THE FOREST PRODUCTS INDUSTRY AT A CROSSROADS: NEMS ANALYSIS OF POTENTIAL ENERGY AND CLIMATE POLICIES

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by Marilyn A. Brown and Youngsun Baek

School of Public Policy, Georgia Institute of Technology

ABSTRACT

Many energy and climate policies are being updated in the United States that would have significant impact upon the future of the forest products industry. As a result, the industry appears to be at a turning point. Using the National Energy Modeling System (NEMS), this paper analyzes a variety of scenarios based on three possible policies: (1) a national renewable electricity standard, (2) a U.S. greenhouse gas cap and trade system, and (3) expansion of industrial energy efficiency policies. In addition, this paper examines how these policies might interface with the recently strengthened renewable fuels standards. The principal focus is on how forest products and biomass residues from the pulp and paper industry might be utilized for electricity generation under different combinations of possible future national policies.

Keywords: National Energy Modeling System (NEMS), policy uncertainty, pulp and paper industry, renewable electricity standard, cap and trade, energy efficiency

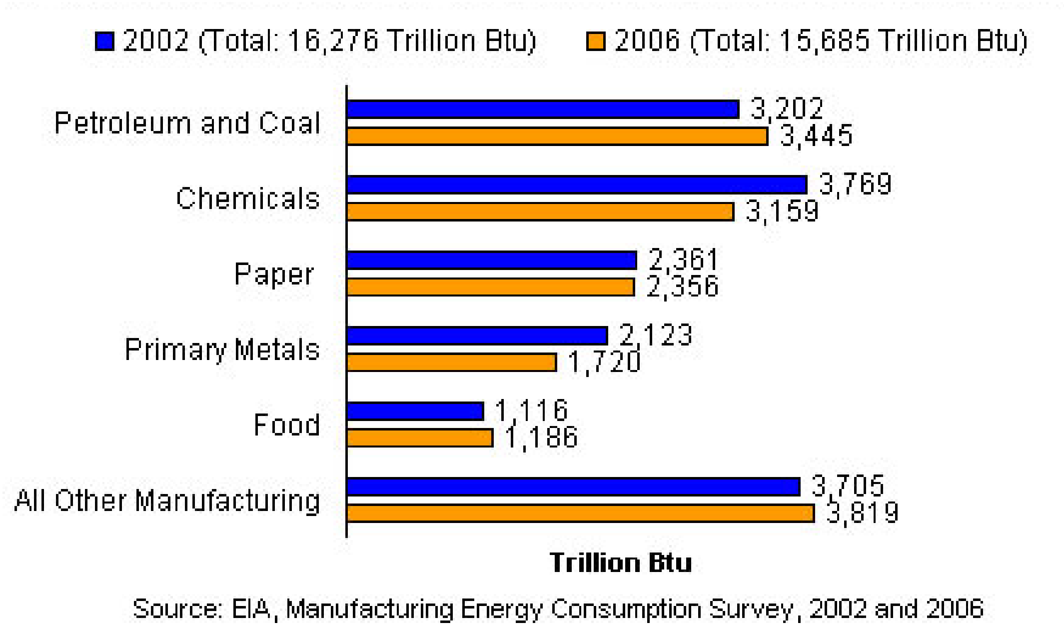
1. INTRODUCTION

The Obama Administration has made addressing climate change a top priority. In this regard, the industrial sector accounts for more than one-third of primary global energy demand and is a major source of energy-related greenhouse gas (GHG) emissions, mainly CO_2 (IPCC, 2007). In the United States, industry accounts for 32 percent of the national energy budget and is responsible for about 27 percent of U.S. CO_2 emissions. Some industrial processes also emit non-CO_2 greenhouse gases, such as methane, nitrous oxide, and high global warming potential industrial gases.

Over the long term, industry is expected to continue to be a significant component of increasing global energy demand and a major source of CO_2 and other GHG emissions. This growth in energy demand will be driven, in large part, by the continuing trends of population and GDP growth. In the United States five industries are responsible for about 60 percent of total industrial energy use. These include petroleum refining, bulk chemicals, papermaking, primary metals, and food processing. While efficiency improvements have been made across the industrial sector, opportunities remain to reduce energy intensity through a combination of best energy management practices, advanced technologies, efficient process designs, and the use of renewable energy.

The pulp and paper industry is the third largest industrial consumer of energy in the United States. According to the 2002 and 2006 Manufacturing Energy Consumption Surveys (MECS), the manufacturing processes of the paper industry consumed 2,361 TBtu of energy in 2002 and 2,356 TBtu in 2006 respectively. While manufacturing fuel consumption as a whole declined by 3.6 percent between 2002 and 2006, the paper industry displayed a relatively stable and consistent energy consumption pattern (Figure 1).

Figure 1. Manufacturing Energy Consumption in the U.S.: 2002 and 2006



Stakeholders who manage U.S. industrial enterprises and deal with U.S. fuel futures must decide what to build as a next generation of production capacity, power plant, and transportation fuels, not knowing if CO_2 will remain uncontrolled. In recent years, the U.S. Congress has proposed hundreds of climate change-related proposals (Pew, 2007), and the pace of climate policy activity appears to be accelerating. When the basis for estimating long-term operating costs and competitive advantage is so uncertain, how are producers to decide whether or not to invest in alternative energy technologies and products?

An increasing number of U.S. companies have been participating in voluntary greenhouse gas emissions reduction programs and registries to prepare for eventual federal regulations (Southworth, 2009). To add further complexity to this already uncertain situation, the existing greenhouse gas emissions reduction registries in the U.S. differ in ways that could affect the provision of credit under future federal legislation (DiMascio, 2007). Various definitional and classification issues regarding CO2 also remain unresolved.

“Historically, biomass consumption for energy use has remained at low levels, although it is the largest nonhydroelectric renewable source of electricity in the United States (Haq, 2002).” In the industrial sector, wood and agricultural residues are burned as a fuel for cogeneration of steam and electricity; in the electricity sector, biomass is used for power generation; in the residential and commercial sectors, it is used for space heating; in the transportation sector; and it can be converted to a liquid form for use as a transportation fuel (Haq, 2002). A consistent, effective, and predictable policy environment with clear and reinforcing signals is needed to encourage the infusion of GHG-reducing technologies to prevent large-scale global climate disruption. In the absence of such an environment, investors can evaluate the probability that policies will change in the future, and can assess the merits of directing capital expenditures to projects in anticipation of new energy and climate policies. This paper illustrates how contingency analysis can help inform strategic planning by examining its use in the forest products industry.

As the emphasis on renewable energy resources increases in the United States and elsewhere, unique opportunities await the forest products industry. Being one of the most energy-intensive industrial sectors and the largest consumer of biomass resources, the pulp and paper industry has the potential both to use its biomass energy more efficiently and to contribute to the further development and wider use of biomass power and fuel production.

This paper estimates the magnitude of the impacts of evolving energy policies on the pulp and paper industry, and probes how the industry is treated in the National Energy Modeling System. NEMS models U.S. energy markets and is the principal modeling tool used by the Energy Information Administration (EIA) of the Department of Energy (DOE). It consists of four supply-side modules, four demand-side modules, two conversion modules, two exogenous modules, and one integrating module. NEMS is one of the most credible national modeling systems used to forecast the impacts of energy, economic, and environmental policies on the supply and demand of energy sources and end-use sectors. Its “reference case” forecasts are based on federal, state, and local laws and regulations in affect at the time of the prediction. The baseline projections developed by NEMS are published annually in *the Annual Energy Outlook*, which is regarded as a reliable reference in the field of energy and climate policy. It is also utilized by an increasing number of other organizations to conduct sensitivity analyses of alternative energy policy scenarios and to validate research findings.

This paper investigates how the energy and climate policies relevant to the pulp and paper industry are modeled in NEMS to figure out the captive renewable potential in the industry and to estimate the magnitude of the impacts of the policies on the industry. This study is a follow-up study of “Potential Impacts of Energy and Climate Policies on the U.S. Pulp and Paper Industry” conducted by Marilyn A. Brown and Nilgun Atmturk that updates the potential energy and climate policies and discusses possible directional changes in biomass energy generation and paper production (Brown and Atamturk, 2008). In particular, we specially focus on the following three policy packages:

- A national renewable electricity standard,
- A U.S. greenhouse gas (GHG) cap and trade system, and
- Expansion of industrial energy efficiency policies.

This research is expected to be an informative resource to help answer questions about how evolving energy and climate policies relevant to the pulp and paper industry are embodied in the national energy policy context, and to what extent the policy changes would affect the industry. The research will also examine the mechanics of the

NEMS modeling as it applies to the pulp and paper industry with the goal of identifying potential methodological improvements.

2. ENERGY AND CLIMATE CHANGE POLICIES UNDER DEBATE

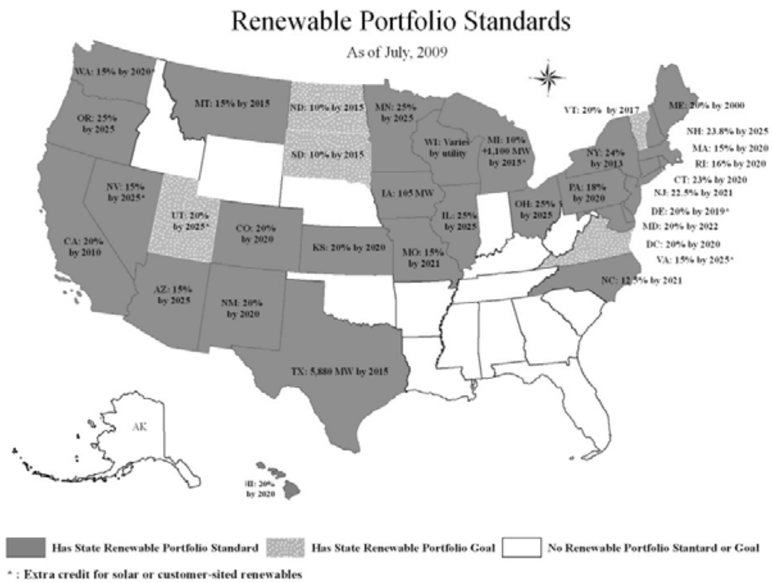
The field of energy and climate policy has become more dynamic than ever nationally and internationally. There are numerous state and federal initiatives in every subfield of energy policy. In the following sections, we provide brief reviews of three policies and discuss their potential marginal impacts on the pulp and paper industry.

2.1. Renewable Electricity Standard

A renewable electricity standard (RES) is a legislative mandate requiring electricity suppliers in a given geographical area to employ renewable resources to generate a certain amount or percentage of renewable power by a target year (e.g., California will generate 20 percent of its electricity from renewables by 2010). Typically, electricity suppliers can either produce their own renewable energy or buy renewable energy credits. Therefore, this policy blends the benefits of a “command and control” regulatory paradigm with a free market approach to environmental protection.

Contrary to enabling a well-lubricated national renewable energy market, however, inconsistencies between states over what counts as renewable energy, when it has to come online, how large it has to be, where it must be delivered, and how it may be traded clog the renewable energy market (Figure 2). Wisconsin set its target at 2.2 percent by 2011, while Rhode Island chose sixteen percent by 2020. In Maine, fuel cells and high efficiency cogeneration units count as "renewables," while the standard in Pennsylvania includes coal gasification and fossil fueled distributed generation technologies. Iowa, Minnesota, and Texas set their purchase requirements based on installed capacity, whereas other states set them relative to electricity sales. Minnesota and Iowa have voluntary standards with no penalties, whereas Massachusetts, Connecticut, Rhode Island, and Pennsylvania all levy different noncompliance fees. Implementing agencies and stakeholders must grapple with inconsistent state goals, and investors must interpret competing and often arbitrary statutes. Because of these inconsistencies, and the desire to accelerate the growth of renewable power production, the U.S. Congress is considering implementation of a national standard. Recent Congressional proposals tend to be consistent with President Obama’s campaign platform in 2008 included a commitment to 25% renewable electricity production by 2025. We examine this “Obama Pledge”.

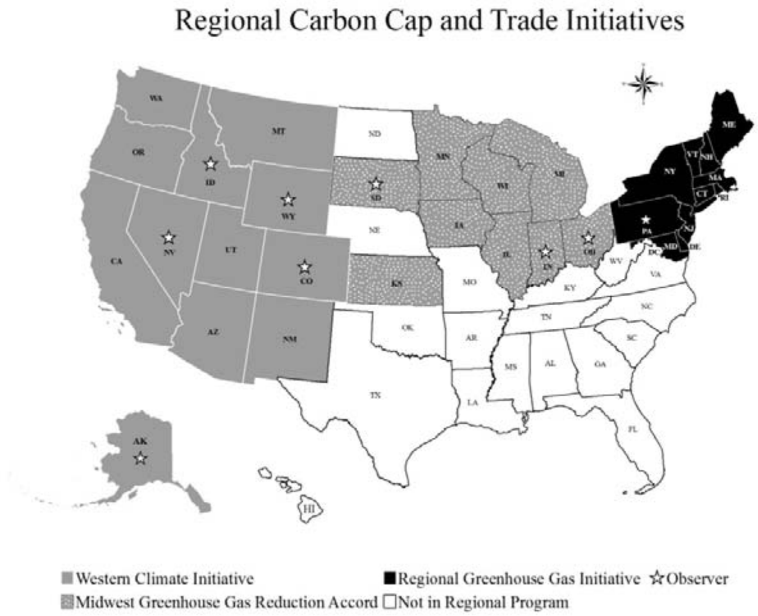
Figure 2: State Renewable Electricity Standards



<u>2.2 Greenhouse Gas Cap and Trade System</u>

Putting a price on GHG emissions can be accomplished with various policies including energy and carbon taxes and cap-and-trade systems. Ten northeastern states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont) are currently participating in the Regional Greenhouse Gas Initiative (RGGI), which will reduce emissions of carbon dioxide from power plants by 10 percent in 2019, but more than half of the U.S. states do not even have GHG reduction goals (Figure 3). This mosaic of divergent policies is particularly challenging to entrepreneurs who are striving to develop national markets. Given the importance of placing a cost on carbon, and the problems associated with the patchwork quilt of regional approaches that exists today, there is great momentum to establish a national cap and trade system.

Figure 3: Regional Carbon Cap-and-Trade Initiatives



It has been argued that the choice of policy is less important than having an effectively designed instrument (Aldy et al., 2009; Goulder, 2009). Following the framework provided by the National Commission on Energy Policy (NCEP, 2004), key design features of a cap-and-trade program pertain to:

- **Emission targets:** What are the emission reduction targets for the program? The American Clean Energy and Security Act (ACES) of 2009, for example, has targets that call for reducing economy-wide global warming pollution to 97percent of 2005 levels by 2012, 80 percent by 2020, 58 percent by 2030, and 17 percent by 2050.
- **Point of Regulation:** Where in the energy production/ consumption chain will the program be implemented? Downstream programs are expected to be more costly because they require more numerous points of regulation (Goulder, 2009). At their extreme, it would be simply infeasible to monitor emissions from vehicles, home heating fuels, and small-scale industrial boilers in a downstream system (Aldy et al., 2009).
- **Price Ceiling and Floor**: Will there by price safety mechanisms to provide cost certainty? A safety valve involves setting a predetermined price ceiling at which the government will sell additional allowances, thereby effectively capping the price of emissions allowances and constraining compliance costs. This safety valve gives companies the regulatory certainty needed to optimize long-term investment decisions. By also establishing a floor to allowance prices, investors in mitigation technologies are assured of some level of consistency in financial incentives. Together, a price ceiling and floor create a "price collar" that has the potential of reducing long-term abatement costs (Fell and Morgenstern, 2009).
- **Offsets:** How will credit be given for sequestration, agriculture/forestry projects, projects in other countries, etc.? Offsets are credits for emission reductions from sources outside the cap. They allow

entities outside the capped countries, sectors, and gases to participate and reduce emissions. Most cap-and-trade proposals limit the amount of allowable offsets (e.g., 10-15 percent of allowances). Such quantitative limits on the use of international offsets help ensure that domestic emission reduction goals do not fall too short.

- **Banking and Borrowing:** How are emissions reductions in the past or future treated? Emissions price volatility under cap-and-trade systems can also be moderated by permitting the banking and borrowing of allowances. Banking mechanisms allow sources to carry forward surplus allowances into future years, thereby creating a cushion that can hedge price spikes in the future. Most existing cap-and-trade programs contain banking provisions. Borrowing mechanisms allow sources to use allowance allocations from future years to meet current emission reduction obligations thereby mitigating price spikes. A variation on borrowing is the use of a multi-year compliance period,. A two-year compliance period is proposed in the ACES Bill (NCEP, 2009).
- **Allocation of allowances:** Will they be auctioned or given away freely? Who will receive allowances? In an upstream GHG trading program, regulated entities (fuel producers and processors) will pass most of the allowance "costs" downstream to fuel consumers, creating "windfall profit" for them. It has been argued that such windfall profits by utilities will not occur in the U.S. under the ACES Bill, even though a large proportion of the allowances are to be given free-of-charge to electric load-serving entities, because many states retain cost-of-service regulation in the power industry (Aldy, et al., 2009).

2.3 Expanded Industrial Energy Efficiency

Many studies have identified a large potential for cost-effective energy-efficiency improvements in U.S. industry. For example, in the pulp and paper industry, there have been at least four recent assessments of the cost-effective energy efficiency potential available by the 2020. These estimates range from a low of 6.1% based on the Clean Energy Future Study (Brown, et al., 2001) to a high of 37% from the Jacobs Engineering and IPST (2006) study. That is, by the year 2020, the pulp and paper industry should be able to cut its energy consumption by at least 6% and as much as 37% by investing in improved equipment and practices that will pay for themselves through reduced energy bills. This range of estimates spans the findings of two additional studies: 16% (from Martin, et al., 2000) and 26% (produced by McKinsey and Company, 2007).

Recognizing that there is a sizable opportunity to cut industrial energy bills, the U.S. Department of Energy operates several programs to provide assistance to industrial energy managers. Two of the largest of these are the Industrial Assessment Center Program and the Save Energy Now Program. For the purposes of this study, we assume that these programs double in size, such that the majority of all manufacturing enterprises have received some form of energy assessment assistance by the year 2030. In addition, we extend the tax credits for combined heat and power (CHP) systems and expand DOE support for R&D activities focused on the use of combined heat and power CHP. The current Investment Tax Credits (ITC) passed by Congress in 2008 expire in 2016. To implement an extended ITC program, we assume the policy continues through 2030 in the GT-NEMS. We also model a national grant program that supports R&D activities for improving the performance of CHP systems. We anticipate that the program would be able to increase the overall efficiency of CHP systems by 0.7% annually and finally raise the average efficiency level up to 83% by 2030 without any additional increase in installation cost.

2.4 Renewable Fuels Standard

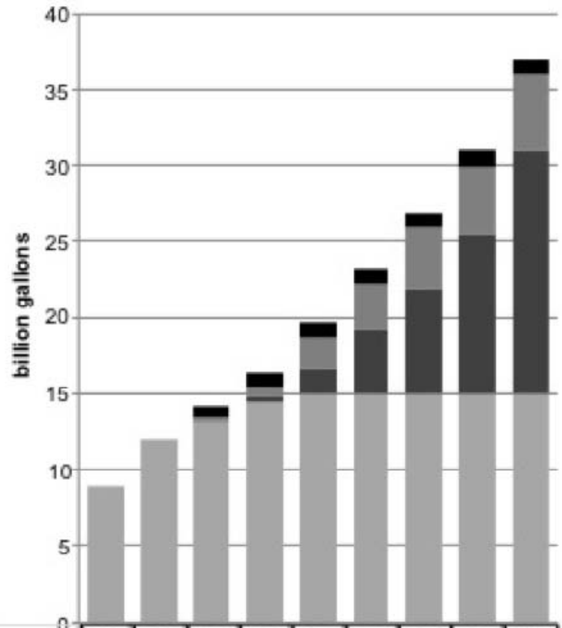
A fourth federal policy has particular relevance to the pulp and paper industry: the renewable fuels standard (RFS). While this policy has already been promulgated, its influence on the forest products industry could be quite significant, given its requirements to produce increasing amounts of bio-based fuels, especially cellulosic ethanol and advanced ethanol. The RFS is a policy instrument used to expand the displacement of gasoline and diesel with renewable fuels. Such fuels are defined in the Energy Policy Act of 2005 as a motor vehicle fuel that is produced from plant or animal products or wastes, as opposed to fossil fuel sources. The two most common motor vehicle fuels made from renewable sources are ethanol and biodiesel.

While the United States was the world's largest producer of biofuels in 2007, with 9 billion gallons produced, biofuels account for a small fraction of the transportation fuels consumed in the U.S. Most ethanol in the U.S. is made from corn and utilized as an oxygenate blended with conventional gasoline (i.e., E-10 is 10 percent ethanol and E-85 is 85 percent ethanol). Cellulosic ethanol and other advanced biofuels promise to expand the source base of biofuels production to include dedicated fuel crops, agricultural and forestry residues, and municipal solid wastes.

While these two high-potential biofuels show great promise, they also require technological improvements and transformational infrastructure investments. Cellulosic ethanol is defined as fuel derived from cellulose, hemicelluloses, or lignin derived from renewable biomass with lifecycle GHG emissions that are 60 percent less than the baseline of blended gasoline. Other "advanced biofuels" are anticipated to be mostly produced from cellulosic biomass such as woody or fibrous feedstocks rather than from starch feedstocks like corn. To be "advanced" based on the U.S. “President's Advanced Energy Initiative (AEI),” they must have lifecycle GHG emissions that are at least 50 percent less than the baseline. While cellulosic and advanced ethanol are not commercially produced today, the AEI aims to make cellulosic ethanol cost-competitive with ethanol from corn by 2012. Numerous alternative technologies for the conversion of biomass to biofuels are being explored worldwide, including fast pyrolysis, chemical refining, algae farms, and the use of alternative enzymes, and microorganisms to break down plant fibers.

The Energy Independence and Security Act of 2007 commits the U.S. to produce 12 billion gallons of transportation biofuels in 2010, 15 billion gallons in 2015, and 36 billion gallons in 2022 (Figure 4). Cellulosic and advanced ethanol is required to increase from 0.1 billion gallons in 2009 to six billion gallons in 2015 and 21 billion gallons in 2022.

Figure 4. RFS Mandates in the Energy Independence and Security Act



	2006	2008	2010	2012	2014	2016	2018	2020	2022
New RFS Total		9	13	15.2	18.2	22.3	26	30	36
Biomass-based diesel			0.65	1	1	1	1	1	1
Undifferentiated advanced biofuel			0.2	0.5	2	3	4	4.5	5
Celulosic biofuel			0.1	0.5	1.75	4.25	7	10.5	16
Any renewable fuel	4	9	12	13.2	14.4	15	15	15	15

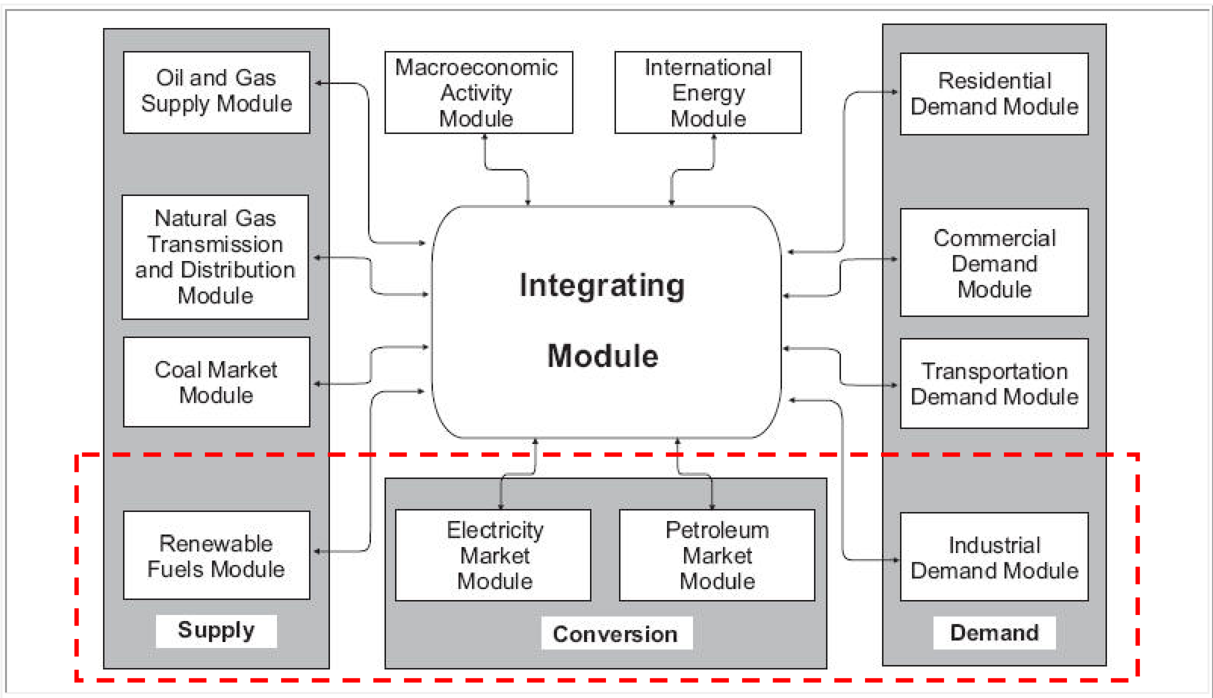
These goals are already stimulating the construction of new bioethanol plants across the country. However, to achieve these goals, the Nation also needs to invest in pipeline infrastructures and distribution systems to bring these new fuels to market. Ethanol today is transported almost exclusively via rail, truck, and barge. Pipeline transport is generally seen as the preferred option for transporting large volumes of conventional liquid fuels over long distances. However, transporting ethanol by pipeline poses several unique challenges, including stress corrosion cracking and failure (NCEP, 2009). Thus, significant infrastructure challenges are likely to accompany a large-scale increase in the use of biofuels to serve transportation needs.

The initial impact of the newly strengthened RFS on forest-based biomass input prices and products will likely be limited because forest-based biomass input is not widely used for ethanol production. In the long-run, however, RFS requirements could result in significant technological breakthroughs in the production of ethanol from forest-based biomass as pilot plants get underway and benefit from “learning by doing.” In addition, technology advances from research activities funded by the U.S. Department of Energy and others could make forest-based ethanol cost-competitive with corn-based ethanol, resulting in competing demands and higher prices for forest-based resources.

3. OVERVIEW OF NEMS

Several different types of models are available for evaluating alternative energy and carbon policies. On the one extreme, "top-down" computable general equilibrium models focus on capital dynamics, demand responses, and factor substitution, but tend to have limited technology characterization. At the other extreme, "bottom-up" engineering-economic models tend to have detailed representation of technologies and can characterize technological innovation but are more limited in modeling macroeconomic effects. Between these extremes are several hybrid models that have been developed to evaluate energy and climate policies (National Academies of Engineering, 2008; Aldy et al., 2009). NEMS is a type of “bottom-up” engineering-economic model (Figure 5).

Figure 5. National Energy Modeling System (NEMS)



Source: National Energy Modeling System: An Overview 2003, EIA 2003

NEMS considers both dedicated biomass and biomass co-firing plants to forecast the capacity of biomass in electricity generation. The co-firing levels are assumed to vary by region as determined by the availability of biomass and coal-fired capacity of each region. The biomass-dedicated plants are called biomass integrated gasification combined cycle (BIGCC) generating plants. NEMS models these plants in the same way as other generation options with a single kind of fuel such as coal, petroleum, and nuclear generations. The main inputs for BIGCC are capital, operating, and maintenance costs, project life, production tax credit, and heat rate (EIA, 2003; EIA, 2008; Haq, 2002). Biomass co-firing plants are embodied in the NEMS by assuming that plant owners could retrofit their coal-fired plants and transform them into biomass co-firing plants. In addition, NEMS assumes that no additional operating and maintenance costs would be incurred after the retrofitting in that the biomass would be commingled with coal, and the mixture would be fed into the boiler trough the existing coal feed system. For that reason, NEMS selects relatively lower levels of co-firing compared to the other generation options available in each region. The co-firing system operated at higher levels would require an additional capital cost to enhance the capacity and performance (EIA, 2003; Haq, 2002).

The renewable fuels module (RFM) provides information on the supply of renewable resources and technologies to the NEMS integrating module for projections of grid-connected U.S. central-station electricity generating capacity using renewable energy resources. The renewable technologies cover the array of commercial market penetration, newer power systems, and technological innovation for cost effectiveness. The RFM has seven submodules respectively representing biomass, geothermal, conventional hydroelectricity, landfill gas, solar thermal, solar photovoltaics, and wind. The submodules interact primarily with the electricity market module (EMM). The biomass electric power submodule (BEPS) is one of the seven submodules that treats biomass. Biomass plants share many components with similar coal-fired plants; these components continue to decline in cost in the low renewables case, although biomass-specific components (especially fuel handling components) do not see cost declines beyond 2005 (EIA, 2003; EIA, 2008; Haq, 2002).

Biomass consumed for electricity generation is modeled in two parts in NEMS; capacity in the wood products and paper industries, so called captive capacity, is included in the industrial demand module (IDM) as cogeneration, and total biomass consumption for electricity generation is represented in the EMM (EIA 2003; EIA 2008; Haq 2002). Biomass competes with other fuels in the EMM, subject to capital and operating costs, capacity factors, and technological advancement. In addition, NEMS has its regional breakdowns to reflect the difference in regional RES in the model.

4. NEMS POLICY ANALYSIS

To assess the potential impacts of the three energy and climate policies currently being debated in the U.S. Congress, we modified the third version of 2009 NEMS with the Economic Stimulus Package. We named the modified model GT-NEMS in order to emphasize that energy projections from the GT-NEMS could be different from projections from the original NEMS.

4.1 Obama's Pledge for an RES

We modeled an aggressive RES goal equivalent to the one pledged by President Obama last year. Specifically, the RES specifies that at least 10 percent of U.S. electricity would come from renewable sources by 2012, and 25 percent by 2025. We took into account the possible technological advancement in renewable energy technologies and updated the supply curves of the renewable energy sources. We found that we could avoid 9% percent of the total U.S. CO_2 emissions emitted solely from the electricity generation sector in 2030 (see Figure 6).

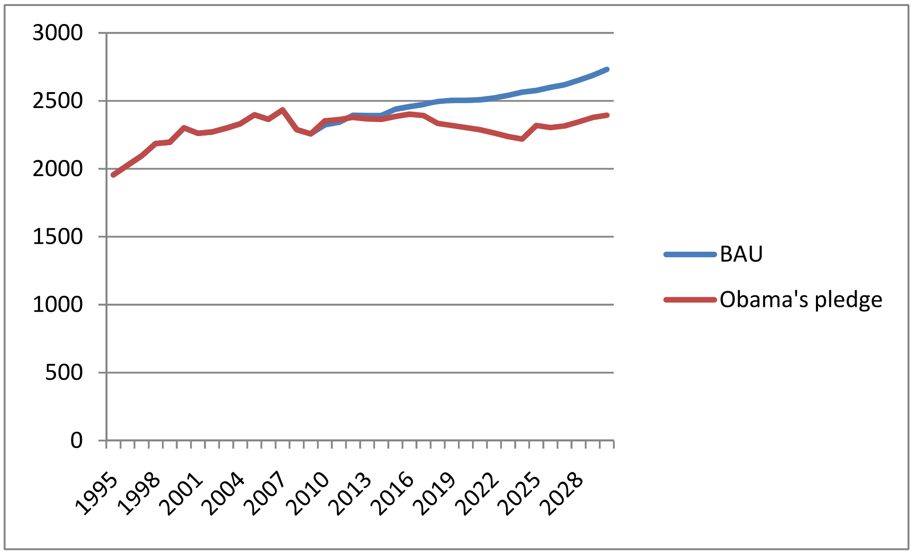


Figure 6. Carbon Dioxide Emissions from Electricity Generation (million metric tons carbon dioxide equivalent)

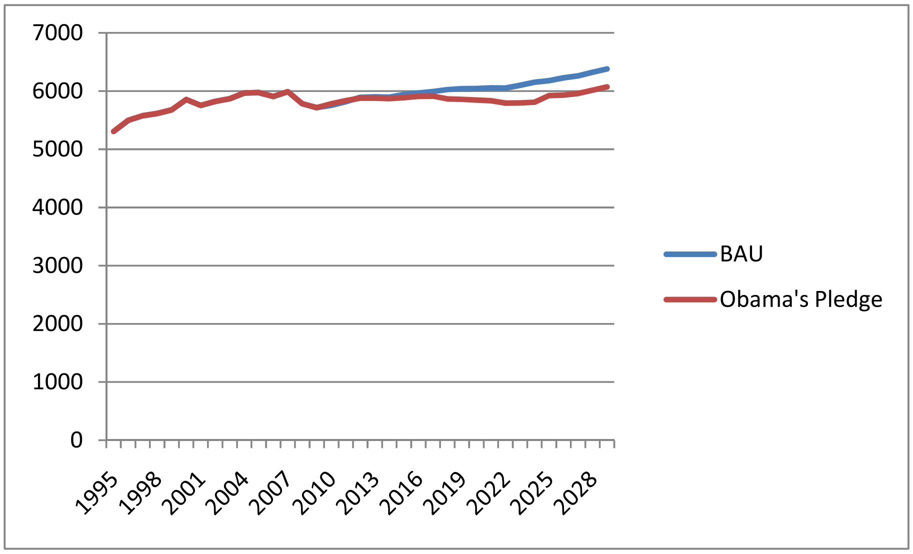


Figure 7. Total U.S. Carbon Dioxide Emissions (million metric tons carbon dioxide equivalent)

Figure 8 indicates that the aggressive RES would not affect the industrial electricity price significantly. The National Renewable Energy Laboratory (NREL) analyzed the potential impact of proposed national RES legislation by using the Regional Energy Development System (ReEDS) model. Their analysis focused on draft bills introduced individually by Senator Jeff Bingaman and Representative Edward Markey, and jointly by representatives Henry Waxman and Markey (NREL, 2009). According to the NREL's analysis, none of the RES bills would have a modest impact on consumer electricity prices at the national level. Differences between average national electricity prices in the RES cases and the base case are less than 1%. Figure 8 show that the impacts on the electricity price estimated by GT-NEMS model are similar to the results in the NREL's study.

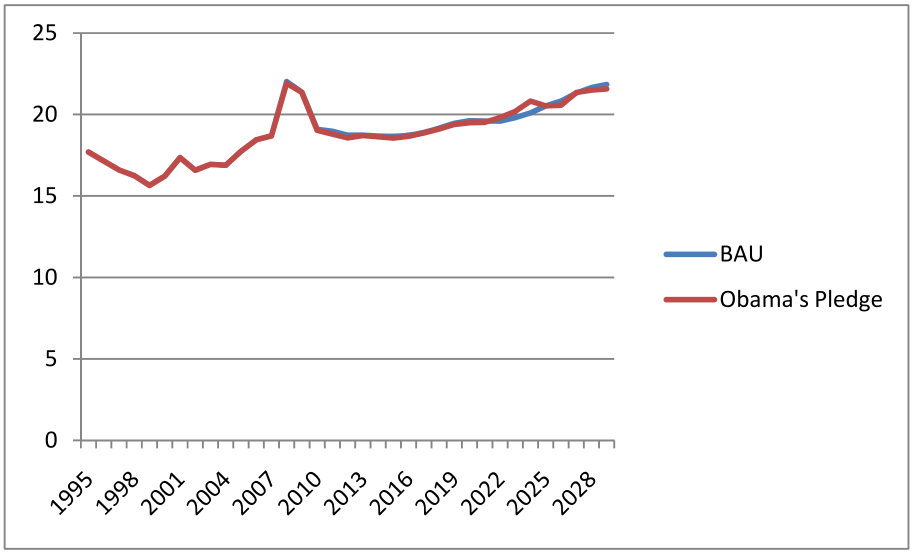


Figure 8. Industrial Electricity Price Projections (2007 dollars per million Btu)

On the other hand, the biomass prices are anticipated to increase exponentially from 2014 to 2025, reaching $6.2 per million Btu in 2030, which is almost three times greater than the current biomass price level (Figure 9). Thus, with an RES, wood and agricultural residues would become a more valuable renewable commodity in the near future.[1]

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[1] GT-NEMS models all of the policies enacted today to simulate its BAU scenario. Since a national RFS has already been promulgated, GT-NEMS BAU takes into account the impact of the RFS. Thus, the price escalation shown here is in addition to any price increase caused by the RFS.

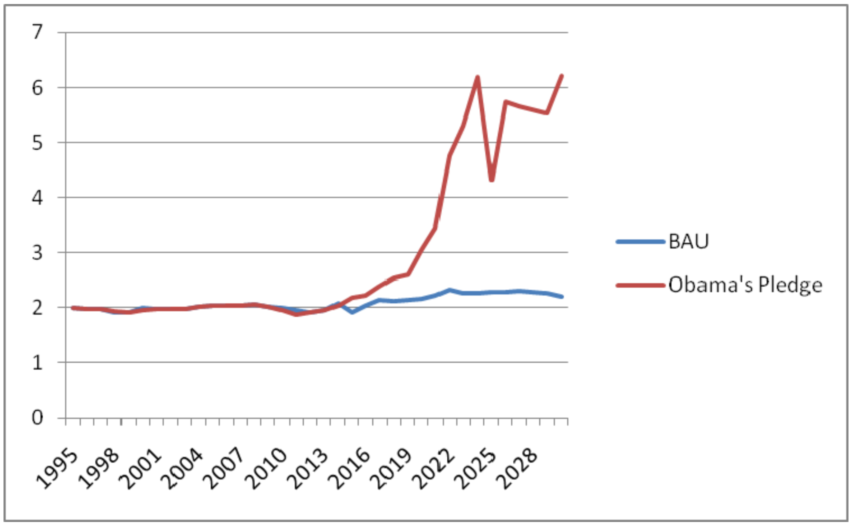

Figure 9. Biomass Price Projections in the Electric Power Sector (2007 dollars per million Btu)

With an RES, industrial energy consumption drops by several quads in the 2008-2025 time frame (Figure 10).

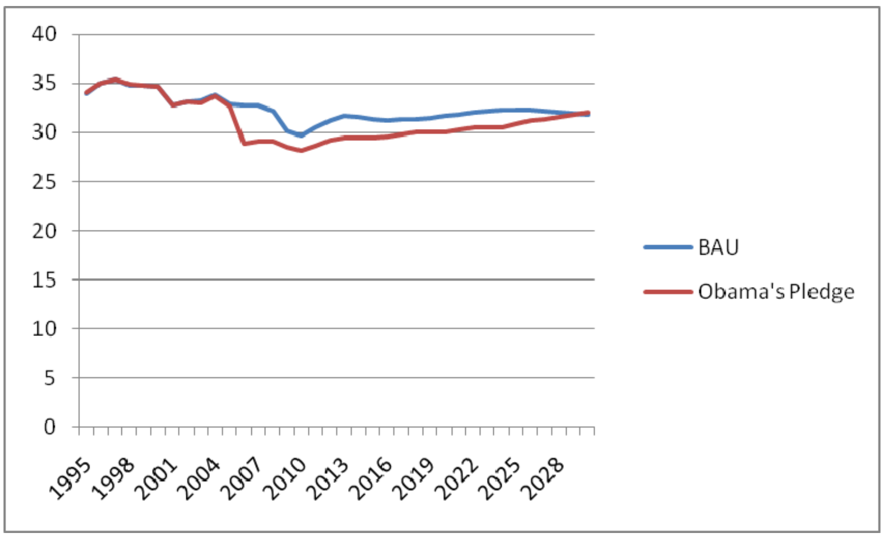

Figure 10. Total Industrial Energy Consumption (quadrillion Btu)

4.2 Greenhouse Gas Cap and Trade System

We analyzed the impact of a national GHG cap and trade system by changing several parameters in NEMS. First, after examining the allowance price projections estimated by EIA, CBO, EPA, and NRDC, we set an annual schedule of carbon tax price starting at $15 per ton of carbon dioxide (2005 dollars) in 2012 growing at 7% annually and reaching $51per ton in 2030. We also implemented an allowance redistribution system that gives 90% of allowances to electricity load serving entities and 10% to generators. The allowances given to the load serving entities are assumed to be passed through to consumers and subdue the increase in retail electricity prices.

GT-NEMS suggests that the U.S. could expect to avoid 11% of CO_2 emissions emitted from the electric power sector in 2020, increasing to 32% in 2030, by implementing a national cap and trade system as specified in this analysis (Figure 11). A total of 16% could be reduced from all sectors in 2030 (see Figure 12).

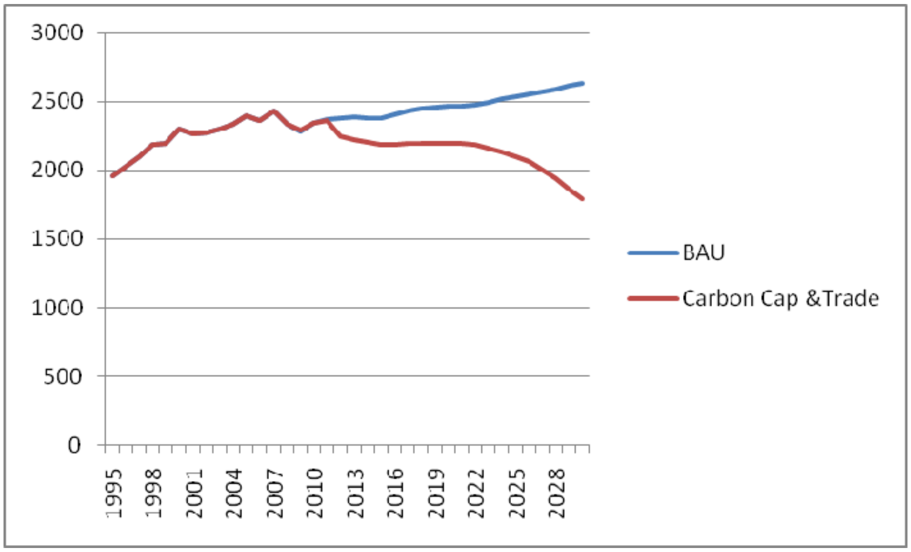

Figure 11. Carbon Dioxide Emissions from Electricity Generation (million metric tons carbon dioxide equivalent)

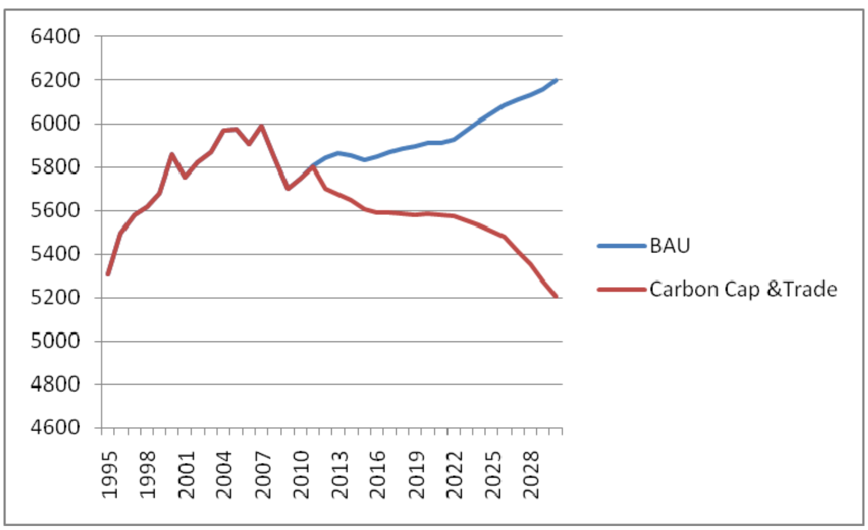

Figure 12. Total U.S. Carbon Dioxide Emissions (million metric tons carbon dioxide equivalent)

The industrial electricity prices are projected to be higher by 10% in 2020 and by 20% in 2030 under the carbon cap and trade system than under the business-as-usual (BAU) scenario. This price inflation is considerably higher than the price increases under the Obama pledge.

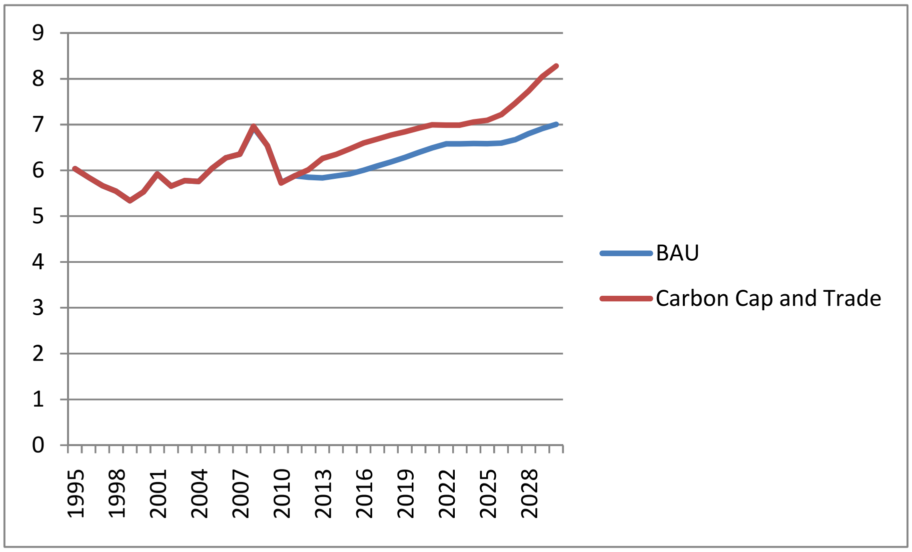

Figure 13. Industrial Electricity Price Projections (2007 cents per kilowatthour)

Compared to the business-as-usual scenario, the carbon cap and trade scenario shows a modest increase in the price of biomass in the electric power sector in 2020 (a 4% rise); however, there is a significant increase (28%) in 2030 (see Figure 14).

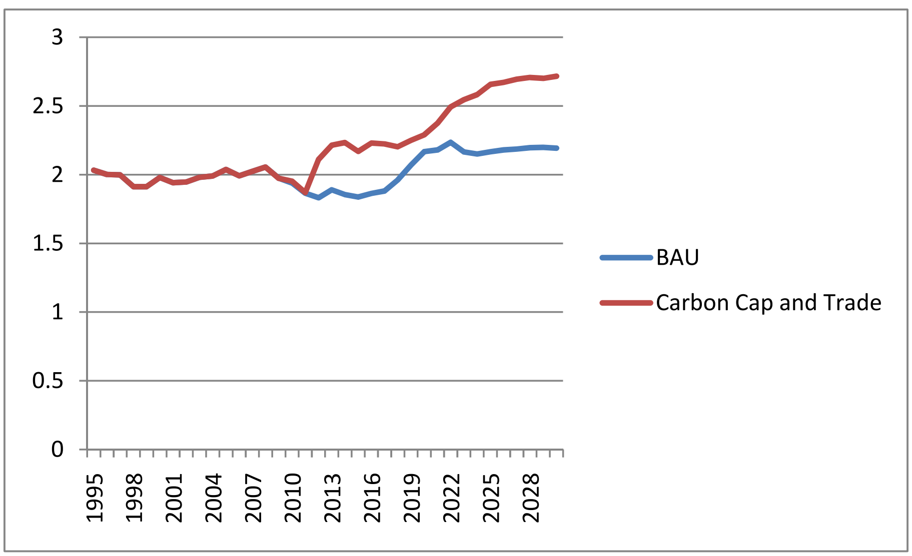

Figure 14. Biomass Price Projections in the Electric Power Sector (2007 dollars per million Btu)

On the other hand, there is only a small reduction in total industrial energy consumption between the carbon cap and trade system and BAU. The reduction is greatest at approximately 0.5 quads between 2015 and 2021, and is similar at about a 1% reduction in 2030 (Figure 15).

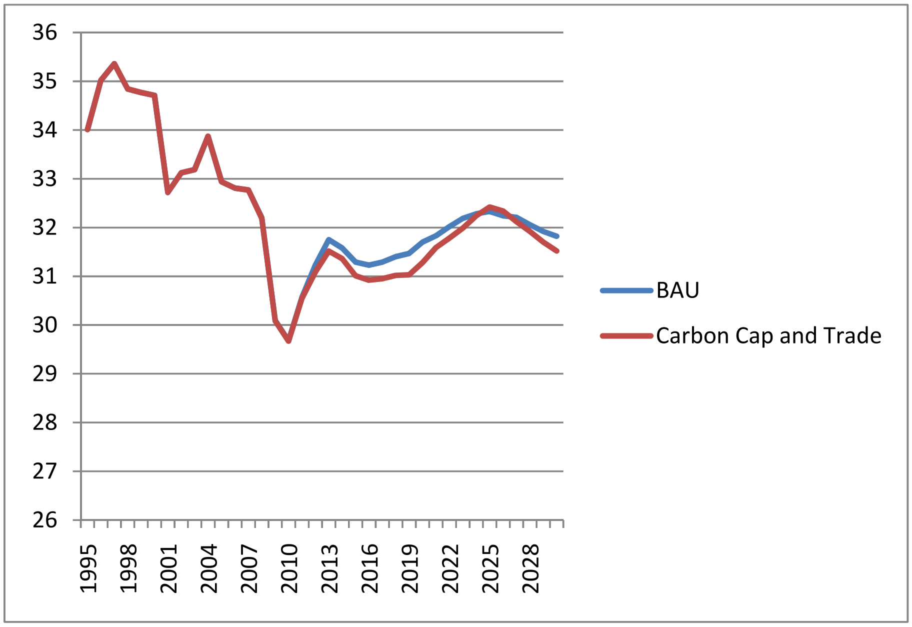

Figure 15. Total Industrial Energy Consumption (quadrillion Btu)

4.3 Expanded Industrial Energy Efficiency

We analyzed a bundle of industrial energy efficiency policies that expand DOE's industrial energy savings assessment programs. In addition, we expanded tax credits and R&D activities focused on the use of combined heat and power (CHP). After calculating the expected energy savings from the assessment programs, we entered a matrix of changed energy intensity by industry into NEMS. To assess the magnitude of cost-effectiveness and achievable energy-efficiency improvements from the proliferation of CHP systems, we assumed implementation of a set of transformative energy policies including the extension of the existing tax credits for CHP in industry, and acceleration of the R&D activities focused on CHP. Thus, we do not include incentives for the purchase of transformational equipment in the major energy-intensive industries; rather, our policies mostly focus on promoting energy best practices in motor and drive, steam, compressed air, and CHP systems.

Compared to the national RES and carbon cap and trade system, the industrial energy efficiency policies modeled here would be relatively small contributors to avoiding CO_2 emissions (See Figure 16, 17). They would have minimal effect on electricity and biomass prices, as well (see Figures 18 and 19). Nevertheless, these policies would contribute to reducing energy consumption in industry by 1% in 2020 and 2% in 2030 (see Figure 20). Clearly there is much greater potential for energy savings in the industrial sector that is going untapped even in this energy efficiency scenario (McKinsey and Company, 2008).

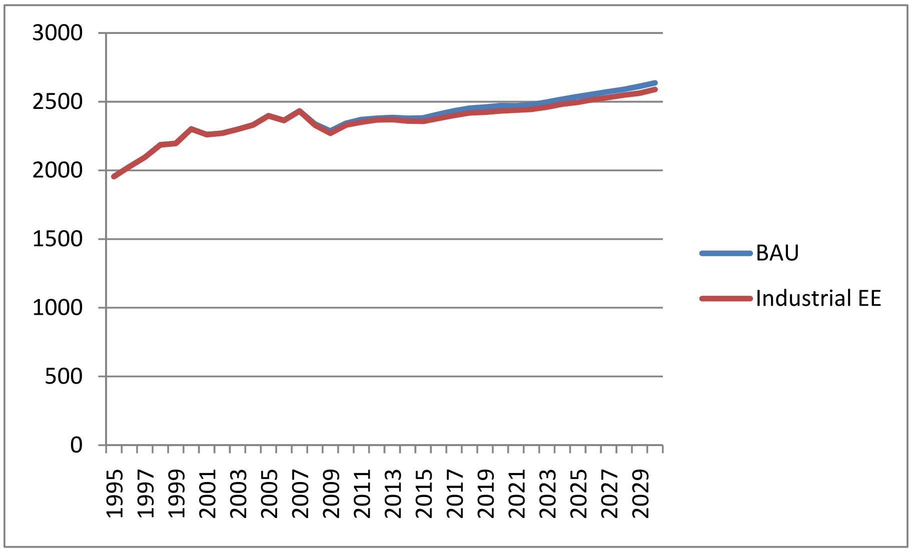

Figure 16. Carbon Dioxide Emissions from Electricity Generation (million metric tons carbon dioxide equivalent)

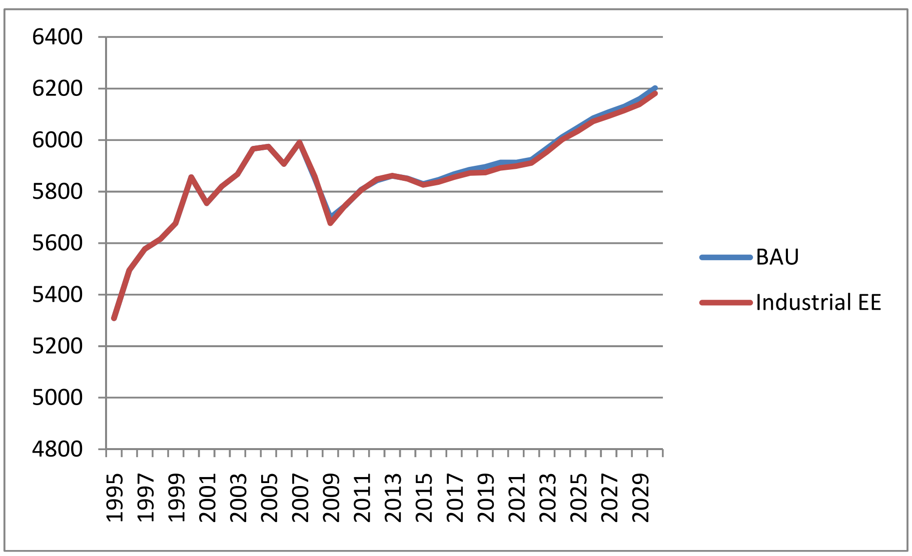

Figure 17. Total U.S. Carbon Dioxide Emissions (million metric tons carbon dioxide equivalent)

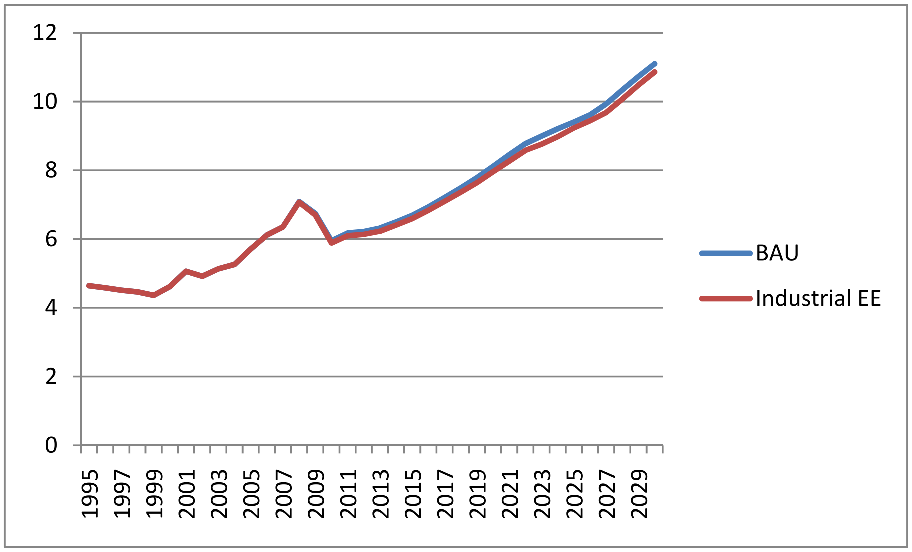

Figure 18. Industrial Electricity Price Projections (nominal cents per kilowatthour)

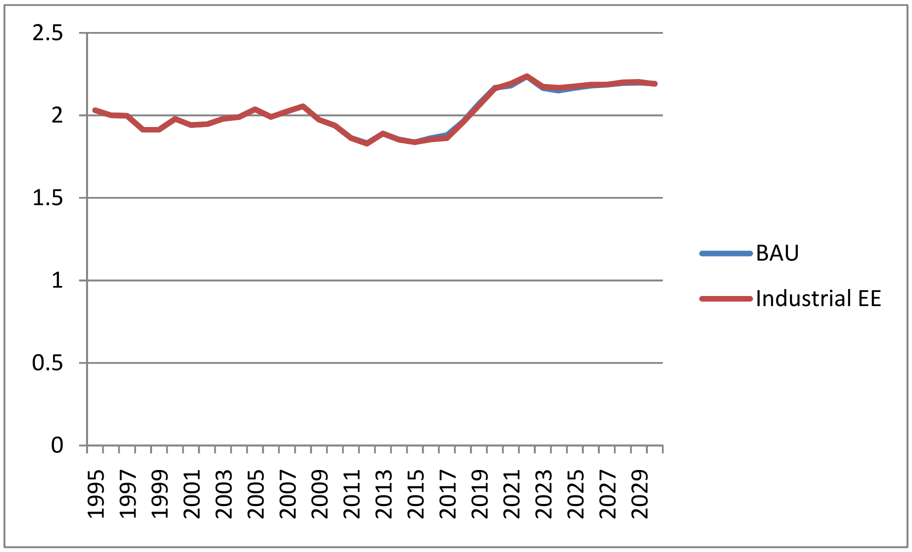

Figure 19. Biomass Price Projections in the Electric Power Sector (2007 dollars per million Btu)

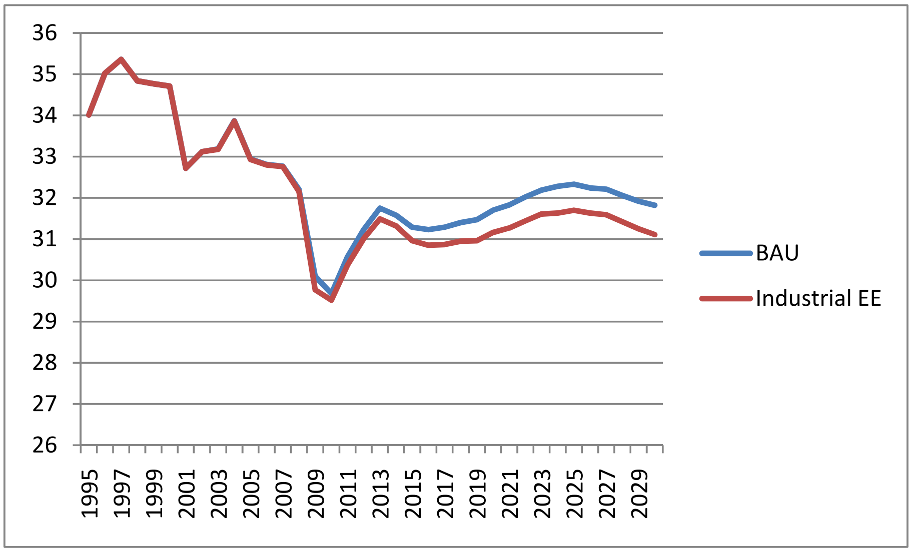

Figure 20. Total Industrial Energy Consumption (quadrillion Btu, unless otherwise noted)

4.4 The Combined Policies

Using NEMS, we have also estimated the impacts when all three energy and climate policies are enacted together. When all three policies are implemented, the intensity of energy use over the 20-year forecast barely changes (Figure 21). In contrast, the combined policies could lower the CO_2 emissions from electricity generation by 50% in 2030, bringing emissions levels to well below 1995 levels (Figure 22-A). The largest reductions are associated with implementation of a cap and trade system (Figure 22-B). Total U.S. CO_2 emissions also decline significantly, dipping below 1995 levels by 2030 (Figure 23).

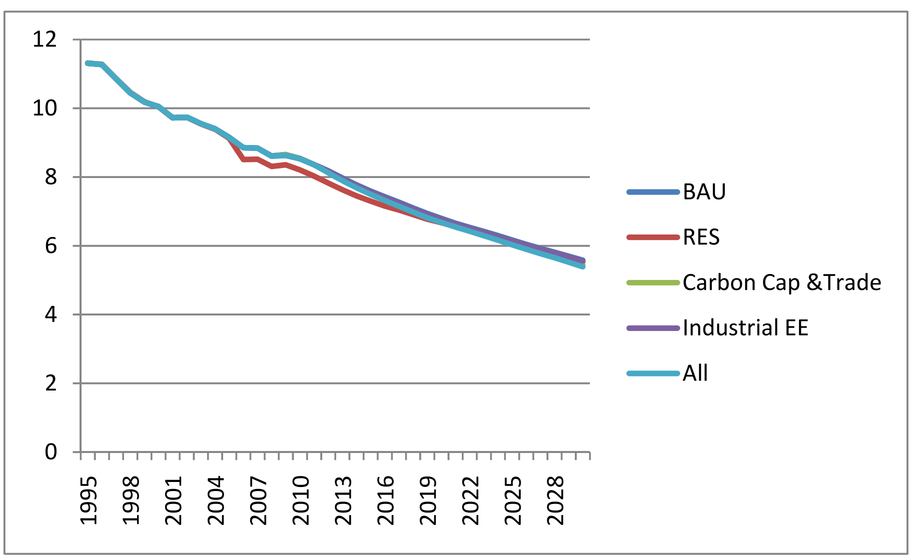

Figure 21. Energy Intensity (thousand Btu per 2000 dollar)

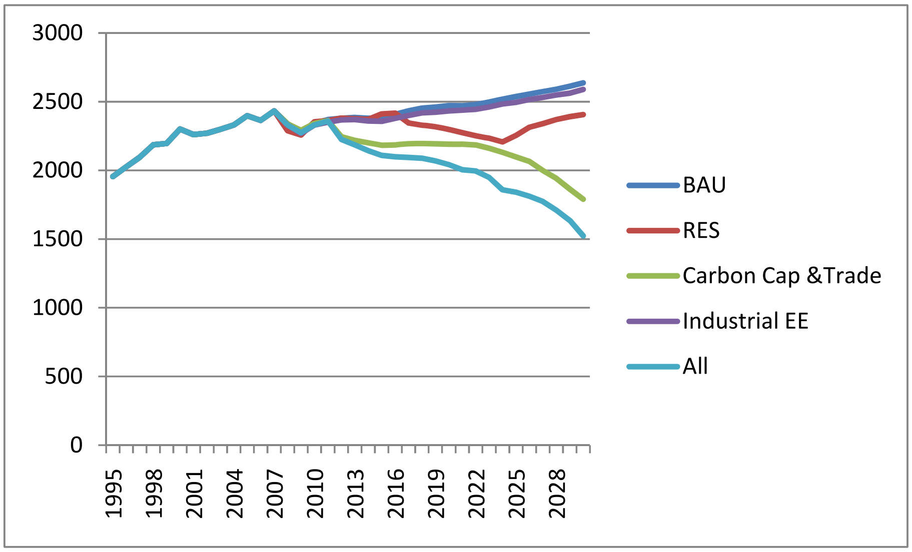

Figure 22-A. Carbon Dioxide Emissions from Electricity Generation

(million metric tons carbon dioxide equivalent)

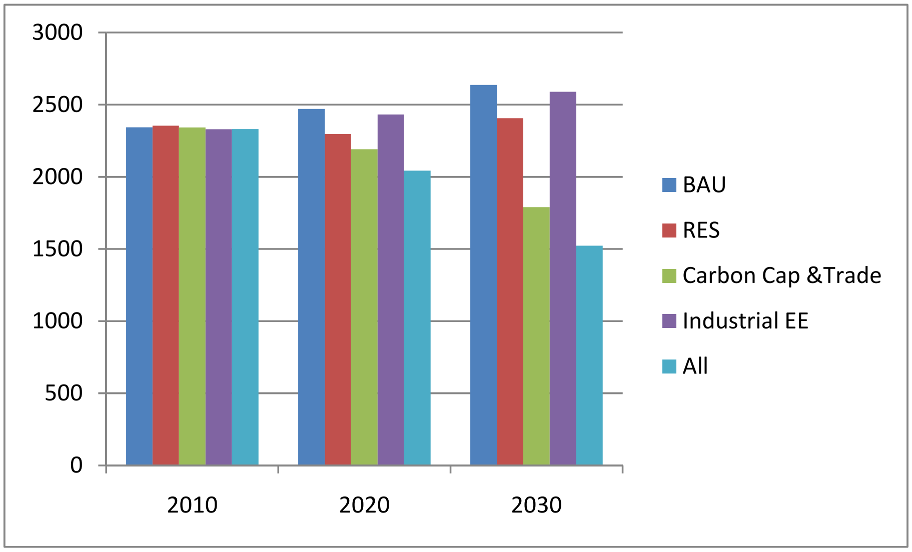

Figure 22-B. Carbon Dioxide Emissions from Electricity Generation

(million metric tons carbon dioxide equivalent)

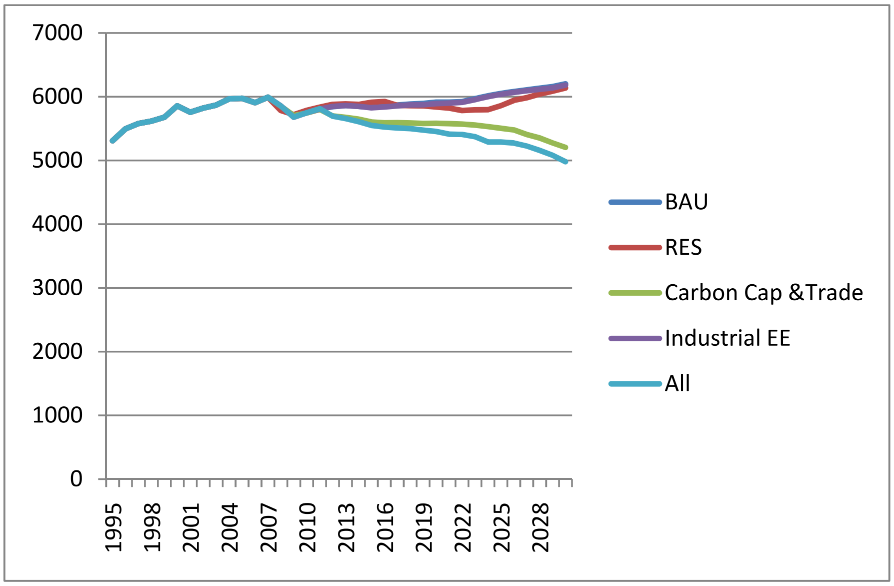

Figure 23. Total U.S. Carbon Dioxide Emissions

(million metric tons carbon dioxide equivalent)

An aggressive national RES would increase the electricity price by 16% in 2010 and 6% in 2020 respectively, but it would finally subdue the price increase by 5% in 2030 after the legislation stabilized (See Figure 24-B). If the combined policies are implemented together, industrial electricity prices would gradually increase by 4% annually.

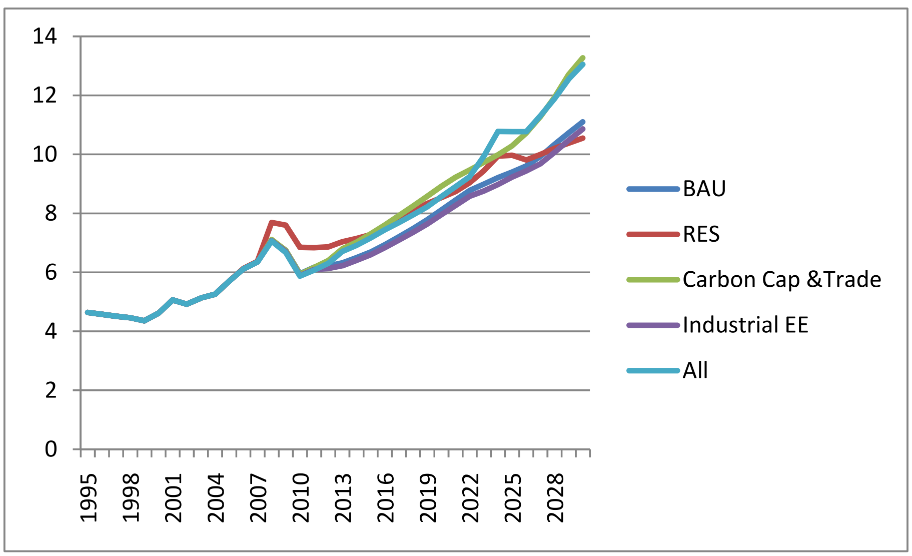

Figure 24-A. Industrial Electricity Price Projections (2007 dollars per million Btu)

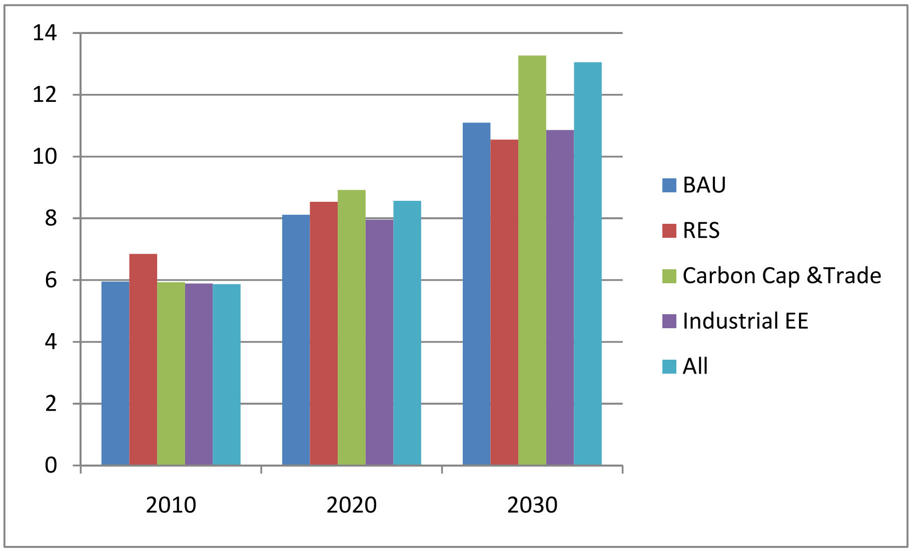

Figure 24-B. Industrial Electricity Price Projections (2007 dollars per million Btu)

A federal RES would cause a dramatic increase in biomass price. However, when the combined policies are implemented together, the impact appears to be mitigated (See Figure 25-A and B).

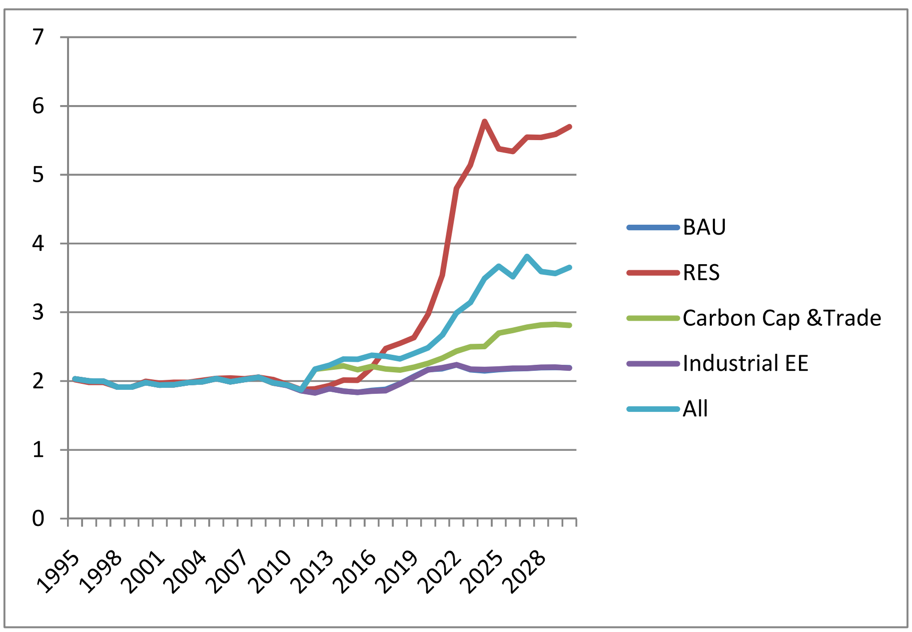

Figure 25-A. Biomass Price Projections in the Electric Power Sector (2007 dollars per million Btu)

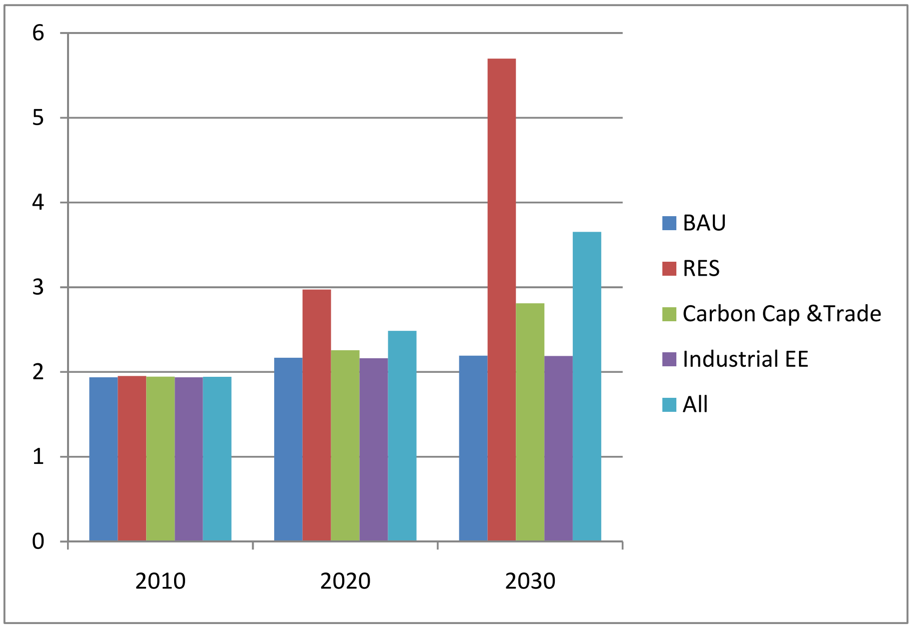

Figure 25-B. Biomass Price Projections in the Electric Power Sector (2007 dollars per million Btu)

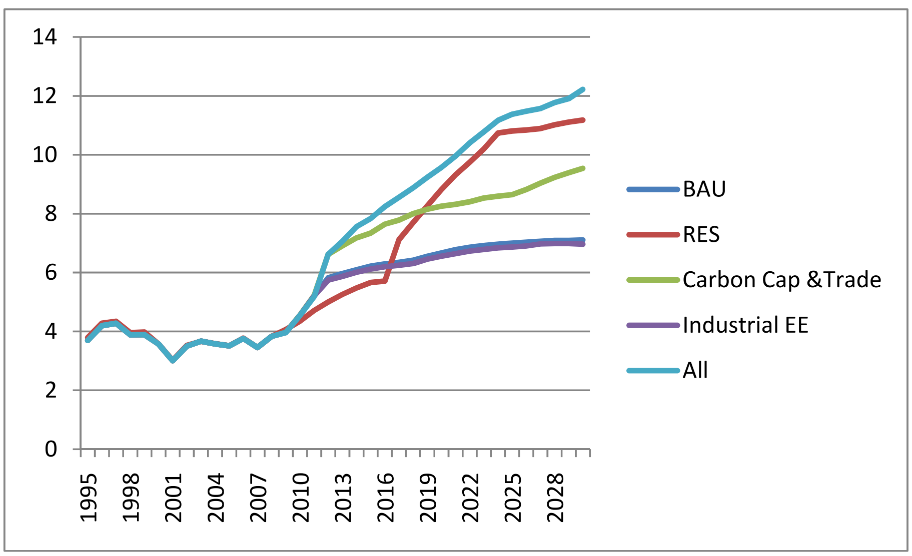

Figure 26-A. Renewable Energy Consumption in the Industrial Sector (quadrillion Btu)

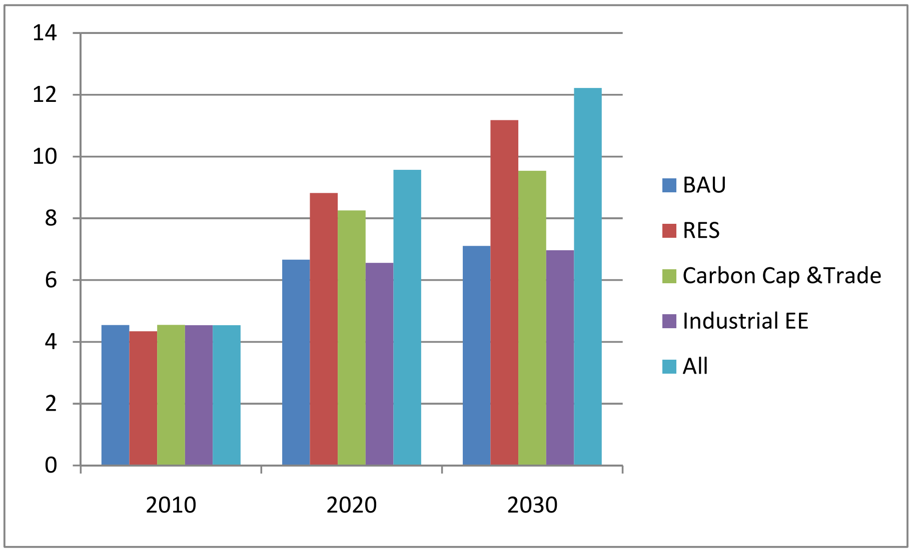

Figure 26-B. Renewable Energy Consumption in the Industrial Sector (quadrillion Btu)

CONCLUSIONS

From the universe of energy and climate policies currently being debated in the United States, we have analyzed three proposed policies with potentially large impacts on the U.S. pulp and paper industry. Table 1 summarizes our assessment of the impacts of these policies on carbon dioxide emissions, industrial electricity price, the price of biomass in the electric power sector, and the total consumption of energy by industry.

Each policy reduces CO_2 emissions, and as a package, the three policies could cut CO_2 emissions from the electricity sector by and estimated 42%. The RES and carbon cap and trade policies have the largest effects in this regard.

As anticipated, our GT-NEMS analysis indicates that these policies would increase the price of timber and other forest-based biomass inputs, relative to a business as usual scenario. An RES is estimated to increases the price of biomass for electric power generation by 160% in 2030. When all three policies are implemented concurrently, this increase drops to 67% in 2030. The carbon cap and trade policy modeled here would also result in a 10 to 20% increase in the price of industrial electricity, but this increase could be moderated by adding an RES and expanding industrial energy efficiency programs as “complementary policies”.

These results underscore the value of designing a portfolio of climate policies that can achieve the desired reduction in CO_2 emissions at minimal expense to the economy.

Table 1. Summary of Energy and Climate Policy Impacts:
Estimated Percentage Changes in 2020 and 2030

	Federal Renewable Electricity Standard	U.S. GHG Cap and Trade	Industrial Energy Efficiency Policies	All (Three Combined Policies)
Point of Impact	Electricity Suppliers	Mostly "upstream" sources of GHGs	Industrial Sector Energy End-Users	Electricity Suppliers/ Mostly "upstream" sources of GHGs/ Industrial Sector
CO_2 Emissions from Electricity Generation	-7% (2020) -9% (2030)	-11% (2020) -32% (2030)	-2% (2020) -2% (2030)	-17% (2020) -42% (2030)
Industrial Electricity Price	+5% (2020) -5% (2030)	+10% (2020) +20% (2030)	-2% (2020) -2% (2030)	+6% (2020) +18% (2030)
Biomass Price in Electric Power Sector	+37% (2020) +160% (2030)	+4% (2020) +28% (2030)	0% (2020) 0% (2030)	+15% (2020) +67% (2030)
Total Industrial Energy Consumption	-5% (2020) +1% (2030)	-1% (2020) -1% (2030)	-1% (2020) -2% (2030)	-3% (2020) -4% (2030)

Table 2. Biopower[2] Supply Changes in 2020 and 2030

	BAU	Federal Renewable Electricity Standard	U.S. GHG Cap and Trade	Industrial Energy Efficiency Policies	All (Three Combined Policies)
Biopower Supply (billion kWh)	92 (2020) 124 (2030)	382 (2020) 637 (2030)	232 (2020) 282 (2030)	90 (2020) 118 (2030)	364 (2020) 549 (2030)
Share of Biopower to Total Electricity (%)	2.00% (2020) 2.46% (2030)	8.25% (2020) 12.39% (2030)	5.12% (2020) 5.82% (2030)	2.00% (2020) 2.37% (2030)	8.14% (2020) 11.58% (2030)

Table 3. Biofuel Demand Changes in 2020 and 2030

	BAU	Federal Renewable Electricity Standard	U.S. GHG Cap and Trade	Industrial Energy Efficiency Policies	All (Three Combined Policies)
E85 Demand (quadrillion Btu)	0.71 (2020) 1.79 (2030)	0.81 (2020) 2.22 (2030)	0.69 (2020) 2.55 (2030)	0.74 (2020) 1.80 (2030)	0.68 (2020) 2.56 (2030)
Share of E85 to Total Transportation Consumption	2.43% (2020) 5.71% (2030)	2.77% (2020) 6.97% (2030)	2.40% (2020) 8.30% (2030)	2.57% (2020) 5.76% (2030)	2.38% (2020) 8.32% (2030)

2 Electricity generated with wood and other biomass

REFERENCES

Aldy, Joseph E., Alan J. Krupnick, Richard G. Newell, Ian W.H. Parry, and William A. Pizer. 2009. Designing Climate Mitigation Policy (Cambridge, MA: National Bureau of Economic Research), Working Paper 15022, June. www.nber.org/papers/w15022Haq, Zia (2002)

Brown, M.A., M.D. Levine, W. Short, and J.G. Koomey. 2001. Scenarios for a clean energy future. Energy Policy 29(14):1179-1196.

Brown, Marilyn and Nilgun Atamturk. 2008. "Potential Impacts of Energy and Climate Policies on the U. S. Pulp and Paper Industry," Georgia Institute of Technology School of Public Policy Working Paper #40, June 2008 (http://www.spp.gatech.edu/faculty/workingpapers.php).

DSIRE. 2009. Renewables Portfolio Standards for Renewable Energy. http://www.dsireusa.org/library/includes/seeallincentivetype.cfm?type=RPS&currentpageid=7&back=regtab&EE=1&RE=1

Energy Information Administration, U.S. Department of Energy. 2002 and 2006. *Manufacturing Energy Consumption Survey*. http://www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html

Energy Information Administration. 2008. Model Documentation Report: Renewable Fuels Module; Electricity Market Module; Petroleum Market Module; Industrial Demand Module

Energy Information Administration. 2003. National Energy Modeling System: An Overview

Fell, H. and R. Morgenstern. 2009. Alternative Approaches to Cost Containment in a Cap-and-Trade System (Washington, DC: Resources for the Future), RFF Discussion Paper DP 09-14, April, p. 23; National Commission on Energy Policy. 2009. Forging the Climate Consensus, July.

Goulder, Lawrence H. 2009. Carbon Taxes versus Cap-and-Trade. Working Paper. Stanford, CA: Department of Economics, Stanford University.

Haq, Zia. 2002. *Biomass for Electricity Generation*. Energy Information Administration.

Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: Mitigation of Climate Change* (2007). Available at http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm.

Jacobs Engineering and IPST (Georgia Institute of Technology Institute of Paper Science and Technology. 2006. *Pulp and Paper Industry Energy Bandwidth Study.* Report for American Institute of Chemical Engineers.

Martin, N., N. Anglani, D. Einstein, M. Khrushch, E. Worrell, and L.K. Price. 2000. *Opportunities to Improve Energy Efficiency and Reduce Greenhouse Gas Emissions in the U.S. Pulp and Paper Industry.* LBNL-46141.

McKinsey and Company. 2007. *The Untapped Energy Efficiency Opportunity in the U.S. Industrial Sector.* Report prepared for the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.

National Academy of Engineering. 2008. Workshop on Assessing Economic Impacts of Greenhouse Gas Emissions, Washington, DC, October 2-3.

National Commission on Energy Policy. 2004. *Ending the Energy Stalemate* (Washington, DC: National Commission on Energy Policy), December;

National Commission on Energy Policy. 2009. Forging the Climate Consensus, (Washington, DC: National Commission on Energy Policy), July.

National Renewable Energy Laboratory. 2009. *Comparative Analysis of Three Proposed Federal Renewable Electricity Standards*

Southworth, Katie. 2009 "Corporate Voluntary Action: A Valuable but Incomplete Solution to Climate Change and Energy Security Challenges." *Policy and Society* 27: 329-350.