REMARKS

LEGAL DISPUTES RELATED TO CLIMATE CHANGE WILL CONTINUE FOR A CENTURY

BY

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These Remarks summarize the expected effects of anthropogenic climate change, discuss the expensive and ineffective mitigation efforts that have been attempted to date, describe a more promising strategy for the future, and explain why the U.S. must prepare to make major changes in the law in order to adapt to some significant, and inevitable, changes in climate. These Remarks were originally presented to the Washington D.C. Bar as the 2012 Harold Leventhal Lecture.

I. INTRODUCTION TO THE PROBLEM

I am confident that my current students will be working on legal issues related to climate change until they retire fifty years from now.

The average global temperature is already certain to increase by 2°F.[1] It will increase by far more, with other major attendant changes in climate, unless we reduce global emissions of greenhouse gases (GHGs) by at least 50% by 2050.[2] The effects of failing to accomplish that daunting task will be catastrophic. They include the deaths of millions and the displacement of

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1 U.S. Envtl. Prot. Agency, *Climate Change Basics*, http://www.epa.gov/climatechange/basics/ (last visited Nov. 18, 2012).

2 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT 67 (2008) [hereinafter IPCC SYNTHESIS], *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

scores of millions.[3] The worst effects will be experienced in places like India and Africa, which will suffer extreme desertification, and in many island states as well as coastal Indonesia and large portions of Bangladesh, which will be underwater.[4] The U.S. will also suffer some significant adverse effects, including desertification of much of the southwest, submersion of significant coastal areas, increases in the incidence and severity of storms of various types,[5] and a 12° increase in the average summer temperature in Washington, D.C.[6]

The task of effectively mitigating climate change is somewhere between extremely difficult and impossible. The main problem is carbon dioxide (CO_2) emissions. CO_2 is by far the most abundant GHG, and it is the inevitable byproduct of hydrocarbon combustion.[7]

While the U.S. is the second largest source of CO_2, neither the U.S. nor the developed world have accounted for any significant increase in emissions in several years.[8] Even if it were to take no steps to reduce CO_2 emissions, the developed world is unlikely to increase emissions of GHGs by any significant amount in the future because of the steady improvements in energy efficiency that always occur over time. The increases in CO_2 emissions over the last few years and in the future will occur almost exclusively in the developing world, with China alone accounting for a majority of the increase.[9]

This trend is easy to explain. The citizens of the developing world want the kinds of goods and services that we have long taken for granted, such as cars and air conditioning, for example. As they become increasingly able to indulge those preferences, they will increase their per capita emissions of CO_2.

Reducing CO_2 emissions in the developed world by 50% would not be nearly enough to accomplish the goal of reducing *global* emissions by 50%. The developed world must reduce its emissions by far more than 50% to offset the inevitable increases in emissions in the developing world. That task is made more difficult by the basic laws of supply and demand. Most hydrocarbons are sold on global markets. To the extent that the developed world is successful in reducing CO_2 emissions through some means—for

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3 *See id.* at 48, 65.

4 *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY 435, 439, 484, 689 (Martin Perry et al. eds., 2007), *available at* http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm.

5 U.S. DEP'T OF ENERGY & CLIMATE CHANGE ET AL., CLIMATE: OBSERVATIONS, PROJECTIONS AND IMPACTS–UNITED STATES OF AMERICA 72, 73, 104, 137–38 (2011), *available at* http://www.metoffice.gov.uk/media/pdf/l/5/USA.pdf (U.K.).

6 *See* FRANK ACKERMAN & ELIZABETH A. STANTON, THE COST OF CLIMATE CHANGE: WHAT WE'LL PAY IF GLOBAL WARMING CONTINUES UNCHECKED, at vi, 2–3 (2008) *available at* http://www.nrdc.org/globalwarming/cost/cost.pdf.

7 U.S. Envtl. Prot. Agency, *Carbon Dioxide Emissions*, http://epa.gov/climatechange/ghgemissions/gases.html (last visited Nov. 18, 2012).

8 *See* JOS G.J. OLIVIER ET AL., PBL NETH. ENVTL. ASSESSMENT AGENCY, LONG-TERM TRENDS IN GLOBAL CO_2 EMISSIONS: 2011 REPORT, at 11 fig.3.1, 13 fig.3.2, 14 tbl.3.2 (2011), *available at* http://edgar.jrc.ec.europa.eu/news_docs/C02%20Mondiaal_%20webdef_19sept.pdf.

9 *See id.* at 10, 11 fig.3.1, 12, 13 tbl.3.2.

example, a carbon tax or subsidies for carbon-free sources of energy—the attendant reduction in the quantity of hydrocarbons demanded will decrease the global price of hydrocarbons. That, in turn, will increase consumption of hydrocarbons in the developing world, unless developing countries also adopt means of reducing this consumption—a step they have not been willing to take to date. The resulting increase in consumption of hydrocarbons in developing countries has the potential to offset 29%–70% of the reductions in hydrocarbon consumption in the developed world.[10] Thus, countries in the developed world need to reduce CO_2 emissions by far more than 50% even if countries in the developing world can be persuaded to take steps to reduce the otherwise dramatic increase in their CO_2 emissions.

While the broad outlines of the relationship between CO_2 emissions and climate change are well known, there is at least one major source of uncertainty. We do not have a good understanding of the shape of the dose-response curve that describes the relationship. Thus, for instance, some climate scientists believe that there is a "tipping point" at which a given concentration of CO_2 in the upper atmosphere will have irreversible catastrophic effects on climate.[11] Others believe that the dose-response curve is roughly linear, thereby creating a situation in which each increment of CO_2 will have a roughly proportionate adverse effect on the climate.[12]

That difference could be important for policy-making purposes. If the relationship is characterized by a "tipping point," and we conclude that we cannot avoid exceeding that point, we should simply accept the inevitable changes in climate and put all of our scarce resources into devising and implementing methods of adapting to the changes in climate. If the dose-response curve is linear, we should devote significant resources to reducing global emissions of CO_2 whether or not we believe that we can avoid a particular concentration of CO_2 in the atmosphere. In that situation, we should act on the basis of a belief that every incremental reduction is important.

The Supreme Court majority in *Massachusetts v. U.S. Environmental Protection Agency* (*Massachusetts v. EPA*)[13] implicitly embraced the assumption that there is a linear dose-response relationship between GHG emissions and climate change. EPA argued that it was not required to regulate emissions of CO_2 from new cars in part because any such effort was unlikely to have any meaningful beneficial effect on climate change.[14] Total emissions of CO_2 from the U.S. transportation sector accounts for only 5% of

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10 Steven Stoft, Global Energy Policy Ctr., No. 10-06, Renewable Fuel and the Global Rebound Effect 2 (2010).

11 *See, e.g.*, James Hansen, Storms of My Grandchildren 115, 171 (2009) (arguing that the earth's climate is near a point where severe climate change consequences are unavoidable).

12 *See, e.g.*, Org. for Econ. Co-operation and Dev. (OECD), Climate Change Mitigation: What Do We Do? 8, 8 fig.2 (2008), *available at* http://www.oecd.org/env/climatechange/41751042.pdf (noting that the curve may well be linear after we reach a tipping point).

13 549 U.S. 497 (2007).

14 *Id.* at 523–24 ("EPA does not believe that any realistic possibility exists that the relief petitioners seek would mitigate global climate change and remedy their injuries.").

global emissions of GHGs.[15] Moreover, even a large reduction in emissions from new cars sold in the U.S. would have little effect on climate change, given the large offsetting increases in CO_2 emissions in developing countries. The majority rejected EPA's argument on the basis that regulating CO_2 emissions from new cars in the U.S. would make a "meaningful contribution" to climate change mitigation.[16]

I will indulge the assumption that the dose-response curve is linear in the balance of these Remarks, but it is merely an assumption. I do not have enough relevant expertise to participate in the debate between the proponents of the "tipping point" theory and those who believe instead that the relationship between GHG emissions and climate change is linear.

II. Impediments to Climate Change Mitigation

The main impediments to effective climate change mitigation are economic and political. Hydrocarbons are much less expensive than carbon-free alternative sources of energy. I will focus primarily on the electricity sector, which accounts for nearly half of CO_2 emissions in the U.S.,[17] but the economic and political impediments are similar in the transportation and industrial sectors.[18]

The most recent estimates of the cost of generating electricity from various sources in the U.S. are: coal, 10¢ per kwh; gas, 8¢ per kwh; wind, 15¢ per kwh; nuclear, 12¢–19¢ per kwh; and solar, 15¢–40¢ per kwh.[19] The cost differences between hydrocarbons and carbon-free sources are less in Europe and Asia, because coal and gas are more expensive in Europe and Asia than they are in North America. [20]

Those are estimates of generating costs only, however. Supplying electricity from wind and solar to consumers is more costly than supplying electricity from gas or coal for two reasons that are independent of generating costs. First, the unit cost of transmission is higher, partly because those sources tend to be long distances from major markets and partly

15 U.S. DEP'T OF TRANSP., TRANSPORTATION'S ROLE IN REDUCING U.S. GREENHOUSE GAS EMISSIONS, VOLUME 1: SYNTHESIS REPORT, ES-2 (2010), *available at* ntl.bts.gov/lib/32000/32700/32779/DOT_Climate_Change_Report_-_April_2010_-_Volume_1_and_2.pdf.

16 *Massachusetts v. EPA*, 547 U.S. 497, 524–25 (2007).

17 *See* CTR. FOR CLIMATE & ENERGY SOLUTIONS, NATURAL GAS IN THE U.S. ELECTRIC POWER SECTOR 2 (2012), *available at* http://www.c2es.org/docUploads/natural-gas-electric-power-sector.pdf ("The electricity sector contributes about 40 percent of all U.S. carbon dioxide emissions.").

18 *See* Arnold W. Reitze, Jr., *Controlling Greenhouse Gases from Highway Vehicles*, 31 UTAH ENVTL. L. REV. 309, 311–13 (2011) (discussing "political/social" problems, such as public resistance to gas taxes, and economic problems, such as the lack of a "cost effective technology to capture CO_2 from mobile sources").

19 *See* U.S. ENERGY INFO. ADMIN., LEVELIZED COST OF NEW GENERATION RESOURCES, *in* THE ANNUAL ENERGY OUTLOOK 2012, at 4–5 (2012), *available at* http://www.eia.gov/forecasts/aeo/pdf/electricity_generation.pdf.

20 *See* Vivek Chandra, *Gas Pricing*, http://www.natgas.info/html/gascontracts.html (last visited Nov. 18, 2012).

because they are much lower load factor sources.[21] Second, both wind and solar are intermittent sources. To compare the cost of intermittent sources with the cost of dispatchable generation sources like coal, gas, and nuclear, the cost of some combination of supplemental dispatchable sources and storage must be added together, or the value of each unit of intermittent energy must be discounted to reflect its lower value.[22] Both adjustments add significantly to the effective unit cost of supplying electricity generated by wind or solar to consumers.[23] To illustrate the effect of those adjustments, consider that the unit cost of the Cape Wind project proposed to be constructed off of Cape Cod will be 83.2¢ per kwh after adjusting for the lower value of the intermittent supply.[24]

A similar adjustment must be made to reflect the lower value of the intermittent supplies of electricity available from solar sources, but the adjustment is lower because the correlation between periods of high electricity demand and periods of sunshine is better than the correlation between periods of high demand and periods of wind velocity sufficient to operate windmills.[25] When unit-generating costs are adjusted to reflect differential transmission costs and intermittency, solar and wind are three to fifteen times more expensive than coal or gas in the U.S.[26]

The political impediments to effective climate change mitigation are primarily derivative of the economic impediments. Four other factors add to these political impediments, however. First, because CO_2 remains in the atmosphere for many decades after it is emitted, the cost of implementing mitigation measures must be incurred many decades before the benefits will be experienced. Second, the benefits will appear in a form that many people either do not understand or do not accept. They will take the form of a negative: catastrophic climate effects that will be avoided. Third, the benefits will be enjoyed disproportionately by citizens of highly vulnerable, developing countries like India and Bangladesh, while the costs will be incurred disproportionately by citizens of less vulnerable developed countries like the U.S. and Germany. Indeed, many people in countries like

21 *See* Roger Bezdek & Robert Wendling, *Not-So-Green Superhighway*, PUB. UTIL. FORT., Feb. 1, 2012, at 35, 35–38.

22 *See id.* at 38 ("[G]iven that [intermittent] resources might not be reliably available when they're needed most . . . the total cost . . . should include the cost of the [intermittent source] system and the cost of [its] backup power system."); Paul Joskow, *Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies*, 101 AM. ECON. REV., 238, 239–41 (2011) (demonstrating how the economic value for certain intermittent technologies drops once a valuation metric is used that accounts for "output and electricity price variations").

23 *See* Bezdek & Wendling, *supra* note 21, at 39 (providing an example of when storage costs lead to an increase in intermittent energy rates of 43%); Joskow, *supra* note 22, at 240–41 (noting that without discounting the value of energy produced by intermittent sources—whose output largely occurs during nonpeak periods—economic losses of up to $42,380 will not be reflected using a traditional levelized cost valuation method).

24 Richard J. Pierce, Jr., *Natural Gas: A Long Bridge to a Promising Destination*, 32 UTAH ENVTL. L. REV. (forthcoming 2012).

25 *See* Joskow, *supra* note 22, at 241.

26 Bezdek & Wendling, *supra* note 21, at 40–42.

Canada and Norway may experience net benefits as a result of climate change.[27] Fourth, most of the projects that must be completed as part of the mitigation effort require regulatory approvals that can take a decade or more to obtain. For instance, Cape Wind, the first offshore wind farm proposed in North America, has been the subject of a complicated and contentious regulatory approval process for over a decade.[28]

III. POTENTIAL METHODS OF MITIGATING CLIMATE CHANGE

A. Carbon Tax

There is a broad consensus among economists that a carbon tax would be the most efficient and effective means of mitigating climate change.[29] A carbon tax of $50–$200 per ton of carbon emitted would provide a powerful incentive to engage in research and development in the dozens of areas in which there is clear potential to reduce CO_2 emissions.[30] These areas include wind, solar, biomass, geothermal, hydro, nuclear, carbon capture and sequestration, storage, and the most promising: increased energy efficiency. It is impossible to predict which of the tens of thousands of research and development efforts would yield the technological improvements necessary to reduce CO_2 emissions significantly. However, it is easy to be confident that some combination of these efforts would be effective both in reducing

27 NICHOLAS STERN, STERN REVIEW: THE ECONOMICS OF CLIMATE CHANGE, EXECUTIVE SUMMARY viii (2007), *available at* http://www.hm-treasury.gov.uk/d/Executive_Summary.pdf.

28 *See generally* MINERALS MGMT. SERV., U.S. DEP'T OF THE INTERIOR, EFFORTS TO REACH A DECISION ON THE CAPE WIND ENERGY PROJECT (2010), *available at* http://www.doi.gov/news/doinews/upload/04-28-10-Cape-Wind-Fact-Sheet-MMS-approved.pdf (chronicling the many regulatory steps taken on the Cape Wind Energy Project since 2001); *see also* Town of Barnstable, Mass. v. Fed. Aviation Admin., 659 F.3d 28, 30–31 (D.C. Cir. 2011) (holding that, because the FAA misread its regulations, its "Determinations of No Hazard" for the Cape Wind project were unjustified).

29 *See* Sheila M. Olmstead & Robert N. Stavins, *Three Key Elements of a Post-2012 International Climate Policy Architecture*, 6 REV. ENVTL. ECON. & POL. 65, 78 (2012) (evaluating various strategies to encourage international cooperation in combating climate change); *see also* William D. Nordhaus, *After Kyoto: Alternative Mechanisms to Control Global Warming*, 96 AM. ECON. REV. 31 (2001) (reviewing the effectiveness of different political and economic approaches to addressing climate change).

30 *See* MARC LEE & AMANDA CARD, CANADIAN CTR. FOR POLICY ALTS., A GREEN INDUSTRIAL REVOLUTION: CLIMATE JUSTICE, GREEN JOBS AND SUSTAINABLE PRODUCTION IN CANADA 52 (2012), *available at* http://www.policyalternatives.ca/sites/default/files/uploads/publications/National%20Office/2012/06/Green%20Industrial%20Revolution.pdf (arguing that "carbon pricing is also the key ingredient to financing the green industrial revolution we envisage"); ERIN BAKER & EKUNDAYO SHITTU, PROFIT-MAXIMIZING R&D IN RESPONSE TO A RANDOM CARBON TAX 29 (2005), *available at* http://www-unix.ecs.umass.edu/mie/faculty/baker/randdproductionfunction0905.pdf (exploring the various profit-maximizing research and development approaches that businesses may take in response to carbon taxes); Charles Komanoff, *A Question of Balance: Finding the Optimal Carbon Tax Rate Carbon Tax Center*, CARBON TAX CTR., Oct. 18, 2008, http://www.carbontax.org/blogarchives/2008/10/18/a-question-of-balance-finding-the-optimal-carbon-tax-rate/ (last visited Nov. 18, 2012) (summarizing the various carbon tax estimates and proposals put forth by economists).

total consumption of electricity from all sources, and in bridging the much smaller gap that would then exist between the cost of using sources that emit CO_2 and the cost of using carbon-free or low carbon sources.

A cap and trade system of the type the U.S. House of Representatives enacted in 2009[31] and the European Union (E.U.) implemented in 1997[32] is functionally equivalent to a carbon tax in most respects, if the cap is low enough to be effective. The cap in the version enacted by the House would not have been effective for many decades, if ever,[33] and even the lower cap in the E.U. version was far too high to be effective.[34] The E.U. version of cap and trade has produced a carbon price of $10.5 per ton in 2012.[35] To be effective, a cap and trade system would need to yield a carbon price of $50–$200 per ton.

There is an obvious impediment to a carbon tax that is high enough to be effective or to a carbon cap that is low enough to be effective—public aversion to taxes. The U.S. now has one political party that opposes all taxes and another that wants to tax only millionaires, billionaires, and big oil companies. However, a carbon tax would need to be paid by everyone.

B. Litigation

The U.S. could make use of the mechanism we rely on to further many other purposes—litigation. Thus for instance, citizens that are, or will be, injured by climate change could sue sources of CO_2. The Supreme Court unanimously rejected that mechanism in its 2011 opinion in *American Electric Power Company, Inc. v. Connecticut*.[36] The Court held that the Clean Air Act (CAA)[37] displaces the power of courts to consider actions filed by states and environmental organizations to force sources of CO_2 to decrease their emissions. In the Court's words:

> It is altogether fitting that Congress designated an expert agency, here, EPA, as best suited to serve as primary regulator of greenhouse gas emissions. The

31 American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. (2009).

32 Olmstead & Stavins, *supra* note 29, at 76.

33 David Schoenbrod & Richard Stewart, *The Cap and Trade Bait and Switch*, Wall St. J., Aug. 24, 2009, at A13.

34 *See* Jonathan Donehower, Comment, *Analyzing Carbon Emissions Trading: A Potential Cost Efficient Mechanism to Reduce Carbon Emissions*, 38 Envtl. L. 177, 197–98 (2008) (arguing that political lobbying led to insufficient caps in the EU and failed to incentivize emissions reductions).

35 Carina Heimdal et al., Thomson Reuters Point Carbon, Carbon 2012, at 2 (2012), *available at* http://www.pointcarbon.com/polopoly_fs/1.1814671!Carbon%202012_FINAL.pdf (noting that the average price for a European Union Allowance (EUA) in 2012 has been about 8 euros per ton). At the time of this writing, the Euro-to-U.S. Dollar exchange rate is about 1.31 to 1. Bloomberg, *Euro-US Dollar Exchange Rate*, http://www.bloomberg.com/quote/EURUSD:CUR (last visited Nov. 18, 2012).

36 131B S. Ct. 2527, 2537 (2011); *see also* Coal. for Responsible Regulation v. U.S. Envtl. Prot. Agency, 684 F.3d 102, 113 (D.C. Cir. 2012) (upholding EPA's greenhouse gas-related rules under the CAA).

37 42 U.S.C. §§7401–7671q (2006).

expert agency is surely better equipped to do the job than individual district judges, issuing ad hoc, case-by-case injunctions. Federal judges lack the scientific, economic, and technological resources an agency can utilize in coping with issues of this order. [38]

C. EPA Regulation Under the Clean Air Act

By contrast, a majority of Justices held that EPA is required to regulate GHGs as pollutants under the CAA in the Court's 2007 opinion in *Massachusetts v. EPA*.[39] The CAA is a poor fit for the problem, however. Most pollutants can be regulated effectively by imposing emission limits that allow an activity to continue at the somewhat higher cost needed to accommodate installation of pollution control devices of some type. The most important GHG—carbon dioxide—is an inevitable byproduct of hydrocarbon combustion. Thus, emission limits on CO_2 can be attained in most circumstances only by ceasing or reducing the activity that yields the emissions.

EPA has taken two actions so far that have some potential to reduce CO_2 emissions. First, EPA issued a rule jointly with the National Highway Traffic Safety Administration in which it required all auto manufacturers to attain new higher average fleet mileage requirements in the future.[40] Second, EPA has proposed a rule that would impose limits on CO_2 emissions from new generating plants that are so low that they would constitute a de facto prohibition on construction of new coal-fired generating plants.[41]

It is not clear that either of those rules will have significant effects on CO_2 emissions, however. As discussed in Part III.E, mandatory efficiency rules usually have limited beneficial effects, and, as discussed in Part III.G, it is unlikely that any new coal-fired generating plants will be constructed in the U.S. even if EPA does not issue its proposed new rule limiting CO_2 emissions from new generating plants. Even if EPA's rules issued under the CAA have some beneficial effect on CO_2 emissions, those effects will fall far short of the reductions in emissions needed to avoid major climate changes.

D. Smart Meters and Real-Time Pricing

Both the cost and the value of electricity vary greatly from time to time. Even within a twenty-four-hour period, the cost of receiving a unit of

38 *Am. Electric Power Co.*, 131B S. Ct. at 2539–40.

39 549 U.S. 497, 533–34 (2007).

40 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, 75 Fed. Reg. 25,324 (May 7, 2010) (codified at 40 C.F.R. pts. 85–86, 600 and 49 C.F.R. pts. 531, 533, 537–38).

41 Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units, 77 Fed. Reg. 22,392 (Apr. 13, 2012) (to be codified at 40 C.F.R. pt. 60).

electricity can vary by a significant factor.[42] This variation is a function of several factors, including the inability to store electricity at a reasonable cost, large temporal variations in the quantity of electricity demanded, transmission capacity constraints, and variations in the unit cost of generating stations that are in use.[43]

Traditional methods of billing consumers disguise the large temporal variation in the costs of making electricity available.[44] State regulators have long required electric utilities to bill on an average cost basis.[45] As a result, consumers confront the same cost for each unit they consume notwithstanding the large variations in the cost of these units.[46] Pilot studies have shown that a shift to real-time pricing—a system of pricing in which consumers confront the constantly changing cost of electricity—might reduce consumption and costs by up to 18%.[47] Such a pricing system would induce consumers to change the temporal pattern of their electricity consumption to reduce their costs. Thus, for instance, most people would choose to operate their clothes dryers and automatic dishwashers when they can purchase electricity for 5¢ rather than 50¢.

One of the variables that determine the cost of electricity is the mix of generating units that are used to supply electricity at various times.[48] During

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42 *See* Severin Borenstein, *Customer Risk from Real-Time Retail Electricity Pricing: Bill Volatility and Hedgability* 1 (Nat'l Bureau of Econ. Research, Working Paper No. 12524, 2006), *available at* http://www.nber.org/papers/w12524.pdf?new_window=1.

43 1 Alfred E. Kahn, The Economics of Regulation: Principles and Institutions 91 (1970) (discussing variations in consumer demand); U.S. Dep't of Energy, National Electric Transmission Congestion Study vii (2009), *available at* http://congestion09.anl.gov/documents/docs/congestion_study_2009.pdf (describing congestion and causes of constricted electrical flow); U.S. Energy Info. Admin., Updated Capital Cost Estimates for Electricity Generation Plants 4 (2010), *available at* http://www.eia.gov/oiaf/beck_plantcosts/pdf/updatedplantcosts.pdf (discussing station specific factors leading to cost variation); Hunt Allcott, *Real-Time Pricing and Electricity Market Design* 2 (N.Y. Univ., Working Paper, 2012), *available at* https://files.nyu.edu/ha32/public/research.html (click on "Download PDF") (noting the non-storable nature of electricity and the effects it has on market supply and demand).

44 Richard J. Pierce, Jr., Perspective Piece, *A Primer on Demand Response and a Critique of FERC Order 745*, 3 Geo.Wash. J. Energy. & Envtl. L. 102, 106 (2012).

45 Kenneth Gordon & Wayne P. Olson, *Retail Cost Recovery and Rate Design in a Restructured Environment*, at v (2004), *available at* http://www.hks.harvard.edu/hepg/Papers/Gordon.Olson.Retail.Cost.Recovery.pdf; *see also* Richard J. Pierce, Jr., *A Proposal to Deregulate the Market for Bulk Power*, 72 Va. L. Rev. 1183, 1183–85 (1986) (providing background information on electricity industry regulation in the United States).

46 Gordon & Olson, *supra* note 45, at vii (noting that retail rates that are based on average-costs do not reflect the "true economic costs associated with changes in consumption").

47 *See* Brandon Davito, Humayan Tai & Robert Uhlaner, The Smart Grid and the Promise of Demand-Side Management 39 (2010), *available at* http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/EPNG/PDFs/McK%20on%20smart%20grids/MoSG_DSM_VF.ashx ("Pilots have shown that real-time access to information provided through smart grid networks can cut energy consumption by up to 18 percent."); *see also* Adrian Booth et al., U.S. Smart Grid Value at Stake: The $130 Billion Question 6, 9 (2010), *available at* http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/EPNG/PDFs/McK%20on%20smart%20grids/MoSG_130billionQuestion_VF.ashx. (arguing that meter monitoring and diagnostics would constitute $8 billion of the $69 billion total expected Grid Application benefits resulting from smart-grid deployment).

48 Pierce, *supra* note 44, at 1192–93.

periods of high demand, utilities must operate their peaking units. Peaking units typically have low capital costs and high operating costs.[49] The high operating costs of peaking units are largely a function of their lower level of efficiency—that is, they generate less electricity per unit of input.[50] The unit of input is almost always a hydrocarbon. Thus, a change from average cost pricing to real-time pricing would reduce CO_2 emissions by reducing the quantity of hydrocarbons required to meet total U.S. electricity needs.

The federal government has engaged in aggressive attempts to encourage utilities and state regulators to implement real-time pricing by, among other things, providing federal funds to purchase the smart meters required to implement realtime pricing.[51] So far, those efforts have achieved little success. Even in jurisdictions in which consumers have federally-funded smart meters, state regulators have been extremely reluctant to switch to a system of real-time pricing.[52] The primary opposition comes from two groups: first, advocates for senior citizens who fear that their constituents will pay higher electricity bills under real-time pricing because they cannot or will not change their temporal patterns of consumption; second, from privacy advocates who fear that real-time pricing will provide utilities and regulators with data about the temporal patterns of consumption of individual consumers that may be be used to harm consumers.[53] Unless advocates for senior citizens and privacy can be persuaded to drop their opposition to real-time pricing, that potential method of mitigating climate change will remain unavailable.

E. Mandatory Efficiency Requirements

For decades, the U.S. has relied to a considerable extent on mandatory efficiency standards to induce manufacturers, and derivatively consumers, to reduce their consumption of hydrocarbons. For instance, the federal government has mandated a series of increasing average fleet mileage rules applicable to automakers and increased efficiency criteria applicable to refrigerator makers.[54] Efficiency standards have some potential to assist in mitigating global warming, but their beneficial effects are overstated by a significant amount because of our failure to take into account three phenomena that have effects on all such measures.

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49 STAN KAPLAN, CONG. RESEARCH SERV., RL 34746, POWER PLANTS: CHARACTERISTICS AND COSTS 3 (2008).

50 *See id.* at 4.

51 Pierce, *supra* note 44, at 105.

52 *Id.*

53 *Id.*; Steven Andersen, *Saving the Smart Grid*, PUB. UTIL. FORT., Jan. 2011, at 38.

54 *See* U.S. DEP'T OF TRANSP., U.S. DEP'T OF ENERGY & U.S. ENVTL. PROT. AGENCY, REPORT TO CONGRESS: EFFECTS OF THE ALTERNATIVE MOTOR FUELS ACT CAFE INCENTIVES POLICY 5 tbl.II-1 (2002); Energy Conservation Standards for Residential Refrigerators, Refrigerator Freezers, and Freezers, 76 Fed. Reg. 57,516 (Sept. 15, 2011) (to be codified at 10 C.F.R. pt. 430) (providing the Department of Energy's most recent energy conservation standards for refrigerators and freezers that were adopted pursuant to the Energy Policy and Conservation Act, 42 U.S.C. §§ 6201–6422(2006)).

First, we usually assume that efficiency would not improve in the absence of mandatory standards. For instance, we attribute all increases in the gas mileage of cars to mandatory standards. That assumption is unsupportable. Even without these requirements manufacturers are driven by market forces to improve the efficiency of the products they make.[55] The fraction of efficiency improvements that are attributable to government mandates is unknown. Second, manufacturers always game mandates in ways that reduce their efficacy. For example, the aggressive average fleet mileage rules issued in the 1980s induced automakers to cease making the popular station wagon because it could not meet the higher fuel efficiency standard for cars. In its place, automakers substituted sport utility vehicles, which were classified as trucks and therefore subject to lower fuel economy standards.[56] Third, any resulting improvements in efficiency are offset to some extent by increased rates of utilization. As an example, the large improvement in the efficiency of refrigerators has dramatically increased the use of refrigerators by creating a situation in which most hotel rooms have refrigerators.[57]

F. Subsidies and Mandates

Both the U.S. and the E.U. have relied heavily on a combination of subsidies for carbon-free sources and mandates to utilities to use carbon-free resources to generate a specified proportion of their total electricity supply.[58] Mandates are functionally indistinguishable from subsidies. They are simply subsidies that are paid involuntarily by consumers rather than by taxpayers. The use of subsidies for carbon-free fuels is an expensive and ineffective means of mitigating climate change.

Since the Europeans have been far more aggressive than the U.S. in subsidizing carbon-free sources of electricity, we can learn a lot from their experience. Germany, Spain, and Portugal embarked on similar ambitious subsidy programs in the early 2000s.[59] Spain cut back on its efforts many

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55 *See, e.g.*, Edan Rotenberg, Energy Efficiency in "Deregulated" Markets 27 (Sept. 28, 2005) (unpublished Student Scholarship Paper, Yale Law Sch.), *available at* http://digitalcommons.law.yale.edu/cgi/viewcontent.cgi?article=1013&context=student_papers.

56 *See* Michael Lynch, *CAFE Standard Insanity*, CTR. INDIVIDUAL FREEDOM, May 5, 2005, http://www.cfif.org/htdocs/freedomline/current/guest_commentary/lynch-cafe-standard-insanity.htm (last visited Nov. 18, 2012).

57 *See* Edward Comer, *The Future of Energy Law – Electricity*, 31 UTAH ENVTL. L. REV. 429, 434 (2011).

58 *See* Lincoln L. Davies, *Power Forward: The Argument for a National RPS*, 42 CONN. L. REV. 1339, 1357–58 (2010) (discussing how most states mandate that electric utilities provide specified percentages of their total supply from renewable energy sources); Steve Hargreaves, *Energy Subsidies Total $24 Billion, Most To Renewables*, CNN MONEY, Mar. 7, 2012, http://money.cnn.com/2012/03/07/news/economy/energy-subsidies/index.htm (last visited Nov. 18, 2012) (noting that renewable energy subsidies exist on multiple governmental levels; the federal government alone spent $24 billion on subsidies for renewables in 2011).

59 *See* Alex Morales & Ben Sills, *Spain Ejects Clean Power Industry with Europe Precedent: Energy*, BUS. WK., May 30, 2012, http://www.businessweek.com/news/2012-05-29/spain-ejects-clean-power-industry-with-europe-precedent-energy (last visited Nov. 18, 2012) (discussing how

times since 2008 to reduce their adverse effects on fiscal policy, and Portugal followed suit in January 2012.[60] Spain and Portugal lead the world in the proportion of their electricity supply that is generated by wind.[61] The resulting electricity has little value, however, because it is available primarily at times of low demand. As Paul Joskow demonstrated in the May 2011 issue of *American Economic Review*, a unit of wind power is worth about one-quarter as much as a unit of power from a dispatchable hydrocarbon source because of the intermittent nature of wind power and its tendency to be available when demand for electricity is low.[62]

Germany has reduced the magnitude and scope of its subsidies for solar energy as it has been forced to confront the high cost and limited efficacy of those subsidies. Germany has spent $130 billion on solar subsidies,[63] creating a situation in which Germany now has more installed solar capacity than the rest of the world combined.[64] Solar power accounts for only 3% of the total electricity supply in Germany, however.[65] Like wind power, solar power is an intermittent, low load factor source. Germany's solar subsidies have cost over $1,000 per ton of CO_2 not emitted[66]—at least five times the cost of using a carbon tax to reduce emissions. Europe's extravagant efforts to decrease GHG emissions have had no apparent effect. Emissions in the E.U. and U.S. decreased by about the same amount, 7%, between 2007 and 2010.[67]

Spain, Portugal, Israel, and Japan adopted Germany's clean power model and invested heavily until 2007).

60 *See, e.g.*, *id.*; Richard Weyndling, *Portugal Extends Wind Tariff Cuts to Existing Projects*, WINDPOWER MONTHLY, May 18, 2012, http://www.windpowermonthly.com/news/1132779/Portugal-extends-wind-tariff-cuts-existing-projects/ (last visited Nov. 18, 2012).

61 Tam Hunt, *Spain and Portugal Lead the Way on Renewable Energy Transformation*, RENEWABLEENERGYWORLD.COM, Feb. 7, 2011, http://www.renewableenergyworld.com/rea/news/article/2011/02/spain-and-portugal-lead-the-way-on-renewable-energy-transformation (last visited Nov. 18, 2012).

62 Paul Joskow, *Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies*, 101 AMERICAN ECONOMIC REVIEW: PAPERS & PROCEEDINGS, 238, 238–39, *avaiable at* http://web.mit.edu/ceepr/www/publications/reprints/Reprint_231_WC.pdf.

63 Bjørn Lomberg, *Goodnight Sunshine*, SLATE, Feb. 18, 2012, http://www.slate.com/articles/news_and_politics/project_syndicate/2012/02/why_germany_is_phasing_out_its_solar_power_subsidies_.html (last visited Nov. 18, 2012).

64 Erik Kirschbaum, *Germany Sets New Solar Power Record, Institute Says*, REUTERS, May 26, 2012, http://www.reuters.com/article/2012/05/26/us-climate-germany-solar-idUSBRE84P0FI20120526 (last visited Nov. 18, 2012).

65 *German Solar Output Up 60 pct in 2011*, REUTERS, Dec. 29, 2011, http://uk.reuters.com/article/2011/12/29/germany-solar-idUKL6E7NT1WK20111229 (last visited Nov. 18, 2012).

66 Lomberg, *supra* note 53.

67 *Compare* U.S. ENVTL. PROT. AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2010, at ES-4 (2012), *available at* http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-ES.pdf (showing a decline in U.S. carbon emissions from 6,118.6 million metric tons (Tg) in 2007 to 5,706.4 Tg in 2010, a reduction of about 7.2%), *with* EUROPEAN ENV'T AGENCY, WHY DID GREENHOUSE GAS EMISSIONS INCREASE IN THE EU IN 2010?, at 3 fig.1 (2012), *available at* http://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2012/why-did-greenhouse-gas-emissions.pdf (illustrating the carbon emissions both from the European Union as a whole, and also from a smaller subset of 15 countries in the EU).

Recent studies predict similar results for other subsidy-based mitigation strategies. For instance, the Fraser Institute estimates that Ontario consumers will pay an average of $285 million per year for solar subsidies, with solar ultimately accounting for only 3% of the total electricity supply in Ontario.[68] The German energy company RWE estimates that British Prime Minister Cameron's plan to rely on subsidies for nuclear energy to mitigate climate change in the United Kingdom will cost every household in the country over $12,000.[69]

G. Switching from Coal to Gas

Coal is now, and has long been, the dominant source of electricity throughout the world.[70] Replacing coal with natural gas as a generating fuel would reduce CO_2 emissions from electricity generation by about 50%.[71] A new application of two old technologies—horizontal drilling and hydraulic fracturing—has had remarkable effects on the supply of natural gas in the U.S.[72] "Fracking" has created a situation in which the U.S. is now the Saudi Arabia of gas.[73] The International Energy Agency (IEA) predicts that the U.S. will become the world's top gas producer by 2017.[74] The U.S. has already completely eliminated its reliance on foreign sources of gas and is about to become a major gas exporter.[75] Gas reserves in the U.S. are now sufficient to supply 100% of U.S. demand for over a century, having increased by the largest amount in history in 2010.[76] The price of gas in the U.S. is now a small fraction of the price of oil and about equal to the price of coal.[77]

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68 GERRY ANGEVINE ET AL., FRASER INST., A SENSIBLE STRATEGY FOR RENEWABLE ELECTRICAL ENERGY IN NORTH AMERICA 3, 66 (2012), *available at* http://www.fraserinstitute.org/uploadedFiles/fraser-ca/Content/research-news/research/publications/sensible-strategy-renewable-electrical-energy.pdf.

69 Stephen Castle, *Britain Charts Way to Wider Nuclear Investment*, N.Y. TIMES, May 22, 2012, http://www.nytimes.com/2012/05/23/world/europe/britain-charts-way-to-wider-nuclear-investment.html (last visited Nov. 18, 2012) (noting that the investment "would add up to about £8,000," or about $12,852 USD).

70 U.S. ENERGY INFO. ADMIN., DOE/EIA-0484, INTERNATIONAL ENERGY OUTLOOK 2011, at 4 (2011), *available at* http://www.eia.gov/forecasts/ieo/pdf/0484(2011).pdf ("[C]oal remains the largest source of world electricity through 2035.").

71 *See, e.g.*, U.S. Envtl. Prot. Agency, *Greenhouse Gas Emissions: Carbon Dioxide Emissions*, www.epa.gov/climatechange/ghgemissions/gases/co2.html (last visited Nov. 18, 2012) (noting that the U.S. electricity sector is a significant source of greenhouse gas emissions).

72 U.S. ENERGY INFO. ADMIN., DOE/EIA-0383, ANNUAL ENERGY OUTLOOK 2012, at 3, *available at* http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf.

73 Barack Obama, President, United States of America, Remarks of the President on American Energy, Aurora, Colorado (Jan. 26, 2012), *available at* http://www.whitehouse.gov/the-press-office/2012/01/26/remarks-president-american-energy-aurora-colorado.

74 INT'L ENERGY AGENCY, MEDIUM-TERM GAS MARKET REPORT 2012: EXECUTIVE SUMMARY 13–14, *available at* http://www.iea.org/Textbase/npsum/MTGMR2012SUM.pdf.

75 U.S. ENERGY INFO. ADMIN., *supra* note 72, at 3.

76 *See* Barack Obama, President, United States of America, Address Before a Joint Session of Congress on the State of the Union at 5 (Jan. 24, 2012), *available at* http://www.gpo.gov/fdsys/pkg/DCPD-201200048/pdf/DCPD-201200048.pdf ("We have a supply of natural gas that can last America nearly 100 years."); U.S. Energy Info. Admin., *U.S. Proved Reserves Increased*

In just the past three years, the U.S. has already replaced over 10% of the coal used to generate electricity with gas.[78] Given the new economic relationship between coal and gas, all new fossil fuel generating plants constructed in the U.S. are likely to be built to operate on gas rather than coal.[79] Thus, as generating plants are replaced over time, the U.S. is likely to eliminate completely its reliance on coal as a generating fuel.

Fracking has the potential to yield similar effects in other regions of the world. Geologists have identified scores of basins all over the world that contain gas-rich shale that can support the production of large quantities of gas through fracking.[80] Over time, fracking has the potential to dramatically increase the quantity of gas available in Europe and Asia—with a corresponding decrease in the price of gas to the point at which its price approximates the price of coal.[81] The IEA predicts that global demand for gas will increase by over 50% by 2035 and that gas will overtake coal as the dominant source of global electricity generation by 2035.[82] Over time, the gusher of new gas supplies will reduce emissions of CO_2 from the transportation sector as well as the electricity sector through a combination of direct substitution of natural gas for gasoline and indirect substitution through cars operating on electricity generated with gas.[83]

All we need to do to realize this rosy future is to implement what the IEA calls the "Golden Rules" of regulation.[84] The IEA has identified a series of critical rules that governments must apply in order to realize the potential of fracking with acceptable environmental consequences. IEA estimates that implementation of the regulatory rules it considers important will add no more than 7% to the unit cost of gas produced through fracking.[85] Such an increase in cost would still render natural gas the cheapest source of

Sharply in 2010 (Aug. 2, 2012), http://www.eia.gov/todayinenergy/detail.cfm?id=7370 (noting that proved oil and gas reserves in 2010 rose by the highest margin since the EIA began publishing records 35 years ago).

77 *See* U.S. Energy Info. Admin., Electric Power Monthly: September 2012, at tbl.4.1 (2012), *available at* http://www.eia.gov/electricity/monthly/pdf/epm.pdf; Donald Marron, *Oil and Natural Gas Prices Move Even Further Apart* (Jan. 9, 2012), http://dmarron.com/2012/01/09/oil-and-natural-gas-prices-move-even-further-apart/.

78 U.S. Energy Info. Admin., Electric Power Monthly: April 2012, at tbl.1.1 (2012), *available at* http://www.eia.gov/electricity/monthly/current_year/april2012.pdf.

79 *See* U.S. Energy Info. Admin., *supra* note 72, at 4.

80 Hobart King, *Hydraulic Fracturing of Oil & Gas Wells Drilled in Shale*, http://geology.com/articles/hydraulic-fracturing/ (last visited Nov. 18, 2012); *see generally* U.S. Energy Info. Admin., World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States (2011) (mapping out 48 major shale basins in 32 countries).

81 Int'l Energy Agency, Golden Rules for a Golden Age of Gas 10 (2012), *available at* http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/WEO2012_GoldenRulesReport.pdf.

82 *Id.* at 63, 76.

83 *See* Christopher Flavin & Saya Kitasei, WorldWatch Institute, The Role of Natural Gas in a Low-Carbon Energy Economy 4, 7–10 (2010), *available at* www.worldwatch.org/files/pdf/Worldwatch%20Gas%20Paper%20April%202010.pdf.

84 *See* Int'l Energy Agency, *supra* note 81, at 9.

85 *Id.* at 53.

electricity generation for the foreseeable future.[86] Replacement of coal with gas alone cannot achieve the daunting goal of decreasing global CO_2 emissions by 50% by 2050, but it will get us a long way toward that goal.[87]

H. Reducing Black Carbon and Methane Emissions

While CO_2 is the most abundant GHG, it is not the most potent. Black carbon and methane are many times more powerful GHGs measured on a per-unit-emitted basis.[88] The United Nations (U.N.) estimates that reducing black carbon and methane emissions can yield far greater mitigation benefits than reducing CO_2 emissions over the next thirty years.[89] The U.N. has identified sixteen ways in which we can reduce black carbon and methane emissions significantly on a cost-effective basis; for example, by improving the filters on diesel engines, implementing "green completions" of natural gas wells, and reducing open burning on agricultural land.[90] Each of the methods identified in the U.N. report would actually yield net economic benefits in forms such as more efficient performance of diesel engines and increased volumes of methane that can be sold by producers.[91] Moreover, implementation of the black carbon and methane mitigation methods urged by the U.N. would simultaneously save 2.4 million lives per year and increase crop production by 52 million tons per year.[92]

Like replacing coal with gas, reducing black carbon and methane emissions alone would not be enough to avoid the catastrophic effects of climate change. Black carbon and methane are powerful but relatively short-lived GHGs.[93] As a result, the beneficial effects of reducing emissions of black carbon and methane dissipate over time. However, reducing black carbon and methane emissions can buy us many decades of time in which to implement effective means of reducing CO_2 emissions.

I. A Carbon Tax Revisited

I hope that the foregoing review of the difficulty and cost of attempting to mitigate climate change through other means will help to persuade you that a carbon tax of $50–$200 per ton is by far the most effective and least expensive method of mitigation. There is broad agreement that technological improvements have the potential to mitigate climate change in

86 *Id.* at 15.

87 Am. Soc'y Mech. Eng'rs., Gen. Position Statement on Reducing Carbon Dioxide Emissions in The Energy Sector 21 (2009), *available at* http://files.asme.org/asmeorg/NewsPublicPolicy/GovRelations/PositionStatements/17971.pdf.

88 U.N. Env't Programme, Integrated Assessment of Black Carbon and Tropospheric Ozone 96 tbl.4.1 (2011), *available at* http://www.unep.org/dewa/Portals/67/pdf/BlackCarbon_report.pdf.

89 *Id.* at 240 fig.6.2.

90 *Id.* at 163, 164 fig.5.1.

91 *Id.* at 163–66.

92 *Id.* at 180, 188.

93 *Id.* at 6.

a timely and cost-effective manner.[94] There is massive disagreement, however, with respect to the critical question: Which of the scores of technological frontiers is most likely to yield developments that will reduce GHG emissions in a cost-effective manner.[95] The candidates include solar, wind, nuclear, conservation, biomass, geothermal, electricity storage, and carbon capture and sequestration. Moreover, each of these broad categories can be divided into countless subcategories. For instance, there are many promising forms of solar energy and many promising methods of storing electricity economically.

Choosing among the many candidates for major breakthroughs in cost-effective mitigation is a fool's errand. No one can be confident that solar or nuclear will provide better results than wind or carbon capture and storage by ten, twenty, or fifty years from now. Implementation of a substantial carbon tax avoids the need to engage in such a hopeless guessing game by providing the same powerful incentive for research and development along each of those promising margins, while simultaneously encouraging implementation of the most cost-effective means of reducing emissions.

Economic conditions are all wrong for implementation of any new tax at present. Once the U.S. and global economies are performing well, and the U.S. is willing and able to confront the need for new revenues to reduce the present unsustainable budget deficit levels, we should choose a carbon tax to simultaneously further both our fiscal policy goals and our climate change mitigation goals. If the U.S. leads the rest of the world in implementing the IEA's "Golden Rules"[96] for regulating gas production and the U.N.'s sixteen methods of reducing emissions of black carbon and methane,[97] we can buy the time required to create the combination of political and economic conditions that are conducive to adopting an effective carbon tax. Once the U.S. adopts a substantial carbon tax, it will have the credibility to lead the rest of the world in a new, more productive round of negotiations to agree on an effective global mitigation effort.

IV. ADAPTATION

Even if we achieve considerable success in our efforts to mitigate climate change, some uncertain amount of change is inevitable. My colleague, Rob Glicksman, has begun the crucial process of identifying the

94 *See generally* ZILI YANG, COPENHAGEN CONSENSUS CTR., AN ANALYSIS OF TECHNOLOGY TRANSFERS AS A RESPONSE TO CLIMATE CHANGE (2009), *available at* http://fixtheclimate.com/uploads/tx_templavoila/AP_Technology_Transfers_Yang_v.4.0.pdf. Professor Yang argues that "technology progress [and subsequent transfer among nations] is the key for the challenges human beings will be facing in the future. Climate change is one of such challenges." *Id.* at 16.

95 *See, e.g.*, Sara Krieger, *Before Adding, Try Reducing*, WALL ST. J., June 15, 2009, http://online.wsj.com/article/SB10001424052970203771904574179270925771280.html (last visited Nov. 18, 2012) (discussing debate between clean energy and energy efficiency technology).

96 INT'L ENERGY AGENCY, *supra* note 81, at 11.

97 U.N. ENV'T PROGRAMME, *supra* note 88, at 237.

hundreds of steps we must take to adapt to climate change.[98] Many of those steps will involve major changes in the legal environment.

In his initial assessment of the need to adapt existing legal institutions to the changing climate, Glicksman explains why climate change would fundamentally rearrange U.S. ecosystems.[99] That fundamental rearrangement would complicate existing relationships among legal institutions and require a fundamental rethinking of the ways in which the U.S. allocates responsibility for management of natural resources.[100]

V. CONCLUSION

I will end where I began. I am confident that my current students will be working on legal issues related to climate change until they retire fifty years from now. I hope that many of them will work on identifying and implementing effective means of mitigating climate change. Even if they are successful in those efforts, however, the climate will change significantly in ways to which the legal system must adapt. Whatever path we take to address climate change, there is no doubt that it will be a dominant factor in the world of law for the foreseeable future. Every lawyer in the country will encounter climate change and its legal implications in myriad contexts for at least a century.

Some of the legal disputes of the future will look a lot like recent disputes with respect to the arguable need for actions by legislatures, regulators, and courts concerning proposed renewable fuel projects, nuclear power plants, transmission lines, fracking operations, efficiency standards, and the like. We are already beginning to see new types of disputes, including for example, disputes about whether zoning boards should authorize construction of long-lived structures on tracts of land that are likely to be completely submerged in a few decades.[101] As deserts and oceans expand dramatically to take increasingly large areas of land that humans and animals have long used for various purposes, we will see hundreds of new disputes with respect to competing uses of increasingly scarce land. The U.S. Department of Defense and Central Intelligence Agency both consider climate change a major source of future global conflicts.[102] Indeed, as hundreds of millions of people in Africa, Asia, and small island states

98 *See* Robert L. Glicksman, *Governance of Public Lands, Public Agencies, and Natural Resources*, *in* THE LAW OF ADAPTATION TO CLIMATE CHANGE: U.S. AND INTERNATIONAL ASPECTS 441 (ABA Michael B. Gerrard & Katrina F. Kuh, eds.) (2012).

99 *Id.* at 53 (quoting Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act; Final Rule, 74 Fed. Reg. 66496, 66525 (Dec. 15, 2010)).

100 *Id.* at 53–54.

101 *See, e.g.*, LAND USE L. CTR., PACE UNIV. SCH. L., LOCAL LAND USE RESPONSE TO SEA LEVEL RISE 80–81 (2011), *available at* http://www.csc.noaa.gov/digitalcoast/_/pdf/Pace_Final_Report.pdf (discussing use of development moratoria while cities plan for sea level rise).

102 Nick Simeone, *Panetta: Environment Emerges as National Security Concern*, AM. FORCES PRESS SERV., May 3, 2012, *available at* http://www.defense.gov/news/newsarticle.aspx?id=116192.

discover that their land has either been submerged or rendered worthless by desertification, the U.S. will confront major new foreign relations challenges.