# THE TRIUMPH OF TECHNOLOGY-BASED STANDARDS

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*In the following article, Professor Wagner chooses a heretofore unpopular approach to pollution control, technology-based standards, as her favorite innovation in environmental law. In selecting technology-based standards, Professor Wagner has chosen to focus on the fundamental or base innovations at the core of environmental programs rather than secondary or tertiary approaches that merely fine-tune existing regulatory controls.*

*The Environmental Protection Agency creates technology-based standards to control air, water, and land pollution. Only after determining the capability of currently available technologies to meet congressional goals with regard to an industry will the Agency set its standards for that industry. Professor Wagner argues that this procedure provides a moral imperative for regulated entities to do their best when public health and the environment are at stake. She also contends that the ease of promulgation, superior enforceability, evenhandedness in application, and eminent adaptability of technology-based standards all serve to enhance their desirability as a foundational regulatory program.*

*Professor Wagner responds to the critics of technology-based standards by showing that these standards are generally more efficient as base innovations than alternative approaches, such as cost/benefit- or market-based controls. In addition, she argues that, rather than freezing technology, the standards can create incentives to pioneer the development of new technologies. Finally, Professor Wagner points to the untapped capabilities and potential breadth of the future applications of technology-based standards as reasons to embrace these standards as a trustworthy approach to environmental protection.*

Although many features of U.S. environmental law have been justly criticized, the one feature that seems safe from reproach is the number

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and scope of innovations that have occurred during the young lifetime of our environmental law. Innovations from Congress, agencies, and the courts have emerged in an almost fireworks-like fashion,[1] revealing themselves not only in the explosive growth of laws and regulations but also in policies, centers, and projects, some of which have been highlighted by other participants in this symposium.[2] Yet now that lawmakers have sowed their wild policies, and the Environmental Protection Agency (EPA or the Agency) has churned out a wide variety of new initiatives with few apparent inhibitions,[3] it is time to take stock of what works best and why. Environmental law has turned thirty.

In my review of the last three decades of mind-numbing legal activity, the innovation I find to be the most important, and one that likely will continue to guide us well into the future, is one of the earliest innovations—technology-based standards.[4] Technology-based standards are not a particularly admired approach to pollution control.[5] With the ex-

1. Two of the most celebrated former EPA administrators have emphatically noted this feature. *See* David Clarke, *Looking at Risk*, ENVTL. F., Mar.-Apr. 1991, at 12; William D. Ruckelshaus, *Environmental Protection: A Brief History of the Environmental Movement in America and the Implications Abroad*, 15 ENVTL. L. 455, 463 (1985) (observing that a "spiral of unachievable standards, missed deadlines, resulting citizen suits and, in turn, even more prescriptive legislation by Congress continues"). Clarke cites William Reilly's comparison of the exponential growth of environmental law and regulation to the Space Invaders video game: "Every time we saw a blip on the radar screen, we unleashed an arsenal of control measures to eliminate it." Clarke, *supra*, at 14.

2. *See, e.g.*, Richard J. Lazarus, *"Environmental Racism! That's What It Is,"* 2000 U. ILL. L. REV. 255; Barton H. Thompson, Jr., *The Continuing Innovation of Citizen Enforcement*, 2000 U. ILL. L. REV. 185.

3. A quick "surf" through the EPA's web site, <http://www.epa.gov>, for example, reveals the following current EPA initiatives, which likely are only the tip of the iceberg: Business Initiative and Assistance Program, <http://www.epa.gov/epahome/program.htm>; Common Sense Initiative, <http://www/epa.gov/ooaujeag/notebook/csi.htm>; Endocrine Disruptors Research Initiative, <http://www.epa.gov/edrlupvx/theindex.html>; Consumer Labeling Initiative, <http://www.epa.gov/opptintr/labeling/>; Environmental Justice Program, <http://es.epa.gov/oeca/main/ej/index.htm>; Key Identifiers Initiative, <http://www.epa.gov/enviro/html/fii/fii_overview.html>; Brownfields Initiative, <http://www.epa.gov/ brownfields/>.

4. Technology-based standards made their initial appearance in the first major statute to impose federal regulatory controls on pollution—the Clean Air Act of 1970. Pub. L. No. 91-604, 84 Stat. 1676 (codified as amended at 42 U.S.C. §§ 7401–7671g (1994)). Section 111 of the Clean Air Act requires the EPA to set technology-based emission limitations for new major sources of air pollution. *Id.* § 111 (codified as amended at 42 U.S.C. § 7411).

5. *See* BRUCE A. ACKERMAN ET AL., THE UNCERTAIN SEARCH FOR ENVIRONMENTAL QUALITY 328–30 (1974) [hereinafter THE UNCERTAIN SEARCH]; ALLEN V. KNEESE & CHARLES L. SHULTZE, POLLUTION, PRICES, AND PUBLIC POLICY 58–63, 72-73, 82–83 (1975); Bruce A. Ackerman & Richard B. Stewart, *Reforming Environmental Law*, 37 STAN. L. REV. 1333, 1335–40 (1985); A. Myrick Freeman III, *Air and Water Pollution Policy*, *in* CURRENT ISSUES IN U.S. ENVIRONMENTAL POLICY 49–58 (Paul R. Portney ed., 1978); Cass Sunstein, *Administrative Substance*, 1991 DUKE L.J. 607, 627–42; Note, *Technology-Based Emission and Effluent Standards and the Achievement of Ambient Environmental Objectives*, 91 YALE L.J. 792, 795–800 (1982). It is important to highlight, however, that some of the negative commentary tends to be slightly schizophrenic. A typical example is the well-known condemnation of the standards by Professors Ackerman and Stewart in response to Professor Latin's article in the *Stanford Law Review*. While characterizing the standards as an example of "Soviet-style central planning" (hardly a complementary characterization) and listing with colorful prose the numerous flaws of these standards, Ackerman & Stewart, *supra*, at 1334, Ackerman and Stewart nevertheless concede in several inconspicuous spots in their article that "the embrace of a Best-Available Technology approach made some sense as a crude first-generation strategy." *Id.* at

ception of a few environmental law scholars,[6] nobody has exactly thrown bouquets to these old-fashioned standards. Ironically, in fact, as technology-based standards have gradually been incorporated into an increasing number of environmental statutes,[7] their popularity among academics seems to have diminished proportionately.[8]

Nonetheless, when one considers the important role technology-based standards have played in reducing pollution levels over the past thirty years, it becomes immediately apparent that their weed-like invasion into almost every facet of environmental law is no accident.[9] Due to the considerable scientific uncertainty that surrounds policy discussions of man's impact on nature and public health, the standards' finger-in-the-dike approach continues to provide one of the most reliable methods for controlling pollution.[10] In touting and reiterating these and other

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1364; *cf.* William F. Pedersen, Jr., *Turning the Tide on Water Quality*, 15 ECOLOGY L.Q. 69, 101 (1988) (conceding, after dedicating a subsection to criticizing technology-based standards used in the Clean Water Act, that "[a]s the current law cannot give rise to a believable system for protecting water quality, it cannot generate any convincing replacements for technology-based standards").

6. Law scholars who have publicly applauded the use of technology-based standards can be counted on one hand. *See generally* David M. Driesen, *Is Emissions Trading an Economic Incentive Program?: Replacing the Command and Control/Economic Incentive Dichotomy*, 55 WASH. & LEE L. REV. 289 (1998); Howard Latin, *Ideal Versus Real Regulatory Efficiency: Implementation of Uniform Standards and "Fine-Tuning" Regulatory Reforms*, 37 STAN. L. REV. 1267 (1985); Sidney A. Shapiro & Thomas O. McGarity, *Not So Paradoxical: The Rationale for Technology-Based Regulation*, 1991 DUKE L.J. 729 [hereinafter Shapiro & McGarity, *Not So Paradoxical*].

7. *See generally* NEIL GUNNINGHAM ET AL., SMART REGULATION: DESIGNING ENVIRONMENTAL POLICY 38–39 (1998) (observing that command and control has been the "dominant government response" to "environmental degradation and industrial pollution" and that in the United States the response predominantly has taken the form of technology-based standards); OFFICE OF TECHNOLOGY ASSESSMENT, CONGRESS OF THE UNITED STATES, ENVIRONMENTAL POLICY TOOLS: A USER'S GUIDE 86–87, tbl.3-2 (1995) [hereinafter OTA] (detailing the dominant reliance on technology-based standards (called "design standards") in the Clean Air and Clean Water Acts and the Resource Conservation and Recovery Act). Technology-based standards have been adopted in the control of point source discharges of organic pollutants in the Clean Water Act of 1972, Pub. L. No. 92-500, 86 Stat. 816 (codified as amended at 33 U.S.C. §§ 1251–1385 (1994)), and the control of toxics in the 1977 amendments to the Clear Water Act, Pub. L. No. 95-217, 91 Stat. 1566 (codified as amended at 33 U.S.C. §§ 1311(b), 1316). Technology-based standards are also required in setting drinking water standards under the Safe Drinking Water Act, 33 U.S.C. § 300g-1(b)(4), and in setting land-disposal standards under the Resource Conservation and Recovery Act, Pub. L. No. 94-580, 90 Stat. 2795 (codified as amended at 42 U.S.C. §§ 6901–6992K); *see also* Hazardous Waste Management System: Land Disposal Restrictions, 55 Fed. Reg. 6640, 6642 (1990) (explaining the technology basis for standards), and in regulating air toxins and new major sources of pollutants in the Clean Air Act. 42 U.S.C. §§ 7411, 7412(b).

8. Professor Orts accurately summarizes the literature on command-and-control approaches as being "heavily criti[cal]." Eric W. Orts, *Reflexive Environmental Law*, 89 NW. U. L. REV. 1227, 1236 (1995); *see also* Shapiro & McGarity, *Not So Paradoxical*, *supra* note 6, at 743 (observing that the "academic failure" of technology-based standards "has been an enormous success in the real world" (citations omitted)).

9. *See supra* note 7. *But see* Nathaniel O. Keohane et al., *The Choice of Regulatory Instruments in Environmental Policy*, 22 HARV. ENVTL. L. REV. 313, 363–64 (1998) (suggesting that "the predominance of command-and-control over market-based instruments despite the economic superiority of the latter" can be attributed in significant part to political realities—both firms and environmental groups favor these regulatory approaches for largely political, self-interested reasons that have little to do with the actual merits of the competing approaches to pollution control).

10. *See generally* Wendy E. Wagner, *The Science Charade in Toxic Risk Regulation*, 95 COLUM. L. REV. 1613, 1618–27 (1995) (detailing the numerous scientific uncertainties that arise in setting

strengths of technology-based standards, I thus join Professors Latin, McGarity, and Shapiro's past efforts to expose the poorly supported but nevertheless self-perpetuating superstitions that obscure many of the virtues of this most noble and enduring approach to environmental protection.[11]

In the first section of this piece, I discuss the assignment given by the *University of Illinois Law Review* and identify at least one way to categorize environmental innovations to avoid apples and oranges comparisons. Next, I explain my selection of technology-based standards as one of the most important innovations in environmental law. In the third and final section, I respond to anticipated criticisms of my selection and suggest modifications that will allow technology-based standards to continue to reign triumphant as one of the most important innovations in U.S. environmental law.

## I. INNOVATIONS IN CONTEXT

The act of selecting one innovation from among the many important innovations that have occurred in environmental law requires some disclaimers. In fact, identifying the decision points that arise in the process of selecting an innovation may shed more light on innovations in environmental law than on the ultimate candidate itself. In this brief initial section, I identify these decision points and explain my analysis and bias at each stage.

In making this selection, I first adopt a generous definition of "innovation" that does not limit the term only to new or wildly creative approaches.[12] Within this large set of possible candidates, additional sorting inevitably takes place. The first and perhaps most important sorting device turns on what type of policy goals one favors. There are innovations in pollution regulation, species protection, regulatory flexibility, public participation, and equity considerations, to name a few. My first disclaimer, then, is that my selection of technology-based standards is most definitely influenced by my fascination with the challenges involved in achieving some form of pollution control.

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"safe" levels for toxins).

11. Because of the circumstances at the time they wrote their articles, these professors' praise for technology-based standards was placed in a defensive posture. *See* Latin, *supra* note 6, at 1267–69 (responding to criticisms of Bruce Ackerman, Steven Breyer, and Richard Stewart urging that technology-based standards be rejected because they are inefficient and technology-freezing); Shapiro & McGarity, *Not So Paradoxical*, *supra* note 6, at 729 (responding to Professor Cass Sunstein's unflattering critique of technology-based standards). In large part because of their excellent work, I can now enjoy the luxury of taking the offensive and offer an account of the positive attributes of technology-based standards without being overburdened with the task of correcting or conditioning the negative commentary.

12. As Professor Rodgers has indicated in this symposium issue, exploring these bounds, as well as what features make a particular activity or event an "innovation," is a fascinating inquiry in and of itself. *See* William H. Rodgers, Jr., *The Most Creative Moments in the History of Environmental Law: "The Whats,"* 2000 U. ILL L. REV. 1.

Even after narrowing the innovations down to a few categories, more sorting must be done to avoid the inevitable apple and orange comparison problems that arise when comparing innovations that have radically different capabilities. In the area of pollution control, innovations may be divided into at least two separate groups depending on their purpose. Some pollution control measures are stop-gap or foundation types of innovations; others may be considered secondary innovations that perfect or fine-tune the more primitive foundation controls.[13] The first category of innovations I call base innovations because they are at the core or foundation of an environmental regulatory program.[14] Secondary and tertiary innovations then add to or, in rare cases, supplant existing regulatory approaches. These innovations improve the base innovations and are often tailored to fix specific problems. In this article I focus on base innovations for the simple reason that, as the most fundamental innovations, they are also the most important.[15]

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13. This dichotomy may be the same as the first- and second-generation innovations that are referenced in the literature, *see, e.g.*, Robert L. Fischman, *The Problem of Statutory Detail in National Park Establishment Legislation and Its Relationship to Pollution Control Law*, 74 DENV. U. L. REV. 779, 801 (1997) (referring to first- and second-generation phases of environmental lawmaking), but in this article "base innovation" refers more broadly to the first stop design consideration for environmental protection, as opposed to an invention of the 1970s that has become obsolete and must be replaced. *See* Sidney A. Shapiro & Thomas O. McGarity, *Reorienting OSHA: Regulatory Alternatives and Legislative Reform*, 6 YALE J. ON REG. 1, 45-50 (1989) (recommending technology-based standards as the first stop in setting worker-protection standards) [hereinafter Shapiro & McGarity, *Reorienting OSHA*]; *cf.* GUNNINGHAM ET AL., *supra* note 7, at 375–448 (providing more complicated design principles for selecting and mixing regulatory instruments that provide policymakers with "one-stop" shopping as opposed to offering policymakers a much simpler but only a first-stop consideration). In some cases, of course, this first stop may not be the appropriate ending point, even in the search for the best base innovation. In the phaseout of lead in gasoline, for example, a tradable-permits system likely was a superior base innovation because of the unusual circumstances involved in that case where the short-term goal was the complete elimination of lead, and the initial entitlements were relatively easy to determine, with no need to account for geographical variations. *See, e.g.*, Ackerman & Stewart, *supra* note 5, at 1348–49 (touting the success of tradable permits in the phaseout of lead additives in gasoline). By characterizing technology-based standards as the most important base innovation for pollution control, I do not mean to suggest that the standards are always the optimal answer for all pollution-reduction programs.

14. Candidates for base innovations in pollution control could include not only technology-based standards but also a variety of other regulatory tools that are now familiar to students surviving the first two weeks of an environmental law class. These tools include standards based on levels necessary to protect public health or the environment; standards based on a "reasonableness" determination, which generally amounts to a cost/benefit determination; performance standards; incentive approaches (such as markets and taxes); liability rules; planning requirements; and information disclosure requirements. *See generally* ROBERT V. PERCIVAL ET AL., ENVIRONMENTAL REGULATION: LAW, SCIENCE, AND POLICY 149–52 (1992) (listing a variety of regulatory approaches).

15. This second decision point is an important one to make explicit. Often in debates over which legal tools are best suited to correct problems, commentators might be more in agreement than in disagreement if they first assigned the tools to one of these two categories—base or secondary innovations. *See* Shapiro & McGarity, *Not So Paradoxical*, *supra* note 6, at 745 (taking great pains to highlight the advantages of technology-based standards as a base innovation to which other regulatory approaches can be added and criticizing Professor Sunstein for viewing technology-based standards as mutually exclusive with market-based approaches); *see also* Driesen, *supra* note 6, at 309 & n.95 (cautioning that "emissions trading cannot wholly supplant traditional regulation" and citing in support literature that suggests that the best approach likely includes a "mix" of regulatory approaches). Even the famous showdown over technology-based standards between Professor Latin and Professors Ack-

After narrowing the universe of innovations to be considered based first on subject matter and second on purpose, it is then possible to undertake a more systematic evaluation of the merits of an innovation candidate. It is at this point that my tribute to technology-based standards begins.

## II. TECHNOLOGY-BASED STANDARDS: A TRIBUTE

Technology-based standards are generally the first and best answer to pollution control. Indeed, they are such dependable base innovations that they should be the first tool considered in designing any program to protect or conserve the environment.[16] In this section, I identify the reasons why technology-based standards are such an important base innovation in pollution control. After specifying what a technology-based standard is and which type of technology-based standard is particularly exceptional, I then identify the qualities that tend to make technology-based standards superior to other types of base innovations.

### A. *Defining Technology-Based Standards*

Technology-based standards (sometimes referred to as "design standards") are predominantly employed to control pollution entering surface waters, outside air, public drinking water supplies, and, to a lesser extent, workplaces and the land.[17] In most instances, Congress requires the EPA to survey currently available (or soon-to-be-available) pollution control technologies for classes and categories of industry and to select the technology in each industrial category that best fulfills congressional goals under the circumstances.[18] The EPA then converts the pollution

erman and Stewart might have ended in amicable agreement had the authors been clearer about these two categories. Professor Latin, apparently taking his cue from the critics to which he was responding, defended technology-based approaches against competitor approaches without discussing how the two approaches might work in tandem. *See* Latin, *supra* note 6, at 1331 (characterizing the debate as whether technology-based standards are comparatively superior to alternative regulatory approaches). Although Professors Ackerman and Stewart take Professor Latin to task for lumping together all regulatory reforms as fungible types of regulatory fine-tuning, *see* Ackerman & Stewart, *supra* note 5, at 1340, their efforts to unpack the types of fine-tuning seem equally lumpy. More particularly, Professors Ackerman and Stewart's discussion of the advantages of market-based approaches could be construed as suggesting only that markets serve as an excellent secondary regulatory approach (thus complementing pre-existing base innovation), *see id.* at 1341, 1357, 1364 (referring to markets as "second-generation" approaches and to Best Available Technology (BAT) as a "first-generation" approach), but in other parts of their article they appear to advance the position that market-based approaches should completely replace technology-based standards as the preferred form of base innovation. *See id.* at 1334 (arguing that Professor Latin "mistakenly" treats incentive approaches as fine-tuning "rather than recognizing them as fundamental alternatives to our current reliance on centralized regulatory commands").

16. Although it is unlikely that technology-based standards are sufficient, standing alone, to serve as "one-stop shopping" for regulatory controls, they at least should be considered the first stop. *See* Fischman, *supra* note 13, at 801.

17. *See supra* note 7.

18. The EPA's process for setting technology-based standards under the Clean Water Act is de-

reduction capabilities of the selected technology to numerical effluent or emission limits for each pollutant of concern.[19] This step, which requires making assumptions about "average" industry pollution loads and how well the selected technology reduces pollution, can be quite controversial.[20] The EPA must become familiar with the capabilities of the nation's industries, the variety of pollution control equipment available, and how this equipment actually works when employed in the field.[21]

The types of technology-based standards that are employed are diverse. Thus, to provide a clear point of reference, the standards that I believe best exemplify what this type of innovation has to offer (and thus the model that frames most of the resulting discussion) are the technology-based standards for air toxins.[22] These standards are superior to the more commonplace "best available" or "best practicable"[23] technology-based standards because Congress is more specific in identifying the effectiveness of the "best" pollution control technology.[24] Section 112(d) of

scribed in detail in two companion articles in the *Iowa Law Review*. *See* Sanford E. Gaines, *Decision-making Procedures at the Environmental Protection Agency*, 62 IOWA L. REV. 839, 839–64 (1977); D. Bruce La Pierre, *Technology-Forcing and Federal Environmental Protection Statutes*, 62 IOWA L. REV. 771, 810-31 (1977).

19. *See* La Pierre, *supra* note 18, at 810–11 (specifying three steps in setting technology-based standards: (1) categorizing industries; (2) identifying the contents of their respective wastewaters; and (3) identifying the range of control technologies available).

20. *See* Gaines, *supra* note 18, at 852 (discussing the industry-averaging problems that arose in setting standards for the wet corn milling industry); *see also* National Lime Ass'n v. EPA, 627 F.2d 416, 416 (D.C. Cir. 1980) (remanding the case to the district court because the EPA did not consider the representativeness of its data or explain why existing data was sufficient for setting a technology-based, water-pollution-discharge standard for all lime manufacturing plants).

21. *See* Gaines, *supra* note 18, at 853 (discussing questions regarding the effectiveness of pollution control technologies under various plant ages, sizes, and manufacturing conditions). The need for the EPA to become familiar with the industrial processes of numerous industries and available pollution control equipment has been flagged as one of the most significant problems with technology-based standards. *See* GUNNINGHAM ET AL., *supra* note 7, at 44 (noting the "clear imbalance of knowledge between regulators and industry" with regard to setting technology-based standards). In his case study of the EPA's process of setting a technology-based standard for the wet corn milling industry, Professor Gaines's analysis suggested that this asymmetry of information did not emerge as an impenetrable obstacle for the EPA despite his other, specific criticisms of the Agency and its capabilities. Indeed, Professor Gaines does not even allude to the imbalance of information as a problem. *See* Gaines, *supra* note 18, at 852–64 (detailing contractor and EPA errors committed in issuing technology-based standards, none of which seem to result from the EPA's lack of access to industrial data, and concluding that in hindsight the EPA's standard appeared to be the appropriate one from the standpoint of technological feasibility and pollution control); *cf. id.* at 857 (observing the unhelpfulness of industry's comments on the EPA's proposed corn milling standard and surmising that this occurred "because the industry [itself] lack[ed] firm data with which to rebut the rulemaking proposal").

22. *See* 42 U.S.C. § 7412 (1994).

23. 33 U.S.C. § 1311(b).

24. Without meandering too far off the subject, I believe it is generally preferable for Congress, rather than the agencies, to specify the basic policy choices made in environmental policymaking. *See generally* DAVID SCHOENBROD, POWER WITHOUT RESPONSIBILITY (1993). This is not to suggest, however, that broad or ambiguous policy delegations are bad, unjustified, or in violation of the Constitution. *But see* American Trucking Ass'ns v. EPA, 175 F.3d 1027 (D.C. Cir. 1999) (remanding an EPA rule because it provided no "intelligible principle" that explained the EPA's policy choices arising in the overbroad statutory mandate passed by Congress). Indeed, in some statutory debates there are excellent reasons why the only law that a majority of Congress can agree on is a law that provides vague policy delegations. *See* STEVEN KELMAN, MAKING PUBLIC POLICY: A HOPEFUL VIEW OF

the Clean Air Act directs the EPA to promulgate emissions standards for air toxins that are at least as stringent as the "average emission limitation achieved by the best performing 12 percent of the existing sources" or, if there are less than thirty sources in an industrial category or subcategory, based on the "average emission limitation achieved by the best performing 5 sources."[25]

The air toxins provision has other important attributes that are generally, but not always, present in technology-based standards employed in the United States. First, like almost all technology-based standards, the air toxins standards take the form of quantitative pollution limits and thus allow industry to choose how best to meet the standards—a choice that includes developing new pollution control technologies that run more cheaply or effectively.[26] Second, the standard makes effective use of secondary regulatory tools that, at least theoretically, allow emission limits to be even more stringent when local or regional air quality appears to be deteriorating below levels protective of the public health.[27] Although there is reason to question whether this particular secondary innovation will be successful,[28] it at least acknowledges that technology-

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AMERICAN GOVERNMENT 56–57 (1987) (describing the extraordinarily limited time of legislators and the resulting need to resort to vague statutory language); Jerry L. Mashaw, *Prodelegation: Why Administrators Should Make Political Decisions*, 1 J.L. ECON. & ORG. 81, 82 (1985); Peter H. Schuck, *Delegation and Democracy: Comments on David Schoenbrod*, 20 CARDOZO L. REV. 775, 778 (1999) (arguing that "social complexity has made it far more difficult for legislators (not to mention voters) to accurately predict the consequences of their choices" and concluding that this may imply the need for "greater delegation to agencies, not less").

25. 42 U.S.C. § 7412(d)(3)(A)–(B). Selection of these particular technological targets as the most appropriate is, of course, a different matter and is not germane to the arguments advanced in this article.

26. *See supra* note 7 (listing technology-based approaches, all of which are numerical standards). Interestingly, one of the few exceptions to this more flexible approach to technology-based standards was Congress's 1977 requirement that new electric utilities install a particular type of "scrubber" (as opposed to using low sulfur coal or encouraging other similar forms of innovative pollution control). *See* Clean Air Act Amendments of 1977, Pub. L. No. 95-95, 91 Stat. 685, 42 U.S.C. § 7411(a)(1)(C) (Supp. II 1978) (amended 1990). The important study of this particular legislative compromise (and the odd coalition of interest groups who supported it) in BRUCE A. ACKERMAN & WILLIAM T. HASSLER, CLEAN COAL/DIRTY AIR (1981), may have inadvertently caused some commentators to believe that this is either the only or the primary form of technology-based standards. *See, e.g.*, Carol M. Rose, *Rethinking Environmental Controls: Management Strategies for Common Resources*, 1991 DUKE L.J. 1, 26 (using pollution control devises such as catalytic converters and scrubbers as examples of command-and-control standards); *see also* Driesen, *supra* note 6, at 297–301 (pointing out that a frequent misconception of command-and-control standards is that they require industry to use a specific technology for pollution control and observing that even in the case of utility scrubbers required by Congress in the 1977 amendments to the Clean Air Act, Professors Ackerman and Hassler may have overstated the inflexibility of Congress's command-and-control standard).

27. *See, e.g.*, 42 U.S.C. § 7412(f)(2)(A) ("[The] Administrator shall . . . promulgate [more protective] standards . . . if promulgation of such standards is required in order to provide an ample margin of safety to protect public health in accordance with this section . . . or to prevent, taking into consideration costs, energy, safety, and other relevant factors, an adverse environmental effect.").

28. The EPA's abysmal record in setting ambient standards for air toxins, promulgating standards for only seven toxins in 20 years, is the most compelling predictor for the Agency's pace in undertaking essentially this same exercise in the future. *See, e.g.*, FRANK B. CROSS, ENVIRONMENTALLY INDUCED CANCER AND THE LAW: RISKS, REGULATION, AND VICTIM COMPENSATION 104–07 (1989) (discussing the EPA's failure to promulgate air toxin standards for ambient air); Phillip D. Reed, *The*

based standards benefit from, but should not necessarily be replaced by, secondary regulatory approaches. Third and finally, the provision allows but does not require the EPA to distinguish between new and existing sources when setting emissions standards.[29] In instances where process controls for new plants can achieve greater pollution reduction at roughly the same or even lower costs than end-of-the-pipe controls for existing industry, the EPA would certainly seem obliged to distinguish new from old sources in setting technology-based standards.[30] Conversely, if the standards required for new sources would be significantly more costly than those for existing sources based on the statutory minimum, the resultant barriers to entry would be a critical policy factor in determining the extent to which different standards should apply to new and old sources. Indeed, statutory mandates that permit but do not necessarily require the EPA to distinguish old from new sources in its setting of standards are not all that unusual in the environmental law, despite the fact that several prominent commentators have suggested otherwise.[31]

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*Trial of Hazardous Air Pollution Regulation*, 16 Envtl. L. Rep. (Envtl. L. Inst.) 10,066, 10,066–67 (Mar. 1986) (same). The current statutory mandate requiring these supplemental, health-based limits for air toxins may also pose some impediments for the efficacious promulgation of health-based standards. *See* Troyen A. Brennan, *Environmental Torts*, 46 VAND. L. REV. 1, 34–35 & n.104 (1993) (detailing some of the limits to the residual risk provision of section 112 of the Clean Air Act).

29. *See* 42 U.S.C. § 7412(d)(3) (requiring that the emissions limits for new sources "shall not be less stringent than the emission control that is achieved in practice by the best controlled similar source" and allowing (but not requiring) the EPA to set slightly less stringent standards for existing sources based on specific criteria); *see also* 33 U.S.C. § 1316 (requiring the EPA to set separate standards for new sources of water pollution based on the "application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants" but not preventing the EPA from defaulting to standards set for existing industry or conversely applying new source standards to update BAT standards set for existing industry).

30. This comparative advantage of new sources of saving considerable money in installing pollution control technologies because they can incorporate them into process and other plant design decisions made at the blueprint stage of construction, is, in fact, often omitted from the criticism of old-new distinctions in the environmental laws.

31. *See, e.g.*, Ackerman & Stewart, *supra* note 5, at 1335–36 (arguing that "BAT controls . . . impose disproportionate penalties on new products and processes"). Somewhat surprisingly, despite widespread concern over the old-new distinction by environmental law scholars, there appears to be very little study of the extent to which this distinction actually imposes barriers to entry in practice. *See, e.g.*, Keohane et al., *supra* note 9, at 315 n.10 (citing two empirical studies on the subject, each of which concerns unique Clean Air Act requirements that (1) new major sources purchase "offsets" before locating in nonattainment areas or that (2) new electric utilities install scrubbers). Perhaps more importantly, virtually no attention has been paid to the extent to which the EPA actually has distinguished between existing and new sources in setting technology-based standards. A limited review of the technology-based standards promulgated under the Clean Water Act and the Clean Air Act (for air toxins), in fact, suggests that the EPA often declines to set more stringent standards for new sources. The similarities between standards set for existing and new sources is most dramatic in the technology-based standards promulgated for air toxins: regulatory requirements that distinguish between existing and new sources appear to be the exception rather than the rule. *See* 40 C.F.R. pt. 60 (1999) (demonstrating that in only limited instances—for example, subpart K governing storage vessels for petroleum liquids—does the EPA separate out members of an industrial subcategory according to whether the facilities are older or newer sources). Although under the Clean Water Act the EPA does set more stringent standards for new sources in some industrial subcategories, *see, e.g.*, 40

### B. *The Outstanding Qualities*

Technology-based standards bring to environmental law an admirable and well-accepted moral imperative, as well as successful results. Both of these qualities are discussed in turn.

#### 1. *The Moral Imperative*

The moral message of technology-based standards is that regulated entities must do their best, or nearly their best, when public health and the environment are at stake.[32] Although this command is a kindred spirit with the precautionary principle, which calls for caution and some form of regulatory intervention in the face of uncertainty,[33] it is more focused. Rather than placing the burden on the proponent of precaution to both identify circumstances under which uncertainty is so great that regulation is justified and detail the form of regulation that is appropriate, technology-based standards skip over this nonsense by assuming that there is pollution, that it is undesirable, and that a strong effort to reduce the pollution is needed. These standards can also be designed to place the burden on the polluter to demonstrate that the technology selected is inappropriate.[34]

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C.F.R. pt. 426 (standards for glass manufacturing point sources), in other instances the EPA either makes no distinction between the standards for existing sources (Best Available Technology) and for new sources (New Source Performance Standards), *see, e.g.*, *id.* §§ 428.40–.115 (standards for various subcategories of industry within the rubber manufacturing industry), or requires only that the new source also meet limits for total suspended solids (TSS) while keeping the effluent limits for the other pollutants identical to the limits set for existing sources. *See, e.g.*, *id.* at pt. 440 (standards for ore mining and dressing industry).

32. *See* Thomas O. McGarity, *Media-Quality, Technology, and Cost-Benefit Balancing Strategies for Health and Environmental Regulation*, LAW & CONTEMP. PROBS., Summer 1983, at 159, 199 n.194 (quoting Senator Bayh as explaining that the technology-based standards adopted in the 1972 Clean Water Act were intended to "force industry to do the best job it can do to clean up the nation's water and to keep making progress without incurring such massive costs that economic chaos would result") (citing SENATE COMM. ON PUB. WORKS, 93D CONG., 1ST SESS., LEGISLATIVE HISTORY OF THE WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972, at 1133 (1973)); Rose, *supra* note 26, at 34 (observing that technology-based standards "tell each would-be polluter that she must do her best, and they do something to create a larger culture in which the expectation is that everyone must do his best").

33. *See generally* David Freestone & Ellen Hay, *Origins and Development of the Precautionary Principle*, *in* THE PRECAUTIONARY PRINCIPLE AND INTERNATIONAL LAW: THE CHALLENGE OF IMPLEMENTATION 3, 12 (David Freestone & Ellen Hay eds., 1996) (identifying the application of BAT as one means of implementing the precautionary principle); David Santillo et al., *The Precautionary Principle in Practice: A Mandate for Anticipatory Preventative Action*, *in* PROTECTING PUBLIC HEALTH & THE ENVIRONMENT: IMPLEMENTING THE PRECAUTIONARY PRINCIPLE 36, 39 (Carolyn Raffensperger & Joel Tickner eds., 1999) ("The Precautionary Principle not only permits action to be taken in the absence of conclusive evidence of cause-effect relationships, but also stresses that action in anticipation of harm is essential to ensure that it does not occur.").

34. *See* American Petroleum Inst. v. EPA, 540 F.2d 1023, 1038–39 (10th Cir. 1976) (placing the burden on industry to show that the EPA's technology-based standards for new industry under the Clean Water Act could not be achieved in practice). *But see* La Pierre, *supra* note 18, at 829 (reporting that other courts place the burden on the EPA to prove that technology-based standards could be achieved in practice).

Thus, the technology-based standards start out by demanding that every facility engaged in producing some generally defined externality "do their best," and the standards often do not even leave the door open for the facility to argue that the best may not be necessary under the circumstances.[35] The theory behind the approach is thus cost-blind and could be extremely inefficient. But, consistent with the resiliency of these standards, the information gaps are typically so large and asymmetrical (with the regulated entities enjoying far greater information) that whatever inefficiencies occur are expected to be less than the costs entailed in identifying and implementing a more "efficient" control strategy.[36] Avoiding the transaction costs associated with arguing over the extent or import of an externality that largely escapes quantification and scientific

35. *See, e.g.*, 33 U.S.C. § 1311(*l*) (providing no exceptions for sources for toxic pollutants under the Clean Water Act); 42 U.S.C. § 7412(g) (providing tightly circumscribed modification procedures for air toxic emission limits under the Clean Air Act). Technology-based standards at times provide limited exceptions from their uniform requirements, but typically the polluter bears the burden of demonstrating that the exception is justified. *See, e.g.*, 33 U.S.C. § 1311(d), (h), (m), (n), (p) (providing exceptions to uniform effluent limits under the Clean Water Act for specific point sources under specific circumstances).

36. Despite this rather obvious impediment to conducting cost/benefit or efficiency analyses, many authors cite literature that they suggest demonstrates the comparative inefficiency of technology-based standards to reduce pollution. *See, e.g.*, Ackerman & Stewart, *supra* note 5, at 1337–40. A careful examination of these studies, however, reveals that most studies are conducted as simulations and are qualified by a number of critical assumptions and caveats. *See, e.g.*, T.H. TIETENBERG, EMISSIONS TRADING: AN EXERCISE IN REFORMING POLLUTION POLICY 47–52 (1985) (discussing the assumptions and sources of error in the cost-savings projections produced by simulation studies of market-based approaches to pollution control); *see also* Daniel H. Cole & Peter Z. Grossman, *When Is Command-and-Control Efficient? Institutions, Technology, and the Comparative Efficiency of Alternative Regulatory Regimes for Environmental Protection*, 1999 WIS. L. REV. 887, 889–91 (observing that among Tietenberg's "'empirical studies'" that confirm the alleged inefficiencies of command and control, only one of the ten is empirical (the rest are simulations or predictions), the single empirical study is "'cautious,'" and most of the studies ignore "implementation and monitoring costs"). In addition to the numerous methodological challenges arising from attempting to extrapolate simulation studies to the real world, many market-based studies also neglect other important realities and assume, for example, that the localized concentration of pollutants within a market trading area does not matter scientifically—that only the total pollutants emitted in a defined water or air shed matter, that there are zero to low transaction costs in market approaches, and that economic efficiency should be the sole factor used to compare regulatory approaches. *See, e.g.*, Lisa Heinzerling, *Selling Pollution, Forcing Democracy*, 14 STAN. ENVTL. L.J. 300, 310 (1995) (summarizing literature on the inefficiency of command and control and observing that the empirical support for the greater efficiency of pollution markets relative to command-and-control approaches is "rimmed by qualifications"). For recent studies that conclude that these assumptions are significantly in error, at least in some circumstances, see sources cited in *infra* notes 53 (discussing the high transaction costs involved in pollution trades and other unanticipated problems in market design), 55 (pointing out the importance of designing a market that includes primarily (and perhaps exclusively) problematic pollution sources), 83 (isolating the potential discriminatory effect of market-based approaches to pollution control); *see also* Cole & Grossman, *supra*, at 888–89, 891–92 (arguing, based on theoretical models, that command-and-control approaches can sometimes be more efficient than market-based approaches and citing empirical studies that support their argument); Heinzerling, *supra*, at 310 (listing additional qualifications identified in the empirical literature on when pollution markets can be expected to be efficient (and presumably when they might not)). Of course, political acceptability properly is put to one side in these studies, even though this might raise the costs of adopting market alternatives as well. *See* Thomas W. Merrill, *Explaining Market Mechanisms*, 2000 U. ILL. L. REV. 275.

understanding is, therefore, administratively brilliant as well as morally compelling.[37]

### 2. *The Results*

With regard to the results achieved, technology-based standards excel in four important respects that, when taken together, cause these standards to reign supreme over their base innovation competitors in most, but not all, pollution circumstances.[38] First, they are relatively easy to promulgate and thus accomplish pollution reductions expeditiously. In addition, they tend to be superior with regard to their enforceability and predictability, even-handed in their application to various regulated entities, and adaptable to additional refinements using other, very different types of regulatory tools. Each of these qualities is discussed in turn.

#### a. Expeditious

Comparatively speaking, technology-based standards are promulgated more quickly than most other approaches to pollution control, and they tend to achieve the intended pollution reductions more quickly. Although technology-based standards are easier to promulgate than other approaches to pollution control, that is not to say they are promulgated with lightening speed. At least one law review article has detailed the sources of error and conflicts that can arise in setting just a single technology-based standard. Not only can it take years to promulgate a single standard, but once promulgated, standards can be challenged in court and sometimes remanded by the court for further consideration at the

37. Professor Latin makes the "administratively brilliant" portion of this argument most compellingly, with the assistance of prominent and detailed case studies that demonstrate the regulatory costs of more information-intensive approaches to regulation. *See* Latin, *supra* note 6, at 1305–31; *see also* Cole & Grossman, *supra* note 36, at 902–03 (underscoring how institutional features can cause market-based approaches to be less efficient than command and control). Professors Shapiro and McGarity not only make this argument with respect to the difficulties of promulgating more information-intensive standards but also raise important moral issues associated with relying on cost/benefit approaches to protect public health. *See* Shapiro & McGarity, *Not So Paradoxical*, *supra* note 6, at 739–44 (highlighting the distributional consequences of a cost/benefit approach to setting worker standards that is neglected by advocates of the approach).

38. My evaluative criteria are similar to four and one-half of the seven factors employed by the OTA to compare environmental policy tools. *See* OTA, *supra* note 7, at 145–48 (including among its seven criteria for evaluating policy tools: "assurance of meeting goals," "environmental equity and justice," "fairness" (paired with "cost-effectiveness"), "demands on government," and "adaptability"). The remaining criteria used by the OTA — "cost-effectiveness," "pollution prevention," and "technology innovation and diffusion" — seem more appropriate for secondary innovations that fine-tune foundational regulatory requirements. Since the OTA does not attempt to distinguish between "base" and "secondary" innovations in its comparative assessment of policy tools, however, it is difficult to integrate their comparative assessment with the instant analysis. Indeed, the OTA's failure to distinguish between these two policy-making needs may have unduly complicated their conclusions and impaired the usefulness of their study for policymakers. *See id.* at 198–200 (recognizing, based on the results of their comparative assessment, that "[c]hoosing the most effective policy instruments to achieve a goal can . . . become a very complicated task for policymakers").

agency level.[39] Thus, there is nothing sure or easy about the promulgation of technology-based standards.[40]

Despite these shortcomings, technology-based standards still significantly outpace—generally by a factor ranging from three to ten times—

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39. *See* Gaines, *supra* note 18, at 846–64 (identifying the challenges that arise in setting a technology-based standard); La Pierre, *supra* note 18, at 812–13 (reporting that by 1977, the EPA's technology-based standards promulgated under the Clean Water Act were attacked in 250 suits that had been consolidated into 21 proceedings in circuit courts and that "[i]n many cases, the courts . . . invalidated the specific effluent limitations established by the two technology-based standards and remanded them to the Agency").

Indeed, one of the principle objections to technology-based standards is the administrative and judicial resources they consume in the standard-setting effort. *See* Ackerman & Stewart, *supra* note 5, at 1337 (arguing that BAT determinations "impose massive information-gathering burdens on administrators, and provide a fertile ground for complex litigation in the form of massive adversary rulemaking proceedings and protracted judicial review"). Yet it appears that industry's decisions to litigate the EPA's technology-based standards promulgated under the early mandate of the Clean Water Act have not been replicated in subsequent technology-based standard promulgation projects. *Compare* Search of WESTLAW, Allfeds File (Nov. 18, 1999) (MACT & EPA & date (aft 1/1/1990)) (locating only four cases that involve challenges to technology-based standards for air toxins promulgated under the Clean Air Act 1990 amendments), *with* La Pierre, *supra* note 18, at 812–13 (reporting on 250 cases consolidated into 21 proceedings against technology-based standards set under the Clean Water Act during the first five years after the statute was passed). This difference may occur for several reasons. First, the statutory authority for the first set of technology-based standards promulgated under the Clean Water Act was vague in several important respects, the most important being whether the EPA had the authority to impose nationally uniform technology-based standards on industry or whether it instead only had authority to promulgate suggestive guidance of what those standards could be to assist regulators in permit-specific decisions. *See* La Pierre, *supra* note 18, at 812–18 (describing the statutory interpretation battles that occurred with regard to the EPA's authority under the Clean Water Act); Pedersen, *supra* note 5, at 85–86 (characterizing the litigation surrounding the EPA's technology-based standards as a "misguided investment of resources" and also observing that apart from challenging the technical accuracy of the standards, the "predominant legal issue" in this litigation concerned the EPA's statutory authority). Second, these standards were the first ones imposed on existing industry, so industry may have been maximizing the delaying effect of litigation and attempting to weaken support for the standards. Both goals, it should be noted, succeeded to some extent. *See* La Pierre, *supra* note 18, at 824 (noting the delay caused by the litigation and the courts' general receptiveness to industry's arguments that the standards were technologically infeasible). The Agency may also have been at the front of the learning curve, particularly with regard to the record-based judicial review requirements that would be used in litigation. *See* Gaines, *supra* note 18, at 893 (attributing the EPA's weakness in setting the wet corn milling standard to an incomplete administrative record and not to a deficient standard). Third, at least with respect to the Clean Air Act toxics provision, many pollution sources may have availed themselves of the voluntary reduction incentive that delays the application of the technology-based standards to the polluters' facilities if the polluters reduce 90% or more of their toxic air pollution before the applicable air toxic standard is proposed. *See* 42 U.S.C. § 7412(i)(5) (1994) (setting forth a "voluntary reduction" program for air toxins). When some or all sources within an industrial category avail themselves of this incentive and engage in voluntary reductions of hazardous air pollutant emissions before the final technology-based standard has been set, the economic benefits from opposing the final technology-based standard may be reduced to such an extent that the litigation is no longer cost-justified.

40. Indeed, to the extent that some technology-based standards still have not been promulgated or appear in need of revision, technology-based standards remain only partly triumphant. *See* ROBERT W. ADLER ET AL., THE CLEAN WATER ACT 20 YEARS LATER 141 (1993) (arguing that technology-based standards have not been promulgated under the Clean Water Act for all categories of industry that would seem to need standards and that some of the existing standards are outdated). These authors also report that significant permit backlogs are commonplace under the Clean Water Act permit system, although this is a problem largely separate from the statute's election of technology-based standards as the base innovation of choice. *See id.* at 158 (detailing the significant problem of permit backlogs under the Clean Water Act's National Pollution Discharge Elimination System (NPDES) permit program).

the promulgation rate of most alternatives, such as standards based on environmental needs, health-related needs, or a cost/benefit analysis of what level of protection is appropriate.[41] The reason technology-based standards are promulgated more quickly than other approaches to pollution control is straightforward—the work associated with promulgating such standards is several times simpler than the alternatives.[42] In contrast to the tremendous information demands posed by science- or cost/benefit-based standards,[43] technology-based standards have information demands that are significant but still attainable.[44] Indeed, in comparison to some of its competitor approaches, the fact that technology-based standards are promulgated at all counts as a major victory.[45] When alternative, information-intensive regulatory approaches such as harm-based standards have been employed, for example, typically only a handful of standards are promulgated for the few pollutants for which considerable information is available. The standard-setting process then tends to drift aimlessly without results for the remaining hundreds of pollutants.[46] Indeed, over half of the major federal statutory provisions that

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41. *See* McGarity, *supra* note 32, at 203–24 (discussing the expedient implementation of technology-based standards in relation to science-based standards); Wagner, *supra* note 10, at 1680 & n.245 (supporting the observation that "the agencies . . . promulgated three to ten times more technology-based standards in the same period of time than they did science-based standards").

Because technology-based standards regulate sources comprehensively, rather than pollutant by pollutant, they also ensure that more pollutants are covered. This attribute of technology-based standards stands in stark contrast to harm-based or cost/benefit-based standards and, in fact, was one of the reasons industry endorsed technology-based standards—because it departed from the "pollutant of the month" regulatory approach of its predecessors. *See* Ridgeway M. Hall, Jr., *The Evolution and Implementation of EPA's Regulatory Program to Control the Discharge of Toxic Pollutants to the Nation's Waters*, 10 NAT. RESOURCES LAW. 507, 519–25 (1977).

42. *See* Hazardous Waste Treatment Council v. EPA, 886 F.2d 355, 363 (D.C. Cir. 1989) (affirming the EPA's standards because its "catalog of the uncertainties inherent in the alternative approach using [health-based] screening levels supports the reasonableness of its reliance upon BDAT [Best Demonstrated Available Technology] instead"). Even one of the most vocal critics of technology-based standards, Richard Stewart, has admitted that these standards may provide the best control option when a lack of information precludes more efficient or creative solutions. *See* Richard B. Stewart, *Models for Environmental Regulation: Central Planning Versus Market-Based Approaches*, 19 B.C. ENVTL. AFF. L. REV. 547, 554–55 (1992); *see also supra* note 5.

43. *See* Latin, *supra* note 6, at 1273–75 (chastising critics for ignoring tremendous information and theoretical deficiencies in estimating environmental and health risks); Shapiro & McGarity, *Not So Paradoxical*, *supra* note 6, at 731–32 (observing, based on risk assessment literature and specific examples, that "the difference between some low and high estimates of cancer risk approximates the difference between the price of a cup of coffee and the national debt").

44. *See* Latin, *supra* note 6, at 1305–14 (using case studies to argue that standards based on harm-based determinations result in complete or nearly complete regulatory failure). I have also supported this argument in tedious detail in former articles and will save readers and the *Law Review* staff by resisting the temptation to repeat it again here. *See generally* Wagner, *supra* note 10, at 1692–95 (identifying more expeditious promulgation of technology-based standards); Wendy E. Wagner, *Congress, Science, and Environmental Policymaking*, 1999 U. ILL. L. REV. 181, 205–13 (recounting unrealistic information requirements of science-based and cost/benefit-based protective standards).

45. *See* Shapiro & McGarity, *Not So Paradoxical*, *supra* note 6, at 745 (arguing that incentive-based regulatory approaches are so information-intensive that "[u]nless agencies are prepared to tolerate potentially high exposures and/or devastating short-term economic consequences during the time it takes for the system to reach 'steady state' proceedings, examining the level of tax or the issuable number of permits are [sic] likely to be highly contentious").

46. *See id.* at 747 (describing the Occupational Safety and Health Administration's (OSHA) pa-

utilize technology-based standards adopted them specifically because alternative approaches resulted in so few standards being promulgated.[47] The Clean Air Act toxics provision offers the most dramatic example of this evolution toward technology-based standards. In less than ten years, the EPA expects to have promulgated technology-based standards for virtually all major sources of toxic air pollution,[48] although in the prior twenty years the same industries had been largely unregulated because the EPA was able to promulgate ambient standards for only seven toxic pollutants out of a universe of almost two hundred.[49]

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ralysis in setting worker protection standards based on risk assessments); Wagner, *supra* note 10, at 1678–84 (detailing both the delays and the skewed prioritization that have occurred for standards based on science or on cost/benefit analysis, when the cost/benefit analysis is premised initially on scientific information regarding risk). The related failure of regulatory programs to work effectively, if at all, because of unrealistic demands for information-intensive fine-tuning is also detailed in Professor Latin's defense of technology-based standards. *See* Latin, *supra* note 6, at 1314–31.

47. The relative expeditiousness of promulgating technology-based standards in relation to the more obvious alternatives is the reason Congress adopted such standards in the Clean Water Act in 1972 and again in the 1977 amendments. *See* S. REP. NO. 414, at 8 (1972), *reprinted in* 1972 U.S.C.C.A.N. 3668, 3675 (reporting that Senate conferees agreed to use technology-based controls for conventional water pollutants because "[w]ater quality standards . . . often cannot be translated into effluent limitations—defendable in court tests, because of the imprecision of models for water quality and the effects of effluents in most water."); Oliver A. Houck, *The Regulation of Toxic Pollutants Under the Clean Water Act*, 21 Envtl. L. Rep. (Envtl. L. Inst.) 10,528, 10,537 (Sept. 1991). Expeditiousness is the reason technology-based standards were adopted in 1990 in regulating air toxins. *See* 136 CONG. REC. S17,234 (daily ed. Oct. 26, 1990) (statement of Sen. Baucus) ("This new [technology-based] approach is desperately needed to overcome the inertia that plagued the health-based standards in air and water pollution control."). Expeditiousness is also the reason the EPA adopted them, despite questionable statutory authority, in setting standards for the treatment of hazardous wastes to be disposed on land under the Resource Conservation and Recovery Act (RCRA). *See Hazardous Waste Treatment Council*, 886 F.2d at 363 (affirming the EPA's reliance on technology-based standards because of numerous uncertainties). For a more detailed account of this evolution toward technology-based standards in regulating water toxins, see Latin, *supra* note 6, at 1307–09 (detailing how "the original harm-based approach for regulation of toxic water pollutants proved ineffective and has largely been replaced by technology-based standards that are more easily implemented").

48. *See* National Emission Standards for Hazardous Air Pollutants: Revision of List of Categories of Sources and Schedule for Standards Under Section 112 of the Clean Air Act, 63 Fed. Reg. 7155, 7158–59 (1998) (noting that under section 112(e)(1) of the statute, all technology-based standards (for 150 source categories) must be promulgated by November 15, 2000, and that 50% of those must be promulgated by November 15, 1997, and providing a timetable for promulgating all remaining standards). The EPA, however, is behind in its promulgation of standards, which could necessitate (by statute) that hazardous air pollutant standards for sources in the remaining industry categories be set on a case-by-case basis. *See* National Emission Standards for Hazardous Air Pollutants Streamlined Development: Announcement and Request for Comments, 60 Fed. Reg. 16,088, 16,089 (1995). In anticipation of this inevitability, the EPA has developed a MACT (Maximum Achievable Control Technology) Partnerships Program that expedites the technology-based standard-setting process while at the same time providing a more accessible default standard for the case-by-case permitting decisions that must occur in the interim. It remains unclear, however, whether the EPA's creative approach will survive legal challenge or result in a more successful technology-based program. *See generally* Patrick D. Traylor, *Presumptive MACT as a Regulatory Tool to Streamline the Development of National Emission Standards for Hazardous Air Pollutants*, 4 ENVTL. LAW. 393 (1998) (describing the EPA's MACT Partnerships Program and raising questions regarding its legality).

49. *See* 42 U.S.C. § 7412(b) (1994) (listing 189 air toxins in need of regulation); *see also* OFFICE OF TECHNOLOGY ASSESSMENT, U.S. CONGRESS, IDENTIFYING AND REGULATING CARCINOGENS: BACKGROUND PAPER 106 (1987) (discussing seven air toxic standards promulgated by the EPA and the extraordinary delays associated with them).

It is true that incentive-based environmental innovations, such as markets and information-disclosure approaches, may be developed and implemented considerably more quickly than technology-based standards. The sulfur dioxide market required under title IV of the Clean Air Act was up and running in less than three years.[50] Voluntary agreements and audit approaches move even more quickly, which is in fact one of their primary virtues.[51] Yet although these approaches may be implemented more quickly than technology-based standards, it is not clear that meaningful pollution reduction is achieved more quickly. Protracted delays in achieving desired results may be most severe with market-based approaches to pollution control because of the inevitable policy feedback that can occur with such incentive-based methods.[52] Determining initial entitlements, appropriate geographic trade areas, and appropriate trading rates typically proceeds incrementally, with unanticipated impediments or delays coming from flaws in the market design and from unexpected behaviors of the private market participants themselves.[53]

50. *See* Rae Tyson, *Auction Floats Air Pollution into the Market*, USA TODAY, Mar. 30, 1993, at 3A (reporting on the EPA's first Chicago Board of Trade auction of title IV permits, which occurred in March 1993, less than three years after the Clean Air Act 1990 Amendments creating the market were passed).

51. *See* Orts, *supra* note 8, at 1332 (providing a comprehensive and insightful account of "reflexive" (noninterventionist and often incentive-oriented) approaches to pollution control and noting that one of their primary benefits are proactive features that provide protections early during the life cycle of a problem, before it is "too late").

52. Because the effectiveness of pollution markets depends heavily if not completely on the behavior of private parties, the likelihood of significant "policy back talk" or even unanticipated reactions is likely to be quite dramatic for this type of innovation. *See* Vivien Foster & Robert W. Hahn, *Designing More Efficient Markets: Lessons from Los Angeles Smog Control*, 38 J.L. & ECON. 19, 20, 43 (1995) (underscoring the critical need for greater study of existing pollution markets to assess how best to design them in the future); Latin, *supra* note 6, at 1295–96 (arguing that a "meaningful comparison of regulatory approaches" must consider "realistic prediction[s]" of how interest groups and regulatory agencies would act in the various regulatory programs); *cf.* DONALD A. SCHÖN & MARTIN REIN, FRAME REFLECTION: TOWARD THE RESOLUTION OF INTRACTABLE POLICY CONTROVERSIES 171–72 (1994) (describing "policy back talk" as an inevitable part of policy design). The lack of trading in established water pollution markets may be another good example of how this policy back talk can cause regulatory reality to diverge significantly and sometimes in unexpected ways from regulatory theory. *See, e.g.*, Ann Powers, *Reducing Nitrogen Pollution on Long Island Sound: Is There a Place for Pollutant Trading?*, 23 COLUM. J. ENVTL. L. 137, 194–95 (1998) (observing the very limited number of trades occurring in four established water pollution markets and opining that few trades occurred because of the incentives created by a simultaneous cap on pollution discharges).

53. *See* Driesen, *supra* note 6, at 327–30 (outlining some of the problems arising in the design of pollution markets that significantly reduce the ultimate success of the emissions-trading approach); Richard T. Drury et al., *Pollution Trading and Environmental Injustice: Los Angeles' Failed Experiment in Air Quality Policy*, 9 DUKE ENVTL. L. & POL'Y F. 231, 258–68 (1999) (discussing the allocation of initial emission reduction credits in Los Angeles's smog market (RECLAIM) that was based on sources' inflated reports of their historic emissions levels and the resulting lack of pollution reduction occurring for the first three years of the program); Foster & Hahn, *supra* note 52, at 42 (reporting, based on their analysis of the Los Angeles smog market, that transaction costs for pollution permits can be high and that "[i]n many cases, the magnitude of transaction costs exceeded the market value of the credits exchanged"); Robert W. Hahn & Gordon L. Hester, *Where Did All the Markets Go? An Analysis of EPA's Emissions Trading Program*, 6 YALE J. ON REG. 109, 116–17 (1989) (discussing practical problems that arise in allocating initial pollution allowances and industry's concern over the permanence and stability of these allowances that ultimately serve to impede the success and expeditiousness of pollution markets); Daniel P. Selmi, *Transforming Economic Incentives from Theory to*

Title IV of the Clean Air Act provides a particularly good illustration of how slow active markets can be in achieving pollution reductions. Title IV employs a pollution market as a base innovation (meaning the sources were not uniformly regulated prior to the creation of the market).[54] Although trading has certainly been a resounding success, results from the perspective of pollution control show that trading may not be as successful in reducing overall emissions.[55] Chicago Board of Trade figures for 1999, for example, suggest that about seventy percent of current allowances and ninety-eight percent of future allowances (2004 and after) were purchased by utilities based in the Midwest.[56] Consequently, utilities in the Midwest—the primary source of pollutants causing acid rain—may not reduce their emissions any time soon and most likely will do so at a slower pace than would have occurred had technology-based standards been implemented first or simultaneously. Although this slower approach to reducing acid rain may be precisely the reason Congress selected a national market-based approach,[57] the likelihood of de-

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*Reality: The Marketable Permit Program of the South Coast Air Quality Management District*, 24 Envtl. L. Rep. (Envtl. L. Inst.) 10,695, 10,698–701, 10,709–10 (1994) (identifying the practical problems that arose in developing an emissions-trading program in Los Angeles, including the determination of how to set baselines equitably and reliably, the tremendous administrative drain posed by establishing and maintaining the trading program, and industry trepidation about the future of the program (and industry's investment in emissions credits)).

54. Indeed, the regulation of existing utilities that did occur—through regional air quality controls—is probably most responsible for the resulting acid rain problem because the utilities found that they were able to escape harm-based regulation through the construction of tall stacks. *See* EDWARD TENNER, WHY THINGS BITE BACK: TECHNOLOGY AND THE REVENGE OF UNINTENDED CONSEQUENCES 86 (1996) (describing the causal connection between the Clean Air Act regulatory approach and acid rain); Frances H. Irwin, *An Integrated Framework for Preventing Pollution and Protecting the Environment*, 22 ENVTL. L. 1, 13 (1992) (same).

The wisdom of markets as a second-generation approach is not germane to this article. It deserves mention, however, that despite a very rough start, markets appear to be an excellent way (once the policy back talk subsides) of effecting ways to bring pollutant levels down after a baseline has been established by a base innovation (like technology-based standards, of course). *See infra* note 116. In fact, recent assessments of Los Angeles's smog market suggest that if all sources had first been subject to uniform technology-based standards, developing an equitable and reliable basis for allocation emissions credits among existing sources would have been much easier. *See* Selmi, *supra* note 53, at 10,700, 10,707 (highlighting the tremendous "equitable" challenges arising in determining how to allocate emissions reductions among some sources that had already been required to reduce emissions to low levels and other high polluters that had not).

55. *See* Andrew C. Revkin, *New York to Sue 17 Power Plants on Air Pollution*, N.Y. TIMES, Sept. 15, 1999, at A1 (reporting on the state of New York's lawsuit against major Midwest utilities for pollutants (causing such problems as acid rain) that drift to New York and identifying these Midwestern sources as "some of the biggest single sources of air pollution in the country"); *see also* Drury et al., *supra* note 53, at 268 (opining that because of several errors committed in the development of Los Angeles's RECLAIM market, "RECLAIM has every indication of amounting to at least a ten-year free ride of avoided emission reductions for the four hundred largest polluters in the Los Angeles area").

56. *See* Mark Golden, *Credits to Emit Sulfur Dioxide Net $53 Million*, WALL ST. J., Mar. 29, 1999, at B7C (reporting that the future allowances were purchased by American Electric Power, a utility in Columbus, Ohio, and that two Ohio utilities accounted for the sale of nearly all of the current allowances).

57. *See* Heinzerling, *supra* note 36, at 318 (concluding, based on detailed investigation of the congressional debates, that the title IV market "created by the 1990 Amendments owes much of its content to the influence of special interest groups").

layed progress under title IV appears to have escaped the attention of the public and media,[58] making it all the more troubling since pollution markets have been portrayed as a transparent and democratically accessible approach to pollution control.[59]

b. Enforceable and Predictable

Technology-based standards are also more enforceable and predictable than most alternative approaches to pollution control. From the standpoint of the regulated entities, technology-based standards provide unparalleled predictability with respect to compliance obligations.[60] New and existing companies need only look up their industry category in the Code of Federal Regulations or related national guidelines to become apprised of what will be expected of them.[61] This predictability and ease of compliance stands in stark contrast to most and perhaps all other approaches to pollution control. Alternative harm- or cost/benefit-based standards typically tether requirements to the regulators' vision of what reductions are needed to protect the environment or to balance costs and

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58. *See, e.g., id.* at 320 (observing, with citations, that "casual readers" as well as more careful commentators tend to mistakenly take the title IV statutory goals—such as the ten-million-ton reduction target—at face value).

59. *See id.* at 318 (examining congressional deliberations over title IV and concluding that title IV "challenges the view [of Professors Ackerman, Stewart, and Sunstein] that establishing a system of marketable pollution permits will promote the democratic values, such as deliberation, decentralization, and freedom from faction").

60. *See* GUNNINGHAM ET AL., *supra* note 7, at 41 (identifying as a strength of technology-based regulation that it "can be specified with considerable clarity . . . [and thus] firms themselves have a clearer understanding of their regulatory obligations").

Curiously, technology-based standards seem repeatedly to take the blame for the results of the *National Law Journal* 1993 survey that reported corporate counsels' difficulty in ensuring their clients were in compliance with the environmental laws. *See* Marian Lavelle, *Corporate Counsel Survey*, NAT'L L.J., Aug. 30, 1993, at S1; *see also, e.g.*, GUNNINGHAM ET AL., *supra* note 7, at 46 (linking technology-based standards to reported compliance problems); Orts, *supra* note 8, at 1240 (same). Yet these standards seem least likely to be the culprit, particularly in comparison to the incomprehensible emissions limits set by state implementation plans (SIPs) under the Clean Air Act or to the vague generator testing requirements set forth under the RCRA. *See* 40 C.F.R. § 262.11 (1998) (instructing generators of potentially hazardous wastes to "[a]pply[] knowledge of the hazard characteristic of the waste" or "[t]est[] the waste" according to federal regulations but not specifying what constitutes adequate "knowledge," how often wastes should be tested, how to ensure wastes being tested are representative, or how generator compliance with the regulation should be documented). The survey itself also does not suggest the connection between technology-based standards and compliance difficulties.

61. *See* 40 C.F.R. pts. 125–129 (1998) (technology-based standards under the Clean Water Act), pt. 61 (technology-based standards for air toxins under the Clean Air Act), pt. 60 (new sources under the Clean Air Act). Robert Adler and others, however, argue that this clarity does not always emerge for technology-based standards promulgated under the Clean Water Act. Specifically, they report that because "some effluent guidelines are written in terms of the mass of pollutants that may be discharged per unit of production," there is considerable ambiguity about what the effluent limit should be for a particular source, and this ambiguity leaves "actual limits open to substantial manipulation" and "gamesmanship" that they allege have occurred on more than one occasion. ADLER ET AL, *supra* note 40, at 165. Other standards have similar flaws with regard to their specificity because they are written "in terms of concentrations of pollutants in the discharge." *Id.* The authors later advance a straightforward proposal on how these types of standards could be reformed. *See id.* at 236.

benefits.[62] As a result, such standards are difficult to predict and, even after becoming codified into an operational permit, may leave sources with the uncomfortable feeling that the next permit could be considerably more stringent due to additional industry operating in the area or changes in environmental science or local or national politics. Even markets (at least as they operate today) cannot give sources a dependable outlay of pollution abatement costs over the future, since the cost of pollution permits can vary dramatically from year to year.[63] These factors may explain why industry seems to have embraced technology-based standards as the preferred base innovation, even though these standards may require more pollution abatement from some individual sources than is economically justified.[64]

Technology-based standards are superior in their predictability not only because pollution sources have a head start in understanding their compliance requirements but also because of the ease by which *regulators* can ensure that compliance obligations are being met.[65] Most importantly, because the reference point is a definable technology for which numerical standards have been nationally developed, technology-based requirements are almost always clear, easy to codify, and easy to reflect in permit requirements.[66] Other standards, such as those based on environmental conditions and cost/benefit analyses, are also capable of being articulated in clear terms in source-specific permits.[67] However, because

62. *Cf.* American Trucking Ass'ns v. EPA, 175 F.3d 1027, 1034 (D.C. Cir. 1999) (holding that the broad health-based mandate of section 109 of the Clean Air Act was overbroad in delegating policymaking authority to the EPA).

63. *See* Foster & Hahn, *supra* note 52, at 30 (observing that in the Los Angeles smog market, pollution permit prices varied considerably over a seven-year period, jumping in one case from a low of "less than $100 to [a high of] over $700 per ton per year"); Golden, *supra* note 56, at B7C (reporting that the clearing prices at the annual auction of sulfur-dioxide emission allowances went up 74% from the prior year for current allowances (from $115.01 to $200.55) and 55% for future allowances (from $108.30 to $167.55)). Markets might also be a particularly costly way to achieve pollution reduction from the perspective of sources that need to buy or sell only small volumes of pollution credits. *See* Foster & Hahn, *supra* note 52, at 35 (observing that "the transaction cost of trades may frequently exceed the market value of the credits purchased [for] exchanges involving very small volumes of credits").

64. *See* Hahn & Hester, *supra* note 53, at 142 (observing industry resistance to emissions trading and explaining that it is based in part on "the fact that industry has a strong preference for greater certainty in environmental regulation. Thus, the potential cost reduction that can be achieved under emissions trading policies may not be worth the uncertainty that is created by participation"); Keohane et al., *supra* note 9, at 348–53 (explaining why firms may prefer certain types of command-and-control standards over alternative, market-based approaches). Although the political palatability of technology-based standards should not influence an objective assessment of their superior workability, neither should this feature be totally ignored given its ultimate importance to the adoption of pollution control approaches.

65. *See* GUNNINGHAM ET AL., *supra* note 7, at 41 (noting that the "major strength of command and control" is that "the behaviour expected of regulatees can be specified with considerable clarity . . . making it relatively straightforward to identify breaches of the legal standard and to enforce the law" (footnotes omitted)).

66. If the reader is in doubt, refer to the technology-based standards cited in *supra* note 61.

67. Depending on one's point of view, the new title V permits of the Clean Air Act may or may not serve as an example of the ability of permits based on ambient conditions and other features to be clear and comprehensible. *See* Adan A. Schwartz, *Rethinking the Clean Air Act Operating Permit Pro-*

of the single reference point associated with technology-based standards—the capabilities of a given technology—the standards are that much easier to isolate, interpret, and enforce in an even-handed way.[68]

Moreover, it follows that the clearer the permit requirements, the more streamlined the regulatory oversight. Regulators can compare a source's emissions or discharges against a set of national numerical requirements.[69] There is no need to refer to masses of documents to identify limitations for individual pollutants emanating from a single source as was generally required for the criteria air pollutants in Clean Air Act state implementation plans.[70] Criminal sanctions also work smoothly and effectively, with little need for the rule of lenity in determining whether the limitations applied to a particular source are clearly within reach of the statute.[71] Finally, unambiguous pollution limits allow self-monitoring programs to operate more effectively. Since the pollution reduction requirements are specific, regulated entities cannot evade the disclosure requirements by arguing that they are ambiguous, as is the case with other self-monitoring programs like generator testing obligations under the Resource Conservation and Recovery Act.[72]

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*gram: A Proposal for Mid-Stream Adjustments*, 1 ENVTL. LAW. 141, 200–01 (1994) (concluding that title V permits facilitate the much-needed "consolidation of all Clean Air Act requirements into one document" but that because of existing legal uncertainties regarding SIPs and the EPA's title V requirements, accomplishing this consolidation will likely involve considerable conflict).

68. This also explains one of the disadvantages of technology-based standards. Both risk averse and lazy sources (or, put in politically correct terms, sources that have "bounded rationality" and are "short-term profit maximizers") will apply the underlying technology upon which the standards are based in the hope that if the technology is ineffective in meeting specified numerical limitations, the sources will be granted some slack in enforcement proceedings. *See* Note, *supra* note 5, at 808–09 (suggesting that firms may adopt preferred technologies to lessen the risk of enforcement proceedings). This tendency is unfortunate because it slows innovation in pollution control technologies. *See* La Pierre, *supra* note 18, at 825–26 (observing that by 1977, industry appeared to be "blindly following EPA's technological models" in some cases for technology-based standards and as a whole was making "little or no effort to develop new methods of effluent control that may [have proven] less expensive than existing technology").

69. *See* Shapiro & McGarity, *Not So Paradoxical*, *supra* note 6, at 748–49 (providing a comparative analysis of how monitoring sources for violations under a technology-based approach is considerably easier than it would be under an incentives-based approach).

70. *See* WILLIAM H. RODGERS, JR., ENVIRONMENTAL LAW 204 (2d ed. 1994) (observing that the SIP approval process has led to "a formidable body of complex and secret law, undermining the rosy assumptions that the SIPs should contain an easily accessible roster of air pollution rules for a given region" (footnote omitted)); *id.* at 207–09 (noting the indeterminacy, incompleteness, and excessive volume of SIPs that make them essentially unreadable).

71. *Cf.* United States v. Plaza Health Lab., Inc., 3 F.3d 643 (2d Cir. 1993) (reversing the conviction in a criminal prosecution brought under the Clean Water Act because the "rule of lenity" required that the ambiguous definition of "point source" be resolved in the defendant's favor).

72. *See* Caroline B. Buenger, *Reliance on Generator Knowledge to Characterize Waste Under RCRA: Gambling on the Use of 'Unacceptable' Knowledge*, 27 Envtl. L. Rep. (Envtl. L. Inst.) 10,439, 10,441–42, 10,447–48 (1997) (outlining the uncertainty of the EPA's generator testing requirements; the EPA's scant enforcement of the requirements (three administrative enforcement cases in 17 years, each of which the EPA lost); and how a source might be able to successfully defend itself in future enforcement actions using the 'fair notice' defense due to the considerable ambiguity of the EPA's regulations). Even voluntary cleanup plans enacted by some states to address the problem of brownfields sites use technology-based standards or essentially their equivalent to eliminate individual discretion and to limit the need for extensive administrative oversight. *See The Cleanup and Redevelop-*

Perhaps most importantly, the characteristics that make technology-based standards enforceable also make them relatively accessible to the public at large. Environmental enforcement by private citizens is highest for violations of the Clean Water Act, a fact that commentators explain by that statute's combination of clear discharge standards specified in permits (often based solely on technology-based standards) and the equally accessible discharge-monitoring reports filed by sources to report on their compliance.[73] But the benefits of the greater accessibility of technology-based standards are not limited to the ease with which citizens can become part of the enforcement artillery. As discussed earlier, technology-based standards employ a common sense, moral approach to pollution control that can be readily understood by citizen-onlookers. Although the EPA's task in setting individual standards is hardly straightforward,[74] the room for discretion is quite narrow as compared to virtually every other regulatory approach. Market imperfections and scientific uncertainties thus cannot be used to hide discretionary policy choices that afflict many other approaches to environmental regulation.[75]

c. Even-handed

Regulatory interventions that change how companies operate have the potential to create inequities in competition or barriers to entry. When implemented properly, however, technology-based standards are

*ment of Contaminated Land*, 1 Brownfields L. & Prac. (MB) § 22.05[1], at 22–20 (Oct. 1998) (discussing some states' use of "cleanup action levels" for voluntary brownfields cleanups).

73. *See* Maria E. Chang, *Citizen Suits: Toward a Workable Solution to Help Created Wetlands*, 6 U. FLA. J.L. & PUB. POL'Y 77, 98 (1993) ("Most citizen suits have concentrated on the [Clean Water Act] because that statute requires monitoring and self-reporting, making it relatively easy to identify violations."); LeRoy C. Paddock, *Environmental Enforcement at the Turn of the Century*, 21 ENVTL. LAW. 1509, 1523–24 (1991) (observing that the greatest number of citizen suits have occurred under the Clean Water Act, despite their abundance in other statutes, "in part, because violations cannot be as easily identified using reports submitted under those [later] programs").

74. There can be no doubt, for example, that an attentive citizen or even a savvy public interest group would quickly become overwhelmed in the technical details of the EPA's proposal for a particular technology-based standard. *See* Gaines, *supra* note 18, at 856–57 (observing that public comments on the EPA's technology-based standard were dominated by industry and that even then, industry's comments offered only inconsequential details or "sweeping unsupported statements" about the unfeasibility of the standards). Yet if the EPA's discretion is narrow and the statutory mandate is relatively clear and accessible with regard to the pollution control goals and standards that it adopts, then the democratic legitimacy of resulting specific standards would seem to remain intact.

75. The deceptive "ten million ton reduction" goal of the title IV market (which is unlikely to translate to anything close to a 50% reduction in the target pollutant—acid rain), *see* Heinzerling, *supra* note 36, at 320–25 (detailing the deceptiveness of the goal when invisible realities are added), and the insidious but often concealed discretion that comes with risk assessments are not possible when technology-based standards must be developed under the scrutiny of judicial review. *See generally* Wagner, *supra* note 10, at 1674–77. Under pollution trading schemes, moreover, the public is essentially excluded from the initial decision regarding whether a particular trade is appropriate or what level of emissions for a particular source will protect the local community. *See* Drury, *supra* note 53, at 278–79 (reporting that under Los Angeles's RECLAIM market, pollution trades "are not subject to public review or comment. In fact, the public faces numerous difficulties finding out what companies are trading to avoid compliance with pollution control standards.").

quite equitable in how they affect industry. Generally, all members of the same class of an existing industry are treated in the same way, although distinctions can be built into the selection of technology-based standards to ensure that smaller businesses are not put at a competitive disadvantage.[76] For example, one steel plant is not required to purchase substantially more expensive pollution abatement equipment than a competitor in another state. Even new entrants may not be (and need not be) penalized by more costly pollution control requirements.[77] Technology-based standards need to be more stringent for a new industry only when the costs of the new standards are not significantly different from the costs of existing standards for the industry. Other common regulatory problems, such as agency capture, the benefits of sophisticated counsel, or the unwillingness of competitive industries to sell their rights to pollute, are also avoided when standardized national standards are set in advance.[78] Although secondary reforms may disrupt this even-handed treatment, these added refinements are imposed only after each source has already been required to "do its best" (or at least do something) and thus prevents drastic inequities, for example, where one facility is burdened with expensive environmental regulatory requirements while its competitor in an adjacent state remains completely unregulated.

Technology-based standards level the playing field not only for competitors within an industry class but also between states and their

76. *See* 33 U.S.C. § 1316(b)(2) (1994) (permitting the EPA, in setting new source technology-based standards under the Clean Water Act, to "distinguish among classes, types, and sizes within categories of new sources").

77. As suggested in *supra* notes 29–31 and the accompanying text, the old-new distinction that is often built into the way Congress has established technology-based standards, *see* Ackerman & Stewart, *supra* note 5, at 1335–36 (arguing that "BAT controls . . . impose disproportionate penalties on new products and processes"), may not, in hindsight, be as pervasive a problem as first appeared. Moreover, and in any case, to the extent that the old-new distinction does improperly advantage existing industries against new entrants, this is the result of a political decision that has been made in a variety of regulatory programs (including markets). *See, e.g.*, 42 U.S.C. § 7651(b) (providing existing utilities with thousands of "free" sulfur dioxide pollution allowances to trade on the market). The resulting barriers to entry are thus neither an inevitable nor a unique adverse side effect of utilizing technology-based standards to control pollution. *See* Keohane et al., *supra* note 9, at 315, 348–53 (explaining the pervasiveness of the old-new distinction in all types of regulatory programs and observing that the pervasiveness is likely due to existing firms' demands for beneficial grandfathering-in during the law-making process).

78. Professors Ackerman and Stewart openly admit their concern over the potentially inequitable features of market-based pollution controls, though they believe it may prove reformable or essentially a minor problem in the end. *See* Ackerman & Stewart, *supra* note 5, at 1351 ("We can foresee situations in which existing polluters might try to manipulate the rights market to deter entry by new firms in a way that is inconsistent with the antitrust laws, by either monopolizing the pollution rights market itself, or using it to block entry by competitors.").

To the extent that compliance obligations are clear, technology-based standards not only assure equitable access to pollution control technologies but also reduce the need for firms, including small businesses, to seek out skilled environmental attorneys to assist them in understanding their regulatory obligations. *Cf.* David B. Spence, *Paradox Lost: Logic, Morality, and the Foundations of Environmental Law in the 21st Century*, 20 COLUM. J. ENVTL. L. 145, 172 (1995) (detailing how "smaller, less-wealthy firms" may be more likely to unintentionally violate environmental laws (with the resultant costs of penalties and injunctions) because they "may not have the resources necessary to keep abreast of frequent changes in complex, technical rules").

citizens. The "race to the bottom" that is still very much at issue in environmental regulation (although its significance may be debated) is avoided at least as far as this base innovation goes because industries must comply with a nationally determined standard.[79] Although states are generally permitted to make standards more stringent than technology-based standards, they cannot induce industry to locate in their state by establishing lower standards. Accordingly, citizens of all states enjoy at least some protection from high concentrations of pollution. Any resulting hot spots of pollution—caused by the combined insult of concentrated industries, environmental conditions that do not maximize the dispersion of pollutants, and technology-based standards that prove insufficient to protect public health—are generally undiscriminating about where they occur.[80] Although these residual hot spots may have a disproportionate impact on communities of color or of lower socioeconomic status, to the extent that insufficient technology-based standards are to blame, these problems are at least inadvertent and essentially color-blind.[81] This, of course, does not mean that the hot spots or disproportionate impact should be forgotten or forgiven, but it does remove these standards from the list of tools, like siting decisions or permissive permits, that may countenance more overt forms of environmental injustice.[82]

d. Adaptable

A final virtue of technology-based standards is that they can easily be supplemented or even supplanted as improved approaches to control-

79. Secondary innovations, however, may lead to interstate competition problems (although this one detrimental feature does not mean that these secondary innovations should be abandoned). *Cf.* Natural Resources Defense Council v. EPA, 16 F.3d 1395, 1398–1408 (4th Cir. 1993) (allowing the EPA to approve water quality standards set by Maryland and Virginia for dioxin that were almost one thousand times more lenient than the EPA recommended because of inherent scientific uncertainties regarding the risks of dioxin).

80. *See, e.g.*, Drury, *supra* note 53, at 255, 284–85 (observing that although pollution problems are concentrated in industrial, low-income areas, mandatory technology-based standards at least ensure that all companies have installed "a technology-based floor to safeguard public health in all communities").

81. Violations of technology-based standards that have been codified into permits with mandatory monitoring reports are also easier to detect and enforce, thus better enabling communities to police violations in their communities through the citizen suit provision. *See supra* note 73.

82. *See* Drury, *supra* note 53, at 251–57, 271–73 (arguing that the design of the Los Angeles smog market (RECLAIM) has "resulted in the creation of toxic hot-spots by concentrating pollution in communities surrounding major sources of pollution" because major sources could buy up pollution that would have been otherwise dispersed throughout the larger metropolitan area and reporting that the EPA has "concede[d] that no proposed or existing pollution trading program contains appropriate safeguards against concentrating pollution in low-income communities of color"); Stephen M. Johnson, *Economics v. Equity: Do Market-Based Environmental Reforms Exacerbate Environmental Injustice?*, 56 WASH. & LEE L. REV. 111, 118 (1999) (arguing that market-based approaches are likely to exacerbate distributional inequities in environmental laws); Robert R. Kuehn, *The Environmental Justice Implications of Quantitative Risk Assessment*, 1996 U. ILL. L. REV. 103, 132–33 (arguing that quantitative risk assessment (used in setting harm- and cost/benefit-based standards) disproportionately places pollution burdens on minority and low-income communities).

ling pollution become available. Unlike pollution markets, voluntary compliance obligations, or other types of command-and-control standards, technology-based standards are not incompatible with most secondary innovations and thus serve as quintessentially hospitable and adaptable base innovations. One can add a pollution market to technology-based standards but would face great difficulty attempting the reverse.[83] Additionally, technology-based standards as base innovations are ideal default requirements or "circuit breakers" that "pre-empt the anticipated failure of another instrument."[84] Since technology-based standards are uniformly and expeditiously applied across all industries and geographic locations, they can be used to ensure that at least some environmental protection is in place if pollution markets do not work or are slow to become operational. Likewise, environment-based controls, which are theoretically compelling, work best when complemented by "environment-blind" technology-based standards. Because toxicity data or other critical information needed to set ambient standards or perform cost/benefit analyses is often incomplete, technology-based standards can be used to protect the environment until the needed information has been assembled and the requisite analysis performed.[85]

The ability of technology-based standards to serve as a foundational regulatory approach becomes still more desirable when one considers the privileged position that status quo rules enjoy in democratic governments,[86] particularly in separation-of-powers systems.[87] Once passed into law, environmental controls often become cemented in place until a full-scale catastrophe or the equivalent proves them to be inadequate.[88] In

83. Although market trading (to achieve still greater pollution reduction) can be required even after technology-based standards are in place, *see infra* note 120, it is difficult to imagine how technology-based standards could be retrofitted to an existing market-based approach to pollution control. *See generally* GUNNINGHAM ET AL., *supra* note 7, at 422–44 (advocating the mixing of regulatory tools and providing some general discussion of complementary mixes; unfortunately, the characterization of technology-based standards is somewhat muddled but generally appears to fall into the performance standard category— one of the approaches most amenable to regulation according to the table at 428–29); Shapiro & McGarity, *Not So Paradoxical*, *supra* note 6, at 745 (noting the ability to combine regulatory approaches in a single protection program).

84. GUNNINGHAM ET AL., *supra* note 7, at 407–08 (discussing the notion of "circuit breakers").

85. *See* OTA, *supra* note 7, at 37–38 (detailing the many instances that harm-based and other standards are paired with technology-based (called "design") standards); *see also infra* note 114.

86. *See* ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION 202 (1990) ("Status quo operational rules always protect some individuals and expose others. A proposed change in these rules must be supported by a set of individuals large enough to have the authority to change them . . . .").

87. *See* David Vogel, *Representing Diffuse Interests in Environmental Policymaking*, *in* DO INSTITUTIONS MATTER?: GOVERNMENT CAPABILITIES IN THE UNITED STATES AND ABROAD 237, 268 (R. Kent Weaver & Bert A. Rockman eds., 1993) (concluding, based on a case study of environmental lawmaking in the United States, England, and Japan, that in a separation-of-powers government like the United States, there is a risk of deadlock between the president and Congress that can slow or halt the law-making process altogether; but that in a parliamentary government such as Japan with single-party-domination, laws can be passed much more quickly).

88. *See* Wagner, *supra* note 44, at 261–62 (describing the tremendous inertia that slowed reform of the dysfunctional air toxics provision in the 1970 Clean Air Act and the Delaney Clause of the Food, Drug, and Cosmetic Act).

contrast, a catastrophe is not needed to dislodge technology-based controls because they are so amenable to being integrated with secondary regulatory approaches.[89] Moreover, the ease with which a wide variety of refinements can be made reduces the congressional and administrative expenses associated with overhauling an entire regulatory program.[90]

## III. RESPONDING TO CRITICS

In advocating technology-based standards as one of the most important environmental innovations, criticism is anticipated. Indeed, virtually all of the literature on the subject is critical of technology-based standards.[91] Many of these criticisms are countered in part II.[92] However, a few important criticisms remain. These criticisms are addressed in this final section and form the basis for suggestions on how technology-based standards might be improved, but not eliminated, in the future.

To be fair, those criticizing technology-based standards do not always deny the multiple benefits previously discussed. Instead, some critics maintain that the adverse features of these standards simply outweigh their benefits.[93] These criticisms focus primarily on the inefficiencies associated with adopting national standards, the problems associated with cementing these less-than perfect standards in place, and the limited applicability of technology-based controls in general. Each of these criticisms is addressed in turn.

The first criticism regarding the "wild[] inefficien[cy]" of technology-based standards[94] has been addressed at several points but deserves a more coherent response. Although national standards are inefficient,[95] technology-based standards may be less inefficient than alternative base approaches to pollution control. As Professors Latin, McGarity, and Shapiro have all articulated in their excellent defense of technology-based standards, the information-intensive, bureaucracy-draining, and often less enforceable standards determined by harm- or cost/benefit-based analyses can cause these more nuanced approaches to be even more inefficient once the balance sheet accounts for all of the expenses,

89. *See* GUNNINGHAM ET AL., *supra* note 7, at 90 (observing that "[m]any of the most constructive and sophisticated innovations, to date, have been modifications to conventional regulation," including a number of important innovations to command and control).

90. *See generally* OSTROM, *supra* note 86, at 198–202 (detailing the various "transformation costs" that accompany wholesale changes in regulatory approach).

91. *See supra* note 5 and accompanying text.

92. For example, those who argue that the costs of technology-based standards may be too high concede that this approach might be the only, or at least a preferred, approach when scientific uncertainties make a risk assessment futile or nearly so. *See supra* note 5. Yet in the case of most pollutants, these conditions prevail most, if not all, of the time. *See supra* Part II.B.2.a.

93. *See supra* note 5.

94. Sunstein, *supra* note 5, at 628.

95. Even proponents of the standards, including myself, have conceded this point, although perhaps too hastily. *See supra* note 36.

including the administrative costs.[96] Markets are capable of producing a much more streamlined approach to pollution control, but ironically, without some base innovation already in place (like technology-based standards), markets may prove so difficult to set up that, at least in the short run (lasting years or even a decade), more costs are expended than saved from this seemingly cost-sensitive approach.[97] The same appears true of other initiatives, like Clinton and Gore's XL initiative, which attempt to introduce more flexibility into regulatory requirements.[98]

The technology-freezing aspects of technology-based standards have also been highlighted as a major disadvantage of employing these types of standards.[99] Generally, the technology-freezing concern applies only to the extent that the firms utilizing the pollution control technologies are the same firms responsible for (or largely in control of) pollution control innovations, a condition that may be the exception more often than the rule.[100] Even to the extent that pollution sources find themselves responsible for leading innovation in control technologies, there are competitive advantages for the sources to stay ahead of the compliance curve and pioneer the development of new and improved control technologies.[101] For example, industries have incentives to develop technolo-

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96. *See* Latin, *supra* note 6, at 1271 (listing advantages of technology-based standards, which include "decreased information collection and evaluation costs, greater consistency and predictability of results" and "decreased likelihood of social dislocation and 'forum shopping' resulting from competitive disadvantages between geographical regions or between firms in regulated industries"); Shapiro & McGarity, *Not So Paradoxical*, *supra* note 6, at 745–49 (detailing the paralysis and enforcement problems that arise with incentive-based approaches and thus make technology-based standards appear relatively superior). In a recent article, Professors Cole and Grossman make this argument with respect to command-and-control approaches more generally, including those standards that require installation of a specific type of pollution control technology. *See* Cole & Grossman, *supra* note 36, at 902–05. In fact, applying the three "cost components" developed by Professor Rose (which serve as a metric for comparing various environmental protection approaches), two of the three costs—administrative costs (e.g., policing) and failure costs (e.g., unaddressed externalities)—are likely to be higher for unproven base innovations (like market-based approaches) than for technology-based standards. Only the third cost, user costs, may arguably be lower, although that may depend on the predictability of the regulatory approaches (e.g., pollution market) from the standpoint of the user. *See* Rose, *supra* note 26, at 12.

97. *See supra* notes 52–55 and accompanying text.

98. *See supra* note 51 and accompanying text.

99. *See* Ackerman & Stewart, *supra* note 5, at 1336 (arguing that technology-based standards do not provide "strong incentives for the development of new, environmentally superior strategies, and may actually discourage their development").

100. *See* Richard B. Stewart, *Economics, Environment, and the Limits of Legal Control*, 9 HARV. ENVTL. L. REV. 1, 9 n.24 (1985) (acknowledging that although compromised by regulatory delay and uncertainty, "[t]o the extent there is an independent pollution control supply industry, it will have a strong incentive to develop new control technologies").

101. *See* Nicholas A. Ashford et al., *Using Regulation to Change the Market for Innovation*, 9 HARV. ENVTL. L. REV. 419, 437–38 (1985) (describing how technology-based standards set for existing mercury chloralkai plants under the Clean Water Act encouraged innovative pollution control efforts within the industry); Cole & Grossman, *supra* note 36, at 911 n.56 (detailing how technology-based standards for new major sources under the Clean Air Act did spur innovation in pollution control technologies); Natalie M. Derzko, *Using Intellectual Property Law and Regulatory Processes to Foster the Innovation and Diffusion of Environmental Technologies*, 20 HARV. ENVTL. L. REV. 3, 21 (1996) (observing that industries do have incentives for pollution control innovation under technology-based standards because they can gain a competitive advantage and noting that "Germany . . . uses

gies that meet existing requirements more inexpensively than the currently available technology. In any case, even if technology-based standards do dampen incentives for innovation in pollution control technologies,[102] there are a number of ways that the incentives can be restored with only slight adjustments to the standards or the regulatory program more generally.[103]

Finally, some have suggested that the utility of technology-based standards is limited to controlling pollution from large, discrete sources and that this objective has been fully accomplished in existing environmental regulatory programs, leaving no future role for this regulatory approach.[104] A review of key environmental programs, however, reveals that we have not begun to tap the capabilities of this base approach to environmental protection. For example, technology-based standards as a base requirement (not necessarily the only requirement) are still not utilized in the Clean Air Act for the seven criteria pollutants emitted by

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technology-based standards in environmental regulation but remains the top exporter of environmental technology" (footnotes omitted)). There may also be added incentives in the global marketplace for "clean technologies," as well as public relations and other benefits for industries to go beyond compliance. *See* GUNNINGHAM ET AL., *supra* note 7, at 43, 414–16, 420–21 (describing literature reporting on possible advantages in international competitiveness for firms that "go beyond compliance").

102. Although the technology-freezing characteristics of technology-based standards are viewed as one of its major disadvantages, the literature contains surprisingly little empirical support for that common wisdom. *See, e.g.*, GUNNINGHAM ET AL., *supra* note 7, at 45 (identifying dampened incentives for innovation in pollution control technologies as "one of the most serious failings of command and control" but citing no literature to support the point); Ackerman & Stewart, *supra* note 5, at 1336 n.8 (making the same assertion but citing only secondary literature that, when consulted, provides no empirical support for the observation); *see also supra* note 101 (listing studies that conclude that technology-based standards do not dampen incentives for technological innovation). By contrast, there does appear to be some empirical evidence suggesting that market-based approaches have not been successful in providing incentives for technological innovation in pollution control. *See, e.g.*, Driesen, *supra* note 6, at 313–22, 324–36 (detailing how the empirical literature calls into question whether various emissions trading programs have stimulated innovation and outlining additional, theoretical reasons why market-based approaches might not "provide an incentive for continuous environmental improvement"); Drury et al., *supra* note 53, at 277 (reporting that market prices in Los Angeles's RECLAIM market have been so low that companies have little to no incentive to "invest in innovative technology").

103. *See* 33 U.S.C. § 1311(k) (1994) (providing incentives under the Clean Water Act for sources to develop innovative technologies, including allowing the source engaged in promising innovations to delay compliance with uniform requirements for up to two years past the otherwise applicable deadline); *see also* GUNNINGHAM ET AL., *supra* note 7, at 45 n.32 (observing the documented success of Germany in using technology-based standards to "give incentives to companies to implement innovative and cutting edge environmental technologies"); *id.* at 49 (describing a Dutch program that provides incentives for going beyond compliance that could easily be retrofitted onto technology-based standards to improve the innovation-improving aspect of these standards); *id.* at 416-18 (describing avenues for creativity in providing positive incentives for firms to go beyond compliance). *But see* Ashford et al., *supra* note 101, at 446–59 (describing inadequacies of innovation waivers under the Clean Air Act and, to a lesser extent, the Clean Water Act and recommending how the waivers could be revised to be more effective).

104. *See* GUNNINGHAM ET AL., *supra* note 7, at 44 (observing that "command and control . . . is not as effective in dealing with transitory, mobile, and/or remote firms which are difficult to identify and keep track of"); Alvin L. Alm, *A Need for New Approaches: Command-and-Control Is No Longer a Cure-all*, EPA J., May/June 1992, at 7, 7–8 (arguing that command and control has outlived its usefulness).

many existing sources,[105] the Toxic Substances Control Act for pre-market testing requirements,[106] the Occupational Health and Safety Act for setting worker protection standards,[107] or the Comprehensive Environmental Response, Compensation, and Liability Act for standardized cleanup requirements (although they are used by some states).[108] Moreover, although technology-based standards do adapt easily to controlling pollution, there is nothing about them that limits their application to these important problems. Thinking more broadly about the standards reveals that they may translate surprisingly well into important areas of natural resources law, including specifying limitations on private party interference with endangered species[109] and providing a more predictable and constructive approach to conserving wetlands.[110] The potential breadth of their application only serves to further highlight their future contribution to environmental law and policy.

The most important criticisms may be those that suggest, directly or otherwise, that technology-based standards have not met their potential because of quirks in authorizing statutes,[111] agency implementation,[112] or

105. *See* Latin, *supra* note 6, at 1300 (agreeing that "uniform regulations would prove more effective than the current system of individualized air quality controls").

106. *See* ENVIRONMENTAL DEFENSE FUND, TOXIC IGNORANCE: THE CONTINUING ABSENCE OF BASIC HEALTH TESTING FOR TOP-SELLING CHEMICALS IN THE UNITED STATES 42–43 (1997) (advocating minimum screening of all chemicals under the Toxic Substances Control Act and recommending as one possible requirement the minimum screening criteria set by the Organisation for Economic Cooperation and Development).

107. *See* Shapiro & McGarity, *Reorienting OSHA*, *supra* note 13, at 45–50. Technology-based standards have been used for setting worker protection standards for toxics, however. *See* 29 U.S.C. § 655(b)(5) (1995); United Steelworkers v. Marshall, 647 F.2d 1189, 1202 (D.C. Cir. 1980), *cert. denied*, 453 U.S. 913 (1981).

108. *See supra* note 72.

109. The Safe Harbors program developed by the Fish and Wildlife Service may, in fact, be a variant of a technology-based standard. Under this program, a landowner who engages in land conservation measures that benefit endangered or threatened species can receive a permit that will allow him later to legally "take" species above background numbers under agreed-upon conditions. *See* J.B. Ruhl, *Who Needs Congress? An Agenda for Administrative Reform of the Endangered Species Act*, 6 N.Y.U. ENVTL. L.J. 367, 393–94 (1998) (describing the program). This program thus codifies, in the form of a permit, a landowner's agreement to engage in conservation measures (equivalent to best technology) provided the landowner can use those measures as shields against future enforcement actions under specified circumstances. Even more specific requirements for conservation measures (consistent with clear technology-based standards) can provide further consistency and predictability to both landowners and regulators.

110. *See* Oliver A. Houck, *Hard Choices: The Analysis of Alternatives Under Section 404 of the Clean Water Act and Similar Environmental Laws*, 60 U. COLO. L. REV. 773, 835–36 (1989) (recommending something akin to technology-based standards for determining whether there are viable alternatives to filling a wetland).

111. *See* La Pierre, *supra* note 18, at 812–18, 824 (reporting that much of the early litigation of the EPA's technology-based standards under the Clean Water Act concerned the EPA's authority under Congress's vague mandate and that much of the Agency's technical errors likely flowed from "the hurried manner in which the EPA was forced to develop regulations governing a vast number of industries employing a wide range of production processes"); Pedersen, *supra* note 5, at 85–86 (noting the costliness of the litigation regarding the EPA's authority to promulgate nationally binding technology-based standards under the Clean Water Act).

112. *See* Gaines, *supra* note 18, at 893 (concluding from the wet corn milling case study that the major defect in the EPA's standard-setting effort was "the failure of EPA decisionmakers to act upon

judicial review.[113] These criticisms tend to be drowned out in the comparative, often strawman-dependent debate of technology-based standards versus the universe of other regulatory tools.[114] Yet these criticisms are important to the future effectiveness of technology-based standards and more broadly to the future of environmental law. Critics are correct that technology-based standards should not eliminate concern for environmental quality, including the need to monitor ambient conditions,[115] but the standards need not do so. [116] Nor should technology-based standards dampen incentives for innovation in pollution control technologies, but this is not an inevitability either.[117] Some sources, because of size,

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the perception by some that the record EPA developed was insufficient to support the decision made" (footnotes omitted)); *cf.* La Pierre, *supra* note 18, at 821 (reporting that reviewing courts found that the EPA often failed to provide sufficient evidence of its standard or that the record contradicted the EPA's final standard in the EPA's first round of technology-based standards under the Clean Water Act).

113. *See* La Pierre, *supra* note 18, at 813–18 (describing a repeated split in the circuits regarding the EPA's statutory authority to set technology-based standards under the Clean Water Act); *cf.* Gaines, *supra* note 18, at 903–05 (recommending judicial review of the EPA's technology-based standards that defers to the Agency's technical expertise).

114. For example, William Pedersen's article on reform of the Clean Water Act is generally cited as an all-fronts attack on technology-based standards, even though he ultimately endorses technology-based standards as the best existing answer and offers valuable suggestions on ways in which the technology-based standard programs could be improved. *See* Pedersen, *supra* note 5, at 101.

115. *See id.* at 84–85 (criticizing technology-based standards under the Clean Water Act for precisely this reason, which made "water quality irrelevant to most regulatory decisions").

116. Although toxic pollutants are regulated in the first instance in the Clean Water and Clean Air Acts using technology-based standards, Congress also instituted in both statutes a parallel, largely unenforceable regulatory system in which discharge and emission standards should ultimately be based on science. In the Clean Water Act, if the water quality is degraded below levels that scientifically are deemed fishable or swimmable (or some higher classification set by the state), effluent limits for toxic water pollutants discharged by problem sources should be made more stringent than the applicable technology limitation. *See* 33 U.S.C. §§ 1313(c)(2)(B), 1314(*l*) (1994). In the Clean Air Act, the EPA is directed to research and set more stringent, science-based standards for specific air toxins where such protection is needed. *See* 42 U.S.C. § 7412(f)(2) ("[The] Administrator shall . . . promulgate [more protective] standards . . . if promulgation of such standards is required in order to provide an ample margin of safety to protect public health in accordance with this section . . . or to prevent, taking into consideration costs, energy, safety, and other relevant factors, an adverse environmental effect."). Under the Safe Drinking Water Act, Congress has instituted parallel technology and science-based standards, but the technology-based standards are only relied upon when economically or technologically necessary. *See id.* § 300g-1(b)(7)(A).

In cases where reductions beyond best technology are needed or presumed to be needed to adequately protect public health or the environment, these and still other types of secondary regulatory programs likely will prove essential. Professor Rose makes a compelling case for the use of markets or related property rights approaches in situations where reductions become extremely costly to make. *See* Rose, *supra* note 26, at 24, 26 (observing that "the 'best' control strategy depends on . . . how far we have traveled along the horizontal line of resource pressure," with property rights approaches working best when the resource pressure is greatest); *see also* Cole & Grossman, *supra* note 36, at 903 (concluding, based on a theoretical model, that market-based approaches tend to be more efficient than command and control when abatement costs are high and monitoring and enforcement costs are low). Professor Orts identifies the advantages of noninterventionist, "reflexive approaches" under somewhat similar circumstances—when administrative complexity has overwhelmed regulators and regulatees alike. *See* Orts, *supra* note 8, at 1340 (making a parallel but slightly different argument that reflexive approaches are most helpful as the "complexity of environmental problems . . . outstrip[s] the capacity of even the best scientists and scholars to solve environmental problems").

117. *See* ADLER ET AL., *supra* note 40, at 235 (recommending that in setting technology-based standards, the EPA should incorporate pollution-prevention goals to minimize the "toxic shell game"

age, or other factors, should not be competitively disadvantaged by technology-based standards, but this, too, can be largely avoided.[118] Finally, technology-based standards must not prevent flexible pollutant trading when regulatory realities and the environment do not pose defensible obstacles,[119] but this can also be circumvented with administrative creativity and continued experimentation.[120] Awareness of past pitfalls in the design of technology-based standards will ensure that these unnecessary errors are not repeated in the future. Indeed, there is ample evidence that we have already begun to learn from past mistakes.[121]

## IV. CONCLUSION: THE FUTURE

As our environmental laws turn thirty, we in the environmental law community have a great deal to celebrate. Our legal approaches remain among the best in the world and serve as the starting point for many other countries who endeavor to place restrictions on the use of their natural resources, including the land, air, and water.[122] Moreover, the astonishing volume and creativity of our legal activity provides a reason for great optimism about the future.

Yet in this future, it is important to recognize that, despite the wealth of legal activity, little has changed in the scientific understanding of how human activities affect the environment and public health. We have made only modest strides in understanding how ecosystems work and predicting how much stress they can tolerate.[123] And even though we may soon learn the complete coding of the human genome, we still understand very little about how perturbations to the human body (such as

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in which pollutants captured before they enter the receiving water, per Clean Water Act requirements, are simply transferred to another medium); *see also supra* note 103 and accompanying text.

118. *See supra* notes 29–31 and accompanying text.

119. *See* Pedersen, *supra* note 5, at 84 (criticizing the inflexibility of a technology-based standards program instituted under the Clean Water Act with regard to its receptiveness to the use of bubbles).

120. *See* GUNNINGHAM ET AL., *supra* note 7, at 47–49 (describing a variety of projects that supplement technology-based standards (e.g., Amoco, XL, and related projects implemented by the EPA) and succeed in lowering pollution through more flexible regulatory approaches); Ackerman & Stewart, *supra* note 5, at 1348 (discussing the success of the Clean Air Act bubble policy); Orts, *supra* note 8, at 1234 (describing a variety of reflexive approaches to environmental protection that could supplement and potentially ultimately replace command and control in some circumstances); Selmi, *supra* note 53, at 10,701, 10,710–11 (recommending emissions trading as a supplement to command and control and suggesting how technology-based controls and pollution markets can better work together based on his experience with the Los Angeles market).

121. *See supra* notes 103, 116.

122. *See* SUSAN ROSE-ACKERMAN, CONTROLLING ENVIRONMENTAL POLICY: THE LIMITS OF PUBLIC LAW IN GERMANY AND THE UNITED STATES 18 (1995) (observing that "American [environmental] laws have had a measurable impact on the environment and are frequently used as models for reform proposals in the European Union and the new states of eastern Europe").

123. The recent paradigm shift in theoretical ecology demonstrates in part how primitive this science is. *See, e.g.*, William H. Rodgers, Jr., *Adaptation of Environmental Law to the Ecologists' Discovery of Disequilibria*, 69 CHI.-KENT L. REV. 887, 887 (1994) (discussing how the "'new ecology' . . . revolution in thinking has undermined a legal superstructure that was built on a reality now exposed as nine parts myth").

exposure to man-made chemicals) can be expressed years or decades later as reproductive, neurological, or mutagenic harms.[124] Asymmetries in information, where sources know far more (often in protected ways) than consumers, only further exacerbate these uncertainties.[125]

Conditions continue to be ripe for using technology-based standards, and they are unlikely to change soon. Even if they do, technology-based standards can be fine-tuned with a variety of secondary regulatory strategies such as ambient-based controls, markets, or other incentive-based approaches. Although it may be tempting and is certainly human to ignore these realities in the excitement over new ways of doing things, it is unwise to forget the advances in pollution control that technology-based standards have made possible. They have succeeded where others have failed. Since we have not yet outgrown or exhausted the benefits that can be achieved by using this most simple and trustworthy of our environmental tools, I am hopeful that we will not forget them in our rush to be innovative.

124. *See* Jocelyn Kaiser, *Showdown over Clean Air Science*, 277 SCIENCE 466, 469 (1997) (discussing the difficulties researchers have in understanding why particle concentrations equivalent to those found in polluted cities cause arrythmias in dogs under specific experimental conditions); *see also* Wagner, *supra* note 10, at 1618–27 (detailing uncertainties in science in predicting the effects of toxins).

125. *See generally* Carl F. Cranor, *Asymmetric Information, the Precautionary Principle, and Burdens of Proof*, *in* PROTECTING PUBLIC HEALTH & THE ENVIRONMENT, *supra* note 33, at 74, 77–82 (describing layers of asymmetries in information with regard to learning about the safety of toxic chemicals).