. STATE RENEWABLE PORTFOLIO STANDARDS 5 (2006), *available at* http://www.pewclimate.org/global-warming-in-depth/all_reports/race_to_the_top; RYAN WISER ET AL., LAWRENCE BERKELEY NAT'L LAB., RENEWABLES PORTFOLIO STANDARDS: A FACTUAL INTRODUCTION TO EXPERIENCE FROM THE UNITED STATES, LBNL-62569 1 (Apr. 2007), *available at* http://eetd.lbl.gov/ea/EMS/reports/lbnl-154e-revised.pdf.

179. Bushnell et al., *supra* note 15, at 12. However, note that some states depart from this "pure competition" model to guarantee solar power at a specific fraction of the RPS percentage or, in the case of Washington, grant a generator two renewable energy credits for every unit of solar power generated, rather than one.

180. WISER ET AL., *supra* note 178, at 1.

181. PEW, *supra* note 11, at 7.

182. WISER ET AL., *supra* note 178, at 2.

183. California currently requires that, by 2010, the state's three major utilities produce at least 20% of their electricity using renewable resources. Governor Schwarzenegger has endorsed a goal of 33% by 2020. PEW CTR. ON GLOBAL CLIMATE CHANGE, STATE RENEWABLE PORTFOLIO STANDARDS, *available at* http://www.pewclimate.org.

184. Minnesota requires 20–30% by 2020–2025. WISER ET AL., *supra* note 178, at 7 fig.2.

185. Maine required 30% renewables by 2000. However, Maine is one of the few states to define biomass as a qualifying renewable power source. *Id.* at 7 fig.2.

are much lower.[186] Finally, to reduce compliance costs and promote flexibility, many states allow electricity suppliers to meet their RPS obligations through tradable renewable energy credits.[187]

In large part because of its vast wind resources, Texas has the leading RPS programs in the country.[188] Texas expects to generate 3-4% of its electricity from wind power by 2010, which will reduce its carbon dioxide emissions by an amount greater than the carbon dioxide emissions from all of the sources in Vermont.[189] Economic factors and energy security have propelled the program, especially concerns about the state's limited ability to import electricity and its transition in the mid-1990s to being a net importer of fossil fuels.[190] This movement was facilitated further by the "negligible" technology-switching costs of the program.[191] The broad popularity of the program was reaffirmed in 2005 when the Texas legislature amended the RPS statute to require a doubling of renewable capacity between 2009 and 2015.[192]

The projected GHG emissions reductions achieved through state RPS programs, despite these impressive numbers, are still nominal. The emissions-reducing capacity of an RPS depends on its stringency and the emissions intensity of the electrical supply displaced by renewable generation minus any emissions leakage that may occur. Although increasing at a fast rate, the size of the emissions reductions achievable through state RPS standards is small—the amount of new renewables required by state RPS programs equates to 3% of total U.S. electrical production in 2020.[193] Moreover, a recent study found that the median rate of carbon dioxide emissions displaced by renewable power under a state RPS may be

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186. Arizona, Massachusetts, Montana, and Washington require new generation and their percentage requirement is accordingly lower, from 4–15%. *Id.* at 7 tbl. 2.

187. *Id.* at 5.

188. The program began at the end of the 1990s with the passage of the Texas Public Utility Regulatory Act of 1999, which established several targets for renewable energy production through 2009, with final level set at 2,880 MW of renewable capacity. Rabe, STATEHOUSE, *supra* note 4, at 1, 52–53. By contrast, Texas ranked last among all U.S. states in the percentage of electricity that it generated from renewables in 1995, the national leader in total GHG emissions and total toxic emissions to air, land, and water. *Id.* at 49.

189. *Id.* at 52–53. Professor Rabe observes that "[t]he law would make Texas the 6th largest national or subnational producer of electricity from wind." *Id.* at 60. In 2005, Texas raised the targets for its RPS program to 5,880 MW by 2012 and 10,000 MW by 2025. PEW, *supra* note 11, at 7.

190. *Id.* at 50–51; Rabe, RACE TO THE TOP, *supra* note 178, at 10–11.

191. Rabe, STATEHOUSE, *supra* note 4, at 60 (observing that this is "in part as a result of a 1.7 cent per kWh production tax credit [established by the 1992 federal Energy Policy Act] . . . and an RPS that is sizable enough to drive project economies of scale").

192. Rabe, RACE TO THE TOP, *supra* note 178, at 11–13 (the 2005 amendments as established an additional nonbinding "target" of 10,000 MW of renewable capacity by 2025). The success in Texas is all the more notable given the high-profile failure, and volatile politics, in Massachusetts to install off-shore wind turbines in the Nantucket Sound. *Id.* at 15.

193. *Id.* at 10.

just 25% lower than the emissions rate of a new combined-cycle natural gas generator.[194]

A significant counterbalancing feature of an RPS is its limited susceptibility to emissions leakage. Although the benefits of an RPS can be eroded in this manner, it will be immune to leakage to the extent that it triggers construction of new renewable generating capacity,. Recall that emissions leakage occurs when displaced fossil-fuel-based power is rerouted to users in unregulated jurisdictions or when the drop in demand for dirty power causes its price to fall and a corresponding rise in out-of-state demand.[195] If, however, new renewable generating capacity must be created and demand is projected to exceed existing generating capacity, then the renewable capacity will, in effect, displace the non-renewable capacity that would have been constructed.[196]

More importantly, RPSs are highly effective means of inducing technological change.[197] For most state programs, this will center on technology adoption and learning by doing given the low targets for renewable capacity and short compliance timelines. In particular, by operating as mandatory technology phase-in policies, RPS programs circumvent the many potential barriers to adoption that would otherwise impede the diffusion of renewable technologies.[198] Consistent with these predictions, roughly half of the renewable capacity created in the United States from the late 1990s through 2006 occurred in states with RPS policies.[199] Thus, while other factors may contribute to the diffusion of renewable technologies, a strong correlation exists between the growth in renewable capacity and state RPS programs.[200] The raw percentages for RPSs in the most aggressive states—more than 20% of generating capacity—are impressive in their own right, and this is particularly true relative to the corresponding percentages of global GHG emissions reductions that these programs can achieve.

b. State Public Benefits Funds and Tax Credits

State climate change initiatives that provide direct subsidies or tax incentives are now common. One reason for this popularity is that they often are

194. Cliff Chen et al., *Weighing the Costs and Benefits of State Renewables Portfolio Standards: A Comparative Analysis of State-Level Policy Impact Projections*, Lawrence Berkeley Nat'l Lab., LBNL-61580 32 (2007). Wiser questions the accuracy of this data, which would seem to indicate that the renewable power generated by RPS standards is not replacing much coal-fired generation. Wiser posits that the studies upon which this figure is derived may omit the amount of imported power displaced by renewable energy, which could be predominantly coal-fired electricity. *See id.*

195. Bushnell et al., *supra* note 15, at 10.

196. *Id.* at 11–13.

197. JOHN A. ALIC ET AL., PEW CENTER FOR GLOBAL CLIMATE CHANGE, U.S. TECHNOLOGY AND INNOVATION POLICIES: LESSONS FOR CLIMATE CHANGE 13 (2003), *available at* http://www.pewclimate.org/global-warming-in-depth/all_reports/technology_policy.

198. *See* Malloy & Sinsheimer, *supra* note 125, at 228–29; *see also supra* text accompanying notes 125–33.

199. WISER ET AL., *supra* note 178, at 9 fig.3.

200. *Id.* at 8.

the most effective means for state or local governments to promote innovation and technology adoption.[201] Further, while tax breaks and subsidies suffer from the problems associated with selecting specific technologies,[202] they have important countervailing virtues.[203] Direct subsidies avoid the temporal discontinuity that undermines regulatory efforts to induce investments in research and development. Subsidies also neutralize common barriers to technology adoption, such as limited access to capital, transaction costs, and technological or market risks,[204] and have proven more effective than regulatory penalties.[205]

State subsidy programs have had many notable successes, particularly in promoting wind and solar energy.[206] Public Benefits Funds (PBF) are currently found in almost half of the states and are the most popular form of direct subsidy program.[207] Seventeen states and the District of Columbia have energy-efficiency PBFs with funding levels that range from 1-3% of total state utility revenues.[208] A subgroup of twelve of these states had total investments in 2002–03 of $870 million that were used to save nearly 2.8 million kWh at costs that were highly competitive with average retail prices.[209] More recently, sixteen states established PBFs for renewable energy that, in 2005, were estimated to provide $300 million annually in funding and are projected to grow to $4 billion by 2017.[210] Complementing these programs, eighteen states have organized to establish the

201. Bushnell et al., *supra* note 15, at 17 (arguing that targeted subsidies "may be the only kinds of regulations that can produce meaningful results at the local level"); *see also* Mona L. Hymel et al., *Trading Greenbacks for Green Behavior: Oregon and the City of Portland's Environmental Incentives*, *in* 5 CRITICAL ISSUES IN ENVIRONMENTAL TAXATION (forthcoming 2008); Database of State Incentives, *supra* note 93.

202. Bushnell et al., *supra* note 15, at 17; Jaffe et al., *Tale*, *supra* note 10, at 169 (2005).

203. Bushnell et al., *supra* note 15, at 8 (observing that "[d]espite all the potential disadvantages of direct, targeted subsidies, they do have the advantage of being less vulnerable to leakage. . . . Therefore, smaller jurisdictions, such as US cities or states, may find subsidies more appealing than other regulatory tools that can be more easily circumvented."). Furthermore, some economists argue that the public goods nature of climate change may justify treating the technological development necessary to address climate change as a public good through government subsidies. *Id.*

204. *See supra* text accompanying notes 125–29.

205. *See* sources cited in *supra* note 123.

206. ALIC ET AL., *supra* note 197, at 28 (describing the growth of wind farms and markets for photovoltaic systems, which have in turn fostered substantial learning by doing and producing).

207. PEW, *supra* note 11, at 7. To give just one example, Texas has established the TexasLoanSTAR program, which provides low-interest loans to finance energy conservation retrofits in state facilities. EPA, *supra* note 11, at ES-13. The program is broadly viewed as a success and has reduced annual energy costs by $150 million. *Id.*

208. EPA, *supra* note 11, at ES-14.

209. *Id.* (describing how "the median program cost was . . . 50% to 75% of the typical costs for new power sources and less than half of the average retail price of electricity").

210. *Id.* at ES-16.

Clean Energy States Alliance, which will enable them to leverage and coordinate their investments in renewable energy projects.[211]

California is notable for its leadership (it established the first PBF in 1996) and for the size of its programs.[212] The recently created $3.3 billion Solar Initiative has become a model program for promoting adoption of solar technology through installation subsidies for solar power systems in homes and businesses.[213] The Initiative also spurs investments in and growth of solar industries in California, including firms conducting research and development on new solar technologies.[214] Moreover, there are signs that the growth in solar research is beginning to generate knowledge feedbacks that are characteristic of innovation clusters and may reward California for being a first-mover in this area.[215]

California is not alone in the scale and ambition of its programs. New York has collected about $2.8 billion in public and private sector resources for efficiency-related projects[216] and states like Texas and Wisconsin are investing hundreds of millions of dollars annually in energy efficiency and renewable energy.[217] The scale of these programs, and state PBFs collectively, now rivals federal expenditures in these areas and the states are making substantial contributions to promoting technological change and cultivating centers of innovation for green technologies.

c. State-level Product Standards

Product standards for energy efficiency exist for more than seventy-five products ranging from vehicles to air conditioners.[218] Under federal laws such as the Energy Policy Act of 2005, product standards (many of which are based on earlier state standards) have been set for more than forty products.[219] The

211. PEW, *supra* note 11, at 7.

212. EPA, *supra* note 11, at ES-14 (describing the state's authorization of $2 billion for energy efficiency programs over 2006–08). Had it passed, California Proposition 87 would have added another $4 billion for alternative energy programs directed at reducing petroleum consumption in California by 25%. Cal. Attorney Gen., Proposition 87: Alternative Energy. Research, Production Incentives. Tax on California Oil Producers. Initiative Constitutional Amendment and Statute 70 (2006), *available at* http://www.sos.ca.gov/elections/vig_06/general_06/pdf/proposition_87/entire_prop87.pdf.

213. *See* The California Solar Initiative, http://www.gosolarcalifornia.ca.gov/csi/index.html. Not surprisingly, the CSI has been criticized by economists. Bushnell et al., *supra* note 15, at 13–14.

214. *See* Richtel & Markoff, *supra* note 12, at C1 (reporting that "[m]any of the California companies are start-ups exploring exotic materials like copper indium gallium selenide, or CIGS, an alternative to the conventional crystalline silicon that is now the dominant technology.").

215. *See* sources cited in *supra* notes 98–101 and accompanying text. States have adopted similar strategies to address other innovation challenges, perhaps most notably the $3 billion California Stem Cell Initiative, but smaller programs also exist in other areas. *See, e.g.*, Science Found. of Ariz. (SFAz), http://www.sfaz.org (last visited Sept. 4, 2008).

216. EPA, *supra* note 11, at ES-14.

217. *Id.* at ES-14, ES-16.

218. *Id.* at ES-15.

219. *Id.*

preemptive federal standards are augmented by standards in ten states that cover more than thirty-five types of products.[220]

California is once again at the forefront with the largest number of standards in place.[221] In this context, it is best known for the unique authority to regulate motor vehicle emissions under the Clean Air Act.[222] This authority was granted despite concerns that it would undermine the efficiency of uniform federal product standards by imposing a parallel set of conflicting standards on industry.[223] These concerns have proven to be unwarranted as California has led the way in promulgating rigorous vehicle emissions standards and promoting new technologies.[224] The California experience has demonstrated that federal preemption is not necessarily the optimal policy and that allocation of regulatory authority need not be an all-or-nothing proposition. Importantly, product regulation can remain effective at both the state and federal levels if state regulatory authority is limited.[225] Congress recognized the value of this independent impetus for new standards when it amended the Clean Air Act to allow any state to adopt California's vehicle emissions standards.[226]

Always willing to push the envelope, California recently exploited its authority under the Clean Air Act to address climate change by promulgating regulations on GHG emissions from motor vehicles.[227] Yet, as we have seen with other state programs, the projected GHG emissions reductions are marginal in a global sense. In a recent estimate the regulations would, by 2020, reduce

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220. *Id.*

221. *Id.* The California standards collectively now reduce peak electricity loads in California by 5% and account for 20% of the drop in peak electricity demand across all energy efficiency programs in the state. *Id.*

222. Under the federal Clean Air Act, all state vehicle emission standards are preempted except those established by California. 42 U.S.C. §§ 7507, 7543 (2006).

223. *See* Cooley v. Bd. of Wardens, 53 U.S. 299, 319 (1853) ("Whatever subjects of [the commerce] power are in their nature national, or admit only of one uniform system, or plan of regulation, may justly be said to be of such a nature as to require exclusive legislation by Congress."); William Buzbee, *Asymmetrical Regulation: Risk, Preemption and the Floor/Ceiling Distinction*, 82 N.Y.U. L. REV. 1547, 1610 (2007) (noting that "overlapping regulation can lead to confusion, high compliance costs, and a drag on otherwise beneficial activities").

224. Kirsten H. Engel, *Harnessing the Benefits of Dynamic Federalism in Environmental Law*, 56 EMORY L.J. 159, 169–72 (2006) (describing the impact of California regulations on the Clean Air Act); NRC, MOBILE-SOURCE STANDARDS, *supra* note,108 at 113.

225. California was afforded this special treatment in the 1970 Clean Air Act as a result of its pioneering efforts to address the worst smog conditions in the nation (*i.e.*, those that existed in the Los Angeles basin). *See* H.R. REP. NO. 90–728, at 21 (1967), *as reprinted in* U.S.C.C.A.N. 1938, 1956, 1967 WL 4082; Statement of Rep. Smith, 113 Cong. Rec. 30940–41 (1967) (statement of Rep. Holifield); *Id.* at 30942 (statement of Rep. Holifield). *See also* Motor & Equip. Mfrs. Ass'n v. EPA, 627 F.2d 1095, 1109 (D.C. Cir. 1979).

226. 42 U.S.C. § 7507 (2006).

227. In 2004, the California Air Resources Board (CARB) promulgated standards for GHG emissions from mobile sources (the "Pavley regulations"). A.B. 1493, 2002 Leg., Reg. Sess. (Cal. 2002), *codified as* CAL. HEALTH & SAFETY CODE § 43018.5 (Deering 2008).

cumulative carbon dioxide emissions from the transportation sector by 28% below the level of the recently tightened federal standards.[228] This drop represents only about 3% of the emissions from motor vehicles in the United States and less than 1% of global GHG emissions.[229]

Despite the limited capacity of product standards to achieve significant reductions in global GHG emissions, they have the power to promote technological change.[230] Product standards operate, in effect, as phased-in bans on products that fail to meet specified criteria for energy efficiency or GHG emissions. Similar to RPS programs, product standards do not single out particular technologies, mitigating problems with the inherent uncertainties and potential errors in technology selection. They also circumvent barriers to technology adoption, particularly information gaps, investor/user splits, and technological risks, because they eliminate consideration of inefficient alternatives. For instance, evidence exists in the motor vehicle context that aggressive standards (e.g., zero-emissions vehicles) can stimulate investment in research and development.[231] The primary weakness of product standards is their limited ability to address products already in use, which can encourage inefficiently prolonged use of older technologies. However, mitigation of this problem can be achieved by using product standards in conjunction with subsidy programs or emissions regulations.

d. Green Building Codes and Certification Systems

Green building codes are among the most important measures that states can implement. Yet, current programs while widespread in the United States are very modest in their goals. Forty-three states have adopted energy-efficiency codes for residential buildings and forty-one for commercial buildings.[232] These

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228. CAL. AIR RES. BD., COMPARISON OF GREENHOUSE GAS REDUCTIONS FOR ALL FIFTY UNITED STATES UNDER CAFÉ STANDARDS AND ARB REGULATIONS ADOPTED PURSUANT TO AB1493, ADD. 2 (Addendum to Jan. 2 Technical Assessment, Jan. 23, 2008). CARB estimates that compliance with Pavley by the thirteen states will reduce vehicle emissions by an additional 461 million metric tons of carbon dioxide (MMCO2) over and above the 523 MMCO2 reduced through compliance with the new federal CAFE law by the remaining thirty-seven states. *Id.* at 3. CARB estimates that the adoption of the Pavley rules by all fifty states would result in an 84% increase in the emissions abatement achieved under the federal standards. *Id.*

229. *Id.*

230. EPA has further facilitated the adoption of new technologies by frequently adopting California standards as the national vehicle emission standards. NRC, MOBILE-SOURCE STANDARDS, *supra* note 108, at 92, tbl. 3–3 (documenting EPA's duplication of the California standards).

231. For instance, despite the delays and amendments to California's zero emissions vehicle mandate first issued in 1990, the California Air Resources Board (CARB) recently found that the mandate had been instrumental in promoting research and development on batteries, fuel cells, and other vehicle components. NRC, MOBILE-SOURCE STANDARDS, *supra* note 108, at 173.

232. EPA, *supra* note 11, at ES-4 to ES-20. For residential buildings, states have adopted either the Model Energy Code or International Energy Conservation Code (IECC), while for commercial buildings, states have adopted either the American Association of

measures have great potential, as simple cost-effective measures are available that could reduce energy use in buildings by 30% or more.[233] California has led the way in leveraging these opportunities while facilitating savings to its consumers and businesses of more than $15 billion since 1975.[234] These savings are projected to climb rapidly to $43 billion by 2011 and to reduce post-2005 electricity demand by an amount equivalent to the power consumed by 180,000 average-sized homes.[235] Moreover, while past savings have been modest, particularly for individual consumers and businesses, the aggregate numbers are significant and will grow dramatically in the coming years.[236]

State building codes have been supplemented by much more elaborate voluntary green-building rating systems.[237] Two rating systems have dominated the market: the Leadership in Energy and Environmental Design ("LEED") and Green Globe. Under LEED, developers receive points for adopting environmentally friendly design features, such as energy-efficient heating systems and water conservation features. Buildings with a sufficient number of points receive a "certification" and their builders gain the bragging rights (and potential economic premium) associated with green buildings.[238] But these systems are not without their detractors, and LEED has been particularly criticized for its vulnerability to manipulation given the broad range of features that count towards obtaining green certification and thus the ease with which a building with mediocre green credentials in its major features might nevertheless obtain a LEED certification.[239]

Government policies and private certification also operate in concert. Increasingly, many state and local governments are promoting construction of green buildings by mandating that public buildings receive green-building certification or by offering various subsidies for builders to meet green building certification standards.[240] Local governments, for example, will cut permit fees or grant property tax exemptions to owners that build LEED certified green

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Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) or IECC building codes. *Id.*

233. *Id.* at ES-15.

234. *Id.* at ES-4 to ES-20.

235. *Id.* at ES-15.

236. Consistent with this conclusion, "[t]he American Council for an Energy-Efficient Economy (ACEEE) estimates that upgrading residential building codes could save an 'average' state about $650 million in homeowner energy bills over a 30-year period." *Id.*

237. Green building programs are thus comparable to the many environmental certification programs that now exist, including programs promoting sustainable forestry practices and environmentally-friendly coffee-growing methods. For a discussion of these programs and their quasi-legal status, see Errol E. Meidinger, *Environmental Certification Programs and U.S. Environmental Law: Closer than You May Think*, [2001] 31 ENVTL. L. REP. 10,162.

238. *See* U.S. Green Bldg. Council, LEED Rating System, http://www.usgbc.org/DisplayPage.aspx?CategoryID=19 (last visited Sept. 6, 2008).

239. Meidinger, *supra* note 237, at 10,170.

240. *Id.* at 10,166–68.

buildings.[241] This innovative hybrid of public incentives and private certification reduces oversight burdens on local governments, although with the potential cost of misplaced reliance on the effective implementation of private programs.[242]

Much more ambitious green building policies are beginning to emerge at the local level. A recently adopted program, BuildSmart, in Boulder County, Colorado, is exemplary of a new wave of building codes that integrate renewable energy requirements and GHG emissions limits.[243] The BuildSmart code applies only to residential buildings, and it becomes progressively more stringent with the size of the home.[244] For example, new or reconstructed residences of 3001-5000 square feet are limited to 5000 pounds of carbon dioxide emissions and must offset 50% of their projected energy consumption with on-site sources of renewable energy.[245] Of critical importance, the new codes would not have been promulgated without the presence of an energy-neutral home in the community that demonstrated the viability of the standards and the capacity among local contractors to meet them.[246]

Establishing rigorous building codes for energy efficiency is among the most effective contributions to mitigating climate change that states can make. The GHG emissions from the building sector are a significant fraction of U.S. emissions,[247] and the opportunities for reducing emissions in this sector, many of which can be achieved at negative marginal cost, are among the most cost effecient.[248] The policy tools available to state and local governments are also well established. Performance-based codes are clearly appropriate given the barriers to technology adoption that exist (e.g., investor/user splits), but incentive programs will also be needed to address existing structures. Indeed, the failure of consumers and businesses to exploit cost-saving measures only serves to highlight the barriers to energy-efficient technologies in the building sector and the value of government

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241. *Id.* Baltimore County gives a 100% rebate on property taxes for buildings meeting the silver LEED standard. Sarasota County gives a 50% discount on the first $ 2,000 in permit fees.

242. This is all the more important because in the past lax enforcement of state building codes has resulted in desultory compliance rates and corresponding low effectiveness. EPA, *supra* note 11, at ES-4 to ES-20.

243. Boulder County, Colo., Ordinance N1104.1–N1104.3.7.4 (2008), *available at* http://www.bouldercounty.org/lu/building_division/pdf/BOCCBuildSmartApproved Amendments.pdf; *see also* Barnaby J. Feder, *The Showhouse That Sustainability Built*, N.Y. TIMES, Mar. 26, 2008, at H6.

244. Boulder County, *supra* note 243, at 4, tbl. 1 (the building code employs a table that categorizes homes according to their square-footage with different standards for each category).

245. *Id.* The largest homes must be carbon neutral. *Id.*

246. Feder, *supra* note 243, at H6 (describing the importance of the demonstration project and how the added building costs were estimated to be less than 10%).

247. Direct and indirect GHG emissions from residential and commercial buildings in 2005 constituted almost 33% of U.S. emissions, and this percentage is projected to increase over the coming decades. CREYTS, *supra* note 74, at 10.

248. *Id.* at xii–xiii. In addition, because buildings are spatially fixed, buildings codes are not subject to leakage and can generate significant secondary economic benefits that are localized.

action.[249] Moreover, the federal system reinforces this delegation of responsibility to the states because, as a quintessential state function, building codes lie outside the province of federal authority.

B. Environmental Federalism in an Era of Climate Change

A central premise of this Article is that federal and state climate change policies should be complementary.[250] Federal action is essential to achieving the dramatic GHG emissions reductions that scientists predict will be necessary, and it it will play a critical role in promoting technological change as well. The primary role of the states, as we have argued above, should be fostering technological change, particularly technology adoption and innovation through learning by doing. Federal laws should therefore enhance the ability of states to contribute to climate change mitigation in these ways. With this objective in mind, we propose several recommendations for federal climate change legislation.

1. State and regional cap-and-trade programs should be retained but should not be the focus of state climate efforts.

Much ink has been spilled analyzing the ways in which a federal cap-and-trade regime could be harmonized with state and regional programs, such as RGGI and California's A.B. 32. As we have shown, once a federal program enacts a legitimate cap-and-trade program, investment of substantial resources in parallel state or regional cap-and-trade programs is unwarranted if the objective is reducing GHG emissions, as opposed to promoting new policy development. These programs, particularly if focused on the short-term, generate little in the way of technology development or adoption, and they achieve only nominal reductions in GHG emissions relative to even a modest federal program.

Federal legislation nonetheless should not entirely preempt state and regional cap-and-trade programs. State and regional GHG emissions reduction programs have the potential to augment emissions reductions over and above those of any federal program that is ultimately adopted. While the amount will be small, any federal program is unlikely to be optimally stringent and any additional reductions should not be needlessly precluded.[251]

The policy development and institutional capacity-building generated by state GHG regulations offer further grounds for preservation.[252] RGGI and A.B. 32

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249. Among the most important barriers are investor/user splits (here primarily landlord-tenant) and the marginal attention that purchasers of homes and buildings pay to energy efficiency. EPA, *supra* note 11, at ES-4 to ES-20.

250. Rabe, STATEHOUSE, *supra* note 4, at 154 (concluding that "it might be foolhardy for the federal government to ignore state experience and at some future point try to impose a new national strategy of its own design").

251. *See supra* Part I.A.; *see also* Daniel A. Farber, *Climate Change, Federalism, and the Constitution*, 50 ARIZ. L. REV. 879, 882 (2008) (arguing that courts should not discourage aggressive regulation at any level of government, given that the massive externalities represented by climate change will likely cause governments to respond by under-regulating rather than over-regulating).

252. *See, e.g.*, HAHN, *supra* note 6, at 44–54 (1998) (highlighting the importance of policy experiments and institutional capacity building).

have already made important contributions to policy development by requiring participants to work through the details of regulatory regime and functioning as a proverbial "laboratory of democracy." These contributions will end upon the enactment of federal legislation regime if for no other reason than that federal and state programs differ in many important ways. For instance, while each of the leading climate change bills in Congress allocate most of the GHG allowances without charging a fee,[253] RGGI gives each member state broad discretion in determining whether it will auction off permits.[254] Currently, five states (Maine, Massachusetts, New York, Rhode Island, and Vermont) have pledged to auction off 100% of their state's emissions allowances.[255] Preservation of state programs is particularly important given the complexity of these programs, as it will enable much greater experimentation than a unitary federal system.

2. State technology portfolio standards should not be preempted expressly, impliedly, or structurally by federal regulations.

State technology portfolio standards, most prominently RPSs, can and should coexist with parallel federal regulations. In most cases, federal and state portfolio standards will complement each other. A federal minimum can jumpstart the adoption of new technologies in states that lack such portfolio standards, which will benefit from the technology spillovers from states with more stringent standards, while preserving the preferences and opportunities of individual states to adopt more stringent standards.

Federal preemption is nevertheless a significant risk for state technology portfolio standards. While express federal preemption is unlikely, Congress recently toyed with what we term "structural preemption" of state RPS programs. Until it was amended in response to strong opposition, the House of Representatives' 2007 comprehensive energy bill would have enabled electricity suppliers located in states with existing RPS programs to "double count" renewable energy credits by using them to meet both the federal and state standards.[256] This would have allowed suppliers to sell any surplus created by more rigorous state RPSs to suppliers in other states to enable those suppliers to satisfy the weaker federal RPS. If double-counting were sanctioned by a federal law, it would effectively nullify more stringent state RPSs, converting a federal minimum RPS in effect to a federal maximum.

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253. *See* Pew Ctr. for Global Climate Change, Table 1: Selected Allocation Approaches Proposed in the 110th Congress, *available at* http://www.pewclimate.org/docUploads/images/Table%201%20image.bmp (last visited Sept. 6, 2008).

254. Debra Kahn, *Northeast States Prep for Inaugural Carbon Auction*, GREENWIRE, Jan. 22, 2008, http://www.earthportal.org/news/?p=823.

255. *Id.*

256. *See* Letter from John L. Geesman and Jackalyne Pfannenstiel, California Energy Commission, to Reps. John M. Dingell and Rick Boucher 2 (June 18, 2007) (on file with authors) ("[A]s currently drafted, the Federal RPS being considered in the Senate would allow California utilities to: (1) 'count' renewable energy towards the California RPS requirement and (2) sell the RECs associated with the amount of renewable energy that exceeds the Federal standard to utilities in other states.").

Recent pending federal RPS legislation effectively neutralized the threat of structural federal preemption. It did so through the adoption of an express savings clause that authorized states to retire surplus renewable energy credits generated from satisfying more-stringent state RPSs.[257] While the savings clause was ultimately unnecessary because the federal RPS provision was omitted from the final legislation, any future federal legislation that incorporates technology portfolio standards should include a similar provision.

3. Congress should enhance technology-forcing product regulation by allowing limited exceptions for state standards.

Parallel state regulatory authority can enhance the technology-forcing potential of federal product standards, as evidenced by the success of California's vehicle emissions standards. The success of the California experiment owes a great deal to the severity of air pollution in California cities that prompted aggressive state action, as well as the decision by Congress to leverage the California program by permitting other states to adopt its standards. Nevertheless, the California program remains an exception to the federal government's general policy of preempting state product standards.[258]

Congress should strengthen and extend this model. EPA's recent denial of a preemption waiver for California's GHG emissions standards for motor vehicles is the most dramatic sign that this framework needs shoring up.[259] Above all, the model of partial preemption established under the Clean Air Act should be duplicated with respect to other product standards, although this need not privilege a single state. A number of potential variants could be considered, such as allowing a consortium of states to depart from a federal standard when they have demonstrated leadership and expertise in developing standards for a particular area of commerce. Experimentation with a variety of regimes, perhaps allowing for more than one alternative standard, is warranted given the success of the California program.

4. Federal and state climate change programs should adopt a portfolio of GHG emissions-reducing and technology-forcing measures.

The importance of technological development to climate change policy and the distinct advantages of pursuing multiple policies to induce technological

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257. *Id.*

258. National Appliance Energy Conservation Act of 1987, Pub. L. No. 100–12, 101 Stat. 103 (1987) (codified as amended at 42 U.S.C. §§ 6291–93, 6295–97, 6305–06, 6308 (1987)). Moreover, although states can establish appliance standards prior to federal action, little incentive exists for them to do so because they can be preempted any time the federal government chooses to act. *See generally* Steven Nadel et al., Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards, Rept. No. ASAP-5/ACEEE-A051 (Jan. 2005).

259. EPA's denial detracts from both the technology-forcing capability of the Clean Air Act scheme and its GHG emissions-reducing potential. *See* John M. Broder & Felicity Barringer, *E.P.A. Says 17 States Can't Set Greenhouse Gas Rules for Cars*, N.Y. TIMES, Dec. 20, 2007, at A1. California has sued EPA over the denial, and legislation is now pending in Congress to reverse the denial.

change provide a strong basis for a continuing state role in climate policymaking, even after the enactment of federal climate legislation. By adopting a portfolio approach, states and the federal government leverage synergistic benefits that are greater than either can achieve alone. Under this approach, emissions reductions should be left primarily to federal policy (i.e., cap-and-trade regimes), while states focus on technology change in parallel with the federal government.

A portfolio approach is consistent with standard principles of federalism. It reflects the understanding that some policies are more effectively pursued by the federal government, while others are better addressed by the states.[260] Beyond its focus on reducing GHG emissions, Federal policies can make valuable contributions by establishing minimum technology portfolio standards, regulating sectors that transcend state boundaries (e.g., transportation), and offering subsidies for research and development and technology adoption. The states can play a complementary role by supporting innovations in policy development, particularly strategies for inducing technological change such as technology portfolio standards, product and appliance standards, building codes, and subsidy programs for stimulating energy efficiency and renewable sources of energy.

CONCLUSION

From the narrow perspective of correcting the market failure that underlies excess GHG emissions, the grounds for state climate regulation are modest. State regulation encompasses only a small fraction of global GHG emissions and is vulnerable to the eroding effects of emissions leakage. But focusing on GHG emissions reductions presents an incomplete picture, as it addresses just one of the two market failures implicated by climate change policy. The other market failure, insufficient investment in technological change, is amenable to state policies. States can therefore make important contributions to mitigating climate change by enhancing the variety of new or existing technologies being developed and adopted.

Reorienting state climate change policies to induce technological change necessarily implicates federal programs. Federal policies should preserve and enhance the degree to which states can contribute to technological change. Specifically, a portfolio approach that integrates federal and state programs can reduce the costs of emissions reductions and provide an overarching framework for allocating responsibilities for climate change programs between the states and the federal government. As a general rule, the federal government should have primary responsibility for implementing programs that directly regulate GHG emissions, while states—in parallel with the federal government—should focus on programs for inducing technological change.

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260. *See also* Thomas D. Peterson et al., *Developing a Comprehensive Approach to Climate Policy in the United States That Fully Integrates Levels of Government and Economic Sectors*, 26 VA. ENVTL. L.J. 227 (2008).