THE MISSING INSTRUMENT: DIRTY INPUT LIMITS

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This Article evaluates Dirty Input Limits ("DILs"), quantitative limits on the inputs that cause pollution. An environmental protection instrument that the literature has hitherto largely overlooked, DILs provide an alternative to cumbersome output-based emissions trading and performance standards. DILs have played a role in some of the world's most prominent environmental success stories. They have also begun to influence climate change policy because of the impossibility of imposing an output-based cap on transport emissions. We evaluate DILs' administrative advantages, efficiency, dynamic properties, and capacity to better integrate environmental protection efforts. DILs, we show, not only have significant advantages that make them a good policy tool, they also help us to fruitfully reconceptualize environmental law in a more holistic fashion.

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In recent debates about how best to design regulatory mechanisms to stem global warming, a previously unrecognized regulatory instrument has begun to emerge. But we have yet to recognize it as such — to give it a name or appreciate its implications for environmental law. Once we name and define this seemingly new instrument, we will see that, in a certain sense, it is not new at all. Although the academic literature has largely overlooked it, it has for decades lain hidden in plain sight, playing a key role in some of environmental law's most significant success stories. This Article aims to shine a light on this previously unrecognized instrument: to tell the story of its successes, evaluate its features, and discuss its future prospects.

After decades of experience in designing regulatory instruments to combat various forms of environmental degradation, the discussion still largely revolves around a single dimension of the problem: the choice between traditional regulation — often called "command-and-control" — and market-based mechanisms, like pollution taxes and emissions trading.[1] But designing regulatory instruments to address environmental ills presents another important choice as well: the choice between outputs and inputs. Virtually all of our existing environmental regulation, whether traditional or market-based, focuses on polluting processes' *outputs.* Traditional regulation requires each pollution source to meet the output limit in its permit, while market-based trading schemes allow polluters to trade permits so that a polluter facing high control costs can pay a polluter with low control costs to make extra reductions in her stead.[2] Both methods limit outputs.

Governments, however, can also reduce pollution by reducing or changing inputs. To reduce automobile air pollution, for example, we can

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[1] *See, e.g.*, David M. Driesen, *Is Emissions Trading an Economic Incentive Program? Replacing the Command and Control/Economic Incentive Dichotomy*, 55 Wash. & Lee L. Rev. 289, 290-91 (1998) (explaining that scholars employ a "conventional dichotomy" contrasting "command and control regulation . . . with economic incentives"); Robert Stavins, *Market-Based Environmental Policies: What Can We Learn from U.S. Experience (and Related Research)?*, *in* Moving to Markets in Environmental Regulation: Lessons From Twenty Years of Experience 19 (Jody Freeman & Charles D. Kolstad eds., 2007) (distinguishing market-based approaches from conventional approaches "frequently characterized as command-and-control approaches"); Peter Bohm & Clifford S. Russell, *Comparative Analysis of Alternative Policy Instruments*, *in* 1 Handbook of Natural Resource and Energy Economics 395 (Alan V. Kneese & James L. Sweeney eds., 1985); Nathaniel O. Keohane, Richard L. Revesz & Robert N. Stavins, *The Choice of Regulatory Instruments in Environmental Policy*, 22 Harv. Envtl. L. Rev. 313 (1998); Jonathan Baert Wiener, *Global Environmental Regulation: Instrument Choice in Legal Context*, 108 Yale L.J. 677, 679 (1999); Bruce A. Ackerman & Richard B. Stewart, *Reforming Environmental Law*, 37 Stan. L. Rev. 1333 (1985).

[2] *See, e.g.*, Driesen, *supra* note 1, at 290; J. H. Dales, Pollution, Property and Prices 92-100 (1968).

limit the *output* of exhaust coming out of the tailpipe or the *input* of gas going into the engine. While we have traditionally focused vehicle regulation primarily on the exhaust output, designing regulation to stem global warming poses challenges for that model. Accordingly, some of those designing climate change regulation have begun to shift away from the usual focus on outputs. A number of proposals for climate change regulation, including the Lieberman-Warner Climate Security Act pending in Congress as of this writing, address the transportation sector by imposing a quantitative cap on the carbon content of fossil fuels that refineries and importers introduce into the economy.[3] This represents a fundamental shift in focus from outputs to inputs.

Although it has yet to be recognized as such, a quantitative cap on the carbon content of fossil fuels is an example of a distinct and underused type of regulatory instrument with far-reaching implications both within the climate change context and beyond. We call this new instrument "Dirty Input Limits" ("DILs"). DILs are regulatory limits on the inputs that constitute the root causes of pollution. They can take the form of traditional performance standards, requiring each producer or importer of a dirty input to keep production levels within the limits in its permit, or they can be made tradable, allowing a firm to produce more than the limit allows if it pays another firm to produce less than the limit. We argue below that DILs offer an important alternative to output-focused regulation, and that policy makers should consider this alternative in tackling serious environmental problems requiring fundamental change. Because they have the capacity to simultaneously reduce multiple sources of environmental degradation along a production stream and to spur fundamental technological innovation, DILs offer significant advantages over existing regulation in many contexts. They also have the capacity to spark a reconceptualization of environmental law away from the fragmented, pollutant-by-pollutant approach that now dominates the field.

Part I introduces DILs. Part II analyzes DILs' advantages and disadvantages. Part III articulates some conclusions about DILs' potential role in improving environmental law, using the example of a DIL limiting oil use to illustrate how DILs can offer advantages over existing output-based regulation. Used to limit fossil fuels, DILs offer a streamlined and effective regulatory tool for addressing global climate change, while simultaneously achieving a host of other important policy goals as well.

I. DILs: An Introduction

We begin this Part by distinguishing between two fundamentally different means that polluters can employ to reduce pollution outputs: "end-of-the-pipe controls," which reduce pollution at the end of the production pro-

[3] *See infra* note 72 and accompanying text (addressing the issue of imposing a cap on the carbon content of fossil fuels).

cess, and "pollution prevention," which reduces pollution by reducing or eliminating inputs. We then go on to show that even though policy makers and scholars have consistently stated a preference for pollution prevention, environmental law generally regulates pollution outputs, rather than the inputs that create pollution. We then describe how DILs offer an alternative regulatory instrument that prevents pollution by limiting inputs. Finally, we tell the story of how DILs, while not recognized as a distinct regulatory instrument, have already produced some of our most conspicuous environmental success stories.

A. Inputs, Outputs, and Production Streams

Production usually creates two outputs: a desired product or service and an unsought byproduct, pollution. Driving a car, for example, produces a desirable output, mobility, but also creates air pollution outputs as byproducts. Similarly, a coal-fired power plant releases air pollution as an output through its smokestack as a byproduct of the production of a desirable output, electricity.

A production process creates these outputs by using and often transforming inputs — the gasoline that makes a car's engine run or the coal a power plant burns, for example. The character and quantity of pollution outputs depends heavily upon the nature and quantity of these inputs. The use of unleaded gasoline eliminates lead pollution from a car's exhaust, and the use of low-sulfur coal reduces sulfur dioxide from a power plant's emissions. Moreover, a single input usually produces several different pollution outputs, often in several media. For example, a pulp and paper plant using chlorine as an input produces a variety of water and air pollution outputs.[4]

Polluters can reduce or eliminate pollution outputs in two fundamentally different ways:

1) **End-of-the-Pipe Controls**: Under this method the polluter does not change its inputs or production processes. Thus, it does not reduce the amount of pollution initially created. Instead, the polluter adds on some device — like a catalytic converter, a smokestack scrubber, or a carbon sequestration process — at the end of the production process to reduce the amount of pollution actually released into the environment.
2) **Pollution Prevention**: Polluters can reduce or change inputs in order to reduce or eliminate the initial creation of pollution. Changing or reducing inputs may require moderate or radical changes to the production process itself.

[4] *See* EPA Guidelines and Standards for Pulp, Paper, and Paperboard Category and Pulp and Paper Production, 58 Fed. Reg. 66,078, 66,092, 66,101-02 (Dec. 17, 1993) (describing toxic pollutants discharged into air and water from pulp and paper mills as a result of chlorine use).

> An electric utility, for example, might reduce sulfur dioxide emissions from its coal plant by substituting low-sulfur coal inputs for high-sulfur coal. Alternatively, it might eliminate pollution outputs altogether through a radical alteration of the electricity production process — replacing the coal-fired power plant with a field of wind turbines.

Both academics and policymakers have long favored pollution prevention over end-of-the-pipe controls.[5] For one thing, the literature recognizes that end-of-the-pipe controls sometimes achieve pollution reductions in one medium, in part, by transferring the pollution problem to another medium. Pollution controls that municipal waste combustors use to limit air pollution, for example, often produce a toxic fly ash that can present solid waste disposal problems.[6]

Additionally, end-of-the-pipe controls focus on one type of output into a single medium at a time. Hence, effectively controlling all relevant pollution outputs using end-of-the-pipe controls often requires the installation of multiple devices for different types of pollution. This can involve significant expense and spawn fragmented decision-making.

By contrast, pollution prevention can eliminate many different types of pollution in several different media simultaneously.[7] For example, diminishing the amount of gasoline input a vehicle uses reduces hazardous air pollutants associated with cancer,[8] pollutants associated with smog,[9] carbon dioxide causing global warming,[10] and oil runoff causing water pollution.[11] Furthermore, pollution prevention often saves operators money either in ab-

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[5] *See, e.g.*, Kurt A. Strasser, *Cleaner Technology, Pollution Prevention and Environmental Regulation*, 9 Fordham Envtl. L.J. 1 (1997) (cataloguing pollution prevention's advantages); Nat'l Sci. & Tech. Council, Bridge to a Sustainable Future: National Environmental Technology Strategy 4, 8 (1995) (praising a shift in environmental policy from end-of-the-pipe technology to pollution "avoidance").

[6] *See* City of Chicago v. Envtl. Def. Fund, 511 U.S. 328, 330 (1994) (explaining that incineration of solid waste produces ash); U.S. Envtl. Prot. Agency ("EPA"), Pub. No. EPA-530-R-99-052, Introduction to Hazardous Waste Incinerators 2-3 (2000) (discussing how air pollution controls generate fly ash).

[7] *See* Strasser, *supra* note 5, at 7, 45-46.

[8] *See* Joan Leary Matthews & Louise G. Roback, *California Cruisin' — New York's Adoption of California's Vehicle Emissions Program*, Alb. L. Envtl. Outlook, Summer 1998, 36, 36 (pointing out that vehicle emissions account for over half the cancer risk from toxic pollution in New York urban areas); John Hiski Ridge, Comment, *Deconstructing the Clean Air Act: Examining the Controversy Surrounding Massachusetts's Adoption of the California Low Emission Vehicle Program*, 22 B.C. Envtl. Aff. L. Rev. 163, 167 (1994) (pointing out that mobile sources are the nation's largest source of cancer-causing toxic emissions).

[9] *See* Matthews & Roback, *supra* note 8, at 36 (stating that automobiles account for over half of New York's volatile organic compound and nitrogen oxide emissions).

[10] *See* Michael P. Vandenbergh, *From Smokestack to SUV: The Individual as Regulated Entity in the New Era of Environmental Law*, 57 Vand. L. Rev. 515, 542 n.94 (2004) (citing Office of Air & Radiation, EPA, Pub. No. EPA 420-F-00-013, Emissions Facts 2 (2000)) (quantifying the average annual per-vehicle emissions of carbon dioxide).

[11] *See* Storm Water Discharges, 64 Fed. Reg. 68,722, 68,725 (Dec. 8, 1999) (explaining that pollution runoff from vehicles is a significant source of water pollution).

solute terms or relative to the costs of end-of-the-pipe controls.[12] Thus, the conventional account favors pollution prevention — the reduction or elimination of dirty inputs. Indeed, Congress implicitly endorsed this account in 1990 when it passed the Pollution Prevention Act,[13] which declared a national policy favoring pollution prevention.[14]

Yet the conventional account has both exaggerated and underplayed the benefits of pollution prevention. The conventional account may have exaggerated pollution prevention's benefits by suggesting that it is always cheap.[15] As we explain in Part II, pollution prevention can sometimes prove more expensive than end-of-the-pipe controls, at least vis-a-vis a single polluting output.[16] But the conventional account has also tended to understate some of the most far-reaching and important advantages of pollution prevention. We highlight these under-appreciated advantages here.

As noted above, pollution prevention produces significant advantages over end-of-the-pipe controls because it reduces multiple polluting outputs simultaneously.

This occurs not only because a single production process may produce more than one pollution output, but also because reducing an input may reduce a whole series of pollution outputs from multiple production processes all along a production stream.[17] This feature of pollution prevention arises from inputs' place in a production stream. Inputs consist of either raw materials, such as coal, or manufactured products, such as gasoline. Hence, a given input in one production process must either be the product of some previous production process (e.g., gasoline) or the result of extraction of a natural resource (e.g., crude oil). Inputs can thus be visualized as flow-

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[12] *See, e.g.*, Fully Halogenated Chlorofluoroalkanes, 42 Fed. Reg. 24,542, 24,544 (May 13, 1977) (codified at 40 C.F.R. pts. 712, 762) (predicting $58 to $240 million in consumer cost savings from switching from fully halogenated chlorofluoroalkanes as aerosol propellants to other products).

[13] Pollution Prevention Act of 1990, Pub. L. No 101-508, §§ 6601-6610, 104 Stat. 1388, 1388-321 to 1388-327 (codified at 42 U.S.C. §§ 13,101-13,109 (2000)).

[14] In this statute, Congress found "significant opportunities" to "prevent pollution at the source through cost-effective changes in production, operation, and raw materials use." 42 U.S.C. § 13,101(a)(2) (2000). Accordingly, Congress declared a "national policy" that "pollution should be prevented or reduced at the source wherever feasible." *Id.* § 13,101(b). It declared pollution prevention preferable to recycling, end-of-the-pipe "treatment" and release of pollutants into the environment. *Id.*; *see also id.* § 13,102(5) (defining "source reduction").

[15] *See* Michele Ochsner, *Pollution Prevention: An Overview of Regulatory Incentives and Barriers*, 6 N.Y.U. ENVTL. L.J. 588, 590-91 (1998).

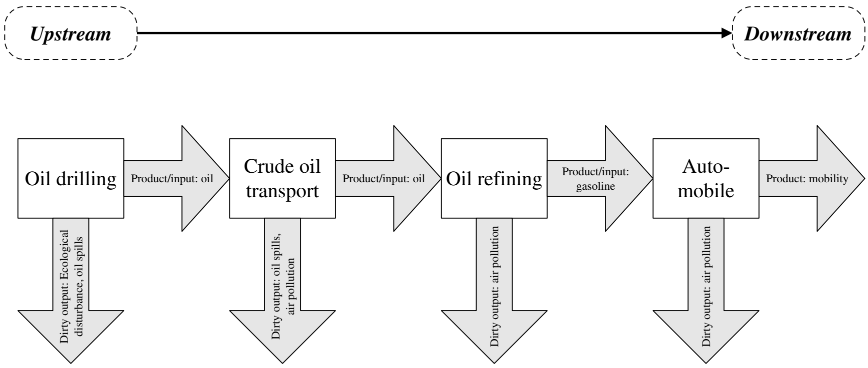
[16] *See infra* notes 138-149 and accompanying text.

[17] A fairly extensive literature on Life Cycle Analysis ("LCA") looks at production streams in a similar way, attempting to describe (usually in quantitative terms) all of the resources used and pollution emitted throughout the life cycle of some product, from resource extraction to manufacture to product disposal. *See* Anthony D. Owen, *The Transition to Renewable Energy*, *in* THE ECONOMICS OF CLIMATE CHANGE 259, 262-63 (Anthony D. Owen & Nick Hanley eds., 2004); Margaret Walls & Karen Palmer, *Upstream Pollution, Downstream Waste Disposal, and the Design of Comprehensive Environmental Policies* (Res. for the Future, Discussion Paper 97-51-REV, 2000); *see also* Peter S. Menell, *Structuring a Market-Oriented Federal Eco-Information Policy*, 54 MD. L. REV. 1435, 1458-59 (1995) (arguing that cost and data limitations require LCA analysts to rely on numerous simplifying assumptions which make LCA highly manipulable in practice).

ing along a production stream from an upstream extraction of a natural resource to a downstream end-use. We will refer to processes closest to the natural-resources-extraction end of these production streams as "upstream" and those processes closest to consumption as "downstream."[18]

We can visualize the production of automobile mobility, for example, as a stream, beginning with the extraction of crude oil, ending with the burning of gasoline in a car's engine to produce mobility, and producing a series of dirty outputs along the way.

FIGURE 1: THE AUTOMOBILE MOBILITY PRODUCTION STREAM



A drilling process produces oil, which the producer ships to a refiner. Both the drilling process and the shipping process create pollution, but they also deliver a useful product, oil, which becomes the input for another process, oil refining. The oil refiner takes oil as an input and creates more pollution, consisting mostly of hazardous organic compounds of various kinds, but also a product, gasoline.[19] And then the gasoline becomes an input into a car, which produces yet more pollution, and a really useful output, mobility.

Imposing end-of-the-pipe controls on the pollution produced by automobiles addresses only one of the many sets of dirty outputs associated with the oil/automobile mobility production stream. Reducing inputs at any point along the stream, on the other hand, constricts the flow through the entire stream and thereby reduces not only the dirty output associated with the particular production process at issue, but a whole series of dirty outputs all along the stream.[20]

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[18] *See infra* figs.1 & 2.

[19] *See* Andrew P. Morriss & Nathaniel Stewart, *Market Fragmenting Regulation: Why Gasoline Costs So Much (and Why It's Going to Cost More)*, 72 BROOK. L. REV. 939, 957-62 (2007) (describing the evolution of oil refining).

[20] *See, e.g.*, Ozone-Depleting Chlorofluorocarbons; Proposed Production Restriction, 45 Fed. Reg. 66,726, 66,730-31 (Oct. 7, 1980) [hereinafter 1980 CFC Proposal] (explaining that a production restriction would create price increases that would induce users to switch to other substances, implying a reduction in their use in various manufacturing processes and in consumption).

In this way input reductions have a multiplier effect. If we reduce the amount of gasoline going into every car, we will do more than simply reduce the amount of exhaust coming out of each tailpipe. We will also reduce the pollution and ecological disturbance caused by oil drilling,[21] transporting oil (air pollution from loading oil tankers and potential for oil spills),[22] oil refining,[23] and leaking storage tanks in gas stations.[24]

Similarly, if we reduce (or eliminate) the coal going into each power plant, we do more than simply reduce the amount of air pollution coming out of power plant smoke stacks. We reduce the number of coal miners killed or injured by mining, the ecological devastation and water pollution caused by coal mining, and the pollution from processing and transporting coal.[25]

The production stream associated with the coal input to coal-fired power plants can be visualized as follows:

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[21] *See* U.S. Comm'n on Ocean Policy, An Ocean Blueprint for the 21st Century: Final Report 361-64 (2004), *available at* http://www.oceancommission.gov/documents/full_color_rpt/000_ocean_full_report.pdf (describing the environmental harms associated with offshore oil drilling).

[22] *See* Margriet F. Caswell, *Balancing Energy and the Environment*, *in* The Environment of Oil 179, 182-85 (Richard J. Gilbert ed., 1993) (describing impacts of oil transport on "air, water, and biological resources").

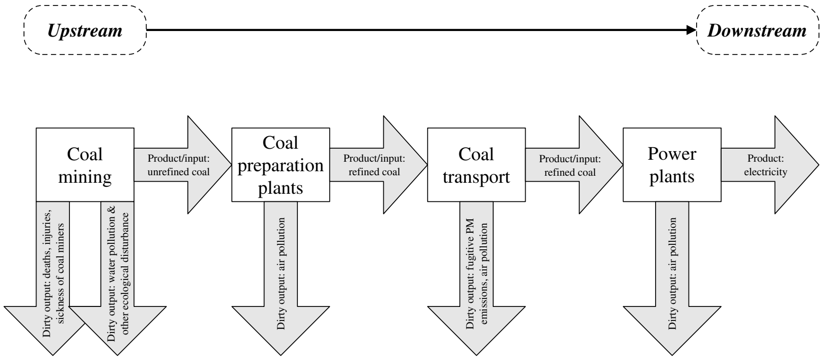
[23] *See* Office of Compliance, EPA, EPA/310-R-95-013, Profile of the Petroleum Refining Industry 42-57 (1995), *available at* http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/petrefsn.pdf (summarizing TRI data on pollution releases from oil refineries).

[24] *See* Use of MTBE as a Fuel Additive to Gasoline, 65 Fed. Reg. 16,094, 16,100-03 (Mar. 24, 2000) [hereinafter MTBE Proposed Ban] (explaining that a ban on MTBE might be necessary because governments have not been able to prevent oil spills and gasoline leaks despite extensive regulation).

[25] *See* Fred Bosselman, *The Ecological Advantages of Nuclear Power*, 15 N.Y.U. Envtl. L.J. 1, 24-37 (2007) (discussing coal's impacts on human health and the environment); Erik Reece, Lost Mountain: A Year in the Vanishing Wilderness (2006) (discussing mountaintop-removal mining's environmental impacts).

Limited DILs may have limited multiplier effects. A DIL limiting the use of high-sulfur coal would reduce the impacts that mining high-sulfur coal has on health and the environment. But it would increase impacts from mining low-sulfur coal, just as the acid-rain program did. A DIL limiting coal use altogether would have broader positive ripple effects on mining's impact on health and the environment.

FIGURE 2: THE COAL-FIRED POWER PLANT PRODUCTION STREAM



Some of the assumptions used in economic modeling suggest that end-of-the-pipe controls can have some of the same ripple effects that pollution prevention measures have up and down the production stream. We might, for example, predict that requiring installation of catalytic converters in automobiles would raise the price of cars and therefore reduce the amount people drive. If this end-of-the-pipe control reduced driving, it would ultimately reduce oil and gasoline consumption just as a pollution-prevention measure would. But the mechanism by which pollution prevention creates ripple effects through the production stream is fundamentally different from the mechanism by which end-of-the-pipe controls might do so. Pollution prevention's ripple effects arise from physical flows, not unpredictable economic incentives.[26]

Furthermore, for a number of reasons, end-of-the-pipe controls rarely produce the consumption changes that economists sometimes posit in modeling environmental policy instruments' efficiency. First of all, the increased cost of an end-of-the-pipe control may never reach the consumer.[27] While producers certainly will want to pass the increased cost associated with pollution control on to consumers, in highly competitive markets they may worry about lost sales and keep prices constant.[28] Second, even if the cost

[26] *Cf.* J. L. Lewin, *Energy and Environmental Policy Options To Promote Coalbed Methane Recovery*, *in* PROCEEDINGS OF INTERGAS '95 — INTERNATIONAL UNCONVENTIONAL GAS SYMPOSIUM 497-508 (1995) (doubting that coal-mining firms will respond to emission fees as vigorously as economic models would predict) (on file with Harvard Environmental Law Review); Margrethe Aune, *Energy Comes Home*, 35 ENERGY POL'Y 5457 (2007) (arguing that home energy consumption does not conform to a rational economic actor model); Kevin Maréchal, *The Economics of Climate Change and the Change of Climate in Economics*, 35 ENERGY POL'Y 5181, 5183 (2007) (discussing overwhelming evidence that consumers neglect cost-saving energy efficiency measures).

[27] *Cf.* Anna-Lisa Lindén, Annika Carlsson-Kanyama & Björn Eriksson, *Efficient and Inefficient Aspects of Residential Energy Behaviour: What Are the Policy Instruments for Change?*, 34 ENERGY POL'Y 1918, 1923 (2006) (noting that Swedish apartment dwellers keep their dwellings hotter than homeowners do because the homeowners bear the incremental cost of additional energy use, but the apartment dwellers do not).

[28] *See, e.g.*, Prohibition on Use of Chlorofluorocarbons as Propellants in Self-Pressurized Containers, 43 Fed. Reg. 11,299, 11,310 (Mar. 17, 1978) (predicting that cosmetic and chemi-

reaches the consumer, the consumer may simply pay the cost rather than decrease consumption.[29] For some consumers, driving is a practical necessity and they will find other ways of cutting costs if forced to absorb increased costs when buying a new car. The large increase in vehicle miles traveled since the introduction of catalytic converters suggests that one should not assume that an absolute decrease in consumption will necessarily result from any minor cost increase, even though consumers have driven less when prices have doubled.[30] End-of-the-pipe controls will only rarely produce the kinds of ripple effects up and down the production stream that pollution prevention measures will reliably produce.

B. The Anatomy of Pollution Control Mechanisms

The vast majority of our mandatory environmental regulations focus on pollution outputs rather than production inputs.[31] This is perhaps understandable, since it is pollution outputs that proximately cause harm. To the extent the U.S. government has focused on inputs, it has usually done so through voluntary programs.[32] For example, the Environmental Protection Agency ("EPA") has created a 33/50 program, where chemical companies volunteer to reduce priority toxic pollutants through pollution prevention, such as process changes that reduce the use of a priority toxic pollutant as a feedstock.[33]

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cal firms phasing out ozone-depleting substances will not be able to pass on cost increases to consumers because doing so will produce market-share losses). Economists use a property known as price elasticity to describe this possibility. If producers can raise prices without losing sales, economists describe the price as inelastic. When the prices are inelastic, economic models predict that producers will pass on cost increases to consumers. When raising prices will reduce sales, economists describe the price as elastic. Elastic prices may force producers to refrain from passing cost increases on to consumers through raised prices. *See* Paul A. Samuelson & William D. Nordhaus, Economics 33-73, 77 (18th ed. 2005).

[29] *See generally* David B. Goldstein, Saving Energy: Growing Jobs 154-72 (2007) (discussing reasons that markets often do not produce economically rational decisions).

[30] *See Implementation of Corporate Average Fuel Economy (CAFE) Standards: Hearing Before the Subcomm. on Energy and Power of the H. Comm. on Commerce*, 104th Cong. 7 (1995) (statement of Barry Felrice, Associate Administrator for Safety Performance Standards, National Highway Traffic Safety Administration ("NHTSA")) (stating that vehicle miles traveled increased by sixty percent between 1975 and 1993).

[31] The Clean Air Act ("CAA") imposes limits on emissions from smokestacks, 42 U.S.C. § 7411 (2000) (New Source Performance Standards), and tailpipes, *id.* § 7521, and the Clean Water Act imposes limits on effluent from outfall pipes and other water pollution outputs, 33 U.S.C. § 1311(a) (2000). Two exceptions to this focus on outputs are the Toxic Substances Control Act of 1976 ("TSCA"), 15 U.S.C. §§ 2601-2692 (2000), which authorizes EPA to ban or limit the production of toxic substances, and the Federal Insecticide, Fungicide, and Rodenticide Act Amendments of 1972 ("FIFRA"), 7 U.S.C. §§ 136-136y (2000), which authorizes EPA to ban the sale of or limit use of pesticides. Both of these statutes, however, have produced remarkably little regulation by EPA. *See* Thomas O. McGarity, *Professor Sunstein's Fuzzy Math*, 90 Geo. L.J. 2341, 2343 (2002).

[32] *See* Ochsner, *supra* note 15, at 598-601; Robert F. Blomquist, *Government's Role Regarding Industrial Pollution Prevention in the United States*, 29 Ga. L. Rev. 349 (1995).

[33] *See* Timothy T. Jones, Walter G. Wright, Jr. & Mary Ellen Ternes, *Environmental Compliance Audits: The Arkansas Experience*, 21 U. Ark. Little Rock L. Rev. 191, 236 (1999).

The mandatory output-based regulation that currently dominates U.S. environmental law falls into four fundamental categories: (1) work practice standards; (2) performance standards; (3) pollution taxes; and (4) environmental trading schemes. Work practice standards dictate the use of specific technologies to control pollution outputs.[34] Such a regulation might, for example, require the installation of catalytic converters in automobiles, or require the installation of scrubbers in coal-fired power plants.[35] Performance standards require a particular level of pollution reduction without directly dictating technological choices.[36] A performance standard would require that emissions from a tailpipe or a smoke stack not exceed a particular limit, but give the car manufacturer or the power plant operator discretion as to how to meet that limit. Pollution taxes simply require a polluter to pay a set fee to the government for each unit of pollution she produces.[37] Environmental trading schemes, like emissions trading, establish performance standards, but allow each polluter to exceed the limit set for his own facility if he pays somebody else to reduce in his stead.[38] Under such a scheme, polluters with low pollution control costs have an incentive to reduce pollution levels and sell excess permits to producers with high pollution control costs.[39] In this way, polluters deliver a given amount of aggregate pollution reduction at the lowest cost.[40]

Scholars frequently frame debates about these regulatory mechanisms in terms of a conventional dichotomy between "command-and-control" reg-

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[34] *See, e.g.*, Bohm & Russell, *supra* note 1, at 444; Adamo Wrecking v. EPA, 434 U.S. 275, 287, 294-95 (1978) (discussing a work practice standard requiring wetting down of buildings during demolition to avoid asbestos emissions); *cf.* 42 U.S.C. §§ 7411(h)(3), 7412(h)(3) (authorizing EPA to approve adequately demonstrated substitutes for the compliance technique required by its regulations). The provisions in the environmental statutes authorizing work practice standards allow for a wide variety of techniques, including pollution prevention. *See, e.g.*, 42 U.S.C. §§ 7411(h)(1), 7412(h)(1). But the agencies usually focus on output controls in practice.

[35] *Cf.* Driesen, *supra* note 1, at 298 & n.50 (showing that pollution control law disfavors work practice standards). In fact, the EPA regulations that encouraged installation of catalytic converters and scrubbers took the form of performance standards. *See id.* at 300-301; 42 U.S.C. § 7521(g). These are stylized examples to make the point clear.

[36] *See* Driesen, *supra* note 1, at 297-98; Robert W. Hahn & Robert N. Stavins, *Incentive-Based Regulation: A New Era for an Old Idea?*, 18 Ecology L.Q. 1, 5-6 (1991) (describing performance standards as identifying a "specific goal" without specifying the means the firm must use to meet the goal); Richard B. Stewart, *Regulation, Innovation, and Administrative Law: A Conceptual Framework*, 69 Cal. L. Rev. 1259, 1268 (1981) (recognizing that performance standards allow firms to choose the cheapest method of achieving compliance).

[37] *See* Stavins, *supra* note 1, at 21 (describing a pollution tax as assessing a charge on the amount of pollution that a firm or other source generates).

[38] *See* Driesen, *supra* note 1, at 290 & n.2 (describing trading as allowing "polluters to avoid pollution reductions at a regulated pollution source," if they pay for or make "equivalent reductions elsewhere"); David A. Malueg, *Emission Credit Trading and the Incentive to Adopt New Pollution Abatement Technology*, 16 J. Envtl. Econ. & Mgmt. 52, 52 (1989).

[39] *See* Stavins, *supra* note 1, at 22 (stating that firms reducing their emission below allotted levels can sell "surplus permits" to other firms).

[40] *Id.* ("[T]radable permits — in theory — can achieve the same cost-minimizing allocation of the control burden as a charge system.").

ulation and "market-based mechanisms."[41] Writers often lump work practice and performance standards together under the pejorative term, "command-and-control regulation" (a term that sounds like a reference only to work practice standards) while they laud pollution taxes and emissions trading schemes as exemplars of a more modern and enlightened "market-based" approach.[42] To avoid confusion and misleading pejorative terminology, we use the term "traditional regulation" to refer to both performance standards and work practice standards, rather than the term "command-and-control regulation."

As noted above, all of these regulatory mechanisms — whether traditional or market-based — focus on the reduction of pollution outputs rather than inputs.[43] Nonetheless, with the exception of work practice standards, all of these mechanisms give polluters discretion to choose how to reduce those outputs.[44] Accordingly, under a scheme of pollution taxes, emissions trad-

[41] In fact, this distinction is overdrawn. *See* Driesen, *supra* note 1, at 299. Traditional command-and-control regulation also operates by way of economic incentives. Regulated entities comply with government rules precisely because they have an economic incentive to do so in the form of fees or penalties that will be assessed for noncompliance. *Id.* at 323. Conversely, so-called economic incentive programs also depend on government command to a substantial degree — the command to pay a tax at a certain rate or to refrain from polluting without a permit. *See, e.g.*, *id.* at 324 (explaining that an emissions trading program relies on government commands limiting emissions); Amy Sinden, *The Tragedy of the Commons and the Myth of a Private Property Solution*, 78 U. Colo. L. Rev. 533 (2007) (criticizing the distinction and offering an alternative typology); Lesley K. McAllister, *Beyond Playing "Banker": The Role of the Regulatory Agency in Emissions Trading*, 59 Admin. L. Rev. 269, 274 (2007) (describing agency decisions about emission caps as a "basic component" of trading). Moreover, the common assertion that our current constellation of federal environmental statutes relies primarily on command-and-control regulation is overstated. Most current regulation actually takes the form of performance standards, which do not "command" the use of any particular technology, but rather specify the level of environmental performance that must be met to avoid penalties, leaving the choice of method of compliance to the individual firm. Driesen, *supra* note 1, at 297-98; *see, e.g.*, 42 U.S.C. § 7411(a)(1) (2000) (defining "standard of performance" as "a standard for emissions of air pollutants which reflects the degree of emission limitation achievable through the application of the best system of emission reduction which . . . [EPA] determines has been adequately demonstrated"); *see also* PPG Indus., Inc. v. Harrison, 660 F.2d 628, 636 (Former 5th Cir. 1981) (explaining that CAA standards of performance must be "established only in the form of emissions limitations based on output, and not in the form of work practice or operation requirements."). In some instances, where emissions are difficult to monitor, regulations impose work practice standards, which dictate the use of specific pollution control technologies, but such standards are the exception rather than the rule. Driesen, *supra* note 1, at 299.

[42] *See, e.g.*, Keohane et al., *supra* note 1, at 313-14; Wiener, *supra* note 1, at 679; Ackerman & Stewart, *supra* note 1.

[43] *See* Gloria E. Helfland, *Controlling Inputs To Control Pollution: When Will It Work?*, AERE Newsl. (Ass'n of Envtl. & Res. Economists, Wash., D.C.), Nov. 1999, at 13, 14 (stating that the "theory of pollution taxes and permits has been developed primarily" in terms of emissions or damages, rather than inputs).

[44] Ethyl Corp. v. EPA, 541 F.2d 1, 11 n.14 (D.C. Cir. 1976) (en banc) observing that output regulation leaves "[t]he method for achieving the required result . . . entirely in the hands of the manufacturers"). In fact, even work practice standards offer some limited flexibility. The provisions authorizing them direct EPA to accept alternative technologies that perform as well as the technology required by a work practice standard. *See, e.g.*, 42 U.S.C. § 7411(h)(3). But since EPA employs these standards when measurement is not feasible, *see, e.g.*, *id.* § 7411(h)(1)-(2), such a demonstration may often prove difficult in practice.

ing, or performance standards, a producer can choose to achieve pollution output limits (or avoid pollution taxes) by limiting inputs through pollution prevention measures rather than installing end-of-the-pipe technologies.[45] Under this approach, the decision to choose pollution prevention over end-of-the-pipe controls is purely voluntary. Polluters will presumably limit inputs when such an approach offers a cheaper option than end-of-the-pipe controls for meeting a pollutant-specific output limit or avoiding a pollutant-specific tax.

C. Locating the Missing Instrument

While the vast literature on regulatory instrument choice has generally focused on different ways of regulating outputs and paid little attention to the alternative of regulating inputs, some of the economic literature on pollution taxes has obliquely addressed this idea by focusing on the choice between upstream and downstream taxes.[46] The distinction between upstream and downstream often correlates with the distinction between inputs and outputs, but it need not necessarily do so. A prime example of an upstream tax that arises frequently in the literature on climate change is the idea of levying carbon taxes "at the wellhead."[47] This would be a tax on inputs rather than outputs. Indeed, since all goods ultimately rely upon inputs derived from natural resources, moving upstream far enough inevitably brings one to the question of inputs. But a partial move upstream can also simply involve a move to an earlier pollution output along the production stream. Thus, EPA has regulated both tailpipe emissions[48] (downstream) and emissions from petroleum refineries[49] (further upstream). In any case, the tax literature

Commentators usually associate emissions trading with pollution prevention, but this association is somewhat misleading since traditional performance standards and pollution taxes also can induce polluters to adopt pollution prevention as an alternative to end-of-the-pipe controls. Moreover, experience has shown that emissions trading programs, like other output-based regulations, often spur end-of-the-pipe control. *See infra* notes 147-149 and accompanying text.

[45] *See* Ochsner, *supra* note 15, at 596-98 (describing examples of pollution prevention initiatives undertaken by firms in response to incentives created by output-based regulation).

[46] The environmental tax literature identifies the administrative advantages of levying taxes upstream rather than downstream. *See* Andrea Baranzini et al., *A Future for Carbon Taxes*, 32 Ecological Econ. 395, 406 (2000) (recognizing that "upstream" carbon taxation might reduce monitoring costs); Frank Muller & J. Andrew Hoerner, *Greening State Energy Taxes: Carbon Taxes for Revenue and the Environment*, 12 Pace Envtl. L. Rev. 5, 41 (1994) (noting that to simplify enforcement it is "commonly proposed" that a carbon tax be levied at the point where fossil fuels enter the economy, such as the wellhead, the mine mouth, or the dock). The stream of production tends to begin with a narrow group of actors conducting a particular type of process. But as we move downstream, the variety of actors and processes can multiply, thus increasing administrative costs associated with administering a pollution tax. Indeed, in practice carbon taxes are almost always imposed upstream, on the carbon content of fuels, rather than downstream on CO_2 emissions. *See* Fanny Missfeldt & Jochen Hauff, *The Role of Economic Instruments*, *in* The Economics of Climate Change, *supra* note 17, at 115, 135. As we discuss in Part II.A, these advantages often apply to DILs as well.

[47] *See* Muller & Hoerner, *supra* note 46, at 41.

[48] *See* 42 U.S.C. § 7521.

[49] *See* 40 C.F.R. pt. 60, subpart J (2007).

usually does not explicitly distinguish taxation of inputs from taxation of outputs.[50]

While the idea of using taxes to regulate inputs has received some attention, though oblique, in the academic literature, that literature has generally ignored the idea of applying the other market mechanism — trading — to inputs rather than outputs.[51] As we discuss in more detail in Part I.D.1, several recent papers have discussed the idea of a cap-and-trade program limiting the carbon content of fossil fuel inputs as a method for regulating carbon emissions.[52] But these papers conceptualize these measures as a form of output regulation and are narrowly focused on the context of climate change.[53] They do not recognize that input limits might be more generally

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[50] *Cf.* Arild Vatn, *Input Versus Emission Taxes: Environmental Taxes in a Mass Balance and Transaction Costs Perspective*, 74 LAND ECON. 514 (1998); Walls & Palmer, *supra* note 17, at 4, 10-11 (discussing possibility of taxing inputs rather than outputs).

[51] In their classic article on instrument choice, Bohm and Russell mention briefly in passing the possibility of regulating inputs rather than pollutant outputs when the inputs "are perfectly correlated with the volume of pollutants discharged and less costly for the government to monitor." *See* Bohm & Russell, *supra* note 1, at 443. Clearly, they view the idea as simply a proxy for measuring pollution outputs that are difficult to monitor, rather than a fundamentally different approach to pollution control regulation.

[52] *See* Robert N. Stavins, *A Meaningful U.S. Cap-and-Trade System to Address Climate Change*, 32 HARV. ENVTL. L. REV. 293, 309-10 (2008) (recommending imposition of an economy-wide cap on emissions "upstream" at the point where fossil fuels are extracted, processed, or distributed); Robert R. Nordhaus, *New Wine into Old Bottles: The Feasibility of Greenhouse Gas Regulation Under the Clean Air Act*, 15 N.Y.U. ENVTL. L.J. 53, 57 (2007) (mentioning the possibility of "an 'upstream' cap-and-trade program" regulating "fuel producers, refiners or transporters"); Robert R. Nordhaus & Kyle W. Danish, *Assessing the Options for Designing a Mandatory U.S. Greenhouse Gas Reduction Program*, 32 B.C. ENVTL. AFF. L. REV. 97, 129-34 (2005) [hereinafter Nordhaus & Danish, *Assessing Options*]; Jason Shogren, *Climate Protection: What Insight Can Economics Offer?*, *in* THE ECONOMICS OF CLIMATE CHANGE, *supra* note 17, at 57, 64 (mentioning choice between upstream and downstream approach in designing carbon trading program); Catherine Boemare & Philippe Quirion, *Implementing Greenhouse Gas Trading in Europe: Lessons from Economic Literature and International Experiences*, 43 ECOLOGICAL ECON. 213, 215 (2002) (discussing upstream and downstream approaches to designing greenhouse gas trading programs); Edwin Woerdman, *Organizing Emissions Trading: The Barrier of Domestic Permit Allocation*, 28 ENERGY POL'Y 613, 616-19 (2000) (discussing upstream and downstream approaches to designing international greenhouse gas trading program); ROBERT R. NORDHAUS & KYLE W. DANISH, DESIGNING A MANDATORY GREENHOUSE GAS REDUCTION PROGRAM FOR THE U.S., at iii (2003) [hereinafter NORDHAUS & DANISH, PEW REPORT], *available at* http://www.pewclimate.org/docUploads/USGas.pdf (describing an upstream cap-and-trade program as requiring fossil fuel suppliers to "surrender allowances equivalent to the carbon content of fossil fuels they distribute"); CONG. BUDGET OFFICE, AN EVALUATION OF CAP-AND-TRADE PROGRAMS FOR REDUCING U.S. CARBON EMISSIONS, at viii (2001) [hereinafter CBO REPORT], *available at* http://www.cbo.gov/ftpdocs/28xx/doc2876/CapTrade.pdf (discussing an "upstream program" under which fuel producers and importers would have to hold allowances "based on the carbon emissions that would be released when their fuel was combusted"); CTR. FOR CLEAN AIR POLICY ("CCAP"), US CARBON EMISSIONS TRADING: DESCRIPTION OF AN UPSTREAM APPROACH 1 (1998) [hereinafter CCAP, UPSTREAM APPROACH] (suggesting a DIL "requir[ing] fossil fuel producers to hold allowances for the potential greenhouse gas emissions embodied in their fuels"); *see also* Helfland, *supra* note 43 (discussing input taxes and tradable permit systems in a brief article for a newsletter).

[53] *See infra* note 63.

conceptualized as a distinct regulatory instrument, nor do they systematically explore the full potential of such an instrument.

Thus, a potentially significant regulatory instrument is missing from the discussion on regulatory instrument choice. We call that missing instrument "Dirty Input Limits" or "DILs."[54] A DIL is a regulation that imposes a limit on the amount of an input allowed to be produced or consumed. DILs can take several forms. Regulators can limit the production of an input, or regulators can limit the amount of the input that manufacturers or consumers can use. They can establish DILs by simply imposing an input limit for each producer or user of a targeted substance (performance standard DILs), or they can create tradable DILs.[55]

For example, a regulator could use a DIL to limit the amount of oil used in the economy by requiring producers and importers of crude oil to hold allowances.[56] Once the regulator introduced such production (or consumption) allowances, she could make them tradable, thereby allowing one producer, the buyer, to extract more oil than the allowance permitted if the producer paid another producer, the seller, to extract less oil than the seller's allowance permitted. Thus, it is possible to create DILs in the form of either tradable or non-tradable quantitative restrictions on inputs.

D. Examples of Dirty Input Limits

While DILs may have lain hidden from scholars, they already exist in practice and, indeed, have a proven track record. As of this writing, Congress has bills before it to make a DIL variant part of the United States' strategy to address global warming,[57] and governments around the world have already used them to achieve some of humanity's most celebrated successes in addressing environmental problems. The two most prominent historical examples of the use of DILs will be familiar to every environmental law or policy professional: the phaseout of chemicals depleting the strato-

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[54] The very term "emissions trading" may help explain the neglect of DILs in the realm of quantitative mechanisms. This term focuses on pollution outputs and leading scholars have explained the mechanism in terms of trading limits on pollution outputs. Yet, scholars sometimes employ broader terms like "tradable allowances" to refer to quantitative market-based mechanisms, in place of the narrower "emissions trading" term. This broader terminology suggests awareness that trading programs in practice do not focus solely on emissions, a term that, strictly speaking, refers only to air pollution outputs. We have, for example, trading programs for water pollution, wetlands, habitat conservation, and fishing. *See* Sinden, *supra* note 41 (describing various types of trading programs).

[55] *See* 1980 CFC Proposal, *supra* note 20, at 66,730 (explaining how such an approach could apply to CFC production limits)

[56] *See* CBO Report, *supra* note 52, at viii (explaining that "under an upstream program" fossil fuel producers and importers would hold allowances); CCAP, Upstream Approach, *supra* note 52, at 4 (suggesting a DIL requiring those involved in the production or transportation of fossil fuels "to hold allowances for the potential greenhouse gas emissions embodied in their fuels"). Alternatively, a DIL could be imposed at some other point in the production stream, on refineries or even consumers of gasoline.

[57] *See, e.g.*, Climate Security Act of 2007, S. 2191, 110th Cong. (2007).

spheric ozone layer and the elimination of lead from gasoline. We discuss the climate change, ozone depletion, and lead applications below.

1. *Climate Change*

As soon as policy makers began the work of designing regulatory instruments to cut greenhouse gas ("GHG") emissions, they recognized that the transportation sector posed particular problems. From the outset, most proposals focused on cap-and-trade as the regulatory instrument of choice.[58] And for the substantial portion of GHG emissions that come from electricity generation and large industrial plants, designing such a system is relatively straightforward. Indeed, the most widely recognized and successful prototype — the acid rain trading program — itself involved emissions from power plants.[59] Designing a similar system for carbon dioxide emissions only requires minor tweaking.

But tackling the substantial portion of GHG emissions that come out of the tailpipes of individual motor vehicles is far more complicated.[60] Involving every vehicle owner in a trading program would be far too cumbersome to be practicable.[61] Nor could one effectively cap emissions by focusing on auto manufacturers, since total emissions are affected not only by factors that a car manufacturer can address, like fuel efficiency, but also by factors outside the manufacturer's control, like the number of miles driven or the type of fuel used. Because of this, existing cap-and-trade programs addressing climate change leave out transportation and therefore fail to cap economy-wide emissions.[62]

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[58] *See* RICHARD D. MORGENSTERN, CLIMATE POLICY CTR., U.S. EXPERIENCES WITH DOMESTIC CLIMATE POLICIES 1990-2012: A MODEL FOR FUTURE INTERNATIONAL STRATEGIES? 2-3 (2003), *available at* http://www.cleanair-coolplanet.org/cpc/documents/2003_future_international_strategies_model.pdf ("[T]he principal option for a mandatory policy to reduce U.S. carbon emissions is an emissions trading system."); *see also* 151 CONG. REC. S7033-37 (daily ed. June 22, 2005) (Sense of the Senate Resolution adopted as an amendment to the Energy Policy Act of 2005) (stating that "[i]t is the sense of the Senate that Congress should enact a comprehensive and effective national program of mandatory, market-based limits and incentives on emissions of greenhouse gases"); INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2001: IMPACTS, ADAPTATION, AND VULNERABILITY 476 (2001), *available at* http://www.ipcc.ch/ipccreports/tar/wg3/pdf/7.pdf ("Many advocates prefer emissions trading over carbon taxes [as the instrument for climate change regulation].").

[59] *See* 42 U.S.C. §§ 7651-7651(o) (2000).

[60] The same problems arise in designing a system to cover emissions from small industrial sources as well as home heating using natural gas and oil. If a regulation leaves these sources out, then regulation of electricity producers might simply result in a shift from homeowners heating with electricity to heating with oil or natural gas.

[61] *See* Stavins, *supra* note 52, at 313 (finding a downstream cap-and-trade system infeasible, in part because of the need to regulate millions of vehicles).

[62] *See, e.g.*, REG'L GREENHOUSE GAS INITIATIVE ("RGGI"), MEMORANDUM OF UNDERSTANDING (2005), *available at* http://www.rggi.org/docs/mou_12_20_05.pdf (describing the Northeast region's cap-and-trade system as limited to electric utilities); Council Directive 2003/87, annex I, 2003 O.J. (L 275) 32, 42 (EC) (listing sources regulated under the EU emissions trading scheme); Bent Mortensen, *The EU Emissions Trading Directive,* 13 EUR. ENVTL. L. REV. 275, 277 (2004) (same); Electric Utility Cap and Trade Act of 2007, S. 317, 110th Cong. (2007). *See generally* Note, *The Compact Clause and the Regional Greenhouse*

The impossibility of capping transport emissions through output controls has pushed some policy makers to focus on inputs rather than outputs in designing climate change regulation.[63] A number of policy analysts recommend an approach that would impose a cap on the carbon content of fossil fuel inputs rather than on carbon dioxide ("CO_2") emissions as they come out of the smoke stack or tail pipe.[64] An input-based system that imposed a permit requirement on all petroleum refineries, oil importers, natural gas pipelines, and coal processors in the United States would involve fewer than two thousand entities in the permit market.[65] That is similar to the number of facilities subject to the Clean Air Act's acid rain trading program.[66]

The Lieberman-Warner Climate Security Act,[67] which was voted out of committee to the Senate floor on December 5, 2007, adopts a hybrid ap-

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Gas Initiative, 120 HARV. L. REV. 1958, 1959-60 (2007) (describing the political process establishing RGGI); Rie Watanabe & Guy Robinson, *The European Union Emissions Trading Scheme (EU ETS),* 5 CLIMATE POLICY 10 (2005) (describing the EU's emissions trading scheme).

[63] Since there is no end-of-the-pipe technology available to limit carbon dioxide emissions from cars anyway, *see* Control of Emissions from New Highway Vehicles and Engines, 68 Fed. Reg. 52,922, 52,929 (Sept. 8, 2003) ("No technology currently exists or is under development that can capture and destroy or reduce emissions of CO_2 . . . ."), an input-based approach to regulating greenhouse gas emissions from the transportation sector involves a relatively minor conceptual shift. Indeed, these proposals tend to still focus on outputs, treating limits on the carbon content of fossil fuels as a kind of proxy for limits on carbon dioxide emissions. Thus, none of the literature discussing such DIL-like regulation on carbon inputs has noted or investigated the ancillary pollution control benefits that such an approach can provide with respect to the other pollution outputs in the fossil fuel production streams. *See supra* note 52.

[64] *See* Stavins, *supra* note 52, at 309 & n.73, 312 (recognizing that an "upstream" trading approach "makes economy-wide scope of coverage feasible"); NAT'L ROUND TABLE ON THE ENV'T & THE ECON., GETTING TO 2050: CANADA'S TRANSITION TO A LOW-EMISSION FUTURE 24-25 (2007), *available at* http://www.nrtee-trnee.com/eng/publications/getting-to-2050/Getting-to-2050-low-res.pdf (discussing the possibility of upstream cap-and-trade system); PETE V. DOMENICI & JEFF BINGAMAN, DESIGN ELEMENTS OF A MANDATORY MARKET-BASED GREENHOUSE GAS REGULATORY SYSTEM 4 (2006), *available at* http://members.4cleanair.org/rc_files/3243/Domenici&Binghamanwhitepaper2-2-06.pdf ("It is hard to see how greenhouse gas emissions from the transportation sector could be addressed in a downstream permitting system."); Inho Choi, *Global Climate Change and the Use of Economic Approaches: The Ideal Design Features of Domestic Greenhouse Gas Emissions Trading with an Analysis of the European Union's CO_2 Emissions Trading Directive and the Climate Stewardship Act*, 45 NAT. RESOURCES J. 865, 909-11 (2005); NORDHAUS & DANISH, PEW REPORT, *supra* note 52; MORGENSTERN, *supra* note 58, at 3 ("[T]he strong efficiency advantages of an upstream system suggest that if the United States is to achieve major reductions in carbon emissions, it will ultimately need to rely on such a system."); HIDENORI NIIZAWA ET AL., PROPOSAL OF UPSTREAM EMISSIONS TRADING IN JAPAN (2003), *available at* http://www.oecd.org/dataoecd/11/28/2957725.pdf; RICHARD D. MORGENSTERN, RES. FOR THE FUTURE, REDUCING CARBON EMISSIONS AND LIMITING COSTS (2002), *available at* http://rff.org/rff/Core/Research_Topics/Air/McCainLieberman/upload/4482_1.pdf; CBO REPORT, *supra* note 52; RAYMOND KOPP ET AL., RES. FOR THE FUTURE, A PROPOSAL FOR CREDIBLE EARLY ACTION ON CLIMATE CHANGE (1999); CCAP, UPSTREAM APPROACH, *supra* note 52.

[65] CCAP, UPSTREAM APPROACH, *supra* note 52, at 6.

[66] *See* EPA, ACID RAIN AND RELATED PROGRAMS: 2006 PROGRESS REPORT 3 (2006), *available at* http://www.epa.gov/airmarkets/progress/docs/2006-ARP-Report.pdf ("The [acid rain trading] program affected 3,520 electric generating units . . . in 2006 (with most emissions produced by 1,062 coal-fired units).").

[67] Climate Security Act of 2007, S. 2191, 110th Cong. (2007).

proach, combining input-based and output-based systems.[68] The Climate Security Act would impose an overall cap on emissions from the electricity, industrial, commercial, and transportation sectors of the economy.[69] With respect to major coal-fired power plants and other industrial facilities, the program would work much like the successful acid rain trading program implemented under the 1990 Clean Air Act ("CAA").[70] EPA would require each such facility to monitor the greenhouse gases escaping from its smoke stacks and to hold a tradable allowance for each metric ton of CO_2 (or its equivalent) it emitted into the atmosphere.[71] On the other hand, the bill would address transportation sector emissions by imposing limits on the production of the fossil fuels that will ultimately lead to greenhouse gas emissions. The bill would require producers and importers of petroleum and coal-based transportation fuels to hold an allowance for each unit of fuel sold for use in the transportation sector that would produce one metric ton of CO_2 when combusted.[72] Limiting the amount of carbon in oil is equivalent to limiting the amount of oil itself, since carbon is the primary constituent of oil and the carbon content of oil is essentially unchangeable.[73] This cap-and-trade program, then, would operate like any other DIL, limiting the quantity of the input flowing through the entire production stream.[74]

Because the Climate Security Act employs a hybrid approach, producers in the transportation sector can escape the restraint on fossil fuel production by purchasing credits reflecting end-of-the-pipe approaches outside the transportation sector. Additionally, under the Act's offset provisions, they can satisfy up to fifteen percent of their compliance obligation through the purchase of offsets from carbon sequestration achieved through altered agriculture or forestry practices.[75] Still, the DIL idea has powerfully influenced this pending climate change legislation as well as numerous other proposals

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[68] *See id.* § 1202; *see also* JAN MAZUREK, PROGRESSIVE POL'Y INST., CAP CARBON EMISSIONS NOW: PPL'S HYBRID APPROACH (2003), *available at* http://www.ppionline.org/ppi_ci.cfm?knlgAreaID=116&subsecID=149&contentID=251136; TIM HARGRAVE, CCAP, AN UPSTREAM/DOWNSTREAM HYBRID APPROACH TO GREENHOUSE GAS EMISSIONS TRADING (2000).

[69] This cap would cover emissions of carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, and perfluorocarbons. A separate cap would cover emissions of hydrofluorocarbons. Climate Security Act of 2007, S. 2191 § 4(14)-(15).

[70] *See* 42 U.S.C. §§ 7651-7651(o) (2000).

[71] *See* Climate Security Act of 2007, S. 2191 §§ 4(7)(A)-(B), 1202(a)(1).

[72] *See id.* §§ 4(7)(C), 1202(a)(2).

[73] *See* Arnold W. Reitze Jr., *The Regulation of Fuels and Fuel Additives Under Section 211 of the Clean Air Act*, 29 TULSA L. REV. 485, 488 (1994) (noting that "[n]early all petroleum is 83-86 percent carbon").

[74] Drawing on the literature on upstream and downstream taxes, analysts typically refer to schemes like these that impose limits on the production and importation of fossil fuels as "upstream cap-and-trade programs," highlighting the fact that such programs impose regulation early in the production stream rather than at the point of end use. *See supra* note 52. The focus remains on limiting the final polluting output of the production stream, CO_2 emissions, with the carbon content of fuel viewed as a proxy for subsequent greenhouse gas emissions. But, as explained above, because the carbon content of oil is unchangeable, these schemes actually limit the amount of oil in the economy and are therefore DILs.

[75] *See* Climate Security Act of 2007, S. 2191 § 2403.

for climate change regulation.[76] Indeed, because of the logistical difficulties associated with monitoring emissions from millions of individual tailpipes, capping emissions on an economy-wide basis is impossible without employing at least some elements of the DIL idea.

Similarly, California Governor Arnold Schwarzenegger has employed a DIL to address carbon emissions in the transportation sector. He has promulgated an executive order calling for a ten percent reduction in the carbon intensity of California's transportation fuels by 2020.[77] This order authorizes fossil fuel providers to trade carbon intensity allowances.[78] While the executive order does not cap total carbon emissions because it does not limit the overall amount of fuel used, it does use a DIL to reduce the fuel's carbon content.

2. *Ozone Depletion*

In the 1970s, scientists discovered that chlorine-based compounds tend to destroy ozone.[79] They hypothesized that emissions of these compounds could therefore destroy the ozone layer in the upper atmosphere, which protects us from ultraviolet radiation.[80] This destruction could elevate skin cancer rates,[81] interfere with immune systems,[82] and wreak ecological havoc.[83]

Regulating *outputs* of ozone-depleting chemicals posed daunting challenges. Society used ozone depleters in a wide variety of processes: as in-

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[76] At least two of the other major climate change bills now pending in Congress also employ a DIL-like mechanism in order to limit transportation emissions. *See, e.g.*, Low-Carbon Economy Act, S. 1766, 110th Cong. (2007) (Bingaman-Specter); Climate Stewardship and Innovation Act, S. 280, 110th Cong. (2007) (McCain-Lieberman); Climate Stewardship Act, H.R. 620, 110th Cong. (2007) (Olver-Gilchrest) (House version of S. 280).

[77] Cal. Exec. Order No. S-01-07, § 1 (2007); Alexander E. Farrell et al., A Low-Carbon Fuel Standard for California Part 2: Policy Analysis (2007), *available at* http://www.energy.ca.gov/low_carbon_fuel_standard/UC_LCFS_study_Part_2-FINAL.pdf (providing a detailed policy analysis).

[78] *See* Cal. Exec. Order No. S-01-07, § 4 (allowing transportation fuel refiners, blenders, producers, and importers to earn credits for exceeding carbon intensity targets to sell to undercompliers).

[79] Chlorofluorocarbons in Self-Pressurized Containers: Warning Statements, 41 Fed. Reg. 52,071, 52,072-73 (Nov. 26, 1976) (summarizing the findings of a 1976 National Academy of Sciences study of ozone depletion).

[80] *Id.* at 52,072 (explaining the chemical reaction that destroys ozone).

[81] *Id.* at 52,072-73 (predicting "increased incidence" of various forms of skin cancer from ozone depletion); Prohibition on Use of Chlorofluorocarbons as Propellants in Self-Pressurized Containers, 43 Fed. Reg. 11,299, 11,304 (Mar. 17, 1978) (summarizing a 1977 National Academy of Science report on skin cancer incidence); Self-Pressurized Consumer Products Containing Chlorofluorocarbon Propellants: Proposed Labeling and Data Submission Requirements, 42 Fed. Reg. 21,807, 21,808 (Apr. 29, 1977) (stating that the Consumer Product Safety Commission has "made a preliminary finding that" certain propellants present an unreasonable risk of injury from increased skin cancer).

[82] Ozone Meeting, 49 Fed. Reg. 30,824 (Aug. 1, 1984) (citing a National Academy of Sciences study which suggests a link between ozone depletion and "depression of the general human immune responsive system").

[83] 1980 CFC Proposal, *supra* note 20, at 66,728 (describing specific ecological effects and stating that "these and other environmental effects" could be "more serious" than the human health effects).

dustrial solvents in many different manufacturing processes (e.g., aerospace and electronics);[84] as coolants in air conditioners and refrigerators;[85] as propellants in fire extinguishers, asthmatics' inhalers, and spray deodorants;[86] and as an ingredient in plastic foam cups.[87] Limiting the emissions from all of these processes and uses appeared extremely difficult.

Accordingly, the parties to the Montreal Protocol on Substances that Deplete the Ozone Layer ("Montreal Protocol")[88] agreed to DILs, limits on the inputs of ozone-depleting substances, rather than limits on the emission of ozone-depleting substances into the atmosphere.[89] These particular DILs limited and eventually phased out the consumption of ozone-depleting chemicals.[90] The Montreal Protocol committed developed countries to significant reductions in consumption of leading ozone-depleting substances.[91] Subsequent amendments to the Montreal Protocol went further, eventually phasing out the consumption of the most important ozone depleters entirely.[92]

The parties to the Montreal Protocol accomplished this phaseout of consumption through restrictions on production of the relevant chemicals. The

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[84] *See* Fully Halogenated Chlorofluoroalkanes, 43 Fed. Reg. 11,318, 11,318 (Mar. 17, 1978) (suggesting that use of CFCs as solvents and blowing agents constitutes a substantial portion of non-aerosol production).

[85] *See id.* (stating that about one-half of non-aerosol CFC use involved use as refrigerants).

[86] *See* Protection of Stratospheric Ozone: Manufacture of Halon Blends, Intentional Release of Halon, Technician Training and Disposal of Halon and Halon-Containing Equipment, 63 Fed. Reg. 11,084, 11,085 (Mar. 5, 1998) [hereinafter 1998 Halon Rule] (explaining that halons are ozone-depleting substances used in fire suppression); Assessment of Carbon Tetrachloride as a Potentially Toxic Pollutant, 50 Fed. Reg. 32,621 (Aug. 13, 1985) (stating that carbon tetrachloride has been used as a "fire extinguishing agent"); Self-Pressurized Containers; Warning Statements, 41 Fed. Reg. 52,071, 52,071 (Nov. 26, 1976) (stating that "[c]hlorofluorocarbons are widely used as propellants").

[87] *See* Assessment of Chlorofluorocarbon-113 as a Potentially Toxic Air Pollutant, 50 Fed. Reg. 24,313, 24,313 (June 10, 1985) (describing the blowing of foam as one of several principal uses of CFC-113).

[88] Sept. 16, 1987, S. Treaty Doc. No. 100-10, 1522 U.N.T.S. 29.

[89] In this case, the inputs and the outputs were actually the same chemical substance. This is a bit unusual, as many processes produce outputs different in form from the inputs, although the two are usually related. But, for the most part, the regulatory limits did not apply to the outputs. The relevant law did not take the form of emission limits, nor did government enforce most of these laws at the point where the chemicals were released into the environment. Rather, they were enforced and drafted as input limits, specifically as limits on the production and importation of ozone-depleting substances, as described below.

[90] *See, e.g.*, Protection of Stratospheric Ozone, 53 Fed. Reg. 30,566, 30,566 (Aug. 12, 1988) (codified at 40 C.F.R. pt. 82) [hereinafter 1989 Reduction] (reducing production of certain CFCs by first twenty, and then fifty, percent and capping the production of other CFCs at existing levels under the Montreal Protocol); Protection of Stratospheric Ozone, 58 Fed. Reg. 65,018, 65,019 (Dec. 10, 1993) (codified at 40 C.F.R. pt. 82) [hereinafter 1993 Phaseout] (pointing out that the Montreal Protocol, as amended, requires a phaseout of CFCs by 1996 with a possible exception for critical uses).

[91] *See* Montreal Protocol, *supra* note 88, art. 2(4) (requiring a fifty percent cut in certain ozone-depleting substances beginning in 1998).

[92] *See, e.g.*, London Amendments to the Montreal Protocol art. 2A(5), June 29, 1990, S. Treaty Doc. No. 103-9, 30 I.L.M. 537 (requiring that developed countries reduce consumption of certain ozone depleters to zero by the year 2000 and generally requiring developing country compliance ten years later).

Montreal Protocol defined a country's consumption of an ozone-depleting chemical as the quantity of its production minus exports plus imports.[93] This approach made it much easier to track progress toward meeting national commitments to phase out consumption. It meant that measurement occurred upstream, at the point of production, rather than downstream, at the point of consumption. Instead of having to measure the use of ozone-depleting chemicals downstream in myriad consumer products and manufacturing processes, regulators simply had to monitor the handful of facilities actually manufacturing ozone-depleting inputs along with the volume of imports and exports.[94] Thus, the Montreal Protocol employed DILs to first limit and then phase out ozone-depleting substances.

In addition, the Montreal Protocol provided for some trading of DILs.[95] Specifically, it provided that countries could meet their consumption limits jointly. This provision suggested that one country could under-comply if it paid another country to over-comply. Similarly, the U.S. law implementing the Montreal Protocol allowed producers to trade their production allowances.[96] While these provisions apparently produced no actual trading, their existence reveals the possibility of tradable DILs.

Scholars recognize the phaseout of ozone-depleting chemicals as the major (some say the only[97]) example of successful international environmental protection. While a hole in the ozone layer opened up as the regime began to operate, developed countries phased out many of the principal substances of concern, and developing countries began to follow suit. As a result, scientists now expect the ozone layer to heal.[98] Prior to the regime's enactment, many considered such drastic action impractical.[99] They believed that finding substitutes for many of these products was impossible or too costly.[100] In fact, however, the phaseout stimulated the substitution of new inputs for the old ones, many of which proved cheaper than the ozone-depleting substances they replaced.[101]

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[93] *See* Natural Res. Def. Council v. EPA, 464 F.3d 1, 3 n.1 (D.C. Cir. 2006) (citing article 1, section 6 of the Montreal Protocol).

[94] *See* 1989 Reduction, *supra* note 90, at 30,579 (stating that the phaseout was relatively easy to administer because the producers and importers were few in number).

[95] *See id.* at 30,588 (discussing and interpreting the Protocol's "industrial rationalization" provision).

[96] *See id.* at 30,567.

[97] *E.g.*, Edward A. Parson, Protecting the Ozone Layer: Science and Strategy at vii (2003).

[98] *See* Daniel Pruzin, *U.N. Agency Report Says Ozone Hole Above Antarctic Shows Signs of Shrinking*, 30 Int'l Env't Rep. (BNA) 686 (Sept. 5, 2007) (stating that World Meteorological Organization expects ozone hole to disappear "sometime between 2065 and 2070").

[99] *See* Parson, *supra* note 97, at 9 ("[B]efore regime formation . . . it was widely believed that significant cuts in ozone-depleting chemicals would be difficult and costly, and likely dangerous as well.").

[100] *Id.*

[101] *See id.* at 4 (noting that production and use of ozone-depleting chemicals has fallen ninety-five percent with only modest associated cost); David Lee, *Trading Pollution*, *in* Ozone Protection in the United States: Elements of Success 31, 33 (Elizabeth Cook ed., 1996); Fully Halogenated Chlorofluoroalkanes, 43 Fed. Reg. 11,318, 11,319 (Mar. 17, 1978) (predict-

Some of the substitutes produce environmental risks. For example, some manufacturers substituted a toxic solvent for more stable ozone depleters phased out under the Montreal Protocol.[102] The dangers posed by this toxic solvent, however, are arguably less severe than the risks associated with stratospheric ozone depletion. And in many cases producers avoided any significant risk by substituting soap and water for ozone-depleting substances.[103]

3. *Lead in Gasoline*

While DILs have emerged in just the last two decades in connection with efforts to address the hole in the ozone layer and climate change, the history of DILs actually goes back at least as far as the history of modern environmental law. In fact, Congress authorized DILs in one of the first major pieces of federal environmental legislation ever passed, the 1970 Clean Air Act Amendments.[104] The CAA generally employs output limits, such as emission standards for tailpipe emissions and pollution from smokestacks.[105] But Congress also gave EPA the authority to limit fuel additives or constituents, i.e. the inputs into gasoline.[106] It did this with a particular health hazard in mind, namely that posed by the use of lead as a gasoline additive.[107]

EPA responded by first limiting the amount of lead that could be used as an input into gasoline and later phasing it out.[108] The early stages of the phaseout simply required reductions in the amount of lead in gasoline, a performance standard type DIL.[109] Later, however, EPA allowed gasoline producers to trade their DILs.[110] Unlike in the Montreal Protocol case, a

ing that consumers stand to benefit financially from the use of cheaper propellants than those that deplete the ozone layer).

[102] *See* Parson, *supra* note 97, at 182.

[103] *See* David M. Driesen, *Does Emissions Trading Encourage Innovation?*, 33 Envtl. L. Rep. (Envtl. L. Inst.) 10,094, 10,103 (2003) (citing U.S. EPA, Benefits of the CFC Phaseout, *available at* http://www.epa.gov/ozone/geninfo/benefits.html (last visited Jan. 24, 2001)).

[104] *See* Clean Air Act Amendments of 1970, Pub. L. No. 91-604, § 211(b)(2), 84 Stat. 1676, 1698 (codified at 42 U.S.C. § 7545(c)(1) (2000)).

[105] *See, e.g.*, 42 U.S.C. §§ 7411, 7412, 7521.

[106] *See* Arnold W. Reitze Jr., Air Pollution Control Law: Compliance and Enforcement 326 (2001); Reitze, *supra* note 73.

[107] *See* Ethyl Corp. v. EPA, 541 F.2d 1, 9 (D.C. Cir. 1976) (en banc) ("It is beyond question that the fuel additive Congress had in mind [in CAA § 211(c)(1)(A)] was lead."); Thomas O. McGarity, *MTBE: A Precautionary Tale*, 28 Harv. Envtl. L. Rev. 281, 294 (2004) (stating that Congress empowered EPA to remove lead from gasoline because it interfered with catalytic converters).

[108] *See* Reitze, *supra* note 73, at 499-505 (providing a detailed history of the progression of lead additive standards).

[109] *Id.* at 500 (describing an early DIL as providing for an average concentration of 1.7 grams of lead per gallon ("gpg"), decreasing to 0.5 gpg by 1979).

[110] *See* Regulation of Fuels and Fuel Additives; Banking of Lead Rights, 50 Fed. Reg. 13,116, 13,119 (Apr. 2, 1985) (codified at 40 C.F.R. pt. 80); Suzi Kerr & Richard G. Newell, *Policy-Induced Technological Adoption: Evidence from the U.S. Lead Phasedown*, 51 J. Indus. Econ. 317, 320-22 (2003).

significant amount of trading did occur.[111] EPA employed trading of the lead DILs to enhance the flexibility of the phaseout and, in particular, to try to ease, or at least delay, the potential burden on small refiners.[112]

The CAA generally requires EPA to write National Ambient Air Quality Standards ("NAAQS") to protect public health from ubiquitous dangerous pollutants.[113] EPA set a NAAQS for lead, establishing an atmospheric concentration that in its view would adequately protect public health,[114] and relied on DILs for lead in gasoline to achieve the NAAQS. Primarily as a result of the lead DILs, every populous region in the country has achieved the NAAQS for lead.[115] By contrast, for most other pollutants, EPA has relied primarily upon state and federal output limits to achieve the NAAQS. While some regions have achieved the non-lead NAAQS, many areas still have not achieved the NAAQS for the most ubiquitous pollutants more than thirty-five years after the CAA's enactment.[116]

The lead phaseout constitutes a public health triumph, having greatly reduced blood lead levels, which correlate with neurological disorders.[117] Because EPA reduced lead through input limits, rather than tailpipe controls, the lead phaseout also prevented lead poisoning of workers at plants manufacturing lead additives.[118] Some of the substitutes for lead are toxic and pose some risks of their own, but the evidence of the harms associated with lead is generally much more robust than the evidence of harm from the sub-

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[111] *See* Robert W. Hahn & Gordon L. Hester, *Marketable Permits: Lessons for Theory and Practice,* 16 ECOLOGY L.Q. 361, 386-87 (1989) (describing the trading market as "active" and providing data on the percentages of allowances traded over time).

[112] *See* Driesen, *supra* note 1, at 317 n.131 (explaining in detail how banking of lead credits causes delays in reducing emissions). *See generally* Morriss & Stewart, *supra* note 19, at 1025 (describing lead trading as a means of buying off small refiners).

[113] *See* 42 U.S.C. § 7409 (2000); Whitman v. Am. Trucking Ass'ns, 531 U.S. 457, 462-63 (2001).

[114] *See* National Primary and Secondary Ambient Air Quality Standards for Lead, 43 Fed. Reg. 46,246, 46,247 (Oct. 5, 1978); Lead Industries Ass'n v. EPA, 647 F.2d 1130 (D.C. Cir. 1980) (upholding the lead NAAQS).

[115] *See* EPA, REPORT ON AIR QUALITY IN NONATTAINMENT AREAS FOR 2003-2005 COVERING OZONE, PARTICULATE MATTER, CARBON MONOXIDE, SULFUR DIOXIDE, NITROGEN DIOXIDE, AND LEAD: TECHNICAL SUMMARY 24-26 (rev. 2007), *available at* http://www.epa.gov/air/airtrends/pdfs/20070214_aq_na_2003-2005.pdf. As of 2007, EPA had designated only two areas with a combined population of about 4600 people as not having met the lead standard. *Id.* at 25. A third area, Delaware County, Indiana, has recent monitoring data indicating a violation of the lead standard, but has not yet been designated as violating the standard. *Id.*

[116] *See id.* at 6-7, 15, 20-21, 23 (listing areas violating the NAAQS for ozone, particulate matter both fine ($PM_{2.5}$) and coarse (PM_{10}), and carbon monoxide). In 2004-2005, all designated nonattainment areas for carbon monoxide attained the standard, but one previously compliant area violated it. *Id.* at 22-23. Because air quality can fluctuate from year to year, EPA generally requires several clean years before declaring that an area has attained an air quality standard.

[117] *Id.* at 24 (reporting a seventy-eight percent decline in blood lead levels and noting the link between lead and seizures, mental retardation, and behavioral disorders).

[118] *See* Reitze, *supra* note 73, at 497-98 (explaining that when lead was first introduced, it killed or severely poisoned eighty percent of the forty-nine workers at one processing plant); *see also* Jamie Lincoln Kitman, *The Secret History of Lead*, NATION, Mar. 20, 2000, at 11, 22-25.

stitutes.[119] And the federal government has continued to employ DILs to address harms associated with substitutes for lead and other constituents of gasoline.[120] While some significant sources of lead remain unabated, the DIL phasing lead out of gasoline provides one of environmental law's most striking success stories.

II. Evaluating DILs

This Part discusses DILs' advantages and disadvantages. This discussion not only lays the groundwork for policy makers' consideration of DILs in particular cases, it also establishes that DILs have distinct features that merit further discussion and analysis.

A. *Advantages*

DILs can, at least in certain contexts, provide considerable advantages over traditional output-based forms of regulation. First, they can provide administrative advantages by simplifying monitoring, by eliminating the need to separately regulate multiple outputs, and by reducing the number of entities subject to regulation. Second, by broadening the focus of regulation to whole production streams rather than single outputs, DILs can provide efficiency advantages. Third, because they are more likely to stimulate fundamental technological change and innovation, DILs offer advantages in spurring productive technological change.

1. *Administrative Advantages*

DILs' considerable administrative advantages may have played a large role in motivating policy makers to use them to regulate ozone-depleting chemicals and lead. Sometimes DILs can prove feasible when output regulation is not.[121] Even where output regulation is also feasible, DILs can provide significant administrative cost savings.

The administrative advantages of DILs stem from three sources. First, it is often simpler to monitor inputs than outputs. Indeed, in some instances, monitoring outputs is simply impossible. This is true of ozone-depleting

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[119] McGarity states that we have a "dearth of health effects" data on MTBE, the most controversial lead substitute that manufacturers chose. McGarity, *supra* note 107, at 288. He concludes that in spite of the risks posed by lead substitutes, we are better off with the lead ban than we would be without it. *Id.* at 311-12. Furthermore, he points out that we would be still better off if EPA had used its authority properly to address MTBE early on. *Id.* at 312; *cf.* Reitze, *supra* note 73, at 491 (stating that "it could be claimed that" the replacement of lead with aromatic compounds has made fuels "more environmentally harmful").

[120] *See, e.g.*, 42 U.S.C. § 7545(f)(2) (2000); *see also* MTBE Proposed Ban, *supra* note 24.

[121] *See, e.g.*, Fully Halogenated Chlorofluoroalkanes, 42 Fed. Reg. 24,542, 24,547 (May 13, 1977) (codified at 40 C.F.R. pts. 712, 762) (finding a prohibition on the manufacture of fully halogenated chlorofluoroalkane propellants the "only practicable regulatory alternative").

chemicals, for example. Ozone depleters are released into the atmosphere as "fugitive emissions," i.e. emissions escaping at multiple places in a production process or after use of a product.[122] Monitoring these emissions was impracticable both because of measurement problems and because of the large number of heterogeneous sites potentially requiring monitoring. By contrast, monitoring the production, import, and export of ozone-depleting substances in order to administer a DIL was relatively straightforward. Accordingly, the parties to the Montreal Protocol chose DILs to address ozone depletion in part to avoid the monitoring problems that made output regulation impracticable.[123] Even when monitoring outputs is feasible, it can be more expensive than monitoring inputs. For example, monitoring the amount of coal burned by a power plant is undoubtedly cheaper and less complicated than monitoring the amounts of various pollutants escaping from the smoke stack.[124]

Second, because a DIL can simultaneously reduce a whole series of pollution outputs along a production stream, it can reduce administrative costs by obviating the need for separate regulatory programs for each polluting output.[125] Thus, a DIL limiting or phasing out oil consumption, for example, might eliminate or reduce the need for regulatory programs to minimize the impacts of drilling, to prevent spills, to limit the emissions of hazardous air pollutants, particulate matter, and smog precursors from oil refineries,[126] to prevent leaks from underground storage tanks at service stations,[127] to require vapor recovery devices at service stations,[128] to impose standards for an array of different pollutants from vehicles,[129] and to require periodic inspections of vehicle emission control systems.[130] Of course, the

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[122] *Cf.* Morriss & Stewart, *supra* note 19, at 1041-42 (describing fugitive emissions associated with oil refining).

[123] *See supra* text accompanying notes 84-94.

[124] *See* Byron Swift, *Command Without Control: Why Cap-and-Trade Should Replace Rate Standards for Regional Pollutants*, 31 Envtl. L. Rep. (Envtl. L. Inst.) 10,330, 10,331 (2001) (describing the monitoring regime for sulfur dioxide emissions from coal plants and noting that it costs "almost $1 million per stack").

[125] *See* Stavins, *supra* note 52, at 312-13 (explaining that an upstream regulation point reduces administrative costs); *cf.* McAllister, *supra* note 41, at 304-05 (discussing how the RECLAIM emissions trading program generated high administrative costs, even though it only addressed two pollutants).

[126] *See* 40 C.F.R. pt. 63 (2006).

[127] *See* MTBE Proposed Ban, *supra* note 24, at 16,100-01 (describing the regulations seeking, with limited success, to eliminate leaks from underground storage tanks); McGarity, *supra* note 107, at 292-94 (same).

[128] *See* Arnold W. Reitze, Jr., *Mobile Source Air Pollution Control*, 6 ENVTL. L. 309, 344-46 (2000) (discussing regulation requiring vapor recovery devices).

[129] *See* 42 U.S.C. § 7521 (2000) (directing EPA to regulate emissions from motor vehicles).

[130] *See* Clean Air Council v. Mallory, 226 F. Supp. 2d 705, 708-09 (E.D. Pa. 2002) (discussing Pennsylvania's obligation to implement vehicle inspection and maintenance program under the CAA).

scope and stringency of a DIL affects the extent to which that DIL obviates the need for other regulatory programs.[131]

Third, DILs will often allow government to realize administrative cost savings by moving the locus of regulation upstream.[132] The environmental tax literature has observed that upstream taxes generally have lower administrative costs than downstream taxes,[133] and the same observation holds true for upstream DILs.[134] A supply chain often begins with a small number of homogeneous actors producing fundamental inputs, but ends in products used by numerous heterogeneous businesses or consumers. When this is true, imposing an upstream DIL will generate administrative cost savings.

Accordingly, DILs may have great utility even when output limits or taxes are feasible.[135] Governments have limited resources available for regulating and monitoring pollution.[136] Using these resources efficiently can be very important to realizing environmental goals.[137]

2. *Efficiency Advantages*

Because output regulation focuses on each polluting output in isolation, it can fail to take into account benefits attributable to reductions in other pollution outputs along the same production stream. This can result in an

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[131] DILs reduce administrative costs by obviating the need for multiple regulatory programs most obviously when the DIL phases out an input. Such a DIL may eliminate the need for a lot of output-based regulation entirely. When a DIL only limits production of an input, the relationship between the DIL and avoided cost will be more subtle and complex. For example, imagine a DIL limiting gasoline consumption by ten percent. Society probably would continue to require output regulation of vehicle exhaust, even if gasoline use dropped. The DIL, however, would contribute to something like a ten percent decline in vehicle exhaust. In principle, the regulator could now reduce the control efficiency of the vehicle exhaust regulations in response in order to save money. This would imply that the DIL produced a cost savings in vehicle exhaust regulation. Of course, the regulator might instead keep the regulation intact. If so, the DIL would produce an additional benefit that would help justify it.

[132] *See, e.g.*, 1989 Reduction, *supra* note 90, at 30,579 (finding that engineering controls would be "difficult to administer" because thousands of firms use CFCs).

[133] *See supra* note 46.

[134] *See* Arnold W. Reitze, *Should the Clean Air Act Be Used To Turn Petroleum Addicts into Alcoholics?*, 36 Envtl. L. Rep. (Envtl. L. Inst.) 10,745, 10,746 (2006) (stating that fuel additive requirements "are relatively easy to enforce because refining and distribution systems are centralized"); CBO Report, *supra* note 52, at viii (claiming that an "upstream" allowance requirement minimizes the government's administrative cost); CCAP, Upstream Approach, *supra* note 52, at 6-7 (noting that an upstream approach "would be more workable than a downstream system because it would include fewer regulated . . . entities"). For trading programs, however, the number of actors must remain large enough to create a viable market if trading's cost saving potential is to be realized. *See* Boemare & Quirion, *supra* note 52, at 215 (noting that a large number of participants is required for successful emissions trading programs "to benefit from significant abatement cost differences among firms" and to lessen the risk of monopolistic manipulation); Bohm & Russell, *supra* note 1, at 422-23 (same).

[135] *See, e.g.*, 1980 CFC Proposal, *supra* note 20, at 66,729-30 (listing possible output-based methods for limiting CFC emissions, but warning that growth in industries that use CFCs could offset gains made with an output-based approach).

[136] *See* 1989 Reduction, *supra* note 90, at 30,579 (arguing that EPA could not possibly regulate five to ten thousand CFC customers because of resource and time limitations).

[137] *See id.* (concluding that regulating CFC customers was not feasible).

inefficient choice of pollution reduction strategies. By broadening the focus of analysis to the production stream as a whole, DILs tend to reduce such inefficiencies.

Where an environmental problem stems from a single production process producing a single polluting output, a DIL might prove inefficient to the extent that it limits a polluter's choices with respect to what kind of pollution control strategy to employ. An output-based regulation allows the polluter a choice of complying either through the adoption of end-of-the-pipe controls or through pollution prevention (changing or reducing inputs).[138] A DIL, on the other hand, requires the polluter to adopt pollution prevention strategies.[139] Accordingly, where end-of-the-pipe controls offer a cheaper method for reducing the single polluting output, a DIL will prove inefficient.[140]

More often than not, however, the input that contributes to an environmental problem is part of a production stream that produces multiple pollution outputs. In the context of a pollution stream, the efficiency analysis is quite different. In that case, DILs will often offer efficiency advantages over output-based regulation.

A highly simplified hypothetical example will help to demonstrate the point. Imagine that an electric power plant is faced with output-based regulation requiring it to reduce its sulfur dioxide emissions by half. Imagine that the cost of switching half its generating capacity to wind power is $10 million and the cost of installing scrubbers is $4 million. Clearly, the power plant will choose to install scrubbers rather than switch to wind power, because that option involves the least cost to the power plant. Yet, for society as a whole, the benefits associated with decreasing coal production (reduced deaths and injuries to coal miners, reduced ecological destruction from mining) might well outweigh the extra $6 million cost associated with the switch to wind power.[141] In such a case, the pollution prevention strategy of switch-

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[138] *See supra* note 44 and accompanying text.

[139] *See* CCAP, Upstream Approach, *supra* note 52, at 2 (arguing that an upstream trading program provides no incentive to use "end use emission treatment technologies" (emphasis removed)).

[140] Stavins, in advancing an upstream cap-and-trade approach, argues that the point of regulation does not influence the cost of reductions. Stavins, *supra* note 52, at 310. Stavins makes this point in the context of a proposal that mixes upstream and downstream regulation, rather than a pure DIL. *See id.* at 309-10 (proposing a credit for post-combustion emission reductions, such as through carbon capture and storage). And he may be correct in that context. But he acknowledges, in a footnote, that the point of regulation can make a difference in some cases. *Id.* at 310 n.76. A pure DIL would not provide a credit for an end-of-the-pipe emission reduction option, and therefore could prove more costly in the short-term with respect to a single pollutant with high input control costs and low output control costs. While a pollution *tax* may impose uniform cost regardless of the point of imposition, *id.* (supporting a conclusion about regulation by reference to basic textbook economics of tax policy), *regulatory* costs can vary with the point of imposition.

[141] *See* John M. Broder, *Rule To Expand Mountaintop Coal Mining*, N.Y. Times, Aug. 23, 2007, at A1 (discussing mountaintop removal's ecological impacts); Cara Buckley & Susan Saulny, *Finding Miners Alive Is "Totally Unlikely," Owner Says*, N.Y. Times, Aug. 23, 2007, at A17; Editorial, *Ravaging Appalachia*, N.Y. Times, Aug. 27. 2007, at A16 (discussing mountaintop removal's ecological effects).

ing to wind power would clearly be better for society as a whole. Hence, plants acting cost effectively with respect to a particular output-based regulation may not be acting efficiently with respect to the full range of externalities associated with a production stream.

DILs, on the other hand, expand the field of vision to encompass an entire production stream, and thereby may often produce more efficient results for society as a whole.[142] Under output-based regulation, polluters usually base their pollution control strategy choices on an incomplete accounting of costs and benefits that fails to take into account the full social benefits that would accrue from a pollution prevention strategy's reduction of other polluting outputs along the production stream. If all of the externalities associated with those outputs were fully internalized through perfectly efficient output-based regulation, then the power plant's decision about what pollution control strategy to pursue would reflect the full range of relevant social costs and benefits, because the social harms caused by coal mining would be internalized into the price of coal. But comprehensive regulation of all relevant pollution outputs at the same time usually proves beyond the capacity of government. Often governments leave some pollution unregulated,[143] or they leave regulation that does exist unenforced.[144] And even when they attempt to regulate comprehensively, they almost always regulate one type of pollutant at a time.[145] This makes it impossible for industry to have complete compliance cost information at any one time that might justify investments in whole new approaches to avoid multiple regulatory impacts. Accordingly, in a second-best world of incomplete internalization of externalities, output-based regulation, with its piecemeal focus on individual polluting outputs, may produce inefficient results.

Output-based emissions trading likewise suffers from fragmentation's tendency to produce inefficiency. Many commentators laud emissions trading for its presumed capacity to incentivize pollution prevention strategies,[146]

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[142] *See* MTBE Proposed Ban, *supra* note 24, at 16,100 (justifying a ban on MTBE in part because numerous government programs to prevent gasoline leaks and spills "from the vast array of units and individuals handling gasoline" could not prevent releases into the environment).

[143] *See* William W. Buzbee, *Recognizing the Regulatory Commons: A Theory of Regulatory Gaps*, 89 IOWA L. REV. 1, 7 (2003) (introducing three regulatory challenges that remain unaddressed).

[144] *See* Durwood Zaelke, Matthew Stilwell & Oran Young, *Compliance, Rule of Law, and Good Governance*, *in* 1 MAKING LAW WORK: ENVIRONMENTAL COMPLIANCE AND SUSTAINABLE DEVELOPMENT 29, 47-51 (Durwood Zaelke et al. eds., 2005) (discussing pervasive problem of under-enforcement of environmental laws throughout the world); Daniel A. Farber, *Taking Slippage Seriously: Noncompliance and Creative Compliance in Environmental Law*, 23 HARV. ENVTL. L. REV. 297 (1999) (same).

[145] Typically, separate statutes govern pollution in different media. Thus, at the federal level in the United States, the CAA regulates air pollution, 42 U.S.C. §§ 7401-7671q (2000), the Clean Water Act regulates water pollution, 33 U.S.C. §§ 1251-1387 (2000 & Supp. II 2002), and the Resource Conservation and Recovery Act regulates solid waste disposal, 42 U.S.C. §§ 6901-6992k (2000).

[146] *See* Richard B. Stewart, *Controlling Environmental Risks Through Economic Incentives*, 13 COLUM. J. ENVTL. L. 153, 155, 160 (1988) [hereinafter Stewart, *Incentives*] (noting

thereby suggesting that emissions trading is as comprehensively efficient as a DIL. In fact, however, polluters even under trading often choose end-of-the-pipe control when it is cheaper than pollution prevention at realizing reductions in the pollutants the program targets. This helps explain why almost two-thirds of the credits generated in developing countries for trading in carbon markets created by the Kyoto Protocol have come from end-of-the-pipe controls, which have been cheaper than using renewable energy as a substitute for dirty inputs.[147] Similarly, while polluters subject to traditional performance standard regulation have sometimes complied by employing pollution prevention options not anticipated by regulators,[148] they have more often complied by using "end-of-the-pipe" controls. This suggests that pollution prevention is not always cheap.[149] Output-based regulation makes input reduction voluntary and generally induces it only when it offers a relatively cheap way of meeting a narrowly defined goal. A DIL encourages input reduction (and pollution prevention) when it is efficient for society at large, regardless of whether it is inefficient for individual polluters.

3. *Fundamental Change and Innovation*

We have already alluded to DILs' ability to stimulate innovation.[150] But the idea that DILs may perform better than the alternatives in stimulating innovation requires elaboration. And the underlying assumption that innovation has more value than a beneficial non-innovative approach will receive some attention as well.

We define innovation as a non-obvious departure from prior approaches.[151] Innovation includes not just invention, but also use of a new technology. One can distinguish innovation from diffusion, the spread of well-understood practices.

Technological changes, whether innovative or not, can either involve incremental improvements in existing approaches or a fundamental change

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that technology-based regulation requires installation of "pollution control technology," while "economic incentives" such as emissions trading encourage "new products or production technologies"); Richard B. Stewart, *United States Environmental Regulation: A Failing Paradigm*, 15 J.L. & Com. 585, 592 (1996) [hereinafter Stewart, *Paradigm*] (contrasting the "existing technology-based system['s]" emphasis on "end of pipe" controls with trading's encouragement of "process changes and conservation").

[147] *See* David M. Driesen, *Market Liberalism and Sustainable Development's Shotgun Wedding: Emissions Trading Under the Kyoto Protocol,* 83 Ind. L.J. 21, 40-41 (2008) (characterizing sixty-four percent of credits as coming from end-of-the-pipe controls).

[148] *See* Office of Tech. Assessment, U.S. Cong., OTA-ENV-635, Gauging Control Technology and Regulatory Impacts in Occupational Safety and Health: An Appraisal of OSHA's Analytical Approach 59-61 tbl.3-3, 61 (1995) (discussing costs of pollution prevention measures in response to output-based standards).

[149] *See* Ochsner, *supra* note 15, at 591; Nicholas A. Ashford & George R. Heaton Jr., *Regulation and Technological Innovation in the Chemical Industry*, 46 L. & Contemp. Probs. 109, 139-40 (1983).

[150] *See supra* text accompanying notes 99-103.

[151] *Cf.* 35 U.S.C. § 103 (2000 & Supp IV 2004) (requiring patentable invention to be non-obvious departure from prior art).

in how society produces, uses, and delivers goods and services. Thus, for example, minor changes in the constituents of gasoline to improve its environmental characteristics constitute incremental change. A decision to make vehicles that run on electricity rather than gasoline, on the other hand, involves a fundamental change. Fundamental changes alter multiple steps in a production stream and may also affect what the end consumer does. So, for example, a shift to electric vehicles would eliminate gasoline use, thereby reducing refinery emissions, oil spills, and so on, but conversely increase electricity use, thereby raising power plant emissions. It might also change consumers' behavior, relieving them of the responsibility to go to gasoline stations while requiring them to plug in a car overnight and perhaps take shorter trips. While the line between fundamental and incremental change will not always be as sharp as these examples suggest, the distinction will prove useful in evaluating DILs.

In general, pollution prevention is more likely than end-of-the-pipe controls to involve fundamental technological change. Because pollution prevention reduces or eliminates inputs, it involves making changes to the production process itself. End-of-the-pipe technology, on the other hand, tends not to alter existing processes significantly, but instead consists of an add-on. Under output-based regulation, firms can choose whether to meet regulatory standards through pollution prevention or end-of-the-pipe controls,[152] and frequently they choose the latter. Since DILs require firms to use pollution prevention techniques rather than end-of-the-pipe controls, DILs tend to produce more fundamental change and more innovation than output-based regulation.[153] The magnitude of the fundamental change will depend upon the stringency of the DIL,[154] but a DIL focusing on a fundamental input like gasoline will always produce some fundamental change. By contrast, emission limits tend not to produce fundamental changes unless they are so stringent and expensive that they make existing approaches nonviable.

Scholars have recognized that the phaseouts of lead and ozone-depleting chemicals stimulated innovations.[155] In fact, both of these DILs stimulated fundamental changes in the early stages of the program, *before* the

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[152] *See supra* notes 44-45 and accompanying text.

[153] As between output-based regulatory instruments, emissions trading tends to spur even less fundamental change than performance standards, as one of us has shown in several previous articles. *See* David M. Driesen, *Design, Trading, and Innovation*, *in* MOVING TO MARKETS IN ENVIRONMENTAL REGULATION: LESSONS FROM TWENTY YEARS OF EXPERIENCE, *supra* note 1, at 436, 443; Driesen, *supra* note 103. This is because fundamental change is often costly, and emissions trading favors the least costly approaches.

[154] *See, e.g.*, 1993 Phaseout, *supra* note 90, at 65,025 (predicting that acceleration of a phaseout schedule for ozone-depleting substances would accelerate technological development).

[155] *See, e.g.*, PARSON, *supra* note 97, at 183-92 (discussing specific technological changes made in response to the phaseout of ozone-depleting chemicals); Reynaldo Forte & Robert Livernash, *Chilling Out*, *in* OZONE PROTECTION IN THE UNITED STATES: ELEMENTS OF SUCCESS, *supra* note 101, at 97, 98 (same); Kerr & Newell, *supra* note 110, at 322-23 (2003) (describing the technological responses to the ultimate ban of lead in gasoline).

regulators required full phaseouts.[156] Even mild DILs tend to stimulate innovation, since they demand some basic change. Stringent DILs demand even more use of innovative technologies, often innovations that involve fundamental changes in inputs.

This raises the question of whether fundamental change is superior to incremental change. Incremental change often proves more cost effective than fundamental change in the short run. It allows for the continued use of existing capital stock, already-developed human capital (*e.g.*, expertise in the mechanics of internal combustion engines), and experience with an existing technology's properties. In the long run, however, fundamental change can prove superior. Fundamental change can produce economic growth by stimulating new industries. It can also improve the quality of life over time and may be essential to addressing extremely difficult environmental challenges. Finally, a DIL's capacity to solve multiple environmental problems at once through pollution prevention is at its highest when that DIL stimulates fundamental technological change.

Innovation, whether fundamental or not, can lower the costs of producing goods and services over time. Innovation can also improve the quality of goods and services. Innovations, however, often prove costly in the short run even if they either reduce costs in the long run or produce quality improvements justifying their cost. While much of the instrumental choice literature tends to associate relentless pursuit of cost effectiveness with innovation,[157] one of us has argued elsewhere that innovation and short-term cost effectiveness often conflict.[158] For example, we have relatively cheap personal computers ("PCs") because of decisions to build very expensive supercomputers, which produced the experience that ultimately made PCs viable.[159] PCs are still more expensive than typewriters, but they make revi-

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[156] *See, e.g.*, EPA, ACHIEVEMENTS IN STRATOSPHERIC OZONE PROTECTION: PROGRESS REPORT 15 (2007) (describing DuPont as leading the chemical manufacturing industry's search for alternatives by abandoning CFCs before the Montreal Protocol was signed in 1987); PARSON, *supra* note 97, at 40, 183-192 (describing various innovations and dating them prior to the ozone phaseout); René Kemp, *Technology and Environmental Policy: Innovation Effects of Past Policies and Suggestions for Improvement*, *in* ORG. FOR ECON. CO-OPERATION & DEV. ("OECD"), INNOVATION AND THE ENVIRONMENT 35, 35 (2000) (stating generally that firms searched for CFC alternatives ten years before the ban); Forte & Livernash, *supra* note 155, at 98 (explaining that York International, a major manufacturer of commercial air conditioning systems, introduced a "chiller" using an alternative HCFC as early as 1988); Nicholas A. Ashford et al., *Using Regulation To Change the Market for Innovation*, 9 HARV. ENVTL. L. REV. 419, 436 (1985) (reporting innovative responses to the lead phasedown in the late 1970s).

[157] *See, e.g.*, Bruce A. Ackerman & Richard B. Stewart, *Reforming Environmental Law: The Democratic Case for Market Incentives*, 13 COLUM. J. ENVTL. L. 171, 183 (1988); Daniel J. Dudek & John Palmisano, *Emissions Trading: Why Is This Thoroughbred Hobbled?*, 13 COLUM. J. ENVTL. L. 217, 234-35 (1988); Hahn & Stavins, *supra* note 36, at 13; Robert N. Stavins, *Policy Instruments for Climate Change: How Can National Governments Address a Global Problem?*, 1997 U. CHI. LEGAL F. 293, 302-03.

[158] *See* Driesen, *supra* note 153; Driesen, *supra* note 103.

[159] *See* LINDA NULL & JULIA LOBUR, THE ESSENTIALS OF COMPUTER ORGANIZATION AND ARCHITECTURE 19-25 (2d ed. 2006) (stating that the first supercomputer built with transistors cost $10 million, but integrated circuits and then microprocessors to miniaturize transistors dropped the price and made PCs possible). *See generally* Sabine Messner, *Endogenized Tech-*

sions of documents much easier. Hence, the PC example illustrates the tendency of initially expensive innovation to lead to both cost reductions over time and enhanced quality. The same pattern prevails with respect to innovation addressing environmental problems. Renewable energy, for example, offers an example of initially expensive innovation delivering high environmental quality, insofar as it provides energy while reducing emissions for a variety of pollutants to zero. While it has proven initially expensive, its costs have fallen over time.[160] Hence, innovation has value that may justify choosing it over more conventional approaches, even when the conventional approaches are cheaper in the short term. This value may justify DILs or other measures that may be needed to overcome inertia produced by the short-term cost effectiveness of sticking with conventional approaches.

B. Disadvantages

Depending on the context, DILs may also have disadvantages. First, by stimulating fundamental technological change, DILs may also cause economic disruption. Second, because they frequently necessitate the substitution of new inputs, DILs can introduce new risks. Finally, in some quarters, DILs may generate political opposition.

1. *Disruption*

While fundamental changes can dramatically improve environmental quality and reduce costs over time, they tend to disrupt existing processes. Indeed, the material above defines fundamental change as that which changes the nature of multiple processes all in one blow.[161] And DILs tend to spur more fundamental change than output-based regulation.[162]

Indeed, Congress has recognized that DILs have this potential for disruption and has limited their use because of it. When Congress constructed a system to address the treatment and disposal of solid waste in the Resource Conservation and Recovery Act ("RCRA"),[163] it recognized that pollution prevention ("conservation," in the words of the statute's title) could help us avoid expensive and incomplete treatment of solid waste altogether.[164] Yet

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nological Learning in an Energy Systems Model, 7 J. Evolutionary Econ. 291, 293 (1997) (describing "learning by doing" as "among the best empirically corroborated phenomena characterizing technological change in industry").

[160] *See, e.g.*, *Sunlit Uplands: Wind and Solar Power Are Flourishing, Thanks to Subsidies,* Economist, June 2, 2007, at 16 (noting that wind power costs have fallen from $2 per kilowatt hour (kWh) in the 1970s to 5-8 cents per kWh and that solar power costs have dropped from $20 per watt of production capacity in the 1970s to $2.70 in 2004).

[161] *See supra* text accompanying notes 151-152.

[162] *See supra* Part II.A.3.

[163] Pub. L. No. 94-580, 90 Stat. 2795 (1978) (amending 42 U.S.C. §§ 6901-6992k (1976)).

[164] *See* 42 U.S.C. § 6902(b) (2000) (establishing a national policy favoring pollution prevention over disposal); S. Rep. No. 98-284, at 65 (1983) (describing treatment as something only necessary for "wastes that are generated"); *see also* EPA Guidance to Hazardous Waste Generators on the Elements of a Waste Minimization Program, 58 Fed. Reg. 31,114, 31,115

Congress generally declined to give EPA the authority to promulgate DILs to realize these benefits. Instead, the statute requires generators of hazardous waste (an important subset of solid waste) to reduce use of the inputs that lead to hazardous waste only to the extent the generator deems practicable.[165] In other words, Congress left the decision about whether and how much to reduce inputs to industry, rather than to EPA.[166]

Congress understood that industry would only carry out input reduction under such a mandate when doing so would save the industry money.[167] This means that even when more input reduction would be optimal for society because it would produce additional benefits along the production stream, industry would not limit dirty inputs.

The legislative history shows that concerns about disruption of industry processes drove Congress to forego DILs in the RCRA context that may well have been environmentally and economically desirable.[168] The selection of inputs into production processes requires expertise and judgment about how to make a safe and effective product.[169] The congressional rejection of mandatory input reduction reflects concern that EPA, if given authority to require input reduction, might unwittingly make decisions that unduly interfered with sound production decisions. Of course, Congress has authorized interference with production decisions in order to realize environmental benefits when it views an environmental problem as sufficiently serious (as in the lead and ozone cases).[170] Yet, DILs present the possibility of unwise intrusion to a greater extent than output regulation.[171] This possibility often leads regulators to rely on voluntary approaches to realize input reduction goals.

Even voluntary input reduction, however, carries with it more risk of disruption than an end-of-the-pipe approach. Voluntary input reduction avoids disruption of the volunteer's manufacturing process, because manufacturers will only choose pollution prevention moves that they can manage effectively. But even voluntary input reductions can produce disruptions, including unemployment, in other industries. Input reduction can cause a

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(May 18, 1993) (explaining that minimizing waste generation reduces waste management costs).

[165] 42 U.S.C. § 6922(b).

[166] *See* S. Rep. No. 98-284, at 66 (describing the provisions as encouraging "generators to voluntarily" reduce toxic waste).

[167] *See id.* (stating that the decision about what is "economically practicable" will be made by the generator of hazardous waste and "is not subject to subsequent re-evaluation").

[168] *See id.* (stating that this provision. . . does not authorize EPA to "interfere with or intrude into" individual generators' "production process or production decisions").

[169] *See* 1980 CFC Proposal, *supra* note 20, at 66,730.

[170] *See* Ethyl Corp. v. EPA, 541 F.2d 1, 11 n.14 (D.C. Cir. 1976) (en banc) (stating that when EPA acts under the CAA provision authorizing it to impose DILs on fuel additives, "it is essentially telling manufacturers how to make their fuels, a task Congress felt the Agency should enter upon only with trepidation").

[171] *See, e.g.*, Fully Halogenated Chlorofluoroalkanes: Temporary Exemption for Automatic Timed-Release Insecticide Dispensing System Used in Long-Term Storage of Tobacco, 46 Fed. Reg. 27,120, 27,121 (May 18, 1981) (noting possible risks from replacement systems).

manufacturer to stop purchasing a particular supply.[172] If the input it chooses to reduce or eliminate turns out to be the sole product or the major product of a supplier, voluntary input reduction can cause the supplier to lay off labor or even shut down.[173]

While the pollution prevention literature pays little attention to this problem, Congress has paid attention to it on occasion. For years, it insisted on regulating sulfur dioxide from power plants using an end-of-the-pipe approach, because of concerns that a more flexible performance standard might lead electric utilities to stop using high sulfur coal, which could reduce mining jobs in regions producing it. When Congress finally authorized emissions trading to address acid rain, it recognized that this approach might encourage wider use of low sulfur coal, thereby threatening miners' jobs. It therefore provided economic aid for miners impacted by these voluntary input reduction choices under emissions trading.[174] Any input reduction approach, whether voluntary or not, can disrupt labor markets.

While this problem may justify coupling especially disruptive DILs with some kind of transition aid, this labor disruption problem should not count as a substantial reason to refrain from using DILs. DILs may lead not only to job losses, but to offsetting job increases as well. DILs stimulate demand for substitutes for the restricted input, which may generate employment in the industries supplying the alternative input.[175] Indeed, some amount of disruption is inevitable in competitive markets. Desirable economic changes disrupt labor markets all the time. No one would ever suggest that we should have avoided the development of personal computers because it hurt the business of typewriter manufacturers. It may be that we should make better transitional arrangements for workers regardless of the cause of disruption. Or perhaps we should not provide such assistance in the interest of having flexible labor markets. But it makes no sense to eschew disruption of labor markets for the sake of environmental benefits, while allowing disruption of labor markets in pursuit of all kinds of other benefits.

The disruption DILs may cause is generally greatest when they demand fundamental change. But this is not always true. In the case of ozone-depleting chemicals, many of the firms manufacturing ozone depleters could easily begin making substitutes.[176] As a result, phaseouts of ozone-depleting chemicals caused little disruption of labor markets. While they did disrupt

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[172] *See, e.g.*, Prohibition on Use of Chlorofluorocarbons as Propellants in Self-Pressurized Containers, 43 Fed. Reg. 11,299, 11,311 (Mar. 17, 1978).

[173] *Id.*

[174] Robert V. Percival et al., Environmental Regulation: Law, Science, and Policy 552 (4th ed. 2003).

[175] *See, e.g.*, Mikael Román, Ctr. for Climate Sci. & Policy Research, Report No. 07:02, What Order in Progress? Brazilian Energy Policies and Climate Change in the Beginning of the 21st Century 70-71 (2007), *available at* http://polopoly.liu.se/content/1/c4/10/58/Mikael%20Roman.pdf (stating that Brazilian support for ethanol as an alternative to gasoline produced some 720,000 jobs directly and some 200,000 indirectly between 1978 and 1990).

[176] *See* Prohibition on Use of Chlorofluorocarbons as Propellants in Self-Pressurized Containers, 43 Fed. Reg. at 11,311.

manufacturing processes, they did so quite productively. By contrast, the phaseout of lead involved less fundamental change, but may have put some firms out of business. The degree of disruption depends partly upon the nature of changes demanded and partly upon market structure and technological factors.[177]

In sum, DILs' disruptive capacity may constitute a disadvantage. But DILs' history suggests that the positive benefits, environmental and economic, may sometimes justify the disruption.

2. *Risk/Risk Problems*

While the reduction or elimination of dirty inputs can provide multiple benefits, it can also create new risks.[178] Generally, firms choose inputs to perform some function.[179] If they must eliminate or reduce an input, they will usually introduce some substitute input to perform a similar function.[180] That substitute can carry risks of its own.[181] The use of toxic substitutes for ozone depleters and for lead in gasoline provides an example of this problem.[182]

The oft-repeated claim that risk/risk problems pervade environmental law[183] suggests that DILs do not differ in this respect from other regulatory instruments. Risk/risk problems, however, do not pervade all environmental

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[177] *See id.* (predicting that a phaseout of the use of CFCs as propellants would produce unemployment in companies using them, but not in the less specialized companies manufacturing them); Protection of Stratospheric Ozone: Adjusting Allowances for Class I Substances for Export to Article 5 Countries, 71 Fed. Reg. 49,395, 49,396-97 (Aug. 23, 2006) (explaining that phasing out U.S. manufacturing of pharmaceutical-grade CFCs would lead to a relocation of facilities to developing countries).

[178] *See, e.g.,* Cass R. Sunstein, *Health-Health Tradeoffs,* 63 U. CHI. L. REV. 1533, 1541-42 (1996) (suggesting that regulatory bans can lead to introduction of risky substitutes); 1980 CFC Proposal, *supra* note 20, at 66,730.

[179] *See, e.g.*, Protection of Stratospheric Ozone: Listing of Substitutes in the Foam Sector, 67 Fed. Reg. 47,703, 47,709 (July 22, 2002).

[180] *See, e.g.*, Helfland, *supra* note 43, at 15; Protection of Stratospheric Ozone, 62 Fed. Reg. 27,874 (May 21, 1997) [hereinafter 1997 SNAP Rule].

[181] *See, e.g.*, Helfland, *supra* note 43, at 15 (arguing that substitution of inputs can increase "damages"); 1997 SNAP Rule, *supra* note 180. Helfland also discusses the possibility that a restricted input might contribute to pollution in some uses, but not in others, using water as an example. Helfland, *supra* note 43, at 15. This problem probably would not arise frequently if one regulates *dirty* inputs, substances with a clear association with pollutants of concern, rather than innocuous substances like water. Similarly, her concern that eliminating polluting inputs that complement abating inputs could have perverse results, *see id.*, should not arise often if regulated inputs are carefully chosen, *see id.* at 16 (arguing that perverse results are not likely in some contexts).

[182] *See supra* text accompanying note 102 and *supra* note 119 and accompanying text.

[183] *See, e.g.*, AARON WILDAVSKY, SEARCHING FOR SAFETY 20-21, 34-35 (1988) ; Sunstein, *supra* note 178; Cass R. Sunstein, *Paradoxes of the Regulatory State*, 57 U. CHI. L. REV. 407 (1990); RISK VERSUS RISK: TRADEOFFS IN PROTECTING HEALTH AND THE ENVIRONMENT (John D. Graham & Jonathan B. Wiener eds., 1995); *cf.* ALBERT O. HISRSCHMAN, THE RHETORIC OF REACTION 11-42 (1991) (arguing that political reactionaries typically respond to social welfare initiatives not by attacking the lofty goals those initiatives purport to serve, but by "urg[ing] that [they] will produce, via a chain of unintended consequences, the *exact contrary* of the objective being proclaimed and pursued").

law equally. While all environmental instruments can create ancillary risks, DILs have special problems in this regard that merit consideration.[184]

Because DILs demand a change in inputs, they can provide unusually great opportunities to avoid risks associated with current technologies. But this demand for change in inputs also suggests a capacity to create fundamental new problems.[185] Input change may produce net environmental gains as well as serious ancillary risks.[186] Still, experience suggests that targeting serious environmental risks through DILs has often worked well from a risk/risk perspective. The lead and ozone DILs both produced risk/risk tradeoffs that ultimately proved beneficial. In both instances, by targeting very serious risks, we made enormous progress in protecting public health and the environment, even though producers created some arguably less severe ancillary risks in the process.[187]

Like any regulation that provides firms with freedom to make technological choices, DILs have significant potential to stimulate introduction of ancillary risks without public evaluation. When government imposes a work practice standard, it makes the choice about what new technology will be employed, and its general responsibility to avoid arbitrary decisions combined with specific statutory language directed at risk/risk tradeoffs will usually require it to consider ancillary risks.[188] But when government imposes a DIL requiring a phaseout of a particular substance, producers are free to introduce any substitute they choose to replace it, unless some other regulation restrains them.[189] This choice of substitutes can occur largely without public oversight. While DILs share this defect with most output-based regulation, including emissions trading, pollution taxes, and performance standards,[190] the problem may be worse in the context of DILs since they are more likely to spur fundamental technological change.

Nonetheless, one should not leap to the conclusion that we should eliminate private technological choices by eliminating DILs to assure public evaluation of important ancillary risks. First, private actors have some incentives to consider the risks of substitute inputs, because of fears of liability or future regulation. Private creativity may itself contribute to risk avoidance. Furthermore, while risk/risk tradeoffs exist, it does not follow that the new risks will be worse than the old ones, as the lead and ozone examples

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[184] *See* Ethyl Corp. v. EPA, 541 F.2d 1, 32 n.67 (D.C. Cir. 1976) (requiring EPA to evaluate substitutes in writing fuel DILs to avoid "counterproductive results").

[185] *See, e.g.*, 1997 SNAP Rule, *supra* note 180, at 27, 876-87.

[186] *See, e.g.*, 1998 Halon Rule, *supra* note 86, at 11,089.

[187] *See supra* Parts I.D.2, I.D.3.

[188] *See* 42 U.S.C. §§ 7411(a)(1), 7412(d)(2) (2000); Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29, 43-44 (1983).

[189] *Cf.* 1997 SNAP Rule, *supra* note 180, at 27,875-81 (listing acceptable substitutes for ozone-depleting substances).

[190] *See* Daniel J. Dudek, Richard B. Stewart & Jonathan B. Wiener, *Environmental Policy for Eastern Europe: Technology-Based Versus Market-Based Approaches*, 17 COLUM. J. ENVTL. L. 1, 3 (1992) (describing "market-based approaches" as those that leave "the choice of . . . specific technologies . . . to private actors").

demonstrate. Finally, regulators can prevent DIL-related ancillary risks by prohibiting certain substitutes or through subsequent regulation.[191]

We may need some reforms to avoid serious new risks. Such reforms could include improvement in the generation of information about new toxic substances or a requirement for some government evaluation of alternative new technologies before DILs are imposed.[192] There is a tension, however, between the desire to evaluate all risks of substitutes thoroughly in advance and the desire to use private initiative to promptly reduce known serious risks.[193] Thus, while regulators should be attuned to the risk/risk problems that may accompany DILs, those potential problems do not warrant a wholesale rejection of the instrument.

3. *Political Feasibility*

DILs can pose formidable political challenges because they can significantly disrupt prevailing practices. This suggests that policy makers might best employ DILs when society needs disruption to solve serious long-term environmental problems and not when less disruptive mechanisms appear adequate.

Opponents may wish to paint DILs as akin to Soviet-style economic planning.[194] Policy makers should recognize that such charges are ill-founded. Under a regime of central economic planning, the government chooses targets for the production of desirable outputs and dictates the inputs to be used for these purposes. DILs, in contrast, do not involve production targets or government selection of inputs. Instead, under a DIL, government simply limits the use of a particular input, leaving private parties free to choose any economically and environmentally desirable substitute. And tradable DILs use a market mechanism to further enhance private sector flexibility. Still, unfounded charges have considerable potential to create political obstacles.

Any judgment about political practicality, however, must remain contingent upon the particular time and place. Even if DILs do not pass a political feasibility test in Washington, D.C., circa 2009, they may pass such a test

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[191] *See, e.g.*, 1997 SNAP Rule, *supra* note 180, at 27,876-87; Protection of Stratospheric Ozone: Listing of Substitutes for Ozone-Depleting Chemicals, 63 Fed. Reg. 5491, 5493 (Feb. 3, 1998).

[192] Congress imposed just such a requirement in the context of the lead DIL, requiring EPA, before prohibiting a fuel additive, to make a finding that "any fuel or fuel additive likely to replace the prohibited one will not 'endanger the public health or welfare to the same or greater degree.'" Ethyl Corp. v. EPA, 541 F.2d 1, 11 (D.C. Cir. 1976). In response to a DIL phasing out asbestos, the Court of Appeals demanded that EPA evaluate available information about substitute products' risks. Corrosion Proof Fittings v. EPA, 947 F.2d 1201, 1222-23 (5th Cir. 1991); *see also* 1997 SNAP Rule, *supra* note 176.

[193] *See* Prohibition on Use of Chlorofluorocarbons as Propellants in Self-Pressurized Containers, 43 Fed. Reg. 11,299, 11,309 (Mar. 17, 1978).

[194] *Cf.* Stewart, *Incentives*, *supra* note 146, at 154 (describing "[o]ur current environmental regulatory system" as "nothing less than a massive effort at Soviet-style central planning of the economy").

in California, in Sweden, or perhaps in Washington, D.C., after another decade of climate-related disasters. It is not too soon to start a debate about them among academics and policy makers.

III. DILs' Promise

Now that we have defined DILs, examined some historical examples of their use, and outlined some of their advantages and disadvantages, we outline some thinking about the nature of DILs' potential contribution to environmental law's future. We will first explore what sorts of problems they might best address. We will then show how the mechanism can reshape our thinking about environmental law.

A. *When are DILs Appropriate?*

We will first discuss a general theory of when DILs may prove most helpful. We will then offer a tentative proposal for a DIL limiting oil production and consumption and offer some other ideas for future DIL-related research. Our proposals remain tentative, because a thorough exploration of any one proposal would require an entire article and conclusions about such a proposal would require a set of normative assumptions that would themselves require a detailed defense. DILs' powerful advantages, however, particularly their capacity to simultaneously solve multiple environmental problems and their history of having driven beneficial cost-reducing innovations, suggest that policy makers should consider them seriously in the types of situations we describe below.

1. *Relevant Factors*

The foregoing discussion suggests that a number of factors may make DILs a desirable option for particular environmental problems. First, DILs are most promising when actions reducing inputs can cure substantial inefficiencies or where less environmentally harmful substitute inputs are available or at least conceivable.[195] Moreover, DILs will prove particularly attractive for addressing environmental problems that involve a production stream with multiple significant pollution outputs.

Because DILs provide no incentive for the installation of end-of-the-pipe technologies, they may be most attractive in situations in which such technologies are not available. Since they do not require polluting emissions to be measured or monitored, DILs are also likely to be attractive in circumstances where pollution outputs cannot be easily monitored, as where pollution seeps into the environment from numerous diffuse locations. And because DILs tend to promote fundamental technological innovation with all

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[195] *See* 1980 CFC Proposal, *supra* note 20, at 66,730; *cf.* Prohibition on Use of Chlorofluorocarbons as Propellants in Self-Pressurized Containers, 43 Fed. Reg. at 11,312-13.

the potential for economic disruption that goes along with such change, they may be most appropriate for environmental problems that warrant such changes in order to address serious harms, especially those that would be irreversible.

Finally, DILs may be useful when government lacks the resources to comprehensively regulate all relevant outputs. By and large the instrument choice debate has focused on the efficient use of private resources and has paid much less attention to how government's limited regulatory capabilities can best be deployed. For important environmental problems of broad scope, efficient use of government resources can be critical, especially in less developed countries. And DILs will often use government resources more efficiently than most competing instruments.

To summarize, where one or more of the following factors is present, an environmental problem may be one for which DILs present a desirable alternative:

1) **Feasibility**: Reductions of inputs are feasible.
2) **Multiple Outputs**: The production process from which the environmental problem stems produces multiple environmentally damaging outputs.
3) **End-of-Pipe**: End-of-the-pipe technologies are not available.
4) **Serious or Irreversible Environmental Harm**: The problem is serious enough to warrant forcing significant innovation, even at the cost of some disruption.
5) **Monitoring:** The polluting outputs cannot be easily measured or monitored.
6) **Government**: Government does not have the resources to adequately address each relevant output and harm using an output-based approach.

All of these factors do not need to be present in order for DILs to present a good option. Ozone-depleting chemicals, for example, did not involve a long production stream with multiple environmentally damaging outputs. Nor will DILs necessarily be the best option in all circumstances in which one or more of these factors are present. If government can adequately address multiple outputs cheaply through comprehensive output regulation and the problem does not demand fundamental innovation, then perhaps an output-based approach may prove superior.

History suggests that policy makers tend to consider DILs most seriously when other approaches simply seem impracticable. But their powerful advantages suggest that policy makers should consider them even when other alternatives are practicable, but the need for innovation or the lack of governmental capacity for sufficiently comprehensive output controls justifies the use of DILs. In any event, the feasibility, multiple outputs, end-of-pipe, monitoring, innovation, and government factors provide a good starting point for analyzing the desirability of particular DILs.

2. *Fossil Fuel DILs and Other Possibilities*

DILs have the potential to address a number of environmental problems more effectively than many competing instruments. The federal government has used them in a limited way to address pesticide use, and might productively use them more expansively, perhaps limiting overall pesticide use rather than just individual chemicals. The entire area of non-point source pollution, the most serious remaining water pollution problem in the United States, poses challenges for output-based regulation and arguably possesses all of the characteristics that invite serious consideration of DILs.[196]

While many possibilities exist, we wish to focus here on the use of DILs to address fossil fuel use. This focus will allow us to make the entire mechanism more concrete and better explore some of the key factors we have mentioned. This exploration will also set the stage for understanding DILs' broader significance as an aid to reconceptualizing environmental law. While we focus primarily on a DIL limiting oil use, most of our observations about this DIL would apply to DILs limiting other fossil fuels or a DIL limiting the carbon content of fuels generally.

a. Fossil Fuel DILs: Some Options

All of the factors that may justify a DIL are present to some degree in the fossil fuel context. Reductions in fossil fuel inputs are feasible, through both improved energy efficiency and deployment of alternative energy sources (factor 1). We have already shown that they flow through production streams that generate numerous heavily polluting outputs[197] (factor 2) and that end-of-the-pipe controls do not exist for carbon dioxide emissions from transportation[198] (factor 3). Fossil fuels are by far the most important cause of global warming, accounting for some eighty percent of the warming potential from all greenhouse gases combined.[199] And global warming threatens such severe and irreversible harms that widespread agreement now exists on the need for substantial innovation to address it, especially in the energy sector (factor 4).[200] While some of fossil fuels' pollution outputs can

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[196] *See* Mark Dorfman & Kirsten Sinclair Rosselot, Testing the Waters: A Guide to Water Quality at Vacation Beaches 13 fig.9 (18th ed. 2008), *available at* http://www.nrdc.org/water/oceans/ttw/ttw2008.pdf; MTBE Proposed Ban, *supra* note 24, at 16,102.

[197] *See supra* notes 19-25 and accompanying text.

[198] *See supra* note 63.

[199] Nordhaus & Danish, Pew Report, *supra* note 52, at 2.

[200] *See, e.g.*, Andrew E. Dessler & Edward A. Parson, The Science and Politics of Global Climate Change: A Guide to the Debate 102-06 (2006); Kevin A. Baumert, Note, *Participation of Developing Countries in the International Climate Change Regime: Lessons for the Future*, 38 Geo. Wash. Int'l L. Rev. 365, 388 (2006) (stating that effectively addressing climate change will require "large-scale technological and behavioral changes"); Telephone Interview with Lewis Milford, President, Clean Air Group, Clean Energy Group (July 5, 2006) (stating that experts agree that the world needs significant innovation in how energy is produced to adequately address climate change); *cf.* Stephen Pacala & Robert Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, 305 Science 968 (2004) (arguing that existing technologies can stabilize

be reliably and inexpensively monitored (emissions from large industrial sources), others, like motor vehicle emissions, are too numerous and disparate for effective monitoring to be practicable (factor 5). This, in turn, raises concerns about whether governments have the necessary resources to adequately regulate each of the many pollution outputs along each fossil fuel's production stream (factor 6). These concerns are even more acute when it comes to the over-extended and under-resourced governments of many developing nations. Indeed, a number of scholars have already raised doubts about the ability of developing country governments to properly implement the output-based trading mechanisms called for by the Kyoto Protocol.[201] Thus, fossil fuel DILs merit serious consideration.

For convenience, we focus on the possibility of a DIL limiting the production and use of oil. We could have chosen coal. One could choose to use DILs to limit some fossil fuels and not others. One could also use a suite of DILs to address all fossil fuels. Alternatively, one might focus on carbon as an input.[202] Since coal, oil, and gas consist mostly of carbon, a limit on carbon would function as a limit on gasoline, coal, and oil.[203] Designing a DIL this way would add flexibility and might merit policy makers' consideration. We focus on an oil DIL here in part because this single substance DIL provides a simpler illustration of the concept than would a very broad DIL. Moreover, a carbon DIL suggests a focus on global warming (even though in practice it would provide many non-carbon environmental benefits). While that is certainly an important problem, one of the prime values of a DIL is its capacity to spur a broader framing of environmental issues. Focusing on the many adverse environmental effects of a substance like oil provides a nice illustration of that potential.

Policy makers designing a DIL for oil would first have to confront the question of how stringent the limit on inputs should be. One approach would be simply to limit the projected increase in oil consumption. For example, a government could decide that oil consumption would only increase by one percent per year. If the economy would otherwise increase oil consumption by ten percent per year, this limit would spur some fundamental technological change and avoid future environmental damage, but to a limited extent. Alternatively, a government could set a DIL preventing any rise in oil consumption above current levels.[204] Or it could limit future oil consumption to some fraction of existing consumption.[205] This last approach

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climate over the next fifty years, but not making this claim with respect to the cuts needed after that time).

[201] *See, e.g.,* Ruth Greenspan Bell, *Choosing Environmental Policy Instruments in the Real World*, *in* OECD, GREENHOUSE GAS EMISSIONS TRADING AND PROJECT-BASED MECHANISMS 69 (2004).

[202] *See, e.g.*, NORDHAUS & DANISH, PEW REPORT, *supra* note 52; CBO REPORT, *supra* note 52; HARGRAVE, *supra* note 68.

[203] *See* FARRELL ET AL., *supra* note 77, at 1-2 (noting that compliance with California's carbon intensity target for transportation fuels will require movement to new fuels "that do not require petroleum").

[204] *Cf.* 1980 CFC Proposal, *supra* note 20, at 66,729.

[205] *Cf. id.*

would demand real cuts, produce substantial environmental improvements, change technologies in a profound way, and might seriously disrupt existing industry in favor of new industries with competing technologies. Finally, government could phase out oil altogether.[206] This last approach would maximize both environmental benefits and disruptions of the oil industry. Accordingly, it would probably require a long implementation period to manage and ameliorate the disruption.[207]

Let us assume a government decided to implement a twenty percent reduction in oil consumption. It would next have to decide where along the production stream to impose the DIL. One possibility would be to impose the DIL downstream, on the gasoline and other oil products purchased by consumers. A gas rationing scheme of this sort, however, would pose substantial administrative difficulties. While the United States rationed gas as part of the effort to win the Second World War, it is not clear that environmentally motivated gas rationing could induce the degree of citizen cooperation that the war effort produced.[208] It does not seem practicable to enforce gas rationing without such cooperation. Even if such cooperation were a realistic possibility, such a scheme would require an enormous administrative apparatus.[209]

A better model would take an approach more like the Montreal Protocol and impose the DIL further upstream. The government could limit the production and importation of oil by auctioning off allowances equal to eighty percent of the oil consumption in a given year.[210] It would then require producers to hold allowances for every barrel of oil produced and importers to hold allowances for every barrel imported. To soften the transition, the government might choose to follow the practice of other trading programs and allocate more allowances in the early years of a program with the number of allowances declining to eighty percent over time.

If the DILs were going to be tradable, the government would simply add a rule stating that anybody producing or importing less than their DIL could sell surplus allowances to anybody wishing to exceed their DIL. These allowances could be expressed in terms of barrels of oil. Notice that tracking barrels of oil should be much simpler than tracking emissions, as we do in emissions trading.

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[206] *Cf.* 1993 Phaseout, *supra* note 90.

[207] *Cf. id.* at 65,024.

[208] *See* Chester Bowles, *OPA Volunteers: Big Democracy in Action*, 5 PUB. ADMIN. REV. 350, 350, 358-59 (1945) (crediting "active, widespread public cooperation" with allowing rationing programs to succeed in the United States during the Second World War).

[209] *See* George H. Watson, *State Participation in Gasoline Rationing,* 3 PUB. ADMIN. REV. 213 (1943).

[210] *Cf.* CBO REPORT, *supra* note 52, at ix. We have provided a simplified model that would work adequately in a country that consumed all of the oil it produced. If the country, however, exported oil, this model would produce more than a twenty percent reduction of domestic consumption. If policy makers wanted to limit only domestic consumption and not the domestic economy's impact on oil use worldwide, they could give extra allowances to producers who ship oil overseas to cover the exports. This highlights a problem of leakage, which is not unique to DILs.

This is not a complete description of how the mechanism would work, nor is it necessarily the best way to design it. But it suffices to make the idea of a DIL concrete in this context.

b. An Oil DIL as Climate Change Policy

Most scientific descriptions of how society might ameliorate global warming recognize the need to abandon fossil fuels over time and therefore focus on the variety of technological substitutes available for fossil fuels.[211] Yet, the vast literature on potential legal responses to climate change does not generally investigate how governments might craft regulation to spur a substitution of new technologies for fossil fuels directly. Rather, it engages in a rather abstract debate about mechanisms that would generally encourage carbon "abatement."[212]

The Kyoto Protocol contains no less than three different types of emissions trading programs, all conceived as opportunities for countries with expensive abatement options to purchase cheaper reductions abroad.[213] While scholars have predicted that trading under the Kyoto Protocol would encourage innovation, it has in practice encouraged mostly end-of-the-pipe compliance options, such as the application of thermal oxiders to control HFC-23, a potent greenhouse gas.[214] The reason for this is that end-of-the-pipe controls are less expensive than the fundamental technological changes that would prevent most of the pollution causing global warming. The Kyoto Protocol encourages the most cost-effective options in the short term, taking existing technological choices as a given. It tends, therefore, to disfavor expensive investments that would fundamentally change technologies over time.

Furthermore, the end-of-the-pipe focus has provided no means for getting a handle on stopping the fundamental drivers of climate change: the proliferation of dirty vehicles and coal-fired power plants around the world. The output focus of Kyoto's mechanisms is certainly not the major culprit in this failure. The inability to reach a global consensus on sufficiently ambitious and comprehensive emission caps is much more important. But the

[211] *See, e.g.,* Pacala & Socolow, *supra* note 200, at 969-71 (listing technologies that could be used to ameliorate global warming, almost all of which address energy).

[212] *See* THE LONG-TERM ECONOMICS OF CLIMATE CHANGE: BEYOND A DOUBLING OF GREENHOUSE GAS CONCENTRATIONS (Darwin C. Hall & Richard B. Howarth eds., 2001); CLIMATE CHANGE ECONOMICS AND POLICY: AN RFF ANTHOLOGY (Michael A. Toman ed., 2001); IPIECA SYMPOSIUM ON CRITICAL ISSUES IN THE ECONOMICS OF CLIMATE CHANGE (Brian P. Flannery & Charlotte A.B. Grezo eds., 1997); OECD, RESPONDING TO CLIMATE CHANGE: SELECTED ECONOMIC ISSUES (1991); GLOBAL WARMING: ECONOMIC POLICY RESPONSES (Rudiger Dornbusch & James M. Poterba eds., 1991).

[213] *See* Richard B. Stewart, James L. Connaughton & Lesley C. Foxhall, *Designing an International Greenhouse Gas Emissions Trading System,* 15 NAT. RESOURCES & ENV'T. 160 (2001).

[214] *See* Driesen, *supra* note 147, at 24. Output-based trading sometimes produces innovation and may produce some under the Kyoto Protocol in time. One of us has elsewhere questioned the idea that emissions trading better stimulates innovation than performance standards of identical scope and stringency. *See, e.g.*, Driesen, *supra* note 153; Driesen, *supra* note 103.

failure of current regulatory approaches to reach the fundamental drivers of climate change has meant that the world has felt free to build new coal-fired power installations that condemn us to more rapid climate change in the future, with Kyoto's emissions trading mechanisms functioning as a minor band-aid — an amelioration of very bad fundamental technological choices that remain largely unconstrained in most countries. Considering DILs forces a confrontation with the need to change these choices.

In addition, Kyoto's focus on outputs by necessity leaves out a significant percentage of the greenhouse gas emissions driving climate change, since emissions trading covering the transportation sector is infeasible.[215] DILs provide a relatively simple and elegant mechanism for regulating climate change on an economy-wide basis.

DILs may also offer some advantages over the more viable non-trading methods that have been used to address transport emissions. Insofar as countries address vehicle emissions at all under Kyoto, they tend toward fragmentary responses. The most common measures used in this sector involve fuel efficiency standards.[216] But if people drive more as fuel efficiency improves, these changes may not provide absolute reductions in greenhouse gas emissions. So, this response is attractively cheap, but unreliable unless accompanied by DILs.

Subsidies can also help encourage movement away from fossil fuels.[217] Brazil, which may have made more progress than any other country in reducing dependence on gasoline, has employed a combination of subsidies and regulation of fuel content.[218] Where governments are sufficiently honest and effective to choose targets for subsidies wisely, subsidizing alternatives to fossil fuels can be an effective approach. In other cases, DILs offer the advantage of relying on private sector selection of substitutes, when government corruption might otherwise lead to poor environmental choices. Subsidies combined with DILs will provide a powerful impetus for change, both raising the price of gasoline and lowering the price of the subsidized substitutes.

A DIL reducing oil consumption by twenty percent would impose a fundamental constraint that would force fuel producers, car manufacturers,

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[215] *See supra* notes 58-62 and accompanying text.

[216] The latest set of Corporate Average Fuel Economy ("CAFE") standards issued by NHTSA in 2006, Average Fuel Economy Standards for Light Trucks Model Years 2008-2011, 71 Fed. Reg. 17,566 (Apr. 6, 2006) (to be codified at 49 C.F.R. pts. 523, 533, 537), took what many viewed as far-too-modest steps to tighten fuel efficiency standards for SUVs, minivans and pickup trucks. A lawsuit brought by a coalition of states and environmental groups challenging the rule recently resulted in a decision by the Ninth Circuit Court of Appeals striking it down. *See* Ctr. for Biological Diversity v. NHTSA, 538 F.3d 1172 (9th Cir. 2008). The new energy bill passed in late 2007 will raise CAFE standards for cars to thirty-five miles per gallon by 2020. *See* Energy Independence and Security Act of 2007, Pub. L. No. 110-140, § 102(b)(2)(A) (2007).

[217] *See, e.g.*, Governor Signs Bills on Tax Credits, Greenhouse Gas Emission Reduction Goals, 38 Env't Rep. (BNA) 1744 (Aug. 10, 2007); House Passes Bill With Tax Incentives To Promote Renewable Energy, 38 Env't Rep. (BNA) 1730 (Aug. 10, 2007).

[218] *See* Román, *supra* note 175, at 49.

and consumers to innovate to stay within the constraint. As such, it has much greater potential to stimulate the sort of innovation needed to address climate change in the long-term than does the piecemeal approach currently employed to address transport.[219] Moreover, an oil DIL addresses the full array of oil-related pollution, not only carbon dioxide. An oil DIL offers a simpler, more comprehensive approach to this vast array of problems than the piecemeal approach we now use. DILs merit serious consideration by policy-makers, both for fossil fuels and for other problems that strain the output-based regulatory system.

B. *Changing Our Thinking*

DILs have value beyond their potential utility as an instrument in our arsenal of environmental tools. Serious thought about DILs can help us productively rethink environmental law. Below we explore how DILs add to our understanding of instrument choice, raise important questions about cost-benefit analysis, and finally challenge the way we define environmental problems in the first place.

DILs help broaden our thinking about instrument choice, as we suggested at the outset. They help us move beyond the sterile debate about choices between vaguely defined "command-and-control regulation" and equally vaguely defined "market-based instruments." They show that choices about whether to regulate inputs or outputs may matter as much or more than choices among conventional output-based instruments.

1. *Instrument Choice: DILs and Pollution Taxes*

DILs can help improve our thinking about environmental taxes, which in some polities may compete with DILs for policy makers' allegiance.[220] We have seen that economists implicitly distinguish between upstream and downstream taxes and recognize the administrative cost savings that often result from choosing upstream taxes.[221] Our analysis highlights a feature of many upstream taxes that economists have rarely grappled with explicitly, namely that upstream taxes often (although not always) will tax inputs rather than outputs.[222] When they tax inputs, they will have many of DILs' advantages and disadvantages.

To see this, imagine a tax on coal. Electric utilities could only escape this tax by reducing coal usage. Carbon sequestration would not reduce the amount of coal used and therefore would not reduce the tax. Like a DIL, then, an input tax will tend to produce more fundamental innovation (*e.g.*, switching from coal to other fuels) than will an output tax. It may prove less

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[219] *Cf. id.*, *supra* note 175, at 72 (describing new market for new cars created by ethanol requirements in Brazil).

[220] *See* Baranzini et al., *supra* note 46.

[221] *See id.* at 406; Muller & Hoerner, *supra* note 46, at 41.

[222] *Cf.* Vatn, *supra* note 50.

cost-effective in meeting a narrowly defined objective that might be achieved with a cheaper end-of-the-pipe control, but — as with a DIL — if we broaden our focus to include the entire production stream, that apparent inefficiency will often disappear.[223] Also like a DIL, a properly designed input tax on coal may prove superior at addressing the multiple effects of coal mining than an output tax on power plant CO_2 emissions. Thus, one can expect a tax on inputs to offer advantages over output-based taxes similar to those that DILs offer over output-based emissions trading.

The DIL analysis can inform the design of pollution taxes. Economists have dominated this discussion, so that it focuses predominantly on static economic efficiency. For problems that are sufficiently serious to justify major innovation, however, questions of efficacy and dynamic efficiency may prove more important.[224] To design a tax encouraging substitution of cleaner inputs, the main objective of a DIL, one would need to impose a tax high enough to make substitutes cost less than the dirty input one hopes to reduce. Even those who prefer making static efficiency the major goal of environmental regulation may find this approach attractive. Frequently, the uncertainties involved in quantifying the social cost of pollution for purposes of setting optimal tax rates are so great that the economists' call to establish a tax rate equal to social costs offers no practical policy guidance.[225] In such cases, using an analysis of the relative costs of dirty inputs and clean substitutes to inform tax design offers a workable alternative.

In the United States, pollution taxes may be politically infeasible,[226] making DILs, even with their political problems, a potentially attractive option. In other polities, however, the conventional literature on choosing between taxes and tradable permits can inform this choice.[227] This literature suggests that in some circumstances DILs will prove more efficient than input taxes, while in other circumstances the converse will be true.[228] It sug-

[223] *Cf.* Stavins, *supra* note 52, at 312.

[224] *See* DAVID M. DRIESEN, THE ECONOMIC DYNAMICS OF ENVIRONMENTAL LAW 71 (2003).

[225] *See* Stewart, *Incentives*, *supra* note 146, at 161 (noting that inability to quantify social costs associated with certain pollutants makes setting a "workable" tax problematic); David M. Driesen, *The Societal Cost of Environmental Regulation: Beyond Administrative Cost-Benefit Analysis,* 24 ECOLOGY L.Q. 545, 594-600 (1997) (discussing how uncertainties, law, and pressures on regulatory agencies frequently lead to undervalued benefits); David M. Driesen, *Is Cost-Benefit Analysis Neutral?,* 77 U. COLO. L. REV. 335, 340-41 (2006) (discussing uncertainties in cost-benefit analysis that would make a calculation of an optimal tax rate very indeterminate).

[226] *See* Bohm & Russell, *supra* note 1, at 404-05 (listing several failed attempts to impose pollution taxes in the U.S.).

[227] *See, e.g.*, WILLIAM J. BAUMOL & WALLACE E. OATES, THE THEORY OF ENVIRONMENTAL POLICY 58-70 (2d ed. 1988); William A. Pizer, *Prices vs. Quantities Revisited: The Case of Climate Change* (Res. for the Future, Discussion Paper 98-02, 1997), *available at* http://www.rff.org/documents/RFF-DP-98-02.pdf; Robert N. Stavins, *Correlated Uncertainty and Policy Instrument Choice*, 30 J. ENVTL. ECON. & MGMT. 218 (1996); *cf.* Martin L. Weitzman, *Prices Versus Quantities*, 41 REV. ECON. STUDIES 477 (1974).

[228] According to this literature, when there is uncertainty about the costs of control, which instrument produces the more efficient result will depend on the relative slopes of the marginal benefits curve and the marginal cost curve. When the benefits curve is relatively flat and the

gests that allowing the public to directly control the amount of reductions made, as in a DIL, is more democratic than making the amount of reductions depend on private actors' decisions about how to respond to price increases.[229] One might also claim that DILs provide greater certainty about how much pollution reduction is to be achieved, while taxes on inputs provide less, thus suggesting that DILs may prove superior when certainty about the environmental results is of paramount interest.[230] And conversely, one may assert that taxes provide greater certainty about costs, suggesting that taxes may prove better if a cost constraint is of paramount importance.[231] We do not claim that DILs are always better than input taxes, but we do claim that DILs improve our thinking about environmental taxation.

2. *Rethinking Cost-Benefit Analysis*

To the extent that governments employ cost-benefit analysis ("CBA")[232] to evaluate DILs, the instrument requires a different approach than the one analysts have used hitherto. CBA of climate change implicitly evaluates a DIL because economists usually evaluate the costs of climate change abatement by estimating, in various ways, the cost of reducing fossil fuel use.[233] The above analysis, however, suggests that the benefits of a DIL addressing fossil fuels will go beyond climate change benefits. Thus, a proper analysis of an oil DIL's benefits would include consideration of the full array of environmental harms associated with oil use, many of which we have previously discussed.[234]

Yet CBA has proven controversial, in part because we cannot quantify and monetize many of the environmental impacts that matter the most.[235] Demanding that government officials evaluate a DIL's desirability through CBA may prove crippling, even if it should pass the CBA test by a wide

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costs curve is relatively steep, then taxes will be more efficient. When the converse is true, trading will be more efficient. *See* BAUMOL & OATES, *supra* note 227, at 68-70; Weitzman, *supra* note 227.

[229] *Cf.* Prohibition on Use of Chlorofluorocarbons as Propellants in Self-Pressurized Containers, 43 Fed. Reg. 11,299, 11,311 (Mar. 17, 1978).

[230] *See* 1989 Reduction, *supra* note 90, at 30,567; *see also id.* at 30,579.

[231] A critique of these conventional arguments lies beyond the scope of the article.

[232] *See* Amy Sinden, *In Defense of Absolutes: Combating the Politics of Power in Environmental Law*, 90 IOWA L. REV. 1405, 1413-23 (2005).

[233] *See, e.g.*, NICHOLAS STERN, THE ECONOMICS OF CLIMATE CHANGE: THE STERN REVIEW 258-62 (2007); Terry Barker et al., *Avoiding Dangerous Climate Change by Inducing Technological Progress: Scenarios Using a Large-Scale Econometric Model*, *in* AVOIDING DANGEROUS CLIMATE CHANGE 361 (Hans Joachim Schellnhuber et al. eds., 2006).

[234] *See supra* notes 19-24, fig.1, and accompanying text.

[235] *See, e.g.*, Driesen, *Is Cost-Benefit Analysis Neutral?, supra* note 225, at 339-41; Amy Sinden, *The Economics of Endangered Species: Why Less Is More in the Economic Analysis of Critical Habitat Designations*, 28 HARV. ENVTL. L. REV. 129, 202-07 (2004) (discussing non-quantifiability of many benefits associated with critical habitat designations to protect endangered species); *see also* 1989 Reduction, *supra* note 90, at 30,593, 30,595 ("While the [cost-benefit analysis of the EPA rule limiting production and consumption of CFCs] attempts to quantify some of the likely major impacts (e.g., skin cancers), limited research completed to date prevents the quantification of other potentially significant risks. . . .").

margin. CBA of an oil DIL will prove especially difficult because of the large variety of environmental benefits associated with this DIL. CBA may inadvertently discourage governments from adopting the most valuable DILs, because a large array of benefits makes it hard to conduct comprehensive quantitative analysis.

DILs also pose challenges on the cost side of the equation. Economists usually evaluate costs by reference to the current market price of abatement measures. As a result, they have a poor record at predicting the costs of regulation, because regulation itself so often changes markets. This usually causes economists to predict higher costs than regulations actually produce.[236] With respect to DILs, the challenges are even more formidable since DILs tend to encourage innovation. Predicting the magnitude of cost savings from innovation is probably impossible, which may encourage policy-makers and economists looking for an easily defensible methodology to fail to take innovation into account. Failing to take innovation into account will lead to exaggerated estimates of a DIL's costs. This is precisely what has happened with early climate change CBA, which produced very high cost estimates by assuming that no innovation would occur.[237]

A change in thinking about environmental policy might be necessary to properly evaluate DILs. We doubt that an extremely incomplete effort to quantify the dollar value of environmental and health benefits coupled with a terribly unreliable estimate of the cost of a DIL will provide useful guidance to policy makers.[238] Instead, it might make sense to address the primary concerns that DILs raise — those related to disruption and risk/risk possibilities — directly.

With respect to disruption, this would include some evaluation of who might profit from DILs and who might lose out.[239] This could include efforts to convince oil companies to invest in substitutes for gasoline, something which is beginning to occur, in order to minimize disruption of their business. It might include transition mechanisms for workers losing jobs, or efforts to support new businesses that might be needed to make an effective transition. If a gasoline DIL is expected to raise fuel costs significantly, this

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[236] *See* Winston Harrington et al., *On the Accuracy of Regulatory Cost Estimates*, 19 J. Pol'y Analysis & Mgmt. 297 (2000); Hart Hodges, Econ. Pol'y Inst., Falling Prices: Cost of Complying with Environmental Regulations Almost Always Less Than Advertised (1997); Office of Tech. Assessment, *supra* note 148; Ruth Ruttenberg, Not Too Costly After All: An Examination of the Inflated Cost Estimates of Health, Safety, and Environmental Protections (2004), *available at* http://www.citizen.org/documents/ACF187.pdf; Thomas O. McGarity & Ruth Ruttenberg, *Counting the Cost of Health, Safety, and Environmental Regulation*, 80 Tex. L. Rev. 1997, 2042-44 (2002) (collecting studies).

[237] *See* Stern, *supra* note 233, at 261-62, 262 tbl.9.3.

[238] *Cf.* Amy Sinden, *Cass Sunstein's Cost-Benefit Lite: Economics for Liberals*, 29 Colum. J. Envtl. L. 191, 201-28 (2004) (arguing that CBA fails to provide meaningful guidance to policymakers).

[239] *See* Richard D. Morgenstern, Mun Ho, Jhih-Shyang Shih & Xuehua Zhang, The Near-Term Impacts of Carbon Mitigation Policies on Manufacturing Industries (2002).

may suggest a need to subsidize low-income drivers and/or invest in mass transit.[240] We suggest, however, that any evaluation of costs be expressed as a range of values incorporating varying assumptions about innovation.[241] We should recognize that a cost number in a policy evaluation is a prediction about the future, not a fact.[242]

This approach suggests a normative point that one of us has made elsewhere. The distribution of costs may be more important than the total amount.[243] Furthermore, it suggests that cost must be treated not as a fact, but as a factor subject to change in response to human decisions about investment and policy.

We do not mean to stack the deck in favor of any particular DIL. If analysis suggested that our oil DIL, for example, would mean that people could no longer get to their jobs or drop their children off at school, society would have to decide about whether this price would be worth paying in order to effectively address global warming and oil's other environmental impacts. We do think that disruption of people's lives, health, and environment matters and is worthy of analysis. But unreliable and contestable dollar estimates of costs and benefits do not provide information that is helpful in analyzing these factors. Instead (or at least additionally), policy makers should consider qualitative factors.[244] Oil will run out eventually. Society should think about whether moving away from it before we commit ourselves to significantly more global warming has advantages over waiting until we have used the last drop or it has become so costly that even the most expensive substitutes are viable.

In short, a DIL focuses our attention on the question of how to achieve sustainable development. Sustainable development is usually defined as an approach that meets the basic needs of current generations while protecting future generations.[245] Advocates of sustainable development envision an "integrated" approach to decision making, where the public participates in choosing a path that harmonizes desire for economic development with environmental quality.[246] The current focus on pollution outputs basically ac-

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[240] *See* NORDHAUS & DANISH, PEW REPORT, *supra* note 52, at 111-12 (suggesting targeted tax breaks or lump-sum payments to low-income people to compensate for increased energy costs).

[241] *See, e.g.*, STERN, *supra* note 233, at 239 (laying out range of costs for reducing greenhouse gas emissions).

[242] *See* FARRELL ET AL., *supra* note 77, at 79.

[243] *See* David M. Driesen, *Distributing the Costs of Environmental, Health, and Safety Protection: The Feasibility Principle, Cost-Benefit Analysis, and Regulatory Reform*, 32 B.C. ENVTL. AFF. L. REV. 1 (2005).

[244] *See generally* Sidney A. Shapiro & Christopher H. Schroeder, *Beyond Cost-Benefit Analysis: A Pragmatic Reorientation*, 32 HARV. ENVTL. L. REV. 435, 473-75 (2008) (describing, while arguing for change in approach to CBA, "[d]iscursive analysis").

[245] World Comm'n on Env't & Dev., *Our Common Future*, at 54, U.N. Doc. A/42/427 (Aug. 4, 1987).

[246] *See* John C. Dernbach, *Achieving Sustainable Development: The Centrality and Multiple Facets of Integrated Decisionmaking*, 10 IND. J. GLOBAL LEGAL STUD. 247, 248, 250-51, 255-56 (2003); Douglas A. Kysar, *Sustainable Development and Private Global Governance*, 83 TEX. L. REV. 2109, 2115-16 (2005).

cepts development paths chosen with little or no consideration of environmental problems, and then seeks to compensate for those paths' negative environmental consequences. In contrast, evaluating a DIL provides a forum for the sort of integrated consideration of meeting peoples' needs that sustainable development envisions.

A DIL also advances sustainable development in the sense articulated by the economist Herman Daly. He argues that society should hold steady or reduce inputs of non-renewable natural resources and outputs of pollution, i.e., "throughput."[247] He advocates a distinction between economic development, which envisions innovation in meeting human needs, and economic growth, which relies upon constant and ultimately unsustainable increases in throughput.[248] A DIL focuses on throughput reduction, not just output reduction, and therefore provides a mechanism for achieving sustainable development in Daly's sense.

3. *Redefining Environmental Problems*

In considering whether any of the DILs described above would be desirable, the first question one would ask is whether serious environmental problems justify them. Just thinking about this question forces a useful reconceptualization of environmental problems.

We tend to think about environmental problems in a very fragmentary way. We think about global climate change, urban smog, oil spills, and hazardous air pollutants, for example, as separate environmental problems. Many environmental scholars lament the fragmented nature of environmental law and policy.[249] Yet these complaints ring hollow, not because they are necessarily wrong, but because the authors of these laments often have no viable proposal about how to better integrate our effort. It is not possible to address (or even think about) all environmental problems at once, so we must fragment our treatment of environmental threats in some way to begin to analyze these problems or address them. Thus, lamentations about fragmentation and an assertion that we need a "comprehensive approach" to environmental problems do not suffice. We need new approaches to how we think about and address environmental problems that are narrow enough to facilitate meaningful analysis and action, but not so fragmented that we miss too many important connections or act ineffectually.

Viewing all of the many problems to which fossil fuels contribute as separate problems leads to a fragmented response. For example, we regulate volatile organic compounds from petroleum refineries because they contrib-

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[247] *See* HERMAN E. DALY, STEADY-STATE ECONOMICS 14-50 (2d ed. 1991). For a definition of "throughput," see *id.* at 17.

[248] *See* Herman E. Daly, *Sustainable Growth: An Impossibility Theorem*, *in* VALUING THE EARTH 267-73 (Herman E. Daly & Kenneth N. Townsend eds., 1993).

[249] *See, e.g.*, NAT'L ACAD. OF PUB. ADMIN., SETTING PRIORITIES, GETTING RESULTS: A NEW DIRECTION FOR THE U.S. ENVIRONMENTAL PROTECTION AGENCY (1995).

ute to smog.[250] We then regulate most of these same compounds again because many of them are also hazardous air pollutants — pollutants associated with cancer and other extremely serious health risks.[251] We then regulate oil spills separately. And, further downstream, we regulate vehicle emissions traceable to gasoline.[252]

Considering DILs, on the other hand, forces us to broaden our focus and helps us to see how fossil fuels contribute significantly to a vast array of environmental problems. It helps us to reframe the question so that we ask not just about air pollution or water pollution, but about whether we should consider fossil fuel use itself as the problem to solve. This question invites a radical redefinition of environmental policy. It suggests that we consider the myriad impacts of fossil fuel use together along with its myriad benefits. Once we do this, we see instantly that fossil fuel use is absolutely devastating, lying at the heart of global warming and most other serious environmental problems. On the other hand, we see that fossil fuel use performs an important role in powering our economy.

In considering the desirability of a DIL for oil, one would be concerned about whether a reduction in oil consumption would disrupt transportation.[253] This question usefully refocuses debate about environmental policy. It is extremely clear that reducing gasoline consumption is environmentally desirable. It is also clear that gasoline has no intrinsic worth. Rather, it is a means toward the end of mobility. The right question to ask is whether we could have mobility with less (or no) oil.

This question leads to consideration of substitutes for gasoline in the broader sense we discussed earlier,[254] including the potential for energy efficiency improvements, alternative fuels, and perhaps even the potential role of bicycles and mass transit. In other words, it leads to evaluation of the feasibility of moving away from gasoline toward cleaner approaches. We think these are difficult questions to answer. While some information exists about substitutes and their costs, we have already mentioned that DILs tend to change costs by encouraging cost reducing innovation. Thus, any conversation about substitutes should include some discussion of the capabilities of private industry to innovate in response to the DIL and of communities to change modes of transportation, not just a bureaucrat's assessment of the current costs and benefits of the status quo. This focus on feasibility in a broad sense and on the potential for innovation stimulates a conversation that is useful in and of itself, even apart from the conclusions to which it

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[250] *See* EPA Revisions to the California State Implementation Plan, San Joaquin Valley, Unified Air Pollution Control District, 71 Fed. Reg. 14,652 (Mar. 23, 2006).

[251] *See* 42 U.S.C. § 7412 (2000).

[252] *See id.* § 7521 (2000).

[253] This is not the only impact that must be considered. Oil has some non-transportation uses. *See* Hargrave, *supra* note 68, at 9; Tim Hargrave, Sam Keller & David Festa, Accounting for Non-Fuel Uses of Fossil Fuels in an Upstream Carbon Trading System (1998).

[254] *See supra* text accompanying notes 239-242.

might lead. It asks the right questions in light of what we know about fossil fuels' environmental effects.

We have deliberately addressed the DIL proposed here in a fairly general way, focusing on the nature of its potential impacts both on discourse and on society, rather than purporting to calculate its precise effects. This general approach means that the lessons we have drawn as to how DILs productively reshape thinking about environmental law and stimulate significant environmentally productive innovation apply to other DILs that address fundamental inputs as well. DILs' advantages seem powerful enough to merit serious consideration even in cases where output regulation is perfectly feasible.

IV. Conclusion

Although they have not previously been recognized as a distinct regulatory instrument, DILs have actually played an important role in some of the most prominent environmental success stories of the past three decades. They also have significant potential to meet some of the most pressing environmental challenges we now face. Accordingly, policy makers should seriously consider DILs, especially when confronting problems that demand significant technological changes. Consideration of DILs will not only help us craft more effective solutions, but it will help us to reconceptualize environmental law in a more holistic and dynamic way.