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INSTRUMENT CHOICE, CARBON EMISSIONS, AND INFORMATION

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"It is always dangerous to prophesy, particularly about the future."
—Danish Proverb[1]

This Article examines the consequences of a previously unrecognized difference between pollutant cap-and-trade schemes and pollution taxes. Implementation of cap-and-trade relies on a forecast of future emissions, while implementation of a pollution tax does not. Realistic policy designs using either regulatory instrument almost always involve a phase-in over time to avoid economic disruption. Cap-and-trade accomplishes this phase-in via a limit on emissions that falls gradually below the forecast of future pollutant emissions. Emissions taxation accomplishes the same via a gradually increasing levy on pollution.

Because of the administrative complexity of establishing an emissions trading market, cap-and-trade programs typically require between three and five years lead time before imposing obligations on emitters. In this Article, I present new evidence showing that forecast error over this timeframe for United States energy-related carbon dioxide emissions from the Department of Energy's energy model—the model used for policy design by Congress and EPA—is biased and imprecise to such a degree as to make its use impractical. The forecasted emissions are insufficiently accurate to allow for creation of a reliable or predictable market signal to incentivize emission reductions. By contrast, carbon taxes, because they do not depend upon a baseline emissions forecast, create a relatively clear level of policy stringency.

This difference matters because policies that end up weaker than intended face low odds for strengthening, while those that end up stronger than intended are likely to be weakened. The political asymmetry combined with actual model

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1. Charles Clay Doyle, Wolfgang Miedler & Fred R. Shapiro, The Dictionary of Modern Proverbs 90 (2012).

forecast errors leads to bias in favor of suboptimal, weak, policies for cap-and-trade. This is a serious concern if, as is usually the case, a cap is set based on political bargaining rather than on an optimal balancing of abatement costs and avoided climate damage. By contrast, the same model bias would lead to more environmentally effective than forecast carbon taxes but without the political consequences created by price volatility, were such programs to be implemented in the United States. Thus, while theory tells us that cap-and-trade and carbon taxes can be equivalent, imperfect information leads to suboptimal environmental performance of emissions trading, relative to carbon taxation policies. Policymakers should weigh these practical, information-related concerns when considering approaches to controlling emissions of greenhouse gases.

Introduction

Federal legislation to reduce climate change does not appear imminent,[2] but many states have enacted or are considering enacting controls intended

2. The one bill aimed at pricing greenhouse gas emissions introduced during the 113th session of Congress received only two sponsors and did not get either a hearing or a vote in the Environment and Public Works Committee. *See* Library of Congress, *S.332 – Climate Protection Act of 2013*, Congress.gov, https://www.congress.gov/bill/113th-congress/senate-bill/332?q=%7B%22search%22%3A%5B%22s.332%22%5D%7D (last visited Feb. 13, 2015).

to reduce greenhouse gas emissions.[3] In addition, the Environmental Protection Agency (EPA) is in the process of crafting guidelines that will compel reductions in power sector emissions in all states.[4] How to accomplish these reductions remains politically and analytically controversial but one mechanism under serious consideration is emissions trading.[5] In fact, greenhouse gas emissions trading programs of varying stringency already exist in ten states as well as one Canadian province.[6] Cap-and-trade has received strong support from economists and policymakers as a mechanism for reducing emissions because of its potential to be cost-effective. Indeed, because of the apparently higher political opposition to carbon taxes, it is the

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3. To date, greenhouse gas emissions are limited within California under Assembly Bill 32. California Global Warming Solutions Act of 2006, 2006 Cal. Stat. Ch. 488, *available at* http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf. Furthermore, carbon dioxide emissions within the power sector in nine Northeastern and Mid-Atlantic states are covered by the Regional Greenhouse Gas Initiative. REGIONAL GREENHOUSE GAS INITIATIVE, http://www.rggi.org/ (last visited Feb. 13, 2015). Washington and Oregon are both considering the feasibility of limiting greenhouse gas emissions using emissions pricing. *See* CLIMATE LEGISLATIVE & EXEC. WORKGROUP, A REPORT TO THE LEGISLATURE ON THE WORK OF THE CLIMATE LEGISLATIVE AND EXECUTIVE WORKGROUP 4-5 (2014), *available at* http://www.governor.wa.gov/issues/economy/climateWorkgroup/default.aspx (last visited Feb. 13, 2015); Associated Press, *Oregon Lawmakers Call for Carbon Tax Study*, KATU (last updated Dec. 16, 2013, 4:01 PM), http://www.katu.com/politics/Oregon-lawmakers-call-for-carbon-tax-study-236082221.html.

4. As of this writing, EPA had issued draft regulations covering new coal-fired and combined cycle gas turbine electric generating units and draft rules that provide guidance to states on how to limit emissions from existing units in these source categories. *See* Standards of Performance for Greenhouse Gas Emissions From New Stationary Sources: Electric Utility Generating Units, 79 Fed. Reg. 1430 (proposed Jan. 8, 2014) (to be codified at 40 C.F.R. pt. 60, 70, 71, 98); Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 79 Fed. Reg. 34,830 (proposed June 18, 2014) (to be codified at 40 C.F.R. pt. 60); Press Release, Presidential Memorandum—Power Sector Carbon Pollution Standards (June 25, 2013), *available at* http://www.whitehouse.gov/the-press-office/2013/06/25/presidential-memorandum-power-sector-carbon-pollution-standards.

5. Both the Natural Resources Defense Council and a coalition of leading electric utilities have advocated such an approach. *See generally* DANIEL A. LASHOF ET AL., NATURAL RES. DEF. COUNCIL, CLOSING THE POWER PLANT CARBON POLLUTION LOOPHOLE: SMART WAYS THE CLEAN AIR ACT CAN CLEAN UP AMERICA'S BIGGEST CLIMATE POLLUTERS (2013), *available at* http://www.nrdc.org/air/pollution-standards/ (last visited Feb. 25, 2015); CHRISTOPHER E. VAN ATTEN, M.J. BRADLEY & ASSOCS. LLC, STRUCTURING POWER PLANT EMISSIONS STANDARDS UNDER SECTION 111(d) OF THE CLEAN AIR ACT– STANDARDS FOR EXISTING POWER PLANTS (2013), *available at* http://www.mjbradley.com/node/237 (last visited Feb. 25, 2015).

6. *See Program Design*, REGIONAL GREENHOUSE GAS INITIATIVE, http://www.rggi.org/design (last visited April 3, 2015) (outlining the eight state collaboration to establish a cap-and-trade program for greenhouse gas emissions from the electric power sector); CAL. HEALTH & SAFETY CODE §§ 38500-99 (cap-and-trade for greenhouse gas emissions in California); Environmental Quality Act, R.S.Q., c. Q-2 §§ 46.1-46.18 (Can.) (establishing a cap-and-trade program for greenhouse gas emissions in Quebec).

preferred alternative of many policy-oriented economists.[7] Here, I present evidence that cap-and-trade programs—that is, regulatory policies that distribute a fixed number of permits to emit a quantity of a pollutant and then allow trading of these permits—face substantial and underappreciated implementation hurdles. These challenges arise because policymakers, in designing real cap-and-trade programs, need to predict emissions in future years. The evidence presented here demonstrates that, in fact, policymakers are not good at making these predictions and that the magnitude of the error raises questions about the cap-and-trade regulatory strategy.

There is a substantial body of work in economics that argues for the relative advantage of emissions pricing over other types of regulation. Arthur Pigou, in 1920, was the first to suggest pricing of private externalities in order to achieve socially optimal outcomes.[8] Pigou argued for the taxation of private externalities. It was not until much later that proposals for quantity-based approaches to pricing environmental externalities emerged.[9] A quantity-based approach, rather than levying a tax on an externality at a prescribed tax rate, sets a limit on the quantity of the externality that will be allowed. A regulator then issues licenses equal to that quantity to private actors, and then allows for private exchange of these licenses. Price-based approaches in the environmental realm have come to be called emissions taxes while quantity-based approaches are known as cap-and-trade. Since the suggestion of cap-and-trade as an alternative to emissions taxes, a substantial body of literature has emerged comparing the two regimes[10] as well as suggesting hybrids that incorporate some best aspects of both price and quantity regulation.[11]

Parallel to the development of alternative regulatory instruments, academia, the U.S. government, and the International Energy Agency have made substantial efforts to develop models aimed at forecasting energy

7. *See, e.g.*, Robert N. Stavins, *Wonderful Politics of Cap and Trade*, ENVTL. F., Sept.-Oct. 2009, at 16, *available at* http://www.hks.harvard.edu/fs/rstavins/Forum/Column_32.pdf.

8. *See generally* A. C. PIGOU, THE ECONOMICS OF WELFARE (1920).

9. *See generally* W. David Montgomery, *Markets in Licenses and Efficient Pollution Control Programs*, 5 J. ECON. THEORY 395 (1972).

10. The seminal work, comparing how uncertainties in marginal abatement cost might be traded off against uncertainties in marginal damages, is Martin L. Weitzman, *Prices vs. Quantities*, 41 REV. ECON. STUD. 477 (1974).

11. *See* David Weisbach, *Instrument Choice Is Instrument Design*, *in* U.S. ENERGY TAX POLICY 113 (Gilbert E. Metcalf, ed., 2014); Lawrence H. Goulder & Andrew R. Schein, *Carbon Taxes Versus Cap and Trade: A Critical Review*, 4 CLIMATE CHANGE ECON. 1350010 (2013); William A. Pizer, *Prices vs. Quantities Revisited: The Case of Climate Change* 20-21, 26-27 (Res. for the Future, Discussion Paper 98-02, 1997).

trends.[12] Over time, as confidence in these models has grown, their use as long-term forecasting tools in policy design and implementation has expanded. For example, the National Energy Modeling System (NEMS), developed and maintained by the Energy Information Administration (EIA) within the Department of Energy, has extended its energy forecasts for the United States from seventeen years to more than twenty-five.[13] As these forecasts, made annually via a publication called the Annual Energy Outlook (AEO), have accumulated, so has a vibrant discussion within the energy modeling community regarding the forecast accuracy of the model.[14] Analysts comparing forecasts to reality have noted large errors and potential biases in NEMS forecasts for a number of key model outputs.[15]

The argument I make here synthesizes these two literatures and then connects them to actual policymaking by assessing the use of energy model forecasts to design and implement real policies to control greenhouse gas emissions. I show that the extent of energy model forecast error has strong implications for the instrument choice debate. Economists have long-favored carbon taxes and cap-and-trade at least in part because they place lower informational demands upon regulators. In contrast to traditional prescriptive regulation, neither technique requires that regulators know where or even how pollution reductions will occur in covered sectors. The responsibility for designing the method to reduce pollution rests with the regulated party, not the regulator. I argue here that designing *real* cap-and-trade programs may require information that regulators currently do not possess and are unlikely to ever possess. This, in turn, bears critically on the choice of instrument by which to reduce greenhouse gas emissions.

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12. For a history of the Energy Information Administration, see *About EIA*, U.S. Energy Info. Admin., U.S. Dep't of Energy, http://www.eia.gov/about/legislative_timeline.cfm (last visited Feb. 13, 2015).

13. *Compare* U.S. Energy Info. Admin., U.S. Dep't of Energy, Annual Energy Outlook 1993 (1993), *with* U.S. Energy Info. Admin., U.S. Dep't of Energy, Annual Energy Outlook 2013 (2013).

14. *See, e.g.*, Brian C. O'Neill & Mausami Desai, *Accuracy of Past Projections of U.S. Energy Consumption*, 33 Energy Pol'y 979 (2005) (NEMS overestimates future energy demand with no improvements in forecast error since 1982); J.A. Laitner, S.J. DeCanio, J.G. Koomey & A.H. Sanstad, *Room for Improvement: Increasing the Value of Energy Modeling for Policy Analysis*, 11 Util. Pol'y 87, 90-91 (2003) (energy-economic model forecast errors caused by inadequate representation of behavior of firms and households and of technological change); Alexander I. Schlyakhter, Daniel M. Kammen, Claire L. Broido & Richard Wilson, *Quantifying the Credibility of Energy Projections from Trends in Past Data*, Energy Pol'y, Feb. 1994, *at* 119 (normal error density cannot account for the number of extreme outliers in AEO forecasts).

15. *E.g.*, Maximilian Auffhammer, *The Rationality of EIA Forecasts under Symmetric and Asymmetric Loss*, 29 Res. & Energy Econ. 102, 119-20 (2007).

Before making this argument, it is necessary to unpack what I mean by "real" cap-and-trade programs. In this argument, real cap-and-trade programs to control greenhouse gases possess at least two characteristics that ideal or theoretical policy designs may not. The first is that they are actually implemented somewhere between three and five years after enactment of legislation. This time lag is necessary for cap-and-trade because of the complex regulatory apparatus that must be designed and put in place in order to implement them. Cap-and-trade programs require monitoring of emissions; they require monitoring of compliance; they require a market design; they require a system for distributing permits to emit greenhouse gases; and they require market surveillance. All of that takes time to design in detail, write regulations concerning, and put into practice. Typical legislative timelines have envisioned between two and six years of spin-up before regulated firms would face an actual obligation to comply.[16] It is only at this point that the cap starts to fall below *projected* future emissions. In other words, the cap is gradually lowered below the *forecast* of future emissions. This gradual increase in regulatory stringency is intended to avoid any disruptive economic impact of the regulation that might result if the stringency of the program were to increase too rapidly. Therefore, the design of a cap-and-trade program requires detailed knowledge of emissions in the future, not just at the time of legislative enactment.

Second, the stringency of real greenhouse gas cap-and-trade programs is determined by political bargaining in the legislative process, not by reference to what is necessary to achieve some desired climactic outcome or to fully internalize the future costs of climate change. Real programs represent a compromise between the interests of environmental advocates in preventing climate change and the interests of firms in minimizing regulatory costs filtered through their relative political power in the legislative process. In general, this means that real cap-and-trade programs are weaker than necessary to "prevent dangerous anthropogenic interference with the climate system,"[17] at least during the years in which legislators can credibly make

16. The EU Emissions Trading Directive was among the fastest programs from final legislation to implementation. The Emissions Trading Directive creating the ETS was approved in 2003 and the program began in 2005. *See* Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community and Amending Council Directive 96/61/EC, 2003 O.J. (L 275) 32, 35. The American Clean Energy and Security Act of 2009 (Waxman-Markey) envisioned phase-in in 2012, three years later. H.R. 2454, 111th Cong. (2009). The California Global Warming Solutions Act was passed in 2006, and envisioned binding limits on greenhouse gases to be set in 2008 that would apply to 2012 emissions. Assemb. B. 32, 2006 Cal. Stat. Ch. 488.

17. United Nations Framework Convention on Climate Change art. 2, S. Treaty Doc. No. 102–38, 1771 U.N.T.S. 107 (1992).

commitments.[18] Policies that are proposed or enacted are weaker than climate advocates would choose or that economists, seeking to fully internalize an environmental externality, might suggest. This weakness is important because it undermines the argument that so long as a cap-and-trade achieves the objectives it has set (the cap), then environmentalist and/or environmental economist constituencies should rest easy. If the cap is set higher (less stringent) than is optimal to avoid climate change or internalize the costs of climate change, then neither group should be satisfied with simply reducing emissions to the level set by legislation. Of course, half a loaf is better than none at all.

It is important to emphasize that this description of how limits are set in practice for cap-and-trade programs is not the only feasible method or even the first best approach. Theoretically, legislators and regulators could set a cap on greenhouse gas emissions based on the results they aim to achieve from the cap. In other words, legislators could design a cap based upon how much greenhouse gas emissions were environmentally acceptable rather than based upon how much greenhouse gas emissions cuts are politically affordable.[19] The key difference from the process I describe above is an indifference to compliance costs. One might analogize this sort of cap setting process to that which EPA employs to determine National Ambient Air Quality Standards for criteria pollutants.[20] In that process, EPA is forbidden from considering the costs of abatement and must instead focus only on setting the standard at a level requisite to protect the public health with an adequate margin of safety.[21] Costs do not enter in. If a similar procedure were followed for greenhouse gases, a cap would be set based purely upon the environmental outcomes a legislator or regulator found necessary to achieve. While a cost-blind approach to setting caps might require a significant change in normative attitudes about climate change it cannot be ruled out as a possibility. Nevertheless, I do not consider it further here.

Alternatively, legislators or regulators could set the cap in a greenhouse gas cap-and-trade program based upon an optimal balancing of the net pre-

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18. Although this timeframe is impossible to determine, for this argument, the first ten years will suffice. This is very often the timeframe over which U.S. Congressional representatives view legislation because of Senate Pay-Go rules.

19. For a discussion of cap setting in the greenhouse gas cap-and-trade context, see David M. Driesen, *Capping Carbon*, 40 Envtl. L. 1 (2010).

20. *See* 42 U.S.C. § 7409(b)(1) (2014).

21. Whitman v. Am. Trucking Ass'ns, 531 U.S. 457, 465 (2001). Of course, although EPA is forbidden from explicitly considering costs when setting a NAAQS, there is strong anecdotal evidence that the Office of Management and Budget may force it to do so anyway. *See* John M. Broder, *Obama Administration Abandons Stricter Air-Quality Rules*, N.Y. Times, Sep. 2, 2011, http://www.nytimes.com/2011/09/03/science/earth/03air.html.

sent value of future costs of compliance and benefits from avoided climate damages.[22] This economically optimal cap would still consider the costs of compliance but would be superior to the process discussed in this paper because it seeks to maximize social welfare. This process would be distinct from the process I describe in that it would eliminate the political interest group bargaining that serves to set acceptable compliance costs. Instead, a regulator, ideally with perfect information, would determine the socially optimal cap for future years. Even with such a well-informed and powerful regulator, a socially optimal cap setting process that balanced a schedule of costs and benefits would still depend critically on the type of energy modeling I describe below. In particular, it might fall victim to unexpected price shocks due to technological or macroeconomic events that upset the cap setting calculus. In what follows, however, I choose to view these two alternative modes of setting caps as theoretical possibilities rather than current real-world policy challenges. Although recognizing these theoretical possibilities, I assume that caps will instead be set subject to a political bargaining process that focuses on the costs of compliance, as described above.

Energy models such as NEMS have been intimately involved in the design of congressional proposals to regulate greenhouse gas emissions. Designing cap-and-trade policy requires that legislators or regulators set a cap on emissions several years before the advent of the program. In order to reach a political compromise on the stringency of the cap, it also requires that they have some estimate of the regulatory costs that the cap will create for firms. In the end, whether a cap-and-trade program actually produces the environmental benefits and compliance costs that underlie the bargaining positions adopted by all parties to the legislative process will, to a significant degree, be a function of the accuracy of the emissions forecast that underpins it. A forecast that underestimates what emissions would have been absent the program will produce much larger reductions in emissions, hence environmental benefits but also much higher compliance costs than expected for firms. Likewise, a cap-and-trade predicated on a forecast that overestimates future emissions will produce much smaller cuts in emissions—quite possibly none at all—and consequently much lower than expected compliance costs for firms. Both the environmental benefits and the compliance costs depend on accurate information about emissions half a decade hence with sufficient accuracy to create roughly the desired strin-

22. There is a large body of scholarship aimed at determining this idealized cost schedule for pricing carbon based on models that combine economics with simplified climate models. These models are known as integrated assessment models because they integrate both economic and climatic impacts of modern society. *See generally* William Nordhaus, The Climate Casino (2013).

gency of the program. If the forecast is wrong, one party to the political negotiation will not derive their benefit of the bargain. As will be shown in the next Part, obtaining this information about the future is more challenging than it sounds because real cap-and-trade programs require only modest reductions during their early years.

I. Greenhouse Gas Emissions Forecast Skill in the National Energy Modeling System

A. *Energy Models*

Legislators and regulators need estimates of future greenhouse gas emissions in order to set the cap in an emissions trading program. They need this information because cap-and-trade programs phase-in at or near unregulated emissions levels in their early years and then gradually reduce permitted emissions, usually in annual steps, to achieve reductions. The need to forecast follows directly. Accurate forecasting of emissions is theoretically possible, assuming that an accurate energy system model can be developed for a given jurisdiction. Of course, this is no small assumption. At its core, such a model would need to estimate the gross economic output of the region, the amount of energy used per unit of output created, and the carbon intensity of this energy.[23]

$$CO_2 = Population * \left(\frac{GDP}{Population}\right) * \left(\frac{GrossEnergyConsumption}{GDP}\right) * \left(\frac{CO_2}{GrossEnergyConsumption}\right)$$

Numerous modeling groups work at estimating the components of this identity for future states of the world. These models typically function by iteratively solving energy demand or supply within individual modules that separately simulate different aspects of the energy system. By iteration, these models converge on a solution where different sectors of the energy-economic system are in equilibrium with each other. Industries demand fuels or electricity based upon the prices in the market. Oil and coal mining companies produce fuels depending on their costs of production and the prices demanded for their products. The models ultimately produce a stable prediction of supply-demand balance for oil, natural gas, and coal usage. From this balance, the models then derive greenhouse gas emissions by molar conversion of the fuels to their combustion produces, including carbon dioxide (CO_2).

23. This formulation is commonly called the Kaya Identity and has been utilized in numerous future emissions scenario planning efforts. *See* P.E. Waggoner & J. H. Ausubel, *A Framework for Sustainability Science: A Renovated IPAT Identity*, 99 Proc. Nat'l Acad. Sci. 7860, 7860-61 (2002).

The individual sub-modules within these models attempt to capture rich detail within particular segments of the energy sector. For example, the electricity module in the NEMS incorporates data generated by EIA reporting from all power plants across the United States including the technology utilized at the power plant, electric power generated, the number of hours the plant operates, the fuel consumed, and numerous other types of information.[24] In addition, the modules include assumptions about the availability and costs of alternative technologies formed by extensive and systematic study. In the case of the NEMS electricity sector module, these include the feasible range of energy efficiency investments by industry and building type, renewable energy, co-firing of biomass in fossil generation, and advanced nuclear power plants amongst others.[25] The individual modules are also constrained by applicable laws and regulations. For example, power plants in the NEMS electricity cannot simulate behavior that would violate the Clean Air Act.[26]

The energy sector modules, when coupled to a macroeconomic model of the U.S. economy, and to each other, allow for iterative calculation of an equilibrium forecast of various energy sector parameters in supply-demand balance. These include but are not limited to production of various fossil fuels, fuel prices, and fuel consumption by commercial, household, and industrial sectors. For example, the electricity module receives prices for fuels along with demand for electricity, and it then estimates which power plants will operate given the relative fuel costs and demand for energy. This produces a price for electricity as well as a particular level of demand for oil, natural gas, and coal. The price is then fed back to the industrial, commercial, and household modules and may drive changes in demand for electricity. The fuel demanded from the electricity sector is fed back to the oil, natural gas, and coal modules and may drive changes in supply and price of these inputs. Once consumption of different fuels has been estimated, it is relatively straightforward to estimate energy-related greenhouse gas emis-

24. *See* Energy Info. Admin., DOE/EIA-0581, The National Energy Modeling System: An Overview 2009 48 (2009).

25. *Id.* at 43-46.

26. Power plants must comply with the Acid Rain Trading Program and the Clean Air Interstate Rule. *Id.* at 48.

sions.[27] Energy models that incorporate the characteristics just described are maintained in academia,[28] the private sector,[29] and government.[30]

B. *The Use of the National Energy Modeling System in the Legislative Process*

In this study, I focus on one particular EIA energy model: NEMS. This model is arguably the most important energy-forecasting tool for the United States. The primary purpose of NEMS is to provide official U.S. government forecasts of energy demand and consumption for the United States. The NEMS is also the primary tool that Congress uses to assess the costs and benefits, both environmental and economic, of energy and environmental legislation. For example, Congressional representatives requested that EIA utilize NEMS to assess the impacts of five bills aimed at imposing a cap-and-trade on U.S. greenhouse gas emissions,[31] proposing a twenty-five percent renewable energy standard,[32] and lifting the ban on oil drilling in the Alaska National Wildlife Refuge.[33] NEMS is the preferred tool in

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27. It is important to note that these models do not generally estimate either fugitive emissions from fossil fuels, for example leakage from natural gas pipeline infrastructure, or other non-CO_2 emissions, for example methane emissions from livestock. Both are potentially significant sources of greenhouse gases although combustion of fossil fuels is thought to represent approximately eighty-five percent of U.S. emissions. *See* U.S. Envtl. Prot. Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012 3-5 (2014).

28. *See* U.S. Energy Info. Admin., U.S. Dep't of Energy, DOE/EIA-0383ER, Annual Energy Outlook 2014 Early Release Overview (2014), *available at* http://www.eia.gov/forecasts/aeo/er/index.cfm.

29. For example, the Rhodium Group maintains a working copy of NEMS that they modify in order to conduct energy policy studies. *See generally* Trevor Houser & Shashank Mohan, Fueling Up: The Economic Implications of America's Oil and Gas Boom (2014).

30. *See* U.S. Energy Info. Admin., *supra* note 28.

31. *See, e.g.*, U.S. Energy Info. Admin., U.S. Dep't of Energy, SR/OIAF/2009-05, Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009 (2009) *available at* http://www.eia.gov/oiaf/servicerpt/hr2454/index.html?featureclicked=2&; U.S. Energy Info. Admin., U.S. Dep't of Energy, SR/OIAF/2008-01, Energy Market and Economic Impacts of S. 2191, The Lieberman-Warner Climate Security Act of 2007 (2008), *available at* http://www.eia.gov/oiaf/servicerpt/s2191/pdf/sroiaf%282008%2901.pdf; U.S. Energy Info. Admin., U.S. Dep't of Energy, SR/OIAF/2007-06, Energy Market and Economic Impacts of S. 1766, The Low Carbon Economy Act of 2007 (2008), *available at* http://www.eia.gov/oiaf/servicerpt/lcea/pdf/sroiaf%282007%2906.pdf.

32. U.S. Energy Info. Admin., U.S. Dep't of Energy, SR/OIAF/2009-03, Impacts of a 25-Percent Renewable Electricity Standard as Proposed in the American Clean Energy and Security Act Discussion Draft (2009), *available at* http://www.eia.gov/analysis/requests/2009/acesa/pdf/sroiaf%282009%2904.pdf.

33. U.S. Energy Info. Admin., U.S. Dep't of Energy, SR/OIAF/2008-03, Analysis of Crude Oil Production in the Arctic National Wildlife Refuge (2008) *available at* http://www.eia.gov/oiaf/servicerpt/anwr/pdf/sroiaf%282008%2903.pdf.

scoring the impacts of major energy legislation in the United States. In a political debate over climate change and its regulation characterized by partisanship, the model's attraction is that it is unbiased.

In addition, NEMS also plays an important role in legislative design of climate policies. It is an important means, indeed perhaps the only means, for Congress to develop definitive projections of U.S. greenhouse gas emissions into the future. As discussed above, such projections are important to cap-and-trade design because they are the reference point below which the cap is designed to fall in order to both reduce emissions and create a cost for producing pollution that firms will respond to. Because of the need to phase in reductions in order to avoid economic shocks, in most proposals the initial reductions are extremely modest relative to either current emissions or long-term goals. The model is used to specify the critical glide path; it is relied on to plot emissions in future years relative to emissions levels if left unchecked by legislation.

To take one example of the use of NEMS for cap-and-trade design, consider the proposed American Clean Energy and Security Act of 2009 (Waxman-Markey).[34] The Waxman-Markey legislation would have imposed a limit of 4627 million metric tons CO_2 equivalent[35] (MMt CO_2e) for sources covered under the cap in the first year of the program (2012). Thereafter, the cap falls by approximately two percent per year. The most current emissions forecast at the time the legislation was proposed found that sources covered under the cap were projected to emit exactly the same amount as the cap in its first year—4627 MMt CO_2e.[36] This is not a coincidence. The cap in the bill was designed using the forecast from the most recent NEMS reference case.[37] Most other cap-and-trade bills proposed during the last decade have caps very close to the NEMS forecast current when they were introduced (see Table 1). In only one case, of the five bills introduced by Congress during the 109th, 110th, and 111th sessions, did the

34. H.R. 2454, 111th Cong. (as passed by House, June 26, 2009), *available at* http://thomas.loc.gov/cgi-bin/query/z?c111:H.R.2454:.

35. *Id.* at sec. 311, § 721. Carbon dioxide equivalent is a unit of mass that converts emissions of a greenhouse gas to emissions of carbon dioxide using 100-year global warming potentials. It is the standard measure of account under both domestic and international law. *See* Mandatory Reporting of Greenhouse Gases, 74 Fed. Reg. 56,260, 56,264 (Oct. 30, 2009).

36. Author's calculations using data from U.S. Energy Info. Admin., *supra* note 31; SR/OIAF/2009-05, Energy Market and Economic Impacts of H.R. 2454, U.S. Energy Info. Admin., U.S. Dep't of Energy, SR/OIAF/2009-03, An Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook (2009).

37. Email from Phil Barnett, Chief of Staff of Rep. Henry Waxman, to Michael Wara (Feb. 19, 2014) (on file with author).

cap differ from the NEMS estimate of covered emissions by more than 0.5 percent.

TABLE 1

Cap-and-Trade Bill	Date Introduced	Annual Energy Outlook Reference Case	Cap in first year of implementation (MMt CO_2e)	Reference case emissions for covered sectors (MMt CO_2e)	Percent Difference between Cap and Reference Case
H.R. 5049 (109^{th}; Udall-Petri)	Mar. 26, 2006	AEO 2006	6964	6964	0%
S. 280 (110^{th}; McCain-Lieberman)	Jan. 12, 2007	AEO 2006	6130	6161	0.5%
S. 1766 (110^{th}; Bingaman)	Jul. 11, 2007	AEO 2007	6652	6649	0.1%
S. 2191 (110^{th}; Lieberman-Warner)	Oct. 18, 2007	AEO 2007	5775	6678	16.2%
H.R. 2454 (111^{th}; Waxman-Markey)	May 5, 2009	AEO 2009 Update	4627	4627	0%

In that exception, the lack of correlation may be because the bill's authors opted to allow the use of offsets equal to thirty percent of the cap in its first year.[38] When this additional compliance option is included, the cap rises to potentially as high as 7508 MMt CO_2e, or 12.4 percent above projected emissions. In this instance, when the combined cap and offsets is greater than emissions, presumably legislators intended that a combination of offsets and allowances sufficient to cover emissions would be utilized.

Congress has used NEMS in two ways in its attempts to design and pass cap-and-trade legislation. First, it has asked EIA to use its energy model to estimate the costs and benefits of bills introduced by lawmakers. Second, and more importantly, it appears that legislators have relied on available emissions forecasts in designing the cap on emissions that lies at the heart of these bills. In the next Section, I examine the history of NEMS

38. Offsets are certified reductions in greenhouse gas emissions that occur outside of the sectors covered by the cap-and-trade but which can be credited toward compliance by covered entities. *See* Michael Wara, *Measuring the Clean Development Mechanism's Performance and Potential*, 55 UCLA L. REV. 1759, 1770-72 (2008).

reference cases with the aim of determining whether such reliance is warranted.

C. *A Retrospective Analysis of NEMS Greenhouse Gas Emissions Forecasts*

Most people expect weather forecasts for the next several days to be more or less accurate. By contrast, most people do not put much stock in a forecast for a thirty percent chance of rain in fourteen days' time. There are good reasons for this. The atmosphere is a complex system. A model initialized with anything less than complete information about the state of the atmosphere will thus produce less and less reliable forecasts as we look further and further into the future. And, despite the best data efforts of weather forecasters equipped with satellites, information about initial conditions is always incomplete. By about ten days, the weather forecast produced by the best models initialized with the best data is not much better than a guess based on the climatological average in a given location. We have learned to use weather forecasts as useful tools over the one- to seven-day period as a consequence of weather models decreasing predictive skill.[39] Because we understand the rough accuracy and precision of these forecasts, we are able to plan and act accordingly. We do not cancel a picnic in two weeks because rain is in the forecast, but we do take our umbrella with us when we leave the house if the forecast calls for an eighty percent chance of rain later in the day.

Policymakers rely on emissions forecasts by NEMS or other energy models in designing cap-and-trade legislation in a similar fashion to a weather forecast. They depend on such forecasts for designing their plans and approaches to limiting emissions. Therefore it is worth considering the predictive ability of these models over the timeframes upon which they are being relied and relative to the level of accuracy required. In particular, one wonders why it appears that so many cap-and-trade programs are overallocated—that is have their caps set too high—from the start. While weather forecasts deteriorate over ten days because of the complexity of atmospheric circulation, energy models purport to predict the pattern of very complex systems over time periods ranging from years to decades. This Section assesses that predictive skill. I make this assessment by constructing a dataset of Annual Energy Outlook forecasts of U.S. energy-related carbon dioxide emissions for the past fifteen years and comparing them, as forecasts, against the reality that ultimately transpired. That in turn provides an as-

39. *See* Am. Meteorological Soc'y, Weather Analysis and Forecasting: An Information Statement of the American Meteorological Society (2007).

sessment of whether reliance on emissions forecasts in the design of cap-and-trade programs is well founded.

1. Methods

The first step in assessing predictive ability or forecast skill is to develop a reference against which forecasts can be compared. In this case, the obvious reference with which to compare NEMS greenhouse gas emissions forecasts are the greenhouse gas emissions data released on a regular basis by EIA.[40] These emissions data cover all carbon dioxide emissions associated with the combustion of fossil fuels in the United States and are created using the same reporting system used to initialize NEMS. Not included in EIA estimates are fugitive emissions of carbon dioxide or emissions of other greenhouse gases such as methane or nitrous oxide.

I collected EIA NEMS-based forecasts of "Total Energy-Related Carbon Dioxide Emissions" for reference cases from the Annual Energy Outlook for each year from 1999 to 2014 (n=16).[41] I then computed differences between forecast emissions and measured emissions, taken from the EIA Monthly Energy Review Table 12.1.[42] These forecast errors were then collated by year relative to the year of release for the AEO that contained them. For example, the 2005 AEO forecast CO_2 emissions of 6627 $MMtCO_2$ in 2010. The EIA Monthly Energy Review reports that actual emissions in 2010 were 5627 $MMTCO_2$. Thus, the forecast error for the fifth year post-forecast of the 2005 AEO is 1000 $MMtCO_2$. This methodology is applied to every forecast year/pair for the sixteen AEO reference case forecasts analyzed for this study. Then, all the forecast error time series, which range from three years prior to the forecast[43] to twenty-five years after the forecast are arranged and compared by year relative to the year of publication rather than by calendar year. I then compute the mean and standard deviation of forecast error for the dataset by forecast year. This allows

40. *Monthly Energy Review*, U.S. Energy Info. Admin., U.S. Dep't of Energy, http://www.eia.gov/totalenergy/data/monthly/.

41. Prior to 2004, emissions were expressed by EIA in AEOs in units of tons C. These emissions were converted to tons CO2, the current units convention, by multiplying by thirty-two/twelve, the relative atomic masses of CO2 and C. *Compare* U.S. Energy Info. Admin., U.S. Dep't of Energy, DOE/EIA-0383, Annual Energy Outlook 2003 91-93 (2003), *with* U.S. Energy Info. Admin., U.S. Dep't of Energy, DOE/EIA-0383, Annual Energy Outlook 2004 103-04 (2004).

42. U.S. Energy Info. Admin., U.S. Dep't of Energy, DOE/EIA-0035, Monthly Energy Review February 2014 159 tbl.12.1 (2014).

43. Annual Energy Outlook forecasts effectively forecast two to three past years of emissions because these data are not available until after publication of the AEO. Thus, the 2014 AEO includes a "forecast" of 2011, 2012, and 2013 emissions that can vary substantially from actual emissions, once these are known.

for an assessment of forecast skill—that is, the skill of NEMS forecasts in predicting U.S. CO_2 emissions at various time horizons.

2. Results

A comparison of actual energy-related CO_2 emissions as compared to annually released NEMS forecasts taken from successive AEO reference cases from 1999 to 2014 is shown in Figure 1. It can immediately be seen that forecasts of emissions over the past fifteen years deviate significantly from observed emissions. This deviation is due to several factors including the Great Recession, the advent of unconventional oil and gas drilling and consequent switching from higher-emitting coal to lower-emitting gas in the electricity sector, and a general decline in the energy consumption per unit of GDP in the U.S. economy.[44]

44. *See* U.S. Energy Info. Admin., U.S. Dep't of Energy, U.S. Energy-Related Carbon Dioxide Emissions, 2012 (2013), *available at* http://www.eia.gov/environment/emissions/carbon/archive/2012/index.cfm.

FIGURE 1

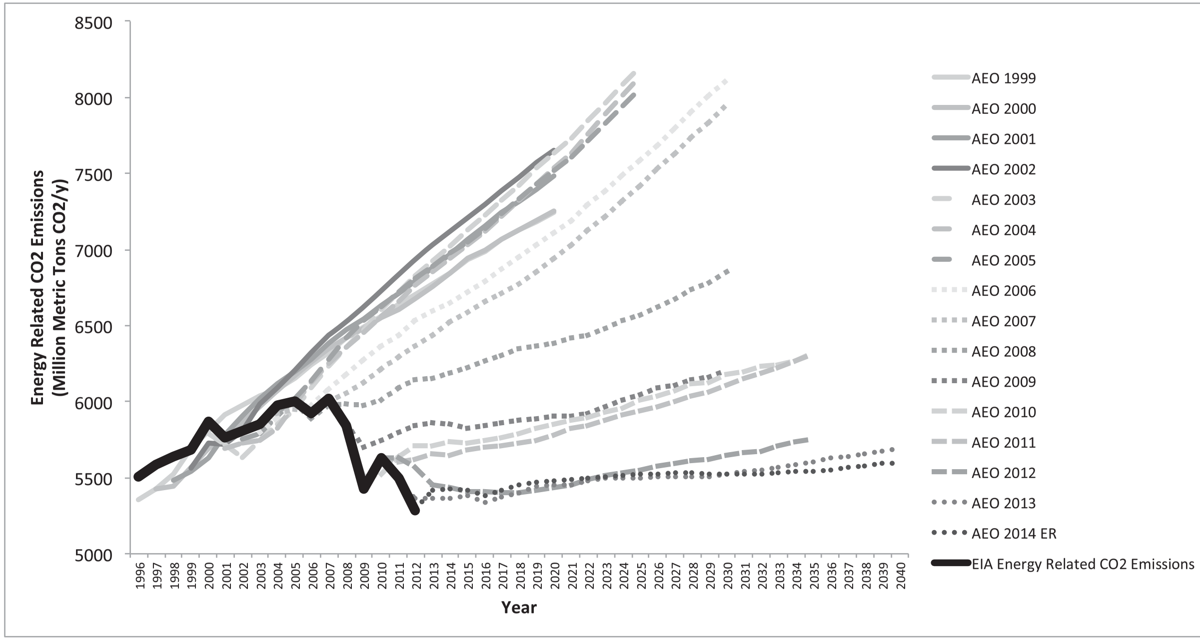

Figure 1. A comparison of EIA energy-related CO_2 emissions to Annual Energy Outlook reference case forecasts of emissions. Reported emissions from 1996 to 2012 are shown in thick line. AEO reference case forecasts from 1999 to 2014 are included as thin lines.[45]

45. EIA Annual Energy Outlooks are available at *Annual Energy Outlook Products - Archive*, U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, http://www.eia.gov/forecasts/aeo/archive.cfm (last visited Jan. 30, 2015). EIA reported emissions data is from U.S. ENERGY INFO. ADMIN., *supra* note 42, at 159 tbl.12.1.

There are reasons to question whether the period from 1999 to 2012 is representative of the true variability in emissions forecasts created by the model. It is certainly the case that two surprises—the subprime mortgage crisis and subsequent global recession and financial crisis which followed and the totally unexpected technological innovation in the oil and gas sector—significantly impact the quality of NEMS forecasts during this interval. Nevertheless, energy surprises have happened frequently since the oil crises of the 1970s. In particular, the reduction in the energy intensity of developed economies in response to these oil shocks. Furthermore, the time period does include more than one full business cycle, including two recessions as well as significant periods of robust economic growth. Nonetheless, for better or worse, it is the sample for which retrospective forecasts of emissions are available.

Calculation of forecast error[46] for 152 year pairs of NEMS forecast and reported energy-related carbon dioxide emissions allows for an estimate of NEMS forecast error as a function of year relative to the year the forecast was made. These data are presented in Figure 2. Over the time interval from 1999 to 2015, the forecasts made by NEMS exhibited a strong positive bias. The model has a strong tendency during the study period to overestimate future emissions. By three years post-forecast, the average error is 383 MMT CO_2e or seven percent of 2012 emissions.[47] By five years post-forecast, average error is 626 MMT CO_2e or twelve percent of 2012 emissions. By ten years, post-forecast, average error appears to stabilize for the time period evaluated at approximately 1100 MMT CO_2e or twenty percent of 2012 emissions.

46. Forecast error = Forecast – Emissions. Thus, positive values in Figure 2 represent overestimates of emissions levels in any given year by a NEMS reference case from an Annual Energy Outlook.

47. 2012 energy-related carbon dioxide emissions were 5282 MMT CO2e. U.S. Energy Info. Admin., *supra* note 42, at 159 tbl.12.1.

FIGURE 2

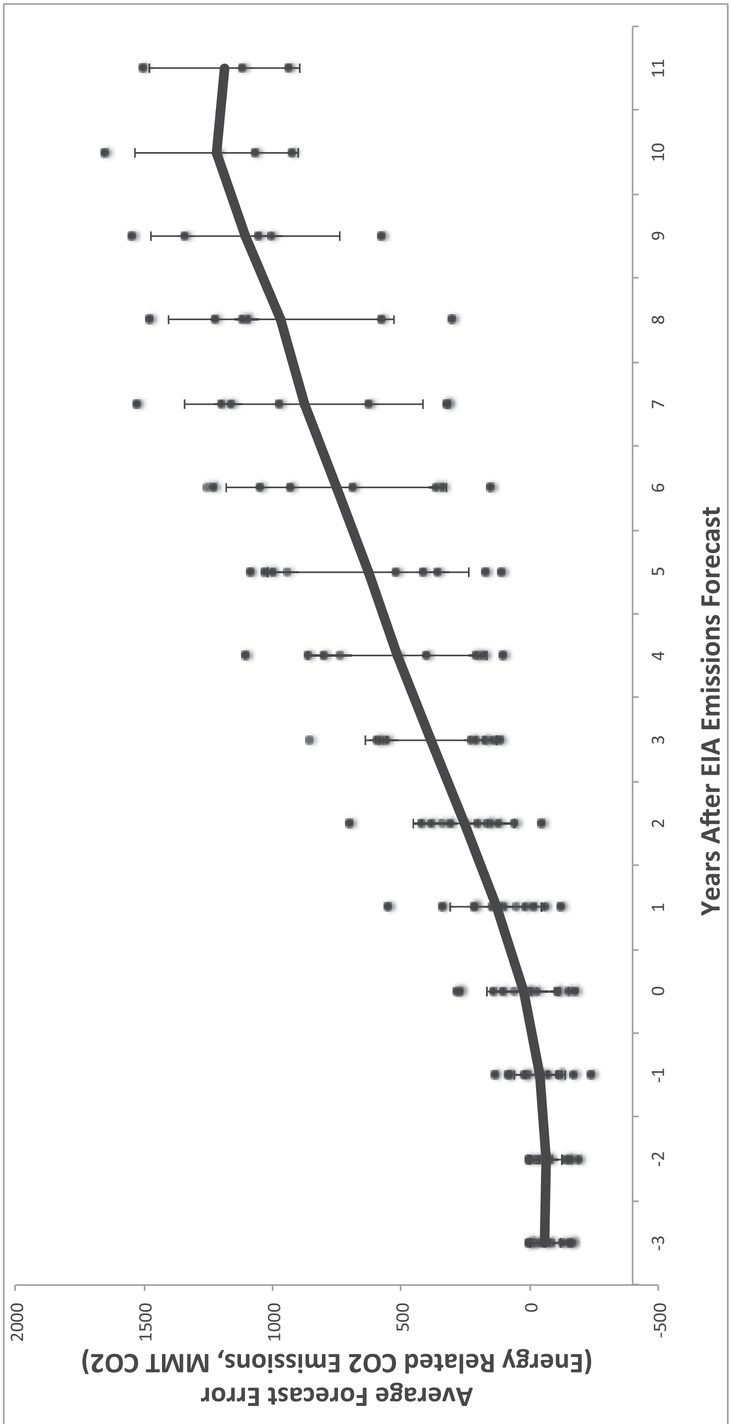

Figure 2. Greenhouse Gas Emissions forecast error as a function of the year after an Annual Energy Outlook is released. Solid line is average forecast error in a given year for AEO reference cases published between 1999 and 2013. Also shown are individual forecast error pairs and the standard deviation of the mean forecast error.

3. Possible Explanations for NEMS Forecast Error

The biased and highly imprecise forecasts produced by NEMS for U.S. energy-related CO_2 emissions are difficult to explain. In it its own error analysis, EIA has noticed these and other persistent errors.[48] Academics have also long noted forecasting problems for other variables predicted by NEMS and other energy models.[49] EIA has noticed that this variable, amongst others appears consistently overestimated and imprecise.[50] But their presentation of the data gives a clue to why EIA may be unconcerned about this issue.

EIA performs an error analysis that looks at many of the variables it estimates and compares them in any given year to the true variables. It then calculates percentage deviations from the true variables. This reflects the use to which the Annual Energy Outlook is generally put—projecting the U.S. energy future over the timeframe of the report. Report authors are unconcerned about particular features of the forecast errors in NEMS because they do not intend to use NEMS for a particular policy design application. EIA's approach to error analysis also tends to blend larger errors in out-years with smaller errors in the more predictable near-future, providing an overly optimistic view of the AEO's predictive ability. So it is possible that EIA is either unconcerned about the errors addressed above because it does not consider the purposes to which the AEO forecast will be put or that its error analysis has lulled it into thinking that the errors are less significant than they actually are for the purposes of climate policy design. In any case, I could find no mention of the problems with greenhouse gas forecast error in any of the multiple analyses of climate bills that EIA has performed for members of Congress.[51]

The persistent bias and imprecision of the NEMS energy-related CO_2 forecasts may be explained by at least two and possibly more underlying factors. First, the model's creators may have an inherent bias toward over-prediction. This would make sense if the costs of over-prediction of fossil fuel use were lower than the costs of under-prediction. In general, over-predicting fossil fuel use should tend to produce under-predictions of fossil fuel prices and, in addition, energy planning that is better positioned to deal with energy crises. That is, when one over-predicts fossil fuel usage, there will tend to be more happy surprises—contexts in which supplies are more

48. *See* U.S. Energy Info. Admin., U.S. Dep't of Energy, DOE/EIA-0640, Annual Energy Outlook Retrospective Review: Evaluation of 2013 and Prior Reference Case Projections 3 tbl.1 (2014), *available at* http://www.eia.gov/forecasts/aeo/retrospective.

49. *See supra* notes 14 and 15 and accompanying text.

50. U.S. Energy Info. Admin., *supra* note 48, at 5.

51. *Supra* note 31 and accompanying text.

abundant and cheaper than expected—than unhappy ones. This institutional reason may at least partially explain the persistent over-prediction of fossil fuel use and consequent bias in energy-related CO_2 emissions in NEMS.

Another reason for over-prediction of fossil fuel use may be that NEMS, like all energy models, is not as flexible as the world of social, market, and technological phenomena it seeks to simulate. To a significant degree, social, cultural, and market structures mediate energy use.[52] But energy models like NEMS cannot simulate changes in the social and cultural factors that underlie and respond to economic and technological change.[53] To the degree that these are significant and responsive to economic and technological forcing, models may tend to be both less sensitive to the general trends of fossil-fuel prices over the last fifty years—toward higher prices, especially for oil and coal—and to the social and cultural responses to shorter term price shocks to the energy system. The former would lead to over-prediction of both fossil fuel use and consequent CO_2 emissions. The latter would go some way towards explaining the lack of precision of NEMS CO_2 emissions forecasts.

To some degree, both mechanisms may cause the bias and imprecision my presentation of NEMS forecasts brings to light. There may also be other important causes. Whatever the combination of factors that leads to inaccurate forecasts, policymakers need to bear these informational limitations in mind when they rely on NEMS as a policy design tool.

4. Implications of NEMS Forecast Error

Consider the size of the average error compared to the size of reductions in cap-and-trade programs considered by Congress. For example, emission reductions under Waxman-Markey would have been about two percent per year, beginning in the fourth year after the legislation was proposed. Thus, in year two of the program (four years after the bill was introduced), when the first reductions below business as usual were set to occur, this forecast error dataset predicts that emissions would have been about ten percent below the cap. In fact, emissions were approximately twelve percent below the Waxman-Markey cap in 2012. The consequences of this difference between assumptions and reality would have been quite stark had the bill been enacted. Covered sources under the bill would have faced no need to cut emissions and the price of allowances would have been close to zero dollars as opposed to the EIA's ex ante estimate of approximately eighteen

52. For a comprehensive history of the social and cultural mediation of electrification in America, see generally David E. Nye, Electrifying America: Social Meanings of a New Technology, 1880-1940 (1990).

53. J.A. Laitner, S.J. DeCanio, J.G. Koomey & A.H. Sanstad, *supra* note 14, at 119-20.

dollars per ton.[54] Under Waxman-Markey, there might have been a positive price for allowances because of their potential use in future years, but that would have depended on the credibility of the program in the face of substantial overallocation of allowances. The Waxman-Markey cap would not actually have fallen below currently projected emissions until 2015, and worse, accounting for allowed use of offsets, no reductions from capped sectors would have been required until 2025.[55]

Figure 2 should generate caution for any policymaker hoping to gradually phase in a greenhouse gas cap-and-trade program three to six years in the future. Indeed, the picture is actually a bit worse than it seems for two reasons: the variance in the forecast errors and the use of allowance banking in cap-and-trade programs. Variance matters because it impacts the ability of a policymaker to simply adjust the forecast to correct for bias. The NEMS forecasts are not only inaccurate; they are also imprecise. Allowance banking matters because it creates contagion between forecast errors in adjacent years. In other words, a mismatch between forecast and reality in year one will turn out to impact the stringency of cap-and-trade not just in that year but also in subsequent years as well.

Taking variance first, note that there is substantial scatter in the forecast error for greenhouse gas emissions shown in Figure 2. In year three, the standard deviation of forecast error is 255 MMT CO_2e growing to 398 MMT CO_2e by year five. This variance is equal to between two and four times the annual reductions of about 100 MMT CO_2e envisioned under Waxman-Markey. This dispersion around the average error has policy relevant consequences for cap-and-trade design. Simply correcting for bias in the forecast will not resolve the problem of setting a cap on emissions today to be implemented three to five years hence. Even correcting for bias, the first compliance obligation, occurring three years after enactment, would very likely produce either much higher than expected carbon prices with the result of an unreasonably large impact on the economy or, if the cap is higher than emissions, a zero dollar carbon price and therefore no impact on greenhouse gas emissions at all.

Next, the problem of emissions forecast error combined with a gradual phase-in of cap-and-trade programs is worsened by a design element common to real cap-and-trade programs: allowance banking and borrowing. The ability to bank or borrow allowances—that is, to use permits issued in any given year in a different one—is intended to manage unexpected shocks that lead to large changes in demand for permits. When a cap-and-trade program allows regulated sources to hold allowances issued in one year for

54. U.S. Energy Info. Admin., *supra* note 31, at 13.
55. Author's calculations.

compliance in a later year, or to borrow allowances from future years for compliance in the current year, the effect is to integrate caps across multiple years. This integration is ultimately limited by the cost of holding (or borrowing) allowances—in theory, representative of a firm's cost of capital. In reality, the incentives to bank allowances are more complex because the policies governing the cap-and-trade may change. Banking and borrowing provisions are attractive to policymakers because they are thought to reduce volatility in emissions trading markets.[56] The consequence of this for a phased-in program is that if emissions estimates used to craft the program were too high or too low in multiple consecutive years, these errors will accumulate leading to either very high prices because of unanticipated stringency over a period of multiple years or, as has more often been the case, very low prices leading to accumulation of a large bank of unused allowances.[57]

In this Part, I have shown the role that energy models play in designing real cap-and-trade programs and the vulnerability this creates. The evidence shows that existing models are not up to the task that cap-and-trade legislation sets for them. Designers of legislation aimed at capping emissions depend on energy models not just to project environmental benefits and abatement costs but also in order to design the phase-in of these programs. Unfortunately, the energy model for projections of future emissions that is actually used to design and evaluate U.S. energy and climate legislation lacks the necessary accuracy and precision to play this role given its forecast error and the timing and rate at which emission reductions occur under most proposals. One response to this problem has been to suggest that cap-and-trade programs should be designed with the expectation that the cap will be adjusted in the future.[58] In theory, such a process might work to strike the balance between expected stringency, environmental benefits, and abatement costs. However, there are compelling reasons to think that in practice, the political economy of *strengthening* the stringency of a cap to achieve expected environmental benefits and incur expected pollution abatement costs differs considerably from the political economy of *weakening* a cap. The next Part discusses the likely responses to a cap that is set too low or too high because of an inaccurate baseline emissions forecast and compares this to the other approach to reducing greenhouse gas emissions favored in the environmental economics literature—carbon taxes.

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56. *See* Goulder & Schein, *supra* note 11, at 13.

57. *See generally* Lesley K. McAllister, *The Overallocation Problem in Cap-And-Trade: Moving Toward Stringency*, 34 Colum. J. Envtl. L. 395 (2009) (observing consistent overallocation in a survey of four existing cap-and-trade programs).

58. *Id.* at 435-36; *see also* Weitzman, *supra* note 10, at 482.

II. The Design and Modification of Emissions Pricing Policies

In this Part, I explain how recent emissions pricing schemes—both cap-and-trade and carbon tax proposals—have been designed in order to avoid creating economic disruption as compliance is phased in. The Article then explores theoretical arguments for and empirical evidence of an asymmetric political economy in the modification of existing cap-and-trade and carbon tax programs. For cap-and-trade, most available evidence supports the hypothesis that it is easier to develop constituencies supporting reductions in stringency in the presence of unexpectedly high allowance prices than the reverse. For carbon taxes, the situation appears different. Here, available evidence suggests that, particularly where carbon taxes involve explicit cuts to other taxes, the status quo is likely to be more stable and, to the degree that policy change is considered, political support for strengthening and weakening the tax is likely to be more balanced. Given that either policy is likely to be weaker than necessary to optimize societal welfare, as described in the Introduction, and the likelihood of large forecasting errors in setting the cap, demonstrated in Part I, these political economy considerations lend support to the choice of a carbon tax over a cap-and-trade program.

At the outset, it is important to emphasize that mid-stream policy adjustment is only necessary or desirable if the initial policy design is suboptimal because of political constraints and/or the actual stringency of the policy turns out to be very different than prior expectations. That is, strengthening of a policy is only important if short-term political constraints result in less than societally-optimal commitments to reduce emissions. Likewise, weakening of a policy is only important if the program turns out to generate much higher costs than anticipated. Given the information presented above, even if a socially optimal approach that appropriately balanced the costs and benefits of climate policy over the relevant time scales were adopted, there still might be a need for midstream policy adjustment because of the variance in emission forecasts used to set the cap. If the right emissions limits are set in a cap-and-trade program *and* the emissions forecast is correct, no adjustment would be needed because they will accomplish the environmental objectives of the policy at the expected price. Because the former, suboptimal outcome is far more likely than the latter, idealized outcome, in a world where regulation of greenhouse gases produces costs today and discounted intergenerational benefits in the distant future, the balance of this discussion will assume that policies under consideration are likely to be too lax rather than too stringent.[59] This assumption is also consistent with the bias in NEMS emissions forecasts described above. These forecasts, because they overestimated emissions, would have tended to make cap-and-trade programs far less stringent than intended.

A. *Phase-In of Greenhouse Gas Pricing Policies*

Many argue that allowance prices should not matter, so long as the cap is set appropriately.[60] In theory, a cap should be determined via optimization of the schedule of social costs and benefits of avoiding climate damages, discounted to present value.[61] In practice, at least so far, limits on greenhouse gas emissions appear to be set, especially in the near to medium term, by a balancing of political interests.[62] Environmentalists favor deep cuts to emissions while high compliance costs are opposed by industry. To some degree, deeper reductions may tradeoff against other provisions that will benefit regulated firms such as transfers of free permits or other types of compliance flexibility such as offsets.[63] This political bargaining boils down to a negotiation about the costs to regulated firms of cuts below a baseline scenario of future emissions. The outcome is ultimately decided by a politi-

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59. For arguments why climate change is a "super wicked" problem because costs are near term while benefits accrue in the distant future, *see generally* Richard J. Lazarus, *Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future*, 94 Cornell L. Rev. 1153 (2009).

60. *See* Robert Stavins, *Low Prices a Problem? Making Sense of Misleading Talk about Cap-and-Trade in Europe and the USA*, Econ. View Env't (Apr. 25, 2012), http://www.robertstavinsblog.org/2012/04/25/low-prices-a-problem-making-sense-of-misleading-talk-about-cap-and-trade-in-europe-and-the-usa/.

61. Caps for greenhouse gas emissions are not typically set based upon a health based standard as is the case for local air pollutants such as those regulated under the Acid Rain Trading Program, the NOx SIP Call, or the Cross State Air Pollution Rule. The reason is that the damages caused by greenhouse gases are separated by decades to centuries from the time of their emission. By contrast, most traditional air pollutants that have been subjected to cap-and-trade regulation cause harm on a timescale of hours to weeks.

62. The best example of this process is the pre-legislative bargaining that occurred in the lead up to the Waxman-Markey legislation. During that process, a formalized process that included stakeholders on all sides was used to develop a rough blueprint that was then adopted by legislators in the legislation. Parties to the negotiation agreed in exchange for a seat at the table to refrain from lobbying outside the four corners of their agreement. *See generally* United States Climate Action Partnership, A Blueprint for Legislative Action: Consensus Recommendations for U.S. Climate Protection Legislation (2009), *available at* http://www.us-cap.org/policy-statements/.

63. For example, the American Clean Energy and Security Act contained numerous grants of allowances to impacted industries as well as provision for use of domestic and international greenhouse gas offsets sufficient to cover close to a third of U.S. emissions. Moreover, the broad outlines of this framework were agreed to by a coalition of environmental and industry groups prior to legislation being introduced. *See id.* at 25.

cal process unlikely to be controlled by optimization of societal costs and benefits, even assuming that all parties could agree to the appropriate method for discounting the future benefits of greenhouse gas regulation.

Even if this regulatory bargaining did not occur, that is, even if legislators set caps based on social welfare maximization or even without consideration of costs, cuts in emissions would likely be phased in gradually from a forecast baseline path in order to avoid unnecessary economic disruption to regulated sectors and energy-intensive industries.[64] To take one real example of this phased-in approach, the cap under Waxman-Markey was designed to fall by between 83 and 107 million metric tons carbon dioxide equivalent per year (MMT CO_2e/y) below an emissions forecast during its first nine years of implementation, after which the rate of decrease was to increase to 155 MMT CO_2e/y.[65] Gradual phase-in of this type is a near universal feature of greenhouse gas cap-and-trade bills introduced during the past decade.[66]

Another way of expressing the magnitude of these early reductions is that typical cap-and-trade programs proposed in Congress during the period from 2006 to 2010 created a glide path that ultimately required cumulative reductions of approximately 5000 MMT CO_2e during their first decade of implementation. This cumulative reduction is particularly appropriate for emissions trading systems that incorporate banking and borrowing provisions. All the bills introduced during this period incorporated banking and borrowing in some fashion.[67]

While there are far fewer examples of federal legislative efforts aimed at implementing a carbon tax, and these efforts have received nothing like the attention bestowed upon cap-and-trade bills, a clear pattern of how this type of legislation handles the phase-in process is also apparent. These programs typically propose an initial tax to be levied on greenhouse gas emis-

64. Gradual phase-in over time combined with trading allows industrial sectors with compliance costs to avoid premature retirement of long-lived capital assets.

65. Data based on U.S. Energy Info. Admin., *supra* note 31 (EIA analysis of H.R. 2454, American Clean Energy and Security Act of 2009) (on file with author).

66. Some bills have a declining yearly cap. Others set a cap that is the same in every year for up to a decade before ratcheting down. In either case, so long as banking and borrowing are allowed, there is no difference in stringency since firms can opt to over- or under-comply based on their abatement opportunities and cost of capital. Because all legislation and policies to date allowed for banking of emissions allowances, it is the integral of allowances issued over some time period that acts to bind emissions. The time period is set either by rules governing when allowances of a particular vintage can be surrendered or by the extent to which participants believe the program will endure.

67. *See, e.g.*, American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong., sec. 311, § 725 (2009), *available at* http://thomas.loc.gov/cgi-bin/query/z?c111:H.R.2454.

sions that increases in some regular way on an annual basis. For example, legislation introduced during the last session of Congress proposed levying a carbon tax of twenty dollars per ton CO_2e on all fossil fuels in 2014. In subsequent years, the tax would have increased under the legislation by 5.6% per year above the consumer price index.[68] Modeling work assessing the likely impacts of this bill on U.S. emissions suggests that it would reduce U.S. fossil fuel related emissions by seventeen percent below 2005 levels by 2020, equivalent to about one percent reduction per year and just achieving the commitment made by the United States under the Copenhagen Accord.[69] Thus, as with cap-and-trade, proposals to tax carbon incorporate a gradual phase-in process in order to avoid introducing an economic shock to the energy sector and so to the economy. In the real world, costs are considered and the forecast economic impacts of climate legislation play an important role in determining its stringency.

The consequences for cap-and-trade and carbon tax phase-in of the model forecast errors discussed in Part I are different in important ways. Two types of forecast error were shown to be significant in Part I: variance and bias. These are worth considering separately and for each policy because the consequences are distinct. Variance of forecast greenhouse gas emissions means that there is uncertainty relative to a forecast emissions level for a given year about how close or far actual emissions will be. Importantly, variance is symmetric about the mean forecast. That is, there is an equal chance of being above or below the forecast in any given year. Because greenhouse gases are stock pollutants—what matters is their total concentration in the atmosphere, not their current emissions rates, there are not strong environmental protection reasons to be concerned with variance in emission rates, but there may be important market start-up or political reasons.

Emissions forecast variance will, for a cap-and-trade program, tend to create variance in allowance prices. To some degree, such uncertainty can be reduced for cap-and-trade by utilizing strategies that allow firms to access additional allowances or carbon offsets when prices or high and by storing or banking unneeded allowances when prices are low. During phase-in of cap-and-trade, the greatest risk or emissions variance may be that initial price formation in the market will be volatile. Because early demand for allowances is modest due to small initial cuts in emissions, any unexpected

68. Climate Protection Act of 2013, S. 332, 113th Cong., sec. 101, § 196 (2013).

69. Michael W. Wara, Danny Cullenward, Jordan T. Wilkerson & John Weyant, *Analysis of the Climate Protection Act of 2013* (Stanford Law Sch. John M. Olin Program in Law & Econ., Working Paper No. 459, 2013), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2392656.

downward demand shock, for example an economic recession, can quickly drive allowance prices to low values, lowering incentives for abatement. For a carbon tax, downward demand shocks will combine with a stable carbon price to produce greater than expected abatement. On the other hand, because firms have certainty with respect to compliance costs, upward demand shocks, for example a large economic expansion, will lead to higher than expected early demand for allowances in cap-and-trade, hence higher compliance costs and higher than expected emissions under a carbon tax. The significance of any of these unexpected outcomes remains modest however so long as such variation in stringency of the policy is cyclical. If so, over time, total emissions to the atmosphere will approximate the forecasts made prior to enactment and so achieve the goals of climate policymakers.

The same cannot be said for the consequences of bias in emissions forecasts for cap-and-trade and carbon taxes. If, as in Part I, the forecast used to construct a cap-and-trade or carbon tax has a bias towards under-predicting emissions in the future, there can be significant and different consequences for phase-in of the two policies. For a cap-and-trade, low-biased emissions forecasts mean that a cap-and-trade market will produce lower allowance prices than expected throughout its lifetime. Firms will have weaker than expected incentives to reduce emissions. Actual abatement will be less than expected. And there will be no expectation that this situation will change over time. This means that, while the agreed to level of reductions will still be achieved, the cap will not reflect the level that could have been achieved by interests favoring environmental protection given their bargaining power had they had unbiased information during the policy formation process.

By contrast, a carbon-tax enacted based upon a low-biased emissions forecast, such as the one discussed in Part I, will tend to outperform expectations during its phase-in period. That is, because firms face the same incentive—the tax rate—to reduce emissions but find that it is easier to do so than predicted by the model, emissions will fall more than predicted by the model as the tax rate increases. In that case, environmental interests will achieve a greater level of reductions than they had expected. Note however, that this achievement is the logical consequence of the balance of environmental and industry bargaining power during the policy formation process. Recall that, as outlined in the Introduction, firms and environmental interests bargain to a socially suboptimal level of greenhouse gas emissions based upon beliefs about compliance costs. If so, then environmental interests have not gotten anything more than the benefit of their legislative bargain when, in response to an agreed upon carbon tax, firms reduce emissions more than they expected to because compliance costs turn out lower than expected.

Of course, these unexpected results are not the end of the story. The next Section examines theoretical arguments for and empirical evidence of how these programs are modified in response to differences between their expected and actual stringency. As was shown in Part I, the actual stringency of cap-and-trade program is likely to be highly uncertain due to its dependence on a forecast of future greenhouse gas emissions. So we should, and do, find that most of the action to modify policies occurs in cap-and-trade programs.

B. *Modification of Greenhouse Gas Pricing Policies*

1. Cap-and-Trade

The timeline needed to develop a cap-and-trade program and the modest near-term objectives implied by a phase-in require that emissions forecasts be sufficiently accurate to avoid either overallocation of emission allowances that results from too high an emission forecast or underallocation of emission allowances that results from too low an emission forecast. Overallocation occurs when there are more emissions allowances than emissions and so permit prices drop to zero or near zero. Underallocation occurs when the demand for allowances is far greater than expected, leading to high prices in the emissions trading market and to higher overall economic costs for the program. Both outcomes are a major source of concern because of the political bargaining that is at the heart of setting near term caps, the concern that climate policy should actually produce reductions in emissions, and the fear that a climate policy might unintentionally create economic disruption.

As was shown in Part I, EIA model forecast error assures that these types of errors are very likely to occur, with a bias toward lack of stringency and hence environmental benefit caused by overestimation of future emissions. Caps that end up being less stringent than expected will lead to calls for renegotiation because they fail to provide expected environmental benefits—emissions reductions. Caps that end up requiring greater than expected reductions will result in similar calls because they create unacceptable economic costs. But the two negotiating situations have starkly differing political economy that shrink the odds of increases to and raise the odds of reductions in the stringency of a cap-and-trade program.

In the case of a cap that is less stringent than expected because baseline emissions turn out lower than forecast, theory and evidence suggest that increasing stringency will be difficult. Forces pushing for increased stringency must overcome opposition from regulated industry to tighten the cap and increase stringency. This is in many ways a challenge equivalent to enacting carbon legislation in the first place. While environmental advocates must have overcome industry opposition to establish a cap-and-trade, there is no guarantee that they will be able to do so again if circumstances suggest it should be modified to increase its stringency.

One real-world example of the challenges associated with tightening a program exists currently in the EU Emissions Trading Scheme (ETS), an EU-wide cap-and-trade covering emissions of greenhouse gases from major stationary sources. The EU ETS was established in 2005. During its first two phases of trading, the program repeatedly struggled with overallocation issues.[70] However, since these first two trading phases were designed as a trial period and then for the purpose of complying with the Kyoto Protocol, low prices were not necessarily a concern. In the current phase of trading—where actual reductions in emissions are the only goal—there is no international agreement with which to comply and the cap was negotiated internally by EU member governments and the European Commission, prices again started high and have ended up quite low due to overallocation.

Environmental advocates have struggled for four years to reduce what they perceive to be an oversupply of allowances in the third phase of the program. In 2013, the European Commission managed to temporarily reduce the supply of permits via adoption of a proposal to "backload" their release.[71] The backloading plan delays the release of 900 million allowances to the market from 2014-2016 until 2019-2020.[72] This is a significant achievement for environmental advocates. But does it count as evidence against my hypothesis that cap-and-trade markets that are less stringent than expected will not be strengthened? I would argue that context matters—expectations prior to the advent of Phase Three of the EU ETS were that carbon prices would be in the range of twenty-seven to thirty-nine euros per ton CO_2.[73] They were initially near the low end of this price before the market realized the lack of stringency in the cap. At the time that the backloading plan was approved, prices had fallen to three euros. The short-term stringency of the EU ETS was definitely increased by deferring issuance of nearly one billion allowances, best evidenced by a price jump to

70. For a comprehensive recent review of the allocation issue in the EU ETS, see generally Tim Laing, Misato Sato, Michael Grubb & Claudia Comberti, *Assessing the Effectiveness of the EU Emissions Trading System* (Ctr. for Climate Change Econ. & Policy, Working Paper No. 126, 2013), *available at* http://www.cccep.ac.uk/Publications/Working-papers/Papers/120-129/WP126-effectiveness-eu-emissions-trading-system.pdf.

71. Commission Regulation 176/2014 of 25 February 2014, Amending Regulation (EU) No 1031/2010 in Particular to Determine the Volumes of Greenhouse Gas Emission Allowances to be Auctioned in 2013-20, 2014 O.J. (L 56) 11 (EU).

72. *Id.* at Annex IV.

73. *See* Carbon Trust, Cutting Carbon in Europe: The 2020 Plans and the Future of the EU ETS 31 (2008), *available at* http://www.carbontrust.com/resources/reports/advice/eu-ets-the-european-emissions-trading-scheme.

six euros in the price of allowances. But the back loading proposal is not an actual reduction in supply of allowances, only a delay, and the cap is still not anywhere near as stringent as was expected in 2008, when it was designed.[74] Those that favored lowering the cap, rather than shifting it when compliance instruments become available, pushed hard for a reduction in overall allowance supply. At least so far, governments opposed to raising the carbon price have been able to block renegotiation of the overall cap on greenhouse gases.[75] Partly as a result, coal-fired power production has actually increased and gas-fired power generation has decreased in the EU during the operation of the ETS.[76] Thus, even in the EU, which is a relatively supportive political environment, the strengthening of a cap-and-trade program in the face of unexpectedly low stringency is a challenging political enterprise.

In theory, once allowances have been distributed, holders of these permits—particularly speculative holders—will have an interest in seeing the value of their assets increase. One logical way to increase the value of an allowance is to increase the level of stringency within a cap-and-trade program. In most cap-and-trade programs to date, the preponderance of allowance-holders purchase allowances for compliance purposes. Thus they do not have a strong interest in seeing the cost of allowances increase because this necessarily implies higher compliance costs. For example, there was no lobbying on the part of the power sector for increased stringency in the EU ETS during any of the phases for which overallocation has occurred.

Another example of overallocation in a cap-and-trade regime occurred closer to home. The Regional Greenhouse Gas Initiative (RGGI) is a cap-and-trade program limiting greenhouse gas emissions from electric power plants in nine northeastern states.[77] RGGI began in 2009 and was designed to be a trial phase that would accustom the power sector in the northeast to operating under a cap—at that time to be (and currently) administered by

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74. In response to the passage of the backloading proposal, prices did increase in the EU ETS, but only from about 3 to about 6 euros. *See* Ben Garside, *EU Plan to Cut Supply of Carbon Permits Passes Into Law*, Reuters, Feb. 26, 2014, http://www.reuters.com/article/2014/02/26/us-eu-carbon-backloading-idUSBREA1P09C20140226.

75. *See* Silvio Marcacci, *EU Parliament Approves Backloading Fix to Cap and Trade Market*, CleanTechnica, July 3, 2013, http://cleantechnica.com/2013/07/03/eu-parliament-approves-backloading-fix-to-cap-and-trade-market/.

76. Another important cause of this increase in coal-fired electricity production is lower coal import prices from the United States. Daneil Gros & Jonas Teucsh, *Does Coal Have a Long Term Future in Europe?*, Cornerstone, Oct. 11, 2013, http://cornerstonemag.net/does-coal-have-a-long-term-future-in-europe/.

77. Current participants include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont. New Jersey was an early member but dropped out of the program. *See Program Design*, *supra* note 6.

state agencies, in the future perhaps by EPA. The first phase of RGGI lasted from 2009 to 2014 and was designed with low prices in mind. Indeed, ex-ante modeling by ICF using its Integrated Planning Model indicated that allowance prices would be on the order of two dollars during the trial phase. In fact, given the economic recession and the plunge in natural gas prices during the first period of RGGI, allowance prices would have plunged to zero but for the fact that almost all allowances in the RGGI system were auctioned and there was a reserve price of less than two dollars per ton CO_2. This reserve price meant that when supply of allowances outstripped demand in RGGI, the states reduced supply to avoid a complete price collapse. In effect, RGGI has served as a modest carbon tax—set at the auction reserve price—whose revenues have mostly been directed towards energy efficiency investments during the early years of the program.

In 2012, the RGGI states decided to lower the cap significantly in order to remove excess supply and move the allowance price above the minimum.[78] Further, the cap is set to fall by 2.5 percent per year during the period from 2014 to 2020.[79] Current allowance prices are approximately five dollars per ton CO_2.[80] This increase in stringency is dramatic and represents contrary evidence to my hypothesis that weak cap-and-trade programs will rarely be strengthened. The states that administer RGGI have indeed strengthened their program—although to a fairly limited degree. What explains this change that appears to contradict my hypothesis that weak cap-and-trade programs tend not to be strengthened?

The explanation may be that RGGI states and their regulators are positioning themselves to comply with forthcoming EPA regulations limiting greenhouse gas emissions from electric power plants.[81] An overallocated cap-and-trade cannot serve as a model for reducing emissions. At the same time, RGGI states regulators would be reasonable in not wanting to have the work they have done negated by preempting EPA regulations. RGGI's future will likely be determined not by decisions that its member states make but by the need to comply with these regulations. These regulations allow for multi-state compliance along the lines of RGGI's program design

78. *See The RGGI CO_2 Cap*, Regional Greenhouse Gas Initiative, http://www.rggi.org/design/overview/cap (last visited Feb. 14, 2015).

79. *Id.*

80. As of this writing, the clearing price in the most recent RGGI auction was $5.02. *Auction 24*, Regional Greenhouse Gas Initiative, https://www.rggi.org/market/co2_auctions/results/auctions-1-25?id=250 (last visited Feb. 14, 2015).

81. *See, e.g.*, *DEEP Proposes Revised Regulations to Strengthen RGGI: New Cap on Power Plants Will Reduce Carbon Emissions*, Conn. Dep't of Energy & Envtl. Prot. (July 16, 2013), http://www.ct.gov/Deep/cwp/view.asp?A=4380&Q=528382 (citing consistency with President Obama's climate plan to regulate CO_2 emissions from power plants).

and have a level of stringency not too different from RGGI's.[82] So here, an example may exist of a cap-and-trade being strengthened—but perhaps only in order to prepare for compliance with or influence the shape of an externally imposed mandate limiting emissions.

These examples suggest a few conclusions. First, it appears that overallocation and a general lack of stringency are serious concerns in many cap-and-trade programs. At the same time, strengthening these programs to produce expected levels of stringency has proven challenging, perhaps except when there are external forces that might encourage legislators and regulators to do so. The evidence from the EU suggests the politics of strengthening a cap is very tough, even where there is general support for climate policy. The evidence from RGGI suggests that under certain circumstances, the politics of regulation do support strengthening caps, but that these circumstances may involve external forces. In the case of RGGI, that external force is likely the expected regulation of power plant CO_2 emissions by the EPA.

By contrast, in the case of a cap that becomes unexpectedly stringent, both theory and evidence suggest that cap-and-trade programs will face a strong political challenge. This is because unexpectedly high allowance prices are likely to be economically disruptive to a large segment of an economy, either directly via the obligation to surrender allowances or indirectly via their impact on energy prices. These impacts would likely induce a broad constituency to lobby for relaxation of the cap-and-trade's stringency.

We have just one real-world example of unexpected stringency caused by an external shock within a cap-and-trade program. This occurred during the California electricity crisis, when power plants were relieved of their obligation to comply with the Regional Clean Air Incentives Market (RECLAIM) program, a cap-and-trade for smog-forming pollutants administered by the South Coast Air Quality Management District. The

82. The RGGI cap for 2014 to 2020 envisions a fifteen percent cut below the 2014 cap. EPA's Clean Power Plan is projected to produce a twelve percent reduction in CO2 reductions from the U.S. electric power sector, but this reduction is not distributed uniformly across states. *See The RGGI CO2 Cap*, *supra* note 78; Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 79 Fed. Reg. 34,830, 34,843 tbl.4, 34,931 tbl.10 (proposed June 18, 2014) (to be codified at 40 C.F.R. pt. 60), *available at* http://www.gpo.gov/fdsys/pkg/FR-2014-06-18/pdf/2014-13726.pdf (showing estimated cuts of twelve percent below 2012 emissions in the year 2020); Sonal Patel, *The EPA's Clean Power Rule in Three Infographics*, Power, July 1, 2014, http://www.powermag.com/the-epas-clean-power-rule-in-three-infographics/ (showing reductions already achieved by 2012); Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 79 Fed. Reg. at 34,952 (EPA Clean Power Plan allows for multistate compliance plans).

RECLAIM program was initially overallocated, with allowances far exceeding emissions by regulated sources. But in 2000, when electricity prices spiked, so did demand for power generation in Southern California. As a result, allowance prices increased by a factor of ten and there was significant scarcity within the market. In response to this crisis, power plants were taken out of the RECLAIM cap-and-trade and allowance prices returned to the "normal" levels. This external shock, caused by poor regulatory design in the newly restructured California electricity market as well as other factors,[83] caused allowance prices to spike. As soon as these environmental compliance obligations became higher than expected, the power sector was relieved of their obligation to comply.[84] Interestingly, although the cap-and-trade was suspended for power plants, long-term electricity contracts signed during the crisis were enforced.[85] Thus, when the energy sector was under strain, the environmental property rights received far less protection than ordinary electricity related contracts. This cautionary tale matches the political economy argument presented above—in a case where compliance costs under cap-and-trade turned out to be higher than expected, firms were relieved of these obligations.

A slightly more hypothetical example exists in California's current cap-and-trade program. Assembly Bill 32 is the statutory basis for California's suite of climate policies, including its cap-and-trade.[86] From the start, Assembly Bill 32 has included explicit provision for delay of all or part of the climate change program by order of the Governor in the event that he finds that the program will cause "significant economic harm" to the state.[87] Even as permit prices are near the reserve price in California's carbon allowance auctions,[88] there is significant concern in California about the need to intro-

83. For a history of the California electricity crisis, see generally James L. Sweeney, The California Electricity Crisis (2002). For a history of the RECLAIM program, including initial overallocation and the response to the California electricity crisis, see U.S. Envtl. Prot. Agency, An Evaluation of the South Coast Air Quality Management District's Regional Clean Air Incentives Market – Lessons in Environmental Markets and Innovation 12-16 (2002), *available at* http://www.epa.gov/Region09/air/reclaim/index.html.

84. U.S. Envtl. Prot. Agency, *supra* note 83, at 15.

85. *See* Morgan Stanley Capital Grp. Inc. v. Pub. Util. Dist. of Snohmish Cnty., 554 U.S. 527 (2008).

86. Assemb. B. 32, California Global Warming Solutions Act of 2006, 2006 Cal. Stat. Ch. 488.

87. *See* Cal. Health & Safety Code § 38599(a).

88. As of this writing, auction clearing prices are very near auction reserve prices. In the most recent CCA Allowance Auction, administered by the California Air Resources Board on August 8, 2014, the clearing price was $11.50 per allowance while the reserve price was $11.34. *See* Cal. Air Res. Bd., Cal. Envtl. Prot. Agency, California Air Resources Board Quarterly Auction 8, August 2014: Summary Results Report, http://www.arb.ca.gov/cc/capandtrade/auction/august-2014/results.pdf (last visited Feb. 14, 2015).

duce additional means of avoiding price spikes for fear of the Governor exercising this option.[89] There is no equivalent provision aimed at increasing the stringency of the program. Therefore, in at least two examples, evidence exists that cap-and-trade programs are vulnerable to weakening in the face of higher than expected allowance prices.

In conclusion, regulated sources of emissions, and those that might invest in new technologies to lower emissions from such sources, face a context in which emissions, hence program stringency, is inexorably uncertain. At the same time, these firms likely realize that if stringency turns out stronger than expected, there is a high likelihood of program modification. They also likely realize that if program stringency turns out weaker than expected, there is a much lower likelihood of program modification and so they are likely to benefit from lower compliance costs. Thus, one might conceive of cap-and-trade programs as giving regulated sources the upside risk that compliance costs will be lower than expected but providing them with a put option on the downside risk in the form of the political ability to suspend the program, should compliance costs turn out higher than expected. Thus, risk adjusted costs of cap-and-trade for regulated firms—that is, the actual incentive that firms will respond to when making investment decisions—are likely lower than the expected value for allowance prices suggests. How much lower will depend most strongly on the maximum compliance cost that is politically acceptable within a jurisdiction.

2. Carbon Tax

A carbon tax sets a price rather than a quantity limit on emissions. Under a carbon tax, firms know how much each ton will cost to emit, but a model is required to determine how much the economy as a whole will produce in response to this incentive. This difference from cap-and-trade creates a different expectations problem. A tax faces the possibility that reductions in emissions may turn out to be different than projected. On the other hand, the costs of compliance per unit of output are much more certain for a carbon tax than for a cap-and-trade. Furthermore, many of the changes that would impact compliance costs are under the control of the firm tasked with compliance—for example, investment in new energy efficient or low-carbon capital stock. Both aspects of the impact of a carbon tax are politically significant because both facilitate planning and minimize the

89. Severin Bornstein, James Bushnell, Frank A. Wolak & Matthew Zaragoza-Watkins, *Report of the Market Simulation Group on Competitive Supply/Demand Balance in the California Allowance Market and the Potential for Market Manipulation* 5-6 (Energy Inst. at Haas, Working Paper No. 251, 2014), *available at* http://ei.haas.berkeley.edu/pdf/working_papers/WP251.pdf.

chance of unexpectedly low (or high) compliance costs. Conversely, what a carbon tax gains in terms of certainty of costs it gives up in terms of certainty on environmental outcome, which may have its own set of political consequences.

The implication of this price certainty but quantity uncertainty is that forecast errors for carbon taxes will take the form of uncertain outcomes in terms of emissions rather than compliance costs. Thus it might be the case that a carbon tax set at some rate, or, more likely, a schedule of rates,[90] will produce more or less emissions as an outcome than forecast at the time of adoption. If a carbon tax produces higher emission levels, hence fewer emission reductions than forecast, it is likely to face many of the same challenges that a cap-and-trade program faces. There will be a wide array of business interests that are opposed to strengthening the scheme with only a few proponents—principally environmentalists and suppliers of low-carbon energy resources—in support. Under such circumstances, a carbon tax may face long odds. Just as for cap-and-trade programs, once enacted, it seems likely that carbon taxes would be difficult to strengthen.

On the other hand, the structure of the carbon tax policy, one that produces relatively certain compliance costs for firms, tends to minimize the chances of an unexpectedly stringent program (one that produces much lower emissions and hence greater emissions reductions) being repealed. In that case, emissions will be lower—perhaps closer to a first best trajectory than political bargaining at the time of adoption allowed for—but without the possibility as in the RECLAIM program that firms will be relieved of their compliance costs for the simple reason that the compliance costs are just what was agreed to in the political bargaining process. It is the results of those costs, emissions reductions, that have turned out greater than expected.

In addition, carbon taxes may create different political coalitions than tend to exist for cap-and-trade. Many carbon taxes, either proposed[91] or actual,[92] involve offsetting cuts in other distortionary taxes.[93] Theoretically,

90. Most proposed or enacted carbon taxes envision a schedule of rates that increases over time, in much the same way that cap-and-trade programs envision a schedule of caps that falls over time. *See, e.g.*, Carbon Tax Act, S.B.C. 2008, c. 40, sched. 1 (Can.), *available at* http://www.bclaws.ca/Recon/document/ID/freeside/00_08040_01#Schedule1.

91. *E.g.*, Climate Protection Act of 2013, S. 332, 113th Cong. (2013).

92. *Carbon Tax*, British Columbia Ministry of Finance, http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm (last visited Feb. 14, 2015).

93. In other words, income taxes are cut equal to the revenue raised from carbon taxes. This potential feature of emissions pricing—that revenues from reducing an environmental externality can be used to reduce distortionary taxation—is termed the "double dividend." Lawrence H. Goulder, *Environmental Taxation and the Double Dividend: A Reader's Guide*, 2 Int'l Tax & Pub. Fin. 157, 158 (1995).

this creates a very different political economy for altering the tax's stringency relative to cap-and-trade. In particular, those that stand to benefit from reductions in other distortionary taxes to a greater degree than they will suffer from an increase in a carbon tax may well support the increase. Thus, both environmental advocates and a broader constituency of beneficiaries from reductions in other taxes are likely to sustain support for carbon taxes once enacted and resist calls to weaken them.

This difference in political economy is also reflected in the legislative process for carbon tax enactment. Carbon taxes, in order to be enacted, typically must either be proposed in or marked up in tax and or finance committees. For examples, the British Columbia carbon tax was introduced by the province's finance minister at the time, Carole Taylor,[94] and was considered alongside other revenue measures, including changes in numerous other taxes.[95] Similarly, the Senate Finance Committee, in considering broader tax reform issues, has mentioned a carbon tax as an option.[96] Thus, rather than being limited to review in the environmental or natural resources committees of a legislature, carbon taxes are often, if not generally, developed in committees with finance or revenue portfolios that implicate different interest group politics both for and against them.

Consider one hypothetical example. Firms that pay very high corporate income taxes, but face little carbon tax liability, such as a retail firm like Wal-Mart, may support high carbon taxes if these are tied to reductions in the corporate income tax rate. On the other hand, if a carbon tax outperforms expectations and so leads to calls by impacted industries for reduction in stringency, firms that disproportionately benefit from reductions in other taxes will help to counter the push for weakening. Wal-Mart, once it has received the benefit of a reduction in tax liability, will be loath to return to a higher rate so that American Electric Power can face a lower carbon tax liability.

Discussions of using funds raised by carbon pricing for reducing other taxes have so far been limited to carbon taxes. There is no theoretical reason why a cap-and-trade could not pursue a similar strategy.[97] Yet to the degree

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94. *See* B. 37, Carbon Tax Act, 38th Parliament, 4th Sess. (Can. 2008) (as introduced in Legislative Assembly), *available at* https://www.leg.bc.ca/38th4th/1st_read/gov37-1.htm.

95. *See* B. 2, Budget Measures Implementation Act, 38th Parliament, 4th Sess. (Can. 2008) (as introduced in Legislative Assembly), *available at* https://www.leg.bc.ca/38th4th/1st_read/gov02-1.htm.

96. Stephen Stromberg, *Carbon Tax on the Table in the Senate*, Washington Post, Apr. 25, 2013, http://www.washingtonpost.com/blogs/post-partisan/wp/2013/04/25/carbon-tax-on-the-table-in-the-senate/.

97. Larry Goulder and Andrew Schein point this out in their discussion of hybrid carbon pricing policies. *See generally* Goulder & Schein, *supra* note 11.

that cap-and-trade revenues, or allowances, have been used for any purpose beyond distribution for free to regulated sources, the purposes have been limited to the energy space. For example, many state participants in the RGGI program utilize auction revenues to fund energy efficiency investments[98] while California utilizes allowance auction revenues to fund further greenhouse gas reduction measures.[99] This may be because cap-and-trade design processes are generally limited to and controlled by environmental and energy regulators. By contrast, design of carbon taxes is generally a shared responsibility of both environmental and budget and finance regulators or legislative committees.[100] For example, the details of the British Columbia carbon tax, including the determination of the size of corporate and personal income tax reductions funded by carbon tax revenues, are administered by the Ministry of Finance rather than the Ministry of Environment or the Ministry of Energy and Mines.[101]

Evidence from British Columbia, where a carbon tax was introduced in 2008 and then increased from ten to thirty dollars per ton CO_2e over a period of several years[102] does provide some evidence for this lock-in effect. Revenues raised by the carbon tax were used to reduce personal and corporate income taxes. This carbon tax, a higher carbon price than in any cap-and-trade program in the world, was phased in during the Great Recession when many firms and households were experiencing economic distress.[103] The British Columbia government opted to keep the tax at thirty dollars after a study of its initial phase-in period and absent moves by neighboring U.S. states or Canadian provinces to move towards regulation of greenhouse gases.[104] This decision to sustain the tax was made despite the fact that the expectation that other jurisdictions would implement carbon pricing during this period did not come to pass.[105] The tax has sustained popu-

98. *See* Reg'l Greenhouse Gas Initiative, Regional Investment of RGGI CO2 Allowance Proceeds 2012 3 (2014), *available at* http://www.rggi.org/docs/Documents/2012-Investment-Report.pdf.

99. Cal Air Res. Bd., Cap-and-Trade Auction Proceeds Investment Plan: Fiscal Years 2013-14 through 2015-16 1-2 (2013), *available at* http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/final_investment_plan.pdf.

100. *See supra* notes 94-96 and accompanying text.

101. *See* Carbon Tax Act, S.B.C. 2008, c. 40, part 2(2) (Can.) (defining "minister" as the Minister of Finance).

102. B.C. Ministry of Fin., June Budget Update 2013/14—2015/16 63 (2013), *available at* http://www.bcbudget.gov.bc.ca/2013_june_update/bfp/2013_June_Budget_Fiscal_Plan.pdf.

103. *See* Kathryn Harrison, *The Political Economy of British Columbia's Carbon Tax* 14 n.27 (Org. for Econ. Cooperation & Dev., Working Paper No. 63, 2013), *available at* http://www.oecd.org/env/workingpapers.htm.

104. B.C. Ministry of Fin., *supra* note 102, at 64.

105. Harrison, *supra* note 103, at 10, 15-16.

larity in the province.[106] Any move to reduce the carbon tax has triggered protest by both voters and firms with high tax liabilities relative to their greenhouse gas emissions levels. This combination is a powerful blocking constituency to the weakening of the carbon tax.

The Australian Carbon Pricing Mechanism (CPM),[107] known popularly as the Australian Carbon Tax,[108] might seem at first blush to be an important counter example to the British Columbia carbon tax. The Australian CPM was passed after great controversy in 2011 and phased-in in 2012.[109] The program was the subject of heated debate in the 2014 elections and ultimately, after the electoral triumph of Tony Abbott, a conservative who opposed the policy, was repealed.[110] But it is important to understand, as many in the press apparently do not, that the CPM was not actually a carbon tax. In its first two years, because of policymakers' fears about volatile carbon prices in cap-and-trade schemes in Europe,[111] the CPM did operate as a fixed price tax on emissions from large stationary sources.[112] But after that brief introductory period, the CPM transitioned to a cap-and-trade system.[113] The fixed price level at which the program was initiated, AUS twenty-three dollars per ton, was extraordinarily high by international standards and lacked the phased-in approach of other programs such as the EU ETS or the British Columbia carbon tax.

In any case, after a closely fought election, the CPM was repealed in 2014 by the new conservative government in one of its first actions. It is hard to know what lessons to draw from the Australian experience beyond the conclusion that whatever the policy—tax, cap-and-trade, or hybrid—it will be unstable if enacted by narrow majority in a context where a simple majority can repeal legislation. This is likely to be especially true where the policy enacted begins at a relatively stringent level without a phase-in as has

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106. *British Columbia's Carbon Tax Woos Skeptics*, The Economist, July 21, 2011, http://www.economist.com/node/18989175.

107. *See About the Carbon Pricing Mechanism*, Clean Energy Regulator, Australian Gov't, http://www.cleanenergyregulator.gov.au/Carbon-Pricing-Mechanism/About-the-Mechanism/Pages/default.aspx (last updated Jun 8, 2014); *see also Clean Energy Act 2011* (Austl.), *available at* http://www.comlaw.gov.au/Details/C2013C00372.

108. *See Repealing the Carbon Tax*, Dep't of the Env't, Australian Gov't, http://www.environment.gov.au/climate-change/repealing-carbon-tax (last visited Feb. 15, 2015).

109. *Carbon Tax Gets Green Light in Senate*, Sydney Morning Herald, Nov. 8, 2011, http://www.smh.com.au/business/carbon-tax-gets-green-light-in-senate-20111108-1n4rp.html.

110. Michelle Innis, *Environmentalists Denounce Repeal of Australia's Carbon Tax*, N.Y. Times, July 17, 2014, http://www.nytimes.com/2014/07/18/world/asia/environmentalists-decry-repeal-of-australias-carbon-tax.html.

111. *See supra* notes 70-76 and accompanying discussion.

112. *Clean Energy Act 2011* § 100.

113. *Cf. id.*, section 14, specifying process for setting a carbon pollution cap, *with id.*, section 100, specifying fixed charges per ton of pollution for initial years of program.

been done for all other emissions trading schemes and for the British Columbia carbon tax.

One last point of comparison is important to draw between outcomes under a carbon tax and a cap-and-trade that relates to the need for program modification. Given the bias in emissions forecasts illustrated in Part I, all cap-and-trade programs proposed by Congress in the past decade would have resulted in substantially fewer emissions reductions below business as usual and much lower allowance prices than forecast. This would have likely led to calls for strengthening of the program via legislative amendment on the part of environmental advocates. The outcome of such proposals would have been highly uncertain, even absent current political realities in Congress. Environmental laws are not often amended. The status quo, once established, is very difficult to alter. Further, most legislators, having expended significant efforts on climate legislation, would no doubt have prioritized other issue areas in allocating their time and political capital.

In other words, if the U.S. Congress had enacted Waxman-Markey or one of the other cap-and-trade proposals, climate policy advocates would have been stuck with a situation in which relatively little abatement was occurring, allowance prices were very low, and the prospect of reform of the cap-and-trade program was a remote possibility. By contrast, passage of a carbon tax with prices similar to those envisioned by all parties for the allowances under Waxman-Markey, would have led to much greater abatement than anticipated and few, or at any rate likely unsuccessful, calls for weakening of the pollution pricing scheme. Given the bias and variance in emission forecasts, and the sensitivity of outcomes under cap-and-trade to these projections, carbon taxes offer a much greater likelihood that all sides in a climate regulation negotiation enjoy the benefit of the bargain.

Conclusions

This Article has argued that key information needed to design real cap-and-trade programs is unavailable to policymakers. To do this, I performed an assessment of forecast error for NEMS with the specific purpose of cap-and-trade design in mind. My conclusions are that legislators need accurate emissions forecasts in order to set the cap in cap-and-trade programs but energy models are not up to the task. Forecasts are both biased and imprecise. This bias and imprecision may be by design, depending on the intentions of model developers, or it may be an inevitable consequence of the modeling framework.

Whatever its causes, the errors introduced into cap-and-trade policy design by this information deficit will predictably lead to weaker than intended cap-and-trade programs. Theoretical analysis and empirical evidence of the political economy of actual cap-and-trade policies points to strong pressure to weaken regulation if programs are too stringent but much weaker pressure to strengthen regulation if programs are weaker than expected. The interaction with model forecast error is important because the bias in emissions forecasts leads predictably to weak programs that are then very difficult to strengthen.

By contrast, carbon taxes do not require the same level of information about future emissions in order to craft real policy. Carbon taxes are likely to produce emissions reductions relative to baseline emissions with greater certainty than a cap-and-trade because a real carbon tax will always create incentives to lower emissions while real cap-and-trade may not. Finally, a carbon tax that offsets other distortionary taxes is likely to be more robust to efforts aimed at weakening it's stringency than a cap-and-trade program that, at the time of adoption, appears equally stringent but that in practice, turns out to be weaker or stronger than predicted. Although a carbon tax does not guarantee a certain level of emissions, given the politics and the information problems of designing programs that do cap emissions, policymakers may be giving up less than they assume if they opt to price rather than limit greenhouse gas emissions. In fact, given the bias in energy models used to design climate policies, carbon taxes are more likely to over-deliver emissions reductions than under-deliver them.

In the short run, these insights may be important to states that face compliance obligations under forthcoming EPA regulations.[114] Eventually, Congress or state legislatures will once again consider adopting comprehensive limits on greenhouse gas emissions. In all cases, policymakers will likely at least consider using some form of emissions pricing. When they do, they should look critically at the quality of information upon which they rely to design and evaluate climate policy. In the case of climate policy, this Article has shown that the inability of energy models to accurately forecast future emissions may favor adoption of a carbon tax approach over cap-and-trade.

114. *What EPA is Doing*, U.S. Envtl. Prot. Agency, http://www2.epa.gov/carbon-pollution-standards/what-epa-doing (last updated Oct. 28, 2014); *see also* Samuel D. Eisenberg, Michael Wara, Adele C. Morris, Marta R. Darby & Joel Minor, A State Tax Approach to Regulating Greenhouse Gases Under the Clean Air Act 1 (May 22, 2014) (discussion paper), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2440925 (arguing that state-level carbon excise taxes are permitted as compliance with New Source Performance Standards under the Clean Air Act).