Reconceiving State Climate Change Regulation

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After years of inaction, it now appears that the federal government will regulate greenhouse gas emissions. Over 100 bills were introduced in Congress during July 2007 alone. Even more encouraging, the Senate Environment and Public Works Committee passed a broad climate change bill in December 2007 that calls for a 70 percent reduction from 2005 greenhouse gas emission levels by the year 2050.[1] Further, the U.S. Supreme Court has ruled that the Clean Air Act applies to climate change[2] and ordered the U.S. Environmental Protection Agency to determine whether emissions of greenhouse gases from mobile sources meet the Clean Air Act standard for required regulation. Such a determination would mandate the promulgation of federal vehicle greenhouse gas emission standards.[3]

The potential for federal regulation comes against a backdrop of a surge in regulatory action on climate change at the local, state and regional levels of government.[4] In the absence of strong federal leadership on the issue, a cadre of leading states have been filling the void in climate policy with a variety of programs, including greenhouse gas emissions limits for vehicles and power plants, renewable energy mandates, greenhouse gas emissions registries, and energy conservation and efficiency initiatives. States regulations span many levels of advancement and stringency on the issue, with some promulgating rigorous climate change programs while others are in the early planning stages.[5]

The question we address in this Article is whether state and local action on climate change in the United States can continue to play an important role even after federal regulation is instituted. We are not interested here in justifications for state action in the absence of national action. This scenario—which continues to define the status quo—has been the topic of much research scholarship.[6] A common view, for example, is that state and local action can act as a

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1 John M. Broder, *Senate Passes Bill to Limit Greenhouse Gases,* N.Y. Times, Dec. 6, 2007.

2 Massachusetts v. EPA, 127 U.S. 1438 (2007).

3 Id. at 1462 ("If 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* Barry Rabe, *Environmental Policy and the Bush Era: The Collision Between the Administrative Presidency and State Experimentation*, PUBLIUS 1, 10-13 (May 2007); 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). Linda Adams, *California Leading the Fight Against Global Warming*, 23 ECO STATES 14, 14–16 (summer 2006); Barry Rabe, FROM STATEHOUSE TO GREENHOUSE: THE EMERGING POLITICS OF AMERICAN CLIMATE CHANGE POLICY (2004); Pew Center for Global Climate Change, available at: Http://www.pewclimate.org/what_s_being_done/in_the_states/.

5 See Kirsten H. Engel and Barak Y. Orbach, *Micro-Motives for State and Local Climate Change Initiatives,* ___ Harv. L. & Pol'y Rev. ___ (forthcoming 2007-08).

6 J.R. DeShazo and 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 an appeal to federal regulation: just enough inconsistency, uncertainty and costly product regulation to frighten industry, yet insufficient progress to satisfy environmental groups); Kirsten H. Engel, *Harmonizing Regulatory and Litigation Approaches to Climate Change Mitigation: Incorporating Tradable Emissions Offsets*

potentially important impetus for federal action by prompting powerful multistate firms to seek preemptive uniform national standards to avoid the costs of complying with heterogeneous state environmental standards.[7] The evolution of climate change legislation appears to be consistent with this theory, as exemplified by growing industry support for federal legislation.[8] This rationale, however, does not provide a basis for continued state involvement once a federal program is enacted. To the contrary, the very impetus for federal legislation is the elimination or harmonization of state programs.[9]

Intuitively, one might wonder what is left for the states once the federal government acts or even whether state climate change regulation is misguided at the outset. After all, climate change is a global problem and individual states cannot meaningfully mitigate greenhouse gas (GHG) emissions—even Texas, the state with by far the highest carbon dioxide emissions, emits just eleven percent of U.S. emissions or only about 2.8 percent of global emissions.[10] As alluded to above, rationales for state action often acknowledge this limitation insofar as they are justified as a means of facilitating federal action.[11] We will argue that state action, and environmental federalism more generally, can continue to play a vitally important role in addressing even global environmental problems such as climate change.

Our thesis challenges prevailing view that climate change regulation should occur at the international level, leaving only derivative roles for U.S. federal or state regulation.[12] The

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into Common Law Remedies, 155 U. Pa. L. Rev. 1563, 1579 (2007) (discussing the "domino effect" created when states adopt differing environmental standards).

[7] E. Donald Elliott, *et al.*, *Toward a Theory of Statutory Evolution: The Federalization of Environmental Law*, 1 J. L. ECON. & ORG. 313, 314 (1985).

[8] 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 Eilpern, Energy Firms Come to Terms with Climate Change, Wash. Post, Nov. 25, 2006, at A1 (According to the President of Shell Oil, "We 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, Lehman Brothers are asking Congress to pass climate legislation and expressing concern about state regulation); Subsequent to the filing of the lawsuit, one of the utility company defendants in the public nuisance lawsuit filed by Connecticut and other northeastern states announced its support of mandatory emissions reductions; Jeffrey Ball & Antonio Regalado, Cinergy Backs U.S. Emissions Cap, Wall St. J., Dec. 2, 2004, at A6 (Cinergy Corp., one of the nation's biggest electric utilities, endorsed the idea of a national cap on global-warming emissions shortly after being sued by a coalition of northeastern states claiming the utility giant's contribution to climate change constituted a public nuisance).

[9] This is notwithstanding the fact that this is not the way that it often turns out in practice, as is demonstrated by the number of federal environmental statutes that employ a cooperative federalism approach. 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. 52-53 (1997).

[10] Wallace E. Oates, *A Reconsideration of Environmental Federalism*, Resources for the Future Discussion Paper 01-54, 2-3 (2001) (describing climate change as a pure global public good because "a unit of pulling emission has the same effect on the vector of national environmental quality regardless of where it takes place; a unit of emissions in jurisdiction i is a perfect substitute in this sense for a unit of emissions in jurisdiction j").

[11] *See, e.g.*, Lawrence H. Goulder, *California's Bold New Climate Policy*, Economist's Voice 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"); [others?].

[12] Jonathan B. Wiener, *Think Globally, Act Globally: The Limits of Local Climate Policies*, 102 Penn. L. Rev. 101, 107-08 (2007).

prevailing view follows from the elementary economic theory, sometimes referred to as the "matching principle," that efficient regulation is possible only when a regulating entity fully internalizes the costs and benefits of its policies.[13] It also implicates the complementary principle that decentralized regulation at 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.[14] Together the two principles imply that federal or international regulation is justified only when jurisdictional spillovers offset the benefits of localized regulatory optimization.[15] Accordingly, 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 developed to address global problems (e.g., stratospheric ozone depletion).

Climate change is as pure a global problem as one is likely to find.[16] Many commentators consequently view national, or even limited multinational, regulation as affording dubious benefits, and subnational regulation as irrational if not utterly fanciful.[17] Consistent with the preceding principles, critics base their objections on the inherent inefficiencies of subglobal regulation and countervailing market dynamics. Put simply, to the extent that subglobal regulation is beneficial, national or subnational governments will internalize only a trivial proportion of the benefits, implying that little or no impetus will exist for subglobal regulation and that in the unlikely event that regulations are promulgated, they will be inefficiently lax.[18] Equally important, critics argue that reductions in GHG emissions will be eroded, if not nullified, through so called "leakage," which refers to competitive market dynamics that cause GHG reductions in regulated jurisdictions to be offset, or possibly more than offset, by increased emissions in unregulated territories.[19]

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13 Lawrence H. Goulder and William A. Pizer, *The Economics of Climate Change in* The New Palgrave Dictionary of Economics, 2[nd] ed, 10 (Steven Durlauf and Lawrence Blume eds., 2006) ("economic efficiency calls for making market-based systems as geographically broad as possible").

14 D. Burtraw and Paul R. Portney, *Environmental Policy in the United States in* Economic Policy Towards the Environment 342 (D. Helm ed., 1991) ("This [matching principle] '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. Moreover, this general prescription has received widespread acceptance.").

15 *Id*.

16 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).

17 Wiener, *supra* note 12, at 102-04. But *c.f*. Nordhaus, *supra* 16, at 28 (acknowledging that "[i]t is necessary to locate decision making at a level in the hierarchy between the household and a weak or nonexistent world government that can efficiently coordinate solutions. This is a particularly thorny problem for global public goods because global coordination is required."); Goulder and Pizer, *supra* note 13, at (observing that "[i]nternational coordination is both crucial and exceptionally difficult to achieve" because "the economic and social impacts of climate change would be distributed very unevenly across the globe").

18 Goulder, *supra* note 11, at 1; Wiener, *supra* note 12, at 106-07; James Bushnell, *et al.*, *Local Solutions to Global Problems: Policy Choice and Regulatory Jurisdiction*, NBER Working Paper 13472 *available at* http://www.nber.org/papers/w13472, at 29. (observing that "the net carbon reductions from the policies proposed by a locality as large as California, assuming it achieves all its goals without circumventions (i.e., leakage/reshuffling), would amount to less than 200 MMTCE economy-wide, while China's emissions are forecasted to rise by several *thousand* MMTCE by 2015").

19 Wiener, *supra* note 12, at 107-08; Bushnell, *supra* note 18, at 2-3.

This Article will show that such blanket indictments of subglobal regulation ignore a critically important benefit—promotion of technological change—that is not reflected in the matching principle. Environmental regulation has the potential to address two distinct issues relevant to mitigating climate change:[20] (1) reduction in GHG emissions, and (2) promotion of new technological development and adoption relevant to cutting GHG emissions.[21] Despite these twin objectives, critiques of subglobal regulation have focused almost exclusively on reductions in GHG emissions.[22] Consequently, while critics have demonstrated, we believe quite convincingly, the degree to which subglobal efforts to reduce GHG emissions are undermined or insignificant, their analysis provides only a partial critique of subglobal action.[23]

This one-sided focus is surprising given both the obvious importance of new technologies to mitigating climate change[24] and the growing economic literature on the capacity of environmental policies to induce innovation.[25] It is also a major shortcoming of the current debate over climate change policy.[26] 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."[27] This prediction is bolstered by the determinative impact that assumptions about rates of technological change have on cost estimate for climate policies—they are often "the

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[20] Goulder, *supra* note 11, at 3; Adam Jaffe, *et al.*, *A Tale of Two Market failures: Technology and Environmental Policy*, 54 Ecol. Econ. 164, 168 (2005). ("technological change relative to the environment [occurs] at the nexus of two distinct and important market failures: pollution represents a negative externality, and new technology generates positive externalities. Hence, in the absence of public policy, new technology for pollution reduction is, from an analytical perspective, doubly underprovided by markets.").

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

[22] *See, e.g.*, Wiener, *supra* note 12, at 102-04.

[23] 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.*, Jaffe, *et al.*, *supra* note 20, at 165 (claiming that "there is very little dispute among economists that flexible, incentive-oriented policy approaches are more likely to foster low-cost compliance paths than prescriptive regulatory approaches"); David M. Driesen, *Design, Trading, and Innovation in* MOVING TO MARKETS IN ENVIRONMENTAL PROTECTION: LESSONS AFTER 20 YEARS OF EXPERIENCE 1-2 (Jody Freeman and Charles Kolstad eds., 2006) (challenging the dominant view that market-based regulations are more effective at stimulating innovation).

[24] Martin I. Hoffert, *Advanced Technology Paths to Global Climate Change Stability: Energy for a Greenhouse Planet*, 298 Sci. 981, 981 (2002) (arguing that "the most effective way to reduce CO_2 emissions with economic growth and equity is to develop revolutionary changes in the technology of energy production, distribution, storage, and conversion"); Richard Newel, *et al*, *The Effects of Economic and Policy Incentives on Carbon Mitigation Technologies*, 28 Energy Econ. 563, 564 (2006) (commenting that "limiting economic activity as a means of reducing carbon emissions has scant political appeal for rich countries, let alone poor ones. Technological improvements that generate enhanced energy and carbon efficiency have therefore been the principal means discussed for addressing climate change."); Alistair Ulph and David Ulph, *Climate Change—Environmental and technological Policies in a Strategic Context*, 37 Environ. Res. Econ. 159, 160 (2007) (observing that "[i]t is now widely recognized by policy-makers that tackling climate change will require a mix of both environmental policies and technology policies.").

[25] *See generally* Jaffe, *et al.*, *supra* note 27.

[26] Goulder and Schneider, *supra* note 21, at 212-13 (commenting on the neglect of induced technology in most climate policy).

[27] Adam B. Jaffe, *et al*, *Technological Change and the Environment in* HANDBOOK OF ENVIRONMENTAL ECONOMICS, vol. 1 461, 476 (Karl-Goran Maler and Jeffrey R. Vincent eds, 2003).

single largest source" of uncertainty.[28] The current debate over federalism and climate change is therefore not only incomplete, but missing a element that is likely essential to the success of climate change policies.

We will argue that inducing technological change provides an independent ground for state-level action on climate change. Importantly, we do not treat technological innovation as derivative of GHG emissions reductions (e.g., its potential to offset leakage problems),[29] but as a distinct regulatory end that is subject to a market failure—technological spillovers—unrelated to the negative externalities that have traditionally justified environmental regulation.[30] Contrary to the standard lines of debate,[31] this framework breaks the dichotomy between "narrow but deep state regulation" and "broad but shallow federal regulation"; both can be justified when directed at distinct and complementary policy objectives.

These distinct policy objectives present different challenges for climate change policy. In particular, the countervailing market dynamics of leakage play out differently when the goal is inducing innovation. At the outset, the geographic scale of regulation necessary to stimulate innovation does not have to be global, as it need only be large enough to create a market that meaningfully enhances the level of technology innovation or adoption.[32] Similarly, there may be distinct economic advantages to a state as a "first mover" if it succeeds in cultivating a critical mass of green technology industries in its jurisdiction that can justify early action.[33] Finally, the high uncertainties associated with technological innovation argue against centralization,[34] as a diverse range of strategies is more likely to succeed over a monolithic approach.[35]

In sum, while we agree that global regulation is the only reliable means of achieving meaningful reductions in GHG emissions, this does not imply that subglobal regulation is foreclosed. Subglobal, and particularly state-level, regulation can offer an effective means of inducing the technological change that will be critical to achieving the dramatic reductions in GHG emissions that scientists believe will be necessary. By recognizing these parallel objectives, our approach reaffirms the relevance of environmental federalism to climate change policy—one can think globally and still act locally. This suggests a two-tier strategy: regulation

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28 Jaffe, *et al.*, *supra* note 27, at 463.

29 Wiener, *supra* note 12, at 111-12.

30 Jaffe, *et al.*, *supra* note 20, at 168-69 (concluding that "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.").

31 Bushnell, *et al.*, *supra* note 18, at 2.

32 Indeed, even for the technologies that are among the most costly to develop, such as pharmaceuticals, markets in the United States, the European Union, and Japan are sufficient. Less expensive technologies would require much smaller markets, including at the subnational level, and in no event would regulation have to include the much more difficult negotiations with developing countries.

33 [need cite].

34 Jaffe, *et al.*, *supra* note 27, at 485 (observing that optimization very hard with the large uncertainties surrounding research and development outcomes).

35 Robert P. Merges & Richard L. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 873 (1990) (observing that with real technological 'prospects' … no one knows for sure what possible inventions are in the technological pool…. Because of this uncertainty, development of technology is critically different from other common pool problems . . . . 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).

of aggregate GHG emissions at the federal level, based presumably on an international agreement, complemented by state (as well as federal) policies designed to promote innovation and adoption of GHG mitigating technologies.

The Article is divided into two primary sections. The first 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 of new innovations or adoption of existing technologies. The second section uses the insights from the first section to identify specific opportunities for state action in the U.S. federal system. We identify and evaluate several state-level climate change programs that are particularly promising in these respects. This analysis is followed by a series of recommendations for structuring federal climate change laws—particularly when, and the degree to which, federal laws should preempt state regulation—that leverages the power of national-level regulation while preserving the states' ability to implement policies for promoting technological change.

I. Two Distinct Market Failures Addressed by Climate Change Regulation

Environmental regulation is typically justified on the basis of one form of market failure—businesses' and consumers' failure to internalize the negative environmental impacts of their actions. However, environmental policy is not simply directed at deterring or restricting behavior with bad environmental consequences; it also seeks to promote development of new technologies that reduce abatement costs or have smaller environmental footprints. This latter objective proves to be doubly difficult because it occurs "at the nexus of two distinct and important market failures," traditional negative environmental externalities and the positive externalities associated with uncompensated technological spillovers.[36]

Climate change, in large part because of its global scope, is 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.[37] For similar reasons, technological 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.[38] A third, less-prominent from of market failure also exists that directly undermines incentives for governments to take regulatory action. Here the informational spillovers from and heightened costs of being a regulatory first-mover encourage delay, as there is no means for governments to recoup the value of the institutional knowledge they generate or the added costs that they incur. All three inhibit efforts to address climate change, but our focus in this Article will be on the first two forms of market failure—negative environmental and positive technology externalities.

This section will examine the relative benefits of national versus state regulation in addressing these two primary types of market failure. While state regulation is demonstrably inferior to national regulation with respect to the first form of market failure, it has significant

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36 Jaffe, *et al.*, *supra* note 20, at 168.

37 Goulder and Pizer, *supra* note 13, at 9.

38 [need cite].

potential to complement federal action, as well as certain advantages over, national regulation with respect to the latter form of market failure. The discussion that follows will show how a properly balanced federal framework for environmental regulation and technology policy can take advantage of the respective strengths of national and state action in addressing these forms of market failure.

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

Climate change exemplifies the classic case of a 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 is only a fraction of what would be efficient. Making matters worse, no single source emits a globally significant quantity of GHGs, which further undermines incentives to take action. These market failures justify government intervention under classical economic theory, but a basic premise of government market corrections is that governments have the authority to ensure that such costs are fully internalized. For climate change, only international regulation can meet this requirement.

U.S. policies for addressing climate change have not adhered to the matching principle. State-level action has dominated U.S. climate change policy. While many state climate initiatives are voluntary, there are an increasing number of stringent state requirements.[39] In January 2007, for example, the California Public Utilities Commission adopted an interim GHG emissions performance standard that requires all new long-term commitments for base-load electric power generation in California to have emissions no greater than a combined-cycle gas turbine plant.[40] Washington State and Oregon have enacted similar standards for power plants serving their markets.[41]

Driven by emission reductions at the state level, U.S. climate policies illustrate what some commentators have characterized as a strategy of “narrow but deep” regulation.[42] This strategy has been criticized as inferior to so called “broad but narrow” approaches on two central grounds. First, the geographic scope of the regulation is simply too small to have a measurable impact on global GHG emissions. Second, narrow but deep strategies are prone to leakage, which involves market responses that offset local emissions reductions. Recently, scholars have raised an even more troubling variant of leakage, under which “reshuffling” of production sources occurs with minimal costs that eliminates any net GHG emissions reductions.[43]

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39 Rabe, *supra* note , at __.

40 That level is defined as 1,100 pounds of CO_2 per megawatt-hour. California Public Utilities Commission, Order Instituting Rulemaking to Implement the Commission’s Procurement Incentive Framework and to Examine the Integration of Greenhouse Gas Emission Standards into Procurement Policies, Interim Opinion on Phase 1 Issues: Greenhouse Gas Emissions Performance Standard (Jan. 29, 2007), available at http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/64072.pdf.

41 Available at: http://apps.leg.wa.gov/documents/billdocs/2007-08/Pdf/Bills/Session%20Law%202007/6001-S.SL.pdf.

42 Bushnell, *et al.*, *supra* note 18, at 2.

43 *Id.*

Regulation of GHG emissions from electric power plants illustrates well the limits of state or 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 U.S. 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.[44] The impact that RGGI could have is nominal at best, as carbon dioxide emissions from power plants (its exclusive focus at the moment) in the committed states constitute only two percent of U.S. emissions from power plants and 4.5 percent for all eleven states and the District of Columbia.[45] Even if California were to join RGGI, the total carbon dioxide emissions at stake would amount to only 5.3 percent of U.S. emissions.[46] The small percentages imply 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 relatively modest national regulation would achieve substantially greater GHG emissions reductions than the current (or expected) patchwork of state regulatory efforts.

The challenges to state action go beyond the potential magnitudes of reductions in GHG emissions. Even if the leading states constituted a major fraction of U.S. GHG emissions, their regulatory efforts in many economic areas would be eroded, if not effectively nullified, by so called leakage problems. As described above, leakage refers to increases in the emissions of GHG emissions outside of a regulating state or region that offset the emissions reductions within that territory. Economists have identified three sources of regulatory leakage—one driven by falling fuel prices, the second by reductions in production levels, and the third by relocation of industries to unregulated jurisdictions.[47] Each of these sources of leakage demonstrates the pneumatic character of market dynamics that confound efforts to regulate "wide-spread and geographically moveable sources."[48]

The first two leakage scenarios follow from standard supply-and-demand economics. The logic is simple: insofar as subglobal regulation diminishes demand for carbon-based fuels, it will trigger a drop in fuel prices that, in turn, causes an offsetting increase in fuel consumption within unregulated territories.[49] The degree to which the reduction in emissions from a regulated territory are offset will depend on the degree to which demand in unregulated areas is sensitive to price—the more price sensitive it is, the more complete the offsetting emissions will be.

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[44] The committed states include Connecticut, Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, Vermont, and four states, the District of Columbia, Massachusetts, Rhode Island, and Pennsylvania, are currently monitoring the program and seriously considering joining it.

[45] [need cite] Total carbon dioxide emissions from these states is somewhat larger, with the committed states contributing nine percent of U.S. carbon dioxide emissions and eleven states and the District of Columbia constituting fifteen percent. *Id*. Similarly, if one considers all the "blue" states in the U.S. 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 thirty-two percent 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 there differential in the base level of emissions subject to regulation.

[46] *Id*. By contrast, in 2006 the 10 U.S. states with the highest carbon dioxide emissions from electric utilities constituted almost fifty percent of total U.S. carbon dioxide emissions from these sources.

[47] Wiener, *supra* note 12, at 107-08.

[48] *Id*. at 104.

[49] *Id*. at 107-09.

The second scenario is a variation of the first, but it involves reductions in the production of goods within the regulatory territory that are driven by the increased costs of production (i.e., higher energy costs) caused by regulation.[50] Similar to the first scenario, the reduction in production levels within the regulated territory lead to compensating increases in production in unregulated areas. Reductions in supply lead to increases in product prices, which motivate producers outside a regulated jurisdiction to expand their production. Moreover, if relatively efficient production in a regulated area is replaced by inefficient production (i.e., higher GHG emissions per unit), the net result could be greater overall GHG emissions.[51]

The significance of price- and supply-based leakage are dependent on the magnitude of actual reductions and the market dynamics.[52] If the reductions in carbon-fuel demand or product supply are nominal, the effects will also be nominal unless price or supply are extraordinarily sensitive (elastic) to demand or price, respectively.[53] Because leakage rises with the impact on price or supply, subnational regulation—given of its small scale—is less likely to suffer from these types of leakage. As already outlined above, states likely to regulate electrical utilities constitute a small fraction of U.S. carbon dioxide emissions (about five percent) from these sources, which implies that they constitute a comparably modest share of the market demand for carbon-based fuels.[54] Thus, a multistate cap that reduced emissions to fifty percent of current levels would constitute about a 2.5 percent drop in demand (assuming conservatively that electrical utilities dominate the market for fuels), implying that offsetting price-induced demand is also likely to be modest.[55]

The third form of leakage results when production facilities are moved out of a regulated area.[56] For example, for energy-intensive industries that are sensitive to energy prices, the differentials in energy prices between regulated and unregulated jurisdictions may justify incurring short-term relocation expenses. Accordingly, if a state like California were to cap GHG emissions, some industrial sources might relocate to Mexico or Arizona to avoid the increased production costs.[57] Thus, rather than achieving stable GHG emissions, a regulating

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50 *Id.*

51 *Id.* ; Bushnell, *et al.*, *supra* note 18, at __.

52 Bushnell, *et al.*, *supra* note 18, at 9.

53 *Id.*

54 [need cite]; get numbers of fraction of U.S. carbon-based fuel market. Likely to be a relatively larger share of the market of natural gas, but if this causes a drop gas prices, which is unlikely in any event, it could have a net positive effect by shift production away from more carbon-intensive fuels like oil or coal [need cites here].

55 The diminished influence of leakage represents an advantage of state action over either federal or international regulation. However, it is somewhat of a perverse benefit, 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.

56 In the case of electricity production, movement of production facilities may not be necessary; instead the courses of production can simply be "reshuffled," thereby largely eliminating any relocation costs. Bushnell, *et al.*, *supra* note 18, at 2 (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 sources and consumers").

57 Again, electrical utilities represent an extreme example of this dynamic. California's efforts to limit GHG emissions from electrical utilities illustrates this problem perfectly, as "ample resource exist outside of California that are compliant with the standards that already exist. California utilities can comply with the standard by buying from the existing low-carbon sources, leaving the 'dirty' sources to meet demand from other states," with the result being no "real impact on pollution." Bushnell, *et al.*, *supra* note 18, at 6.

state would merely prompt companies within its borders to relocate and continue to emit GHGs at the same (or possibly greater) levels than they had prior to the institution of the regulatory program. Clearly, relocation will not be economically or strategically justified for all companies located in a regulated jurisdiction, but such offsetting relocations, economists suggest, can actually overwhelm the regulatory reductions.[58]

The existing empirical studies confirm that leakage undermines efforts to regulate GHG emissions at the regional (e.g., all OECD countries) or national levels. Estimates using standard economic models typically predict leakage rates ranging from about five to twenty percent, although some investigators using such models have predicted rates as high as 41 percent.[59] 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 dynamic effects such as the migration of companies to unregulated jurisdictions.

In one such study, the investigator analyzed leakage from OECD countries caused by implementation of the Kyoto Protocol. The economic model predicted stunningly high leakage rates that ranged as high as 50% to 130%, implying that efforts to reduce GHGs emissions at the subglobal level can cause a net *increase* in global emissions.[60] Significantly, the author found that the disparity between his results and those of previous models were largely driven by the added effects of industry relocation. This finding is reinforced by the fact that his estimates for leakage associated with differentiated goods were consistent with the low end of the predictions derived from standard economic models (i.e., ~ 5%).

The potential significance of leakage is therefore highly variable. For industries that produce differentiated goods, the threat of leakage is relatively modest, whereas for industries that produce undifferentiated commodities, it can wipeout or even overwhelm the GHG emissions reductions from subglobal 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 likely manageable, though by no means insignificant.

To complicate matters further, "leakage" is not always negative.[61] A recent set of studies has shown that technological developments 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 development and 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, then it may be profitable for industries in unregulated areas to adopt the technologies, thereby causing a net reduction in GHG emission both inside and outside the regulated jurisdiction.[62] Particularly where there is little or no

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58 Mustafa H. Babiker, *Climate Change Policy, Market Structure, and Carbon Leakage*, 65 J. Int'l Econ. 421, 441-43 (2004).

59 Carrado Di Maria and 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.

60 Babiker, *supra* note 58, at 441-43.

61 Wiener, *supra* note 12, at 111.

62 Di Maria and van der Werf, *supra* note , at 16.

support for research and development in unregulated regions, economists have shown that subglobal caps on GHGs emissions or taxes can lead to net GHG emissions reductions in unregulated areas with relatively carbon-intensive industrial sectors.[63]

These findings demonstrate the potential effects of technological spillovers on GHG emissions. Econometric modeling shows that even for worst-case scenarios involving highly mobile industries and undifferentiated goods, leakage problems can be erased where development and adoption of cost-effective technologies is induced through a regulatory program, subsidies, or a combination of both.[64] It also reveals that much more information is needed on the rates of technological diffusion.[65] These studies nevertheless anticipate the important role of technological innovation for climate change policy discussed in greater detail below.

The preceding discussion exposes several points about the viability of state-level climate change regulation. First, the modest scale of likely state programs implies that they are will not meaningfully lower GHG emission levels. Second, even large-scale regulatory programs will be undermined, if not overwhelmed, by leakage if they involve mobile industries manufacturing undifferentiated goods—the textbook case being electric utilities. Third, leakage will be modest, and certainly not nullify, state-level GHG reductions if the regulated (or taxed) industries cannot be easily relocated or produce differentiated goods. Under these circumstances, state action will not risk doing more harm than good with respect to global GHG emissions. Thus, while the state-level capacity to reduce GHG emissions is unlikely to be sufficient to justify regulatory action, in most cases the net effects will be neutral or negligible, thereby leaving unencumbered alternative grounds for state-level regulation.

B. Technological Innovation and State Climate Change Policy

Inducing technological change provides a distinct basis for state-level climate change regulation. Technological innovation, as many commentators have recognized, will play a critical role in efforts to mitigate climate change.[66] Technological change in this context encompasses research and development that produces *new* technologies and adoption (or diffusion) of *existing* technologies, which can itself produce innovation through "learning-by-doing" as experience is gained with the use and production of a technology.[67] Economists, in

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63 Rolf Golombek and Michael Hoel, *Unilateral Emission Reductions and Cross-Country Technology Spillovers*, B.E. J. Econ Analysis and Pol'y, vol. 4, no. 2, art. 3, at 18-19 (2004).

64 The rates of technology diffusion will, however, be contingent on relatively low adoption costs (e.g., low information and technology licensing barriers). *Id*.

65 *Id*.

66 Ulph and Ulph, *supra* note , at 160; Jaffe, *et al.*, *supra* note 20, at 168-69 (observing that "where 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."); Nicholas Stern, The Economics of Climate Change __ (2006).

67 Newell, *et al.*, *supra* note , 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.*, *supra* note 27, at 490.

particular, have noted that cost estimates of climate policy are highly sensitive to assumed rates of technological change.[68] This sensitivity suggests that a primary benefit of state-level climate change policies may ultimately be their capacity to promote the development and adoption of new technologies.[69]

In the realm of environmental policy, technological change nevertheless continues to be overshadowed by policymaker and public interest in direct commitments to reducing GHG emissions.[70] This bias is clearly evident in the debate over the merits of subglobal climate change regulation generally and state-level action in particular. As we have seen, the debate over environmental federalism turns largely on the matching principle, which concerns GHG emissions reductions measures (i.e., cap-and-trade programs, environmental taxes) designed to address negative environmental externalities. Virtually no consideration is given of the potential for state- or national-level policies to induce technological change.[71] In this section, we aim to correct this oversight and to examine the potential for state policies to address the technological development that will be essential to mitigating climate change.

We begin by analyzing the market failures that are characteristic of technological change and then evaluate the merits of different policies for inducing it. We then analyze the circumstances under which state-level environmental regulation can induce technological change. Environmental regulation on its own proves to be most effective at spurring adoption of existing technologies and derivatively learning-by-doing—as opposed to the research and development that produces entirely new technologies. These findings draw on recent econometric studies, summarized below, of environmental policy and induced technological change. The discussion then turns to assessing the value that subnational regulation in inducing technological change beyond a purely federal approach. The section concludes by urging a hybrid approach that integrates environmental regulation and direct technology subsidies.

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 inventions.[72] This lost value leads to under-investment in research and development,[73] which in

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68 Jaffe, *et al.*, *supra* note 27, at 463; Newell, *et al.*, *supra* note , at 564 (observing that "the 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." [Yellen, 1998, in Newllew-06 at 564]

69 *Id*. at 476. *See also,* A. Kneese and C. Schultze, POLLUTION, PRICES, AND PUBLIC POLICY (1975); Goulder and Schneider, *supra* note 21, 240.

70 Goulder and Schneider, *supra* note 21, 212-13.

71 Wiener, *supra* note 12, at 111 (mentioning technological change only in passing and otherwise focusing entirely on the capacity of subglobal regulation to achieve meaningful GHG emissions reductions).

72 Jaffe, *et al.*, *supra* note 27, at 471 (observing that "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 . . . .").

this context compounds the incomplete internalization of negative environmental externalities that new inventions are supposed to mitigate. Such spillovers also impede technology adoption and the learning-by-doing innovation that it promotes. Firms that are early adopters of new technologies often function as guinea pigs that absorb the costs of working through the kinks in early versions of a new technology.[74] This learning process produces valuable knowledge and refinements, which firms adopting the technology later benefit from without having to incur any of the costs. Accordingly, because innovators (here early adopters) are unable to fully internalize the value of their efforts, their incentive to invest in costly learning-by-doing is suboptimal from a social welfare standpoint.[75]

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."[76] Thus, insofar as government policies increase the costs of polluting activities or improve the economics of innovative work, they can in theory stimulate innovation that lowers pollution abatement costs and in so doing the collective capacity to reduce GHG emission cost effectively.[77] Under this theory, governments can induce technological change either indirectly by increasing potential market payoffs or directly by conducting or subsidizing it.[78]

Policies will differ, however, according to whether they are directed at adoption of existing technologies or development of new technologies. 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.[79] The potential market size for a technology is often of particular importance in such investment decisions.[80] In 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.[81] None of these

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73 *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.

74 Jaffe, *et al.*, *supra* note 20, at 166.

75 *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.*, *supra* note , at 568)

76 Jaffe, *et al.*, *supra* note 27, at 469-60.

77 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.*, *supra* note 27, at 474.

78 Jaffe, *et al.*, *supra* note 27, 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.*, *supra* note 20, at 173; Montgomery and Smith, *supra* note , at 13-14.

79 *Id*.

80 Jaffe, *et al.*, *supra* note 27, at 490 (observing that "market size tends to be an important determinant of R&D effort and innovative activity").

81 Newell, *et al.*, *supra* note , at 566.

factors is related to market size, which suggests at the outset that inducing technology adoption can occur at any level of government.

These differences prove critical to preserving a role for state-level environmental regulation. Because companies developing new technologies will only rarely be the same as 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.[82] In particular, while market size will bound the capacity of environmental regulation to spur investments in research and develop—the larger a regulated market, the larger the effective incentive—it is irrelevant to inducing technology adoption.[83]

States are clearly disadvantaged, given their much smaller markets, relative to the federal government in their capacities to stimulate private-sector research and development. By contrast, because the incentive to adopt a technology or invest in learning by doing is independent of market size, states are equally capable of inducing these forms of technological change within their jurisdictions. Thus, even where federal programs are instituted (e.g., renewable portfolio standards), states can continue to meaningfully impact technology adoption through programs that either target different technologies or are more aggressive; as discussed further below, the legal issue will be ensuring that federal and state programs can coexist.

2. *Research and Development: The Temporal Conflict Inherent in Technology Forcing via Environmental Regulation*

Limited empirical support exists for the effectiveness of environmental regulation in inducing research and development at any level of government, and the data are especially sparse for pollution abatement technologies.[84] Two recent studies, however, have identified correlations between pollution abatement costs and either patenting rates in related technological areas or levels of research and development.[85] More extensive studies exist on research and development related to energy-efficient technologies.[86] Researchers have, for example, observed "significant amounts of innovation" in response to both increases in energy prices and changes in energy-efficiency standards.[87]

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82 [need cite].

83 See *infra* text accompanying __-__. 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 develop 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 their local markets for the technology. The presence of economies of scale or network effects merely allows to leverage the regulatory power that they already possess.

84 Jaffe-HEE, *supra* note , at 481 ("exceptionally little empirical analysis of the effects of alternative policy instruments on technology innovation in pollution abatement, principally because of the paucity of available data").

85 Jean O. Lanjouw and A. Mody, *Innovation and the International Diffusion of Environmentally Responsive Technology*, 25 Res. Pol. 549, 550-51 (1996); Adam B. Jaffe and K. Palmer, *Environmental regulation and Innovation: A Panel Data Study*, 79 Rev. Econ & Stats 610, 611-12 (1997).

86 Jaffe-HEE, *supra* note , at 475-76, 481-82.

87 *Id*. at 475-76. The studies also found that the rates of patenting in energy-related fields rise with increases in energy prices. *Id*.

None of these studies provides compelling evidence that environmental regulation offers a powerful means of stimulating research and development.[88] This is not to suggest that dramatic success stories do not exist. To the contrary, research an development were successfully spurred by the 1970 Clean Air Act, which mandated a 90 percent reduction in the emissions of three pollutants from new vehicles by 1975.[89] Lacking adequate existing technologies in 1970, the statute fostered the invention of both the two- and three-way catalyst-base system for control vehicle emissions (notably in 1975 and 1981, respectively). However, as well shall see, the relatively brief grace period provided, and the fortuitous timing of the new technology, were likely critical to the success of the regulation.

The spotty empirical data may be reflective of deeper structural problems. The degree to which environmental regulations can promote technological innovation is hampered by the political economy of regulatory process itself. As several commentators have forcefully argued, these problems potentially negate the capacity of environmental regulations to have any effect at all.[90] Their critique turns on the realization that incentives to conduct research and development, because of its long lag times, are tied to the stringency of regulations that are in place when it produces a commercially viable product.[91] As a consequence, it is the credible threat of stringent regulation in the future—not policies currently in place—that provides the incentive to invest in costly research and development.[92] After all, only the future regulations can support the market for the new technology, and they will bound both the price at which the technology can be sold and the total revenues from it.

The extended lag time between investments in research and development and the relevant regulations creates uncertainty that erode the incentives created by regulatory policies. This uncertainty stems from the all too predictable disparities "between what governments will announce as a *future policy* and what governments will *subsequently* be motivated to adopt as policy.[93] To make matters worse, the optimal policy today (permit levels or taxes that reflect the costs of adoption *and* innovation) will not be the politically expedient or economically optimal policy for the government to maintain in the future when it matters.[94] To the contrary, once a technology is available, the government will be under immense pressure to ensure that it is

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88 *Id*.

89 *See* National Research Council, Committee on State Practices in Setting Mobile Source Emissions Standards, State and Federal Standards for Mobile Source Emissions 116 (2006) [hereinafter NRC, Mobile Source Standards]. *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).

90 W. David Montgomery and Anne E. Smith, *Price, Quantity, and Technological Strategies for Climate Change Policy in* HUMAN-INDUCED CLIMATE CHANGE: AN INTERDISCIPLINARY ASSESSMENT (M. Schlesinger, *et al.*, eds, 2005) (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").

91 Ulph-Ulph-07, *supra* note , 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").

92 Montgomery and Smith, *supra* note , 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 . . . .").

93 *Id*. at 1. In some respects, the 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. Thomas C. Schelling, *What Makes Greenhouse Sense?*, 81 Foreign Affairs 1, 2 (2002).

94 Montgomery and Smith, *supra* note , at 27.

adopted as readily and cheaply as possible (e.g., permit prices set at the lowest level that ensures efficient adoption).[95] Moreover, these fears are compounded by the large uncertainties in the projected magnitude and timing of climate change, and corresponding societal impacts, as well as the potential market-eroding effects of regulatory leakage.[96] Yet, the ability of inventors to recoup their investment in research and development is largely contingent on government regulatory policies (e.g., allocation of GHG permits or setting carbon tax rates).[97]

The questionable credibility of government commitments to future levels of regulation clearly diminishes the capacity of environmental regulations to induce companies to invest in long-term research and development.[98] This temporal or "dynamic" inconsistency has led some observers to conclude that environmental regulation has little or no capacity to induce innovation relevant to mitigating climate change.[99] For them, the benefit of environmental regulations rests solely on their effectiveness at "minimizing the costs of technology adoption for *existing* technologies" or, at most, stimulating short-term innovation with "immediate implications for cost savings."[100] This view implies that environmental regulation should be calibrated to existing technologies, not the levels needed to promote extended research and development on entirely new ones.[101]

These arguments expose the pitfalls of ignoring the political (and economic) realities of environmental regulation at any level of government. In fact, forward-looking state polices may be less credible if as some commentators have argued, states are more susceptible than the federal government to the lobbying by concentrated interest groups that is characteristic of

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95 Montgomery, *supra* note , 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"); Fischer-Newell, *supra* note, at 5 (observing that "an emissions price high enough to induce the needed innovation cannot be credibly implemented"). Making matters worse, "widespread diffusion of [an] innovation often lowers the innovator's payoff and accordingly reduces the incentive to innovation." Laffont and Tirole, *supra* note , at 128.

96 Jaffe, *et al.*, *supra* note 20, at 168 ("the 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."); Montgomery, *supra* note , at 20.

97 Montgomery and Smith, *supra* note , at 16-17. In the case of a cap-and-trade system, pollution permits are an alternative to new technology adoption and thus compete with it; as a consequence, the cost of the permits, which is dictated by the government cap, place an upper bound on the price of new abatement technologies. Jean-Jacques Laffont and Jean Tirole, *Pollution Permits and Environmental Innovation*, 62 J. Pub. Econ. 127, 128-29 (1996).

98 Lawrence H. Goulder, *Induced Technological Change and Climate Policy*, Pew Center on Global Climate Change 26 (2004) *available at* ____ (observing that "producers are likely to have less than 100 percent 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 behavior will be muted and associated cost savings will be reduced.").

99 Montgomery and Smith, *supra* note , at 1-2 ("The only role for near-term greenhouse gas caps or taxes would be to achieve emissions reductions that are justifiable immediately because their cost per ton removed is less than the present value of the cost of avoided future emission reductions that would come from future technologies, once they are available.")

100 *Id.* 6-7.

101 *Id*. at 11. This strategy is viable in significant part because of the long lifetime of GHGs in the atmosphere, which implies that emissions reductions in different years are almost perfectly substitutable (assuming that early emissions do not trigger irreversible tipping points). *Id*. at 12.

Public Choice theory.[102] One must be careful, however, not to take the argument too far. For one, it runs contrary to the studies and examples suggesting environmental regulation can influence research and development. More fundamentally, the critique rests on a narrow conception of economic rationality that does not generally match common understanding of political decision-making processes.[103]

Notwithstanding these qualifications, little doubt exists that the political economy of long-term regulation, the uncertainties in climate change science, and the broad variance in projected socioeconomic impacts of climate change diminish the incentives that environmental regulation—whether at the state or federal level—can provide to induce technological change through extended research and development.[104]

3. *Adoption of Existing Technologies: A More Promising Role for State-Level Regulation*

The case for state-level regulation is most solidly grounded on its capacity to induce technology adoption and learning by doing. This is no small matter as the potential gains from more efficient technologies are meaningless without adoption, and learning by doing can lead to substantial technological advances and positive technological feedbacks.[105] In particular, to the extent that environmental regulation encourages firms to adopt existing technologies, the expanded production and use of them as a matter of course often leads to reduced costs and enhanced efficiencies.[106] This process can in turn prompt greater diffusion of the technology, which may further enhance the rate of learning by doing and thus generate a dynamic of increasing returns that accelerates technological change.[107]

Unlike research and development, the empirical evidence for technology adoption is relatively robust. Numerous econometric studies exist showing that environmental regulation can and have induce technology adoption, including prominent regulations under the Clean Air Act (sulfur emissions from coal-fired power plants) and the Clean Water Act (effluent emissions

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102 *See, e.g.*, Richard L. Revesz, *Federalism and Environmental Regulation: A Public Choice Analysis*, 115 HARV. L. REV. 553, 578 (2001); Brian J. Gerber & Paul Teske, *Regulatory Policymaking in the American States: A Review of Theories and Evidence*, 53 POL. RES. QUART. 849, 862-63 (2000) (observing that studies "definitely show that interest group pressure shapes state regulation"; interest group "influence will vary by state, however, as interest group power in particular industries and interest group density generally vary").

103 *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.

104 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 allowance in the future. Laffont and Tirole, *supra* note , at 129. Perhaps more interestingly, they have also suggested allowing permit buyers to trade in allowances at a pre-specified prices or, better yet, to sell options to purchase future allowances at a specified price. *Id.*

105 Alic et al., *supra* note __ at 10; Jaffe, *et al.*, *supra* note 27, at 465.

106 Goulder, *supra* note 98, at 8.

107 Jaffe, *et al.*, *supra* note 20, at 167 (observing that "Dynamic increasing returns can be generated by learning-by-using, learning-by-doing, or network externalities.").

charges).[108] Positive correlations have also been found between energy prices and adoption rates of energy-efficient products.[109] However, some of 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.[110] Consistent with these findings, a study of the law mandating the phased-out of lead in gasoline provides solid evidence that cap-and-trade regimes facilitate efficient technology adoption.[111]

Nor are either technology adoption or learning by doing subject to the temporal inconsistency that undermines regulatory incentives for conducting research and development. As the empirical studies attest, both technology adoption and learning-by-doing innovation are responsive to incentives created by *current* environmental policies because they occur in the near-term. This substantially reduces the uncertainties that undermine regulatory incentives for innovation, although uncertainties are by no means eliminated as nothing precludes state standards from being weakened in the future. Perhaps more importantly, everyone's competitors must comply with the regulation (or tax), which means that no one is potentially at a competitive disadvantage by adopting an under-utilized technology—even if the state later chose to relax its regulatory standards—and free rider problems are minimized because learning by doing largely occurs in parallel. Furthermore, insofar as a regulation requires specific types or classes of technologies (e.g. renewable portfolio standards) it will also be largely immune to regulatory leakage problems.

The potential value of learning by doing is borne out by the existing (though admittedly limited) data for the energy sector. Median learning rates are estimated to be approximately sixteen percent and the corresponding cost saving when integrated over time in the billions of dollars.[112] Not everyone is persuaded by these figures, though. Some prominent commentators have argued, for example, that learning-by-doing is largely firm specific, that it occurs largely within a single generation of a technology, and that it rarely translates into cumulative technological advancements.[113] Others have challenged utility to learning by doing given what

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108 Jaffe-HEE, *supra* note , at 502 (describing one study finding significant price sensitivity to adoption of scrubbers, as opposed to higher-cost low-sulfur coal, in coal-fired power plants, and a second one finding "effluent charges a significant predictor of adoption of biological treatment").

109 Richard G. Newell, et al., *The Induced Innovation Hypothesis and Energy-Saving Technological Change*, 114 Quarterly J. Econ. 941, 967-70 (1999). However, researchers have found that reductions in up-front costs are three times more effective than energy pricing, which is consistent with the "conventional wisdom that adoption is more sensitive to up-front costs than to longer-term operating expenses." Jaffe-HEE, 495-96.

110 D.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); 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 of 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").

111 Suzi Kerr and Richard G. Newell, *Policy-Induced Technology Adoption: Evidence From the U.S. Lead Phasedown*, 51 J. Ind. Econ. 317, 340-41 (2003).

112 Alan McDonald and Leo Schrattenholzer, *Learning Rate 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").

113 William D. Nordhaus, *Economic Modeling of Climate Change: Where Have We Gone? Where should We Go? in* CLIMATE IMPACTS AND INTEGRATED ASSESSMENT __ (2004).

they characterize as the technologically mature industrial sectors relevant to mitigate climate change, but they rely on largely anecdotal accounts.[114]

Consistent with these findings, the most popular forms of technology-forcing regulation found in environmental statutes seek to promote the adoption of superior variants of existing technologies. The basic framework for technology performance standards in the major federal environmental statutes reflect this focus on current technologies [state examples?]. While the specific terminology may vary from statute to statute, representative examples include technology standards that, at the low end, are achievable using the "best available control technology" that has been "adequately demonstrated" considering costs and other relevant factors,[115] and that, at the high end, achieve the "maximum degree of reductions in emissions" deemed "achievable."[116] The basic architecture of these laws is well suited to promoting the adoption of superior technologies and, in doing so, also to foster learning by doing that produces follow-on innovations.

Beyond their capacity to induce technology adoption and learning by doing, state-level regulations have a critical advantages over federal regulation. While a federal standard can reach a much greater number of potential technology adopters, multiple state-level measures avoid the problems of tunnel vision and picking the wrong technology that compromise many innovation programs.[117] State-level programs generate a diversity of approaches based on the native mix of socioeconomic, environmental, and political factors and opportunities relevant to climate change policy.[118] For example, within the field of renewable energy, a subset of states require that solar power constitute a specific share of a retail electricity provider's portfolio, while another emphasizes wind and still others geothermal resources.[119] States such as West Virginia and Wyoming, both of which have large supplies of coal, are likely to support innovation directed at clean coal technology, whereas a state like Arizona, with its abundance of sunshine, may focus on solar cell technologies. These differences reflect the unique geographical and economic conditions that influence the cost-effectiveness of technology options. In short, the concept of states as laboratories and the heterogeneity of local conditions that inform economists'

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114 Montgomery and Smith, *supra* note , at 15 (arguing that energy-related technologies, such as gas turbine combined-cycle 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.

115 Clean Air Act, § 111, 42 U.S.C. § 7411 (new source performance standards).

116 Clean Air Act, § 112(d), 42 U.S.C. § 7412(d) (MACT standards for toxic air pollutants).

117 Bushnell, et al., *supra* note , at 10 (observing that the "information requirements needed to pick the 'right' technologies are daunting").

118 Wallace E. Oates and Paul R. Portney, *the Political Economy of Environmental Policy in* HANDBOOK OF ENVIRONMENTAL ECONOMICS. Vol. 1, 326, 339 (K.-G. Maler and J.R. Vincent eds, 2003) ("but 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"); Jon P. Nelson, *"Green" Voting and Ideology: LCV Scores and Roll-Call Voting in the U.S. Senate, 1988-1998*, __ 1-2 ("a Senator's ideology is by far the most important consideration for voting profiles on environmental issues; and party affiliation and regional loyalty explain about 74% of measured ideology"); James T. Hamilton, *Taxes, Torts, and the Toxics Release Inventory: Congressional Voting on Instruments to Control Pollution*, 35 Econ. Inquiry 745, 754 (1997) (legislators voting on different policy instruments to control pollution were "in part based on the relative costs and benefits to their geographical and electoral constituents").

119 See generally, Database of State Incentives for Renewables and Energy Efficiency, www.dsireusa.org.

preference for traditional state-level environmental regulation are equally relevant to sustaining a diversity and promoting efficiency in policies designed to induce technological change.

The constellation of current state-level programs designed to promote energy efficiency and renewable power are as varied as the states that have adopted them.[120] Thus while state-level regulation may sacrifice breadth, its compensating virtue is the diversity of approaches and experimentation that are the hallmark of state regulatory authority. Moreover, where innovation is subject to substantial uncertainties, diversity is often far more important than the coordinated leverage that is achieved through federal regulation.[121] Add to this the diminish risk of regulatory leakage, which also threatens technology adoption, and the benefits of preserving state-level climate change regulation are manifest.

C. The Merits of a Portfolio Approach to State-Level Climate Regulation

The efficiency gains, as opposed to benefits alone, of induced innovation have proven more difficult to demonstrate clearly.[122] William Nordhaus and other researchers have estimated that "the impact of induced innovation is modest."[123] Yet, some studies have predicted cost savings from induced innovation of fifty percent,[124] 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.[125]

These conflicting findings are reflective of the unavoidable uncertainty that persists over the relative efficiency of induced technological change.[126] A promising way to circumvent this uncertainty is to adopt a hybrid approach that integrates traditional regulations with technology policies. Indeed, economists generally recognize that both environmental and technology

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[120] *Id*.

[121] Richard Nelson book [need cite].

[122] 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. Jaffe-HEE, *supra* note, 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. Lawrence H. Goulder, *Induced Technological Change and Climate Policy,* Pew Center on Global Climate Change 17 (2004) *available at* ____.

[123] Jaffe-HEE, *supra* note , 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. Parry, et al., *supra* note , at 239 (finding that only in exceptional cases where new technology reduces abatement costs dramatically and quickly (i.e., by about 50 percent within 10 years) does induced innovation overtakes direct abatement).

[124] H. Dowlatabi, *Sensitivity of Climate Change Mitigation Estimates to Assumptions About Technical Change*, 20 Energy Econ. 473, 474-74 (1998).

[125] Goulder-PEW, *supra* note , at 14-15. Econometric estimates of the benefits from learning-by-doing are similar in magnitude, with one studying 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 and Newell, *supra* note , at 29-30.

[126] Jaffe-HEE, *supra* note , 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").

policies are essential to mitigating climate change.[127] This conclusion follows naturally from the two distinct types of market failure—one environmental, one technological—that are implicated by climate change policies. As we have seen above, the primary benefit of environmental regulations will be reducing GHG emissions and the primary benefit of technology policies will be stimulating the development and adoption of new technologies. The two types of policies, however, do not operate independently, and this positive interaction provides an important basis for adopting a portfolio approach utilizing both types of policy instruments.

A portfolio approach that decouples environmental and technology *objectives* has the virtue of resolving the tensions created by these sometimes competing goals. Near-term GHG reductions can be pursued efficiently because they are not burdened by the perceived need to implement stringent standards immediately to spur investment in research and development. Further, by appreciating that what matters is market conditions when new technologies are commercialized, as opposed to current regulatory standards, regulations can be phased in to promote efficient technology adoption. Complementing this regulatory strategy, technology policies can focus on supporting investments in learning-by-doing innovation and long-term research and development, thereby ensuring that new technologies will be available in the future that reduce abatement costs and that encourage continual increases in the efficacy and efficiencies of technologies and their production processes over time.

The synergies inherent in a portfolio approach are reflected in the substantial reductions in costs for achieving GHG reductions that it affords.[128] A recent set of studies has evaluated hybrid approaches 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 ten less costly) to a straight technology policy model.[129] While not quite as dramatic, dual approaches that combine a carbon tax with direct innovation subsidies (for research and development and learning-by-doing) can reduce the costs by more than one third over a carbon tax on its own.[130] These studies provide strong support for a hybrid approach that utilizes a portfolio of strategies, such as a carbon tax and subsidies for innovation and learning-by-doing.[131] A portfolio approach also enhances the effectiveness of renewable

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127 Goulder, *supra* note 98, at 31 ("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.")>

128 Fischer-Newell, *supra* note , at 5 (concluding that an "optimal portfolio of policies can achieve emissions reductions at significantly lower cost than any single policy").

129 Stephen H. Schneider and 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 , at 30.

130 Fischer and Newell, *supra* note , at 39-41 (basing their model on "reductions over the near-to-mid term and incremental improvement of existing technology," the authors projected a 36 percent drop in cost relative to the emissions-price only approach to meet a 4.8 percent reduction in CO_2 emissions). *See also* Goulder and Schneider, *supra* note 21, at 240 (concluding that "[i]nduced 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").

131 *Id*.

portfolio standards, making them much more cost effective when combined with market-based regulations.[132]

These findings demonstrate the significant efficiencies gained by integrating the implementation of traditional environmental regulations with technology policies to address climate change.[133] These also highlight the importance remaining attentive to 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. Our findings so far are reducible to three straightforward conclusions. First, state climate change regulations should not center on reducing GHG emissions. Second, the objective of state climate change regulations should be inducing technological change, but primarily technology adoption and innovation through learning-by-doing. Third, a hybrid portfolio of regulatory and technology policies should be utilized, with particular emphasis on market-based regulations, technology portfolio standards, and innovation subsidies.

II. Recommendations for a "Federal" Response to Climate Change Mitigation

Critics disparage subglobal regulation of climate change, and state-level regulation in particular, as be ineffective if not outright counterproductive.[134] While we accept the merits of this critique, we disagree with the conclusion that commentators have drawn from it. The fact that state-level action is of limited value in reducing GHG emissions does not imply that states have no role to play in addressing climate change. To the contrary, as we have shown above, states can play a meaningful role in addressing a second market failure manifested by climate change—inadequate investment in technological change. In this Part, we analyze examples of state policies to assess the suitability of state-level regulation in fulfilling this role. We find that the emissions reductions promised by each of the policies are fairly trivial in a global sense. Thus for those policies targeted at emissions reductions, we find little merit to their continuation after the institution of federal controls that promise much more significant emissions reductions. On the other hand, many of the policies being pursued by the states -- renewable portfolio standards, vehicle and other product standards, subsidies for renewable power, energy efficiency and green building programs – have significant capacity to further technological change. Unlike state or regional-level emissions caps, we conclude that these latter policies can make a meaningful contribution to addressing climate change.

We conclude this part with our recommendations for structuring a federal climate change regulatory framework that will facilitate valuable state-level action to induce technological change. Here we argue against various permutations of federal preemption of technology-

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132 Fischer and Newell, *supra* note , at 4 ("when 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").

133 Goulder and Pizer, *supra* note 13, at 10 (commenting that "there is a particularly strong need for advances in the integration of emissions policy and technology policy . . . .").

134 Wiener, *supra* note __ at 1962 (arguing that "subnational state-level action, by itself, is of limited value, and may even yield perverse results").

oriented state climate initiatives, particularly those that promote technology adoption and innovation through learning by doing. However, because of their minimal emission reduction benefits, we are frankly indifferent to preemption of state and regional-level GHG cap-and-trade programs. Finally, we suggest how states can be integrated into the portfolio approach described above in Part I.C. Under this scheme, state action would complement the GHG emissions-reducing and technology-forcing policies of the federal government with state-level actions focused on inducing technological change.

Prior to moving forward, a brief caveat is required. Although the following section discusses state and local climate actions, we take no position as to whether such actions will necessarily continue in the wake of a federal regulatory program. Instead, our purpose is to determine, assuming such state actions do continue, the actions that states can take that will meaningfully contribute to mitigating the risk of global climate change.

We note, however, that the very existence of climate change programs at the state and local levels points to motivations that would support the continuation of such actions even after a federal regulatory program is implemented. Presumably, the benefits of state action in mitigating climate change damages within the jurisdiction is not an important factor; otherwise, these measures would never have been pursued in the first place. After all, the reductions in GHGs will so minimal that they cannot possibly effect the level of climate change damages anywhere, much less in their home jurisdiction.[135] We infer from this that state and local governments are unlikely to be deterred by the prospect of much larger scale federal regulation. Nor can most state programs be explained as efforts to trigger federal regulation by causing multi-state industry to seek federal preemption in an effort to reduce the costs of complying with disparate state standards.[136] Instead, the evidence points to a different set of controlling factors that appear to include the size of climate damages anticipated in the jurisdiction, the dominant political ideology, local socioeconomic conditions. State legislators may also be motivated by the benefits of being a first-mover (or within a group of first-mover states), both in terms of opportunities for local politicians to stakeout policy positions and for the jurisdiction to attract new businesses in the fields of energy efficiency or renewable technology. All of these factors will influence the degree and type of technology-forcing that state regulation can effectuate.

A. State Climate Change Initiatives

1. State and Regional-Level Carbon Emission Caps

Several of the most ambitious state-level climate initiatives are targeted at reducing emissions, as opposed to inducing the development or diffusion of new technology. Two such programs are discussed here: the Regional Greenhouse Gas Initiative (RGGI), which encompasses New York and nine New England states, and California's legislative proposal (Assembly Bill 32 (AB 32)) to reduce state GHG emissions to 1990 levels by 2020. RGGI currently applies just to the coal, oil and gas-fired electrical generating units that are 25 MW or larger. These states have agreed to cap carbon dioxide emissions at current levels through 2015

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135 See Engel & Orbach, *supra* note _- at __.

136 For instance, many of the initiatives, such as state subsidies for renewable technology, do not impose standards upon multi state firms at all. See *infra* text accompanying notes __-__.

and then to reduce them by 10 percent by 2019.[137] Similarly, although it could cover multiple industries, California's proposal also has focused on the electrical utility industry.

RGGI and AB 32 demonstrate the limits of state and regional emissions-cap programs. Both are hobbled by their limited scope and likely emissions leakage or "reshuffling" of existing energy supplies that stand to reduce further the already limited emissions-reductions gains. The limited scope of these programs was discussed earlier and is a product of both the small fraction of total U.S. sources captured within the regulating states.[138] Estimates of emissions leakage from the RGGI program are quite substantial, ranging from 20 to even 40 percent but with 30 percent being the most likely outcome.[139] These estimates are highly dependent upon a host of factors, including the cost differential of generation within and outside RGGI, physical transmission capability, and the market impacts of transferring power into the RGGI region.[140]

The California program is being designed to avoid the leakage problem. Regulators there are evaluating the benefits of placing the point of compliance upon "load serving entities" or other "first sellers" located within California who purchase power from generators both within and outside the states. This strategy has the potential regulate power generated instate and that generated out of state and imported into California. Studies show, however, that this option risks simply reshuffling who sells power to whom—instate dirty sources might switch to exporting their power while out-of-state clean sources might switch to selling their power into California. The result would satisfy California's standard, but with no net reduction in emissions from electrical generators within the region.[141]

The two most prominent emissions-reductions programs at the state and regional levels are therefore unlikely to achieve much in the way of actual emissions reductions. Nevertheless, might the controls anticipated have a positive impact upon technological developments? Unfortunately, this is also unlikely. With respect to research and development, emission caps and taxes are generally too weak to compel technological innovation,[142] and the example of RGGI, at least, demonstrates that those established on the regional level are no exception. Furthermore, RGGI itself represents a modest decrease in emissions below business as usual

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137 Toshi Arimura, Dallas Burtraw, Alan Krupnick, and Karen Palmer, *U.S. Climate Policy Developments,* Resources for the Future Discussion Paper 18 (Oct. 2007).

138 See *supra* text accompanying notes __-__ (discussing how, even if California were to join RGGI, the total carbon dioxide at stake amounts to only approximately 5.3 percent of U.S. carbon dioxide emissions).

139 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 (March 2007) (estimating leakage will range from 18 and 27 percent through 2015); Dallas Burtraw, Karen Palmer and D. Kahn, *Allocation of CO2 Emission Allowances in the Regional Greenhouse Gas Cap and Trade Program,* Resources for the Future Discussion Paper 05-25 __ (2005) (30 percent leakage the most likely outcome).

140 RGGI Emissions Leakage Multi-State Staff Working Group at 4.

141 Bushnell, *et al.*, *supra* note 18, at 22-23 (suggesting that California could procure power in the western markets from existing sources without exceeding 1990 carbon emissions levels). See also Jim B. Bushnell, *The Implementation of AB 32 and its Impact on Wholesale Electricity Markets,* Center for the Study of Energy Markets Working Paper 170 (Aug. 2007) at 5-7.

142 See text accompanying notes __-__.

levels[143] and the program provides for numerous avenues for compliance,[144] both of which reduce the degree to which it will prompt the adoption of new technologies. In sum, if the existing programs are any guide, state and regional programs aimed primarily at GHG emissions-reductions will effect minimal emissions reductions and minimal pressures for technological advancement.

2. *Promotion of Clean Technologies*

i. State Renewable Portfolio Standards

In addition to emissions caps which are most directly aimed at reducing the negative externality of excess GHGs, states are also pursuing policies to promote the development and adoption of clean technologies. Renewable portfolio standards are a popular state-level policy designed to promote renewable technologies by imposing a market-share quota. Under an RPS, electricity suppliers are required to include a minimum percentage of renewable energy in their portfolio of electricity resources serving a particular jurisdiction.[145] While an RPS is a type of subsidy, most state RPS programs minimize target an entire class of technologies (i.e., qualifying renewables). This avoids the pitfalls of a direct subsidy to a particular technology—the "pick a winner" problem where the winner may be "picked" for political or other reasons and may not, in fact, be the winning technology after all. Instead, an RPS encourages competition among all qualifying renewable technologies for the largest fraction they can obtain of the market share guaranteed to all renewables as a group.[146] The number of states that have adopted RPS programs has grown rapidly since the early 1990s.[147] Today the mandatory RPS programs of twenty-one states plus the District of Columbia cover 40 percent of the U.S.'s electrical load.[148] Most state standards range from 15 to 20 percent and must be phased in by 2010to 2020. A few states, such as California,[149] Minnesota,[150] and Maine[151] require a greater percentage, while

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143 In the absence of a regulatory program, carbon dioxide emissions are expected to grow by 7 percent with in the RGGI states. When this 7 percent is added to the requirement that emissions in 2019 be 10 percent below 2009 levels, RGGI should effect a 17 percent decrease in emissions from affected sources. http://209.85.173.104/search?q=cache:HvYoqnxiwZwJ:www.des.state.nh.us/ard/climatechange/pdf/economic_FAQs.pdf+compliance+with+rggi,+technology&hl=en&ct=clnk&cd=13&gl=us

144 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 reduction from sources other than other electricity generators. While a source's use of offsets is capped at 3.3 percent of their emissions, should the price of allowances levels not only For example, if the price of allowances exceed $7 or $10 respectively, RGGI provides that a source may use offsets to make up 5 percent and 10 percent of its emissions. See www.rggi.org.

145 Ryan Wiser, Christopher Namovicz, Mark Gielecki and Robert Smith, *Renewables Portfolio Standards: A Factual Introduction to Experience from the United States*, Lawrence Berkeley National Laboratory, LBNL-62569 1 (April 2007); 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/.

146 Goulder et al., NBER Working Paper, *supra* note _ at 12. However, note that some states depart from this "pure competition" model to guarantee solar power 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.

147 Wider, *supra* note __ at 1.

148 Wiser, *supra* note __ at 2.

149 California currently requires that, by 2010, the state's three major utilities produce at least 20 percent of their electricity using renewable resources. Governor Schwarzenegger has endorsed a goal of 33 percent by 2020. Pew Center on Global Climate Change, State Renewable Portfolio Standards, www.pewclimate.org.

150 Minnesota requires 20 to 25 percent by 2020 – 2025. Wiser, at 7 (Table 2).

others have instituted programs that apply only to power from newly constructed renewable generators and thus constitute a much smaller percentage.[152] To reduce the costs of an RPS, many states permit compliance with their RPS through renewable energy credits.[153]

The reduction in GHG emissions produced by state RPS standards are nominal. As one might expect, they depend on the stringency of the RPS and the emissions intensity of the electrical supply displaced by renewable generation minus any emissions leakage that may occur. While increasing at a fast clip, the size of the emissions reductions accomplished through state RPS standards is still relatively small: the amount of additional renewables required by state RPS programs equates to just 3 percent of total 2020 electricity sales in the U.S.[154] Studies indicate that the median displaced carbon dioxide emissions rate is just 25 percent higher than the emissions rate of a new combined-cycle natural gas generator, which itself is far below the emissions average in the electric sector.[155]

Unlike emissions caps employed under RGGI and AB 32, however, an RPS is not susceptible to much emissions leakage. Granted, an RPS, like any subsidy, has the potential for emissions leakage by drawing demand away from traditional, dirtier, sources of energy, and toward sources of cleaner renewable energy. Emissions leakage can thus occur if the displaced dirty power can simply be rerouted to suppliers in neighboring states or if the drop in demand lowers the price of the dirty power and thereby increases total electricity consumption.[156] Nevertheless, analysts indicate that the leakage resulting from a renewable subsidy adopted on the state level is likely to be small.[157]

More significant than emissions abatement, however, is the capacity of RPS programs to induce technological change. Granted, an RPS is unlikely to be the driver of new renewable technologies. An RPS is targeted at generators of renewable energy, not the firms developing new renewable energy designs. Moreover, the percentage requirement of most RPS standards is modest and the time period for compliance under most state programs is relatively short. Instead, the importance of state RPS programs lies in their capacity to enhance the diffusion of technologies and learning by doing. Gains from new technologies can only be realized with widespread adoption, but widespread adoption requires the existence and establishment of markets for the technology.[158] This is precisely what state RPS programs can provide. Roughly half of the new renewable capacity additions in the U.S. from the late 1990s through 2006

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151 Maine required 30 percent renewables by 2000. However, Maine is one of the few states to define biomass as a qualifying renewable power source. Wiser, at 7 (Table 2).

152 Arizona, Massachusetts, Montana and Washington require new generation and their percentage requirement is accordingly lower, from 4 to 10 percent. Wiser, *supra* note __ at 7 (Table 2).

153 Wiser, *supra* note __ at 5.

154 Wiser, *supra* note __ at 10.

155 Wiser, *Cost-Benefit*, *supra* note _- at 32. 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. Id.

156 Goulder, NBER Working Paper, *supra* note __ at 10.

157 *Id*.

158 John A. Alic, David C. Mowery, Edward S. Rubin, *U.S. Technology and Innovation Policies: Lessons for Climate Change,* Policy Report, Pew Center for Global Climate Change 10 (2003).

occurred in states with RPS policies.[159] While analysts warn that complicating factors prevent one from concluding that this capacity was motivated solely by state RPS programs, there exists a strong correlation.[160]

ii. State Subsidies and Tax Credits

State governments can also encourage the development and adoption of clean energy technologies through direct subsidies or tax incentives.[161] While this approach potentially suffers from the challenges of "picking a winner,"[162] it may also be the most effective in terms of inducing technology. Specifically, targeted subsidies may be one of the few alternatives available to state government for supporting basic research and development on new technologies.[163] Importantly, a state subsidy would avoid the temporal discontinuity that undermines regulatory efforts to induce investments in research and development. Further, government subsidies have generated notable successes. For instance, tax credits are considered critical to the growth of wind farms during the 1980s, especially in California, and also to the growth of markets for photovoltaic systems used to produce solar power.[164] State-level tax credits can speed the adoption of new technologies, thereby fostering the learning that can lead to additional innovations and additional cost reductions.[165] The potential for subsidies and tax credits to abate GHG emissions may be small but their impact upon technological development, can be quite large.

California's $3.3 billion Solar Initiative is a case in point. The Initiative encourages technology adoption by subsidizing the installation of solar power systems in homes and businesses.[166] However, the Initiative appears also to be spurring investments in and the growth of solar industries in California, including firms conducting basic research and development on new generations of solar materials.[167] This growing research "pipeline" has important feedback effects that may in part explain the state's interest in stepping out ahead of other states—being a first-mover—on solar power technologies. In short, the money that California has committed to subsidizing the adoption of renewable power is triggering basic research and development that is in turn generating new jobs and economic opportunities.[168]

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159 Wiser, at 9 (Fig. 3).

160 Wiser at 8.

161 See Database of State Incentives for Renewables and Efficiency, www.dsire.org; Mona L. Hymel, Roberta F. Mann, and Beth F. Wolfsong, *Trading Greenbacks for Green Behavior: Oregon and the City of Portland's Environmental Incentives* in Critical Issues in Environmental Taxation (forthcoming, 2008).

162 Jaffe, *et al*., *supra* note 20, at 169 (2005); Goulder et al., NBER Working Paper, *supra* note __ at __.

163 Furthermore, some economist argue that the public goods nature of problem of climate change may justify treating the technological development necessary to address climate change as a public good through government subsidies. *Id*.

164 Alic, *et al*., *supra* note _- at 28.

165 *Id*.

166 See The California Solar Initiative, http://www.gosolarcalifornia.ca.gov/csi/index.html. Not surprisingly, the CSI has been criticized by economists. See Bushnell, *et al.*, *supra* note 18, at 13.

167 See Matt Richtell and John Markoff, *A Green Energy Industry Takes Root in California,* N.Y. Times (Feb. 1, 2008) (reporting that many 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.").

168 *Id*.

3. State Mobile Source Emission Standards

The California program regulating mobile source emissions provides a compelling case for state-level product standards. It suggests that state programs have significant potential to induce technological change, especially when paired with provisions that encourage the expansion of a product's market. The federal statute, the Clean Air Act, also strikes a balance between promoting innovation and preserving the efficiencies of product uniformity across the U.S. It limits the costs of manufacturing multiple cars to meet numerous state vehicle emissions standards by preempting state standards. Alone among the 50 states, however, California is exempt from this, as is any state that adopts standards identical to those in California and receives a federal preemption waiver. [169] Fuel efficiency, and hence reductions in greenhouse gases, has long been a priority of the California standards, and in 2004 the California Air Resources Board (CARB) targeted GHGs specifically by promulgating standards for GHG emissions from mobile sources (the "Pavley regulations").

While enhanced by federal law permitting other states to adopt California's standards, the emissions-reductions achieved by even California's path-breaking vehicle standards is relatively trivial in a global sense. CARB recently estimated that, if implemented in California alone, the Pavley regulations together with those measures planned for implementation would, by 2020, would reduce cumulative national carbon dioxide emissions from the transportation sector by an additional 11 percent over and above the reductions achieved under the recently tightened federal standards, and 28 percent if implemented in California and the twelve states that have adopted California's GHG standards.[170] Still, however, it must be recognized that this represents only approximately 3 percent of total national emissions from motor vehicles and less than 1 percent of world GHG emissions.

More importantly, California's mobile-source standards demonstrate the significant technology-inducing potential of state-level product regulation, including both research and development on new technologies and technology adoption. California has consistently led EPA in tightening emissions standards and serving as a laboratory for emission control innovations.[171] For instance, despite the delays and amendments to CARB's zero emissions vehicle mandate that was issued in 1990, CARB recently found that the mandate had been instrumental in promoting research and development on batteries, fuel cells, and other vehicle components.[172] Adoption of the California standards has been leveraged through two critical developments: EPA's history of subsequently adopting the California standards as the national vehicle emission standards,[173] and

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169 42 U.S.C. § § 7509, 7479..

170 California Air Resources Board, *Comparison of Greenhouse Gas Reductions for all Fifty United States under CAFÉ Standards and ARB Regulations Adopted Pursuant to AB1493* 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 CAFÉ law by the remaining 37 states. CARB estimates that the adoption of the Pavley rules by all fifty states would result in an 84 percent increase in the emissions abatement achieved under the federal standards. Id.

171 NRC, Mobile Source Standards, *supra* note __ at 113.

172 Id. at 173.

173 Id. at 92 (Table 3-3) (documenting EPA's duplication of the California standards).

amendments to the Clean Air Act that enable other states to adopt identical standards to that of California.[174] Both have had the effect of enlarging the market for the technologies developed in response to California's standards.

4. *Green-Building Codes and Standards*

States and localities have also been active in promoting energy efficiency in building construction and design. Thus far, state efforts are generally limited to programs related to the construction of new buildings or the renovation of existing buildings: requiring architects learn about green building methods for as part of their professional licensing requirements, extending tax credits to builders who follow green building standards, and encouraging or mandating compliance with green building standards in the construction of state-owned buildings. The establishment of green building codes and standards has been left largely to private organizations. The leading organization is the U.S. Green Building Council, a nonprofit organization consisting of organizations within the building industry, which has developed a voluntary system of benchmarks for the design, construction and operation of energy-efficient buildings with a smaller impact upon the natural environment.

Once again, it is unlikely that any of the state actions being contemplated will reap significant emissions reductions. The emphasis upon new building construction is understandable, but drastically limits the impact of these efforts. Nevertheless, aggressive state action with respect to green buildings, requiring, for instance, compliance with energy efficiency benchmarks, could have a significant impact on technology adoption. At the same time, state green building measures are likely to be important in technological adoption and learning by doing, and perhaps, through subsidies, in research and development. The latter may be the case because the costs of research and development in green buildings are likely to be smaller and effectuated through demonstration models that can themselves function as useful buildings.

B. Implications for Environmental Federalism

The importance of national-level action to address climate change is self-evident. Action at the national level is necessary to achieve the dramatic emissions reductions that scientists predict will be needed to avoid dangerous shifts in climatic conditions. National action will also be critical to inducing technological change. States, as we have shown above, also have an important role to play in climate mitigation policy. States' most valuable role in addressing climate change in the wake of federal regulation is not, as it turns out, reducing GHG emissions, but instead encouraging those technological changes that can lead to enhanced capacity for and more cost-effective methods of reducing greenhouse gas emissions. This conclusion has important implications for federal policy. Specifically, federal legislation that enhances the ability of states to contribute meaningfully to climate change mitigation through technological inducement preserves the relevancy of state action with respect to what many consider to be the foremost environmental challenge of our time. With this goal in mind, we offer below several recommendations for the structure of federal climate change legislation.

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174 42 U.S.C. § 7497

1. *State and regional cap and trade programs, designed primarily to reduce greenhouse gas emissions from the electricity sector, make little sense in view of a federal GHG emissions control program applicable to these same sources.*

Much ink has already been spilled discussing ways in which a federal cap and trade program for electricity generators might be harmonized with similar programs being implemented at the state and regional levels under the auspices of RGGI, AB 32 and the Western Regional Initiative. We conclude, however, that assuming the enactment of federal emissions controls upon the electricity sector of greater than minimum stringency, it makes little sense to retain such state and regional-level regulatory programs targeted, as they are, upon achieving short-term emissions reductions from the production of such a highly fungible good as electricity. This follows from the analysis of the potential of such programs to reduce emissions on the one hand and to induce technological change on the other. The conclusion reached in Part II.A above is that the emissions reduction gains promised by such programs are small relative to a federal program and, at the same time, are vulnerable to being significantly undercut by leakage or the simple reshuffling of the existing mix of electricity generation. At the same time, the short compliance period of such programs and their lack of stringency mean that they can accomplish little in terms of inducing technological change.

This conclusion in no way detracts from the importance of RGGI, AB 32 and the WRI in the absence of a federal emissions cap and trade program. In that (still current) scenario, arguably even these small reductions obtained from the electricity sector are an improvement over the status quo insofar as they function a high-profile demonstration projects and serve a potentially important function in triggering support for federal emissions controls upon the electricity sector and test-driving a cap and trade program.[175]

2. *Where state climate regulation has the capacity to induce technological change, state standards that are more stringent than the federally enacted standards should not be preempted either expressly, impliedly or "structurally".*

In contrast, we conclude that more stringent state standards in areas where a state program has the capacity to induce technological change should be retained and not preempted under a federal climate regulatory program. Thus, for example, more stringent state RPS should not be preempted as part of the enactment of a federal RPS. As shown above, while state RPS programs cannot be expected to significantly offset GHG emissions, they are an effective mechanism to spread the adoption of new renewable technologies and pose only small risks of emissions leakage. Combining a federal minimum RPS with more stringent state RPSs maximizes the potential of this approach to encourage the adoption of renewable power. A federal standard would jumpstart renewables in states that currently lack such standards while preserving more stringent state RPS further enhances renewable technology while respecting the particular energy preferences of individual states.

While express federal preemption of state RPS programs is probably unlikely, Congress recently toyed with what we term "structural preemption" of state RPS programs that are more stringent than a proposed federal RPS by requiring suppliers' portfolios contain a larger

175 See *supra* text accompanying notes ___.

percentage of renewable energy. Until it was amended in response to renewable energy advocates, a 2007 House energy bill may have enabled electricity suppliers located in states with more stringent RPS to “double count” the renewable energy in their portfolio that exceeded the minimum federal percentage. They may have been able to do so by using this renewable power to satisfy their state’s more stringent RPS and selling this surplus, in the form of renewable energy credits, to suppliers in other states to enable such suppliers to satisfy the federally-required minimum renewable power portfolio requirement. Were this arrangement to be allowed, it would undermine the capacity of states with more stringent standards to add to the renewable energy being created on a nationwide basis under a federal RPS that includes a minimum renewable portfolio standard.

To avoid such structural preemption, we would strongly support a savings clause in any federal RPS legislation that permits states to require the retirement of renewable energy credits used to satisfy their state RPS requirement so that they cannot be sold to others to satisfy the federal minimum standard.

3. *Congress should enhance the technology-forcing character of federal product standards by tempering federal preemption with limited exceptions for the standards promulgated by leading states and those states that adopt identical standards.*

The technology-forcing potential of federal vehicle emissions controls has been enhanced by California’s pioneering vehicle emission standards. These standards are in turn made possible by an exception to Congress’s otherwise complete preemption of vehicle emission standards. This exception has resulted in a great deal of technological innovation and adoption, both because California’s history of smog problems gives it ample motivation to regulate vehicle emissions stringently and because Congress permitted other states to copy the California standards, thereby enhancing the market for the technologies developed in response to the California standards.

In view of the success of the limited preemption model represented by the California vehicle standards, efforts should be made by Congress and EPA to strengthen and extend this model. Specifically, EPA’s denial of a federal preemption waiver to California’s vehicle greenhouse gas emissions standards should be reversed.[176] Furthermore, efforts should be made to extend the model to provide for limited exceptions to federal preemption for product standards developed by leading states that will address climate change. Thus, for instance, federal energy efficiency standards for appliances preempt state energy efficiency standards for those same products.[177] Although states can establish efficiency standards prior to federal action, little incentive exists for them to do so, since their standard will be preempted once the federal government acts. Consideration should be given to providing a leading state with an exemption

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[176] The EPA denial detracts from both the technology-forcing capability of the Clean Air Act scheme and its GHG emissions reducing potential. See Micheline Maynard, *E.P.A. Denies Emissions Waiver*, N.Y. Times (Dec. 19, 2007). California has sued EPA over the denial and legislation is now pending in Congress to reverse the denial.

[177] National Appliance Energy Efficiency Act of 1987. On the topic of the historic and continuing state role in establishing energy efficiency standards, see Steven Nadel, Andrew DeLaski, Jim Kleisch and Toru Kubo, *Leadiing the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards,* Rept. No. ASAP-5/ACEEE-A051 (Jan. 2005).

from federal preemption, a measure that, given the California vehicle emission standards experience, might encourage state leadership on appliance technology, especially if, duplicating the vehicle standards' scenario, other states are allowed to adopt standards identical to the lead state's standards.

4. *Follow a "portfolio" approach to GHG regulation whereby multiple approaches, including both emissions reducing and technologically-forcing, are pursued simultaneously.*

Under a portfolio approach, emissions reductions may be achieved at lower cost by combining policies that emphasize emissions reductions with those that emphasize technology forcing. A portfolio approach is amenable to a federal structure of government in that some of the policies could be pursued by the federal government while others could be pursued by state government. Specifically, the federal government could implement an emissions cap and trade program, a minimum RPS, transportation standards for greenhouse gases and investment in technology, including basic research and development. At the same time, however, states could play a valuable role by implementing policies that induce technological change. Thus the states might continue to support renewable power through more stringent RPSs, product and appliance standards, vehicle emission controls (California and copycat states), and various subsidy programs, ranging from energy efficiency, renewable energy and incentives for building and retrofitting green buildings.[178]

III. Conclusions

From the narrow perspective of correcting the market failure represented by excess GHG emissions, state-level climate regulation makes little sense. State regulation encompasses too small a fraction of emissions and is too prone to leakage to have a tangible impact U.S. emission levels. However, emissions reductions addresses just one of the two primary market failures endemic to climate change policy. The other, insufficient investment in technological change, is amenable to state-level policies. States can make a important contribution to national technology policies by enhancing the variety of technologies being encouraged and reducing the likelihood that "loser" technologies are being pursued rather than "winners."

Reconceiving state climate change policies bears directly upon federal climate policy. Specifically, we have argued that federal policy should preserve and enhance the degree to which states can contribute to inducing technological change and have offered specific recommendations for how federal legislation might be structured to achieve this goal. The portfolio approach advocated by many economists to reduce the costs of emissions reductions provides an overall framework for an allocation of climate policy response between the states and the federal government. Under this approach, the federal government would be responsible for implementing policies for reducing GHG emissions (e.g., a tax or cap and trade regime),

[178] See *supra* text accompanying notes __-__. See also Thomas D. Peterson, Robert B. McKinstry, Jr., and John C. Dernbach, *Developing a Comprehensive Approach to Climate Policy in the United States: Integrating Levels of Government and Economic Sectors,* __ Va. Envtl. L. Rev. __ (2008) (forthcoming).

while states—in parallel with the federal government—can contribute meaningfully through policies designed to induce technological change.