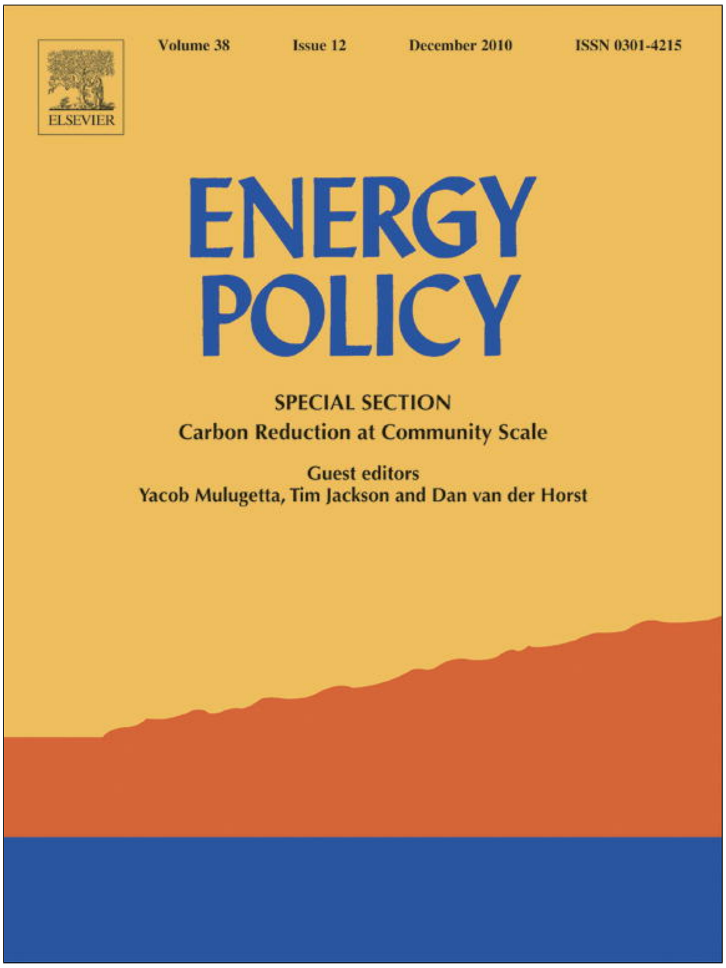
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The forest products industry at an energy/climate crossroads

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ABSTRACT

Transformational energy and climate policies are being debated worldwide that could have significant impact upon the future of the forest products industry. Because woody biomass can produce alternative transportation fuels, low-carbon electricity, and numerous other "green" products in addition to traditional paper and lumber commodities, the future use of forest resources is highly uncertain. Using the National Energy Modeling System (NEMS), this paper assesses the future of the forest products industry under three possible U.S. policy scenarios: (1) a national renewable electricity standard, (2) a national policy of carbon constraints, and (3) incentives for industrial energy efficiency. In addition, we discuss how these policy scenarios might interface with the recently strengthened U.S. renewable fuels standards. The principal focus is on how forest products including residues might be utilized under different policy scenarios, and what such market shifts might mean for electricity and biomass prices, as well as energy consumption and carbon emissions. The results underscore the value of incentivizing energy efficiency in a portfolio of energy and climate policies in order to moderate electricity and biomass price escalation while strengthening energy security and reducing CO_2 emissions.

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1. Introduction

The future is likely to increasingly be shaped by policy interventions aimed at strengthening energy security and mitigating global climate change. These efforts must necessarily address industrial energy use since industry 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% of the national energy budget and is responsible for 27% of U.S. CO_2 emissions (EIA, 2009a, Tables A2 and A18).

Over the long term, industry is expected to continue to be a significant component of increasing global energy demand and a major source of GHG emissions, driven by the expansion of China, India, and other developing economies. Overall, U.S. industrial energy consumption and CO_2 emissions are expected to grow more slowly, due primarily to a shift away from energy-intensive manufacturing and toward service and information-based activities (EIA, 2009a, Tables A2 and A18). Nevertheless, five U.S. industries merit particular attention because they account for about 60% of total U.S. industrial energy use and nearly \$125 billion in annual energy expenditures: petroleum refining, bulk chemicals, pulp and paper, primary metals, and food processing. Among these, the pulp and paper industry is the third largest consumer of energy. According to the 2002 and 2006 Manufacturing Energy Consumption Survey (MECS), the U.S. paper industry consumes nearly 2400 TBtu annually. While manufacturing fuel consumption as a whole declined by 3.6% between 2002 and 2006, the paper industry displayed a relatively stable and consistent energy consumption pattern (Fig. 1).

Stakeholders who manage U.S. industrial enterprises and deal with fuel futures must decide what to invest in plant refurbishment and what to build as a next generation of production capacity, power plants, and fuel refineries, not knowing if CO_2 will remain uncontrolled. In recent years, the U.S. Congress has developed hundreds of climate change-related proposals (Pew, 2007; Congressional Budget Office, 2009), 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?

The conversion of biomass to energy products accounts for a small portion of the energy systems of most industrialized economies, although it is the largest non-hydro renewable source of electricity in the United States. 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; 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

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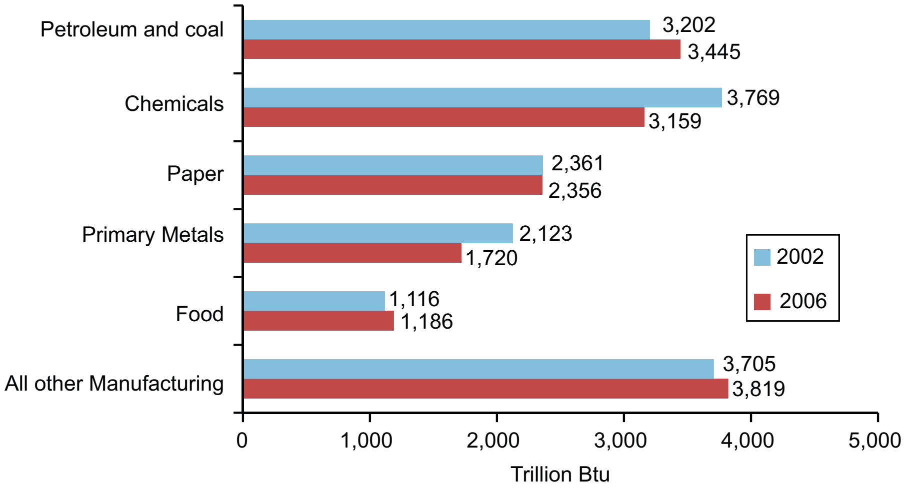

Fig. 1. Manufacturing energy consumption in the U.S.: 2002 and 2006. (Data source: 2002 and 2006 Manufacturing Energy Consumption Survey, EIA, DOE).

the merits of directing capital expenditures to projects in anticipation of new energy and climate policies.

This paper estimates the nature and magnitude of the impacts of evolving energy policies on the pulp and paper industry using 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 U.S. Department of Energy (DOE) (EIA, 2003). 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 (Union of Concerned Scientists, 2004; Brown et al., 2010; Natural Resources Defense Council, 2010).

In particular, we focus on the following three policy packages: A national renewable electricity standard, a national policy of carbon constraints, and incentives for industrial energy efficiency. This research illustrates a methodology for evaluating how evolving energy and climate policies could affect an industry within the context of competing markets for resources. At the same time, we 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 briefly review 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. Referred to as "quotas" or "obligations" in many European and other countries, electricity suppliers can typically 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.

In the U.S., renewable portfolio standards are mandated on a state by state basis. As of June 2010, 29 states along with the District of Columbia have an RPS and an additional seven states have voluntary renewable energy goals as opposed to strict requirements (Beck, 2009).[1] 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 (Fig. 2). Studies have shown that while many state RPS policies have shortcomings, they have on average had a significant positive impact on total in-state renewable electricity investment and generation (Carley, 2009; Yin and Powers, 2010). To reduce state-by-state inconsistencies and further 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, which included a commitment to 25% renewable electricity production by 2025. Responding to requests from Chairman Edward Markey, for an analysis of a 25% Federal RES, the EIA released a report, "Impacts of a 25-Percent Renewable Electricity Standard as Proposed in the American Clean Energy and Security Act Discussion Draft" in 2009. The EIA's scenario for the analysis exempted small retailers from the RES mandate and excluded hydroelectric power and municipal solid waste from the sales baseline. In addition, the EIA report developed another scenario that could lower the target further, assuming that states are able to and take full advantage of the energy efficiency credits for compliance. The three additional treatments on top of the nominal RES target could lower the RES target further to 17% (EIA, 2009b). In this paper, we examine the nominal RES target (25%) and the two effective targets with and without energy efficiency credits (17% and 21%) in GT-NEMS. The nominal target for renewables is applied to both major utility companies

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[1] www.dsireusa.org/

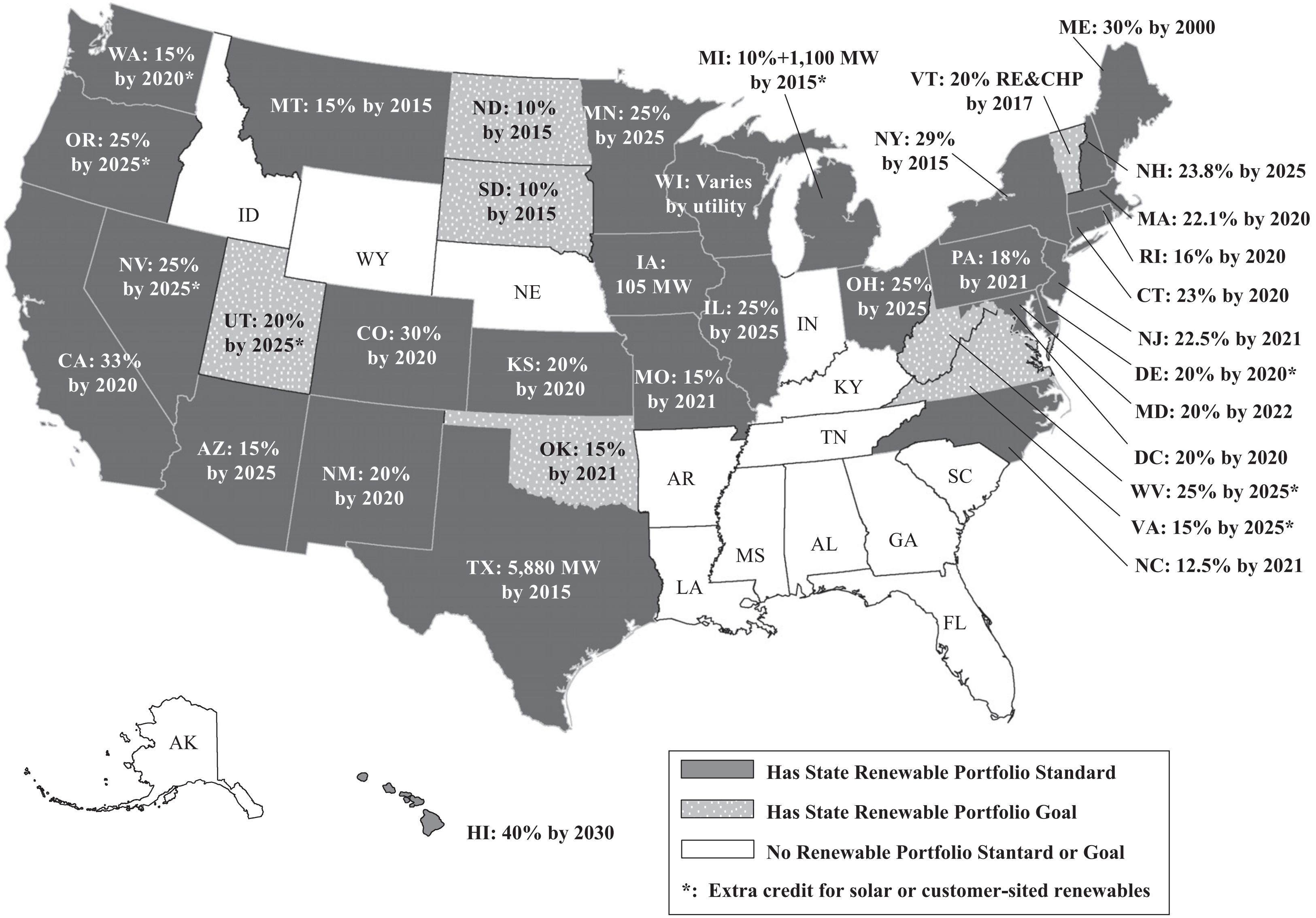

Fig. 2. State Renewable Electricity Standards (Data Source: Database of State Incentives for Renewable Energy, http://www.dsireusa.org/).

and small retailers, and we do not reduce the baseline, nor do we allow energy efficiency to qualify to meet the national RES target.

2.2. National policy of carbon constraints

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% in 2019, but more than half of the U.S. states do not even have GHG reduction goals (Fig. 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 policy of carbon constraints.

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, point of regulation, price ceiling and floor, offsets, banking and borrowing, and allocation of allowances.

For the purposes of this study, we analyzed the impact of a national policy of carbon constraints 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 $51 per ton in 2030. We also modeled a carbon 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.

2.3. Incentives for industrial energy efficiency

While efficiency improvements have been made across the industrial sector, opportunities remain to reduce energy and carbon intensity through a combination of best energy management practices, advanced technologies, efficient process designs, and the use of renewable energy (National Academies, 2009). At least four recent studies have assessed the cost-effective energy efficiency potential available in the pulp and paper industry. Focusing on the year 2020, these estimates range from a low of 6.1% reduction in energy use 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 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 to more than 80% by 2030 without any additional increase in installation cost.

The energy efficiency of manufacturing is often measured by dividing energy consumption (usually in thousand Btu) by the value of the commodities produced (usually using the value of shipments in million constant dollars). The result is labeled the “energy intensity” of manufacturing. The reference forecast of NEMS estimates an “endogenous” increase in industrial energy efficiency over the next 20 years. Specifically, energy efficiency is assumed to bring about a 0.24% annual rate of decrease of industrial energy intensity, and this reduction is captured in the EIA baseline. However, this energy efficiency improvement is eclipsed by a far greater influence on energy intensity driven by the restructuring of industry in the U.S. and an increasing amount of manufacturing off-shore.[2] In assessing the potential impacts of policies on industrial energy use, the improvement in energy efficiency is taken into account. While such future improvements are anticipated, the paper manufacturing industry did not decrease its energy intensity between 1977 and 2004, unlike many other energy-intensive industries (Brown et al., 2011). While a renewable electricity standard or a carbon cap and trade policy might drive more energy efficiency into the pulp and paper industry, historic experience suggests that such a response would be modest in comparison to changes that could occur with energy efficiency incentives and technical assistance.

2.4. Renewable fuels standard

A fourth federal policy has particular relevance to the pulp and paper industry: the renewable fuels standard (RFS). The influence of this policy 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.

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. Recognizing the potential conflict between corn-based ethanol and food production, the renewable fuels standard requires increasing portions of ethanol from alternative sources, which could include woody biomass. Specifically, 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 (NCEP, 2008).

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

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[2] http://www.eia.doe.gov/oiaf/aeo/intensity_trends.html

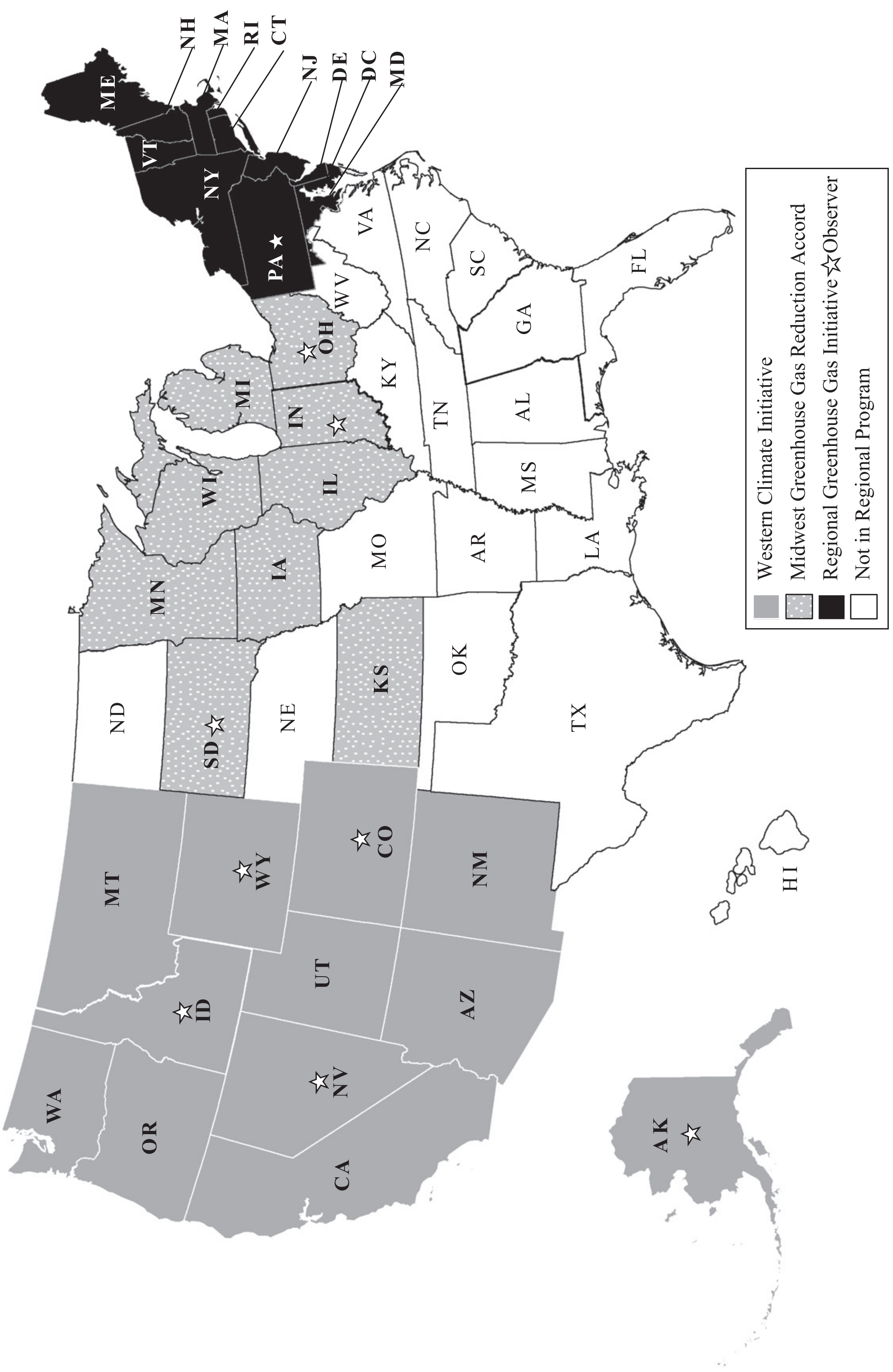

Fig. 3. Regional carbon cap-and-trade initiatives (Data Source: Database of State Incentives for Renewable Energy, http://www.dsireusa.org/).

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, 2009a,b). 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. Treatment of biomass in NEMS

Several different types of models are available for evaluating alternative energy and carbon policies. At 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. The baseline projections predicted by NEMS are published annually in *the Annual Energy Outlook*, which is regarded as the most credible reference in the field of energy and climate policy. It predicts the supply, demand, and price of various energy resources subject to macroeconomic factors; world energy market indicators; resource availability; technological advancement; and regional characteristics (EIA, 2009a) (Fig. 4).

The renewable fuels module (RFM) of NEMS 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 renewable resources compete with other fossil fuels in the electricity market module (EMM) subject to capital and operating costs, capacity factors, and technological advancement. The RFM has seven submodules respectively representing biomass, geothermal, conventional hydroelectricity, landfill gas, solar thermal, solar photovoltaics, and wind. The biomass electric power submodule (BEPS) is one of the seven submodules that treats biomass.

Another module of NEM that models the consumption of biomass for electricity generation is the industrial demand module (IDM). The capacity of biopower in the wood products and paper industries, so called "captive capacity", is modeled in the IDM as cogeneration, and total biomass consumption for electricity generation is represented in the EMM (EIA, 2003, 2008; Haq, 2002).

The BEPS 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. NEMS models the dedicated biomass plants in the same way as other generation options with a single kind of fuel such as coal, petroleum, and nuclear generation. The main inputs for the dedicated biomass generators are capital, operating, and maintenance costs, project life, production tax credit, and heat rate. 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. However, the co-firing system operated at higher levels would require an additional capital cost to enhance the capacity and performance (EIA, 2003; Haq, 2002).

In addition, the EMM has its regional breakdowns to reflect the difference in regional renewable electricity standard and resource availability. The annual supply curves of agricultural residues, energy crops, and forestry residues have recently been updated based on the biomass supply data from the POLYSIS model developed by the University of Tennessee. For estimating the supply curves, the USDA annual projection forecasts are used to

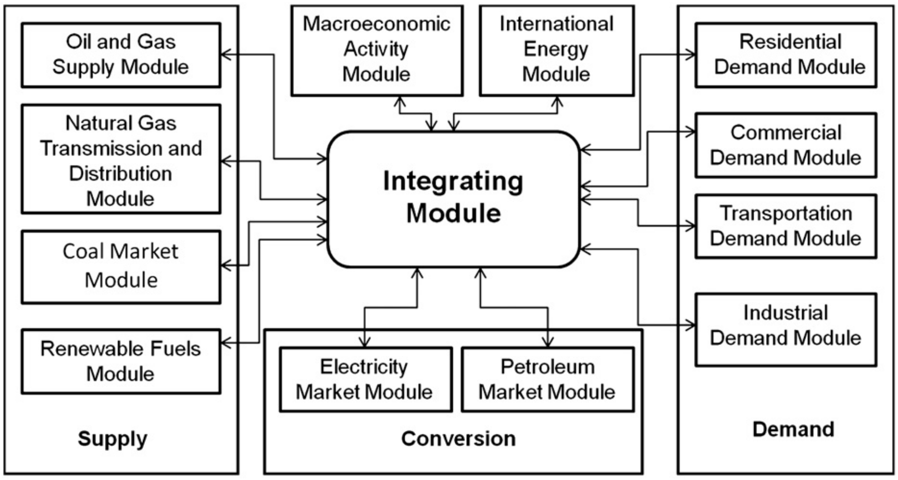

Fig. 4. National energy modeling system (NEMS).
Source: The National Energy Modeling System: An Overview, 2009, EIA, 2009a,b, http://www.eia.doe.gov/oiaf/aeo/overview/figure_2.html

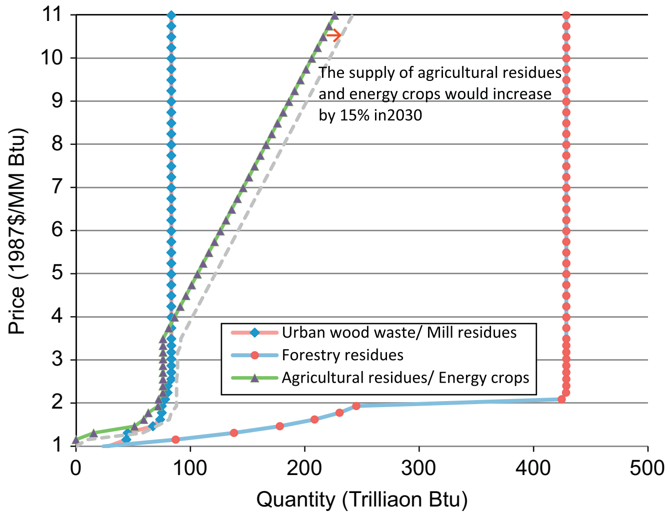

Fig. 5. Biomass supply curves in 2020.

determine the yield rates of energy crops and agricultural residues. The supply plans of urban wood wastes are provided by Oak Ridge National Laboratory (Perlack et al., 2005). As the potential of energy crops grows in the biopower sector, the supply of biomass from the agricultural sector (agricultural residues and energy crops) is expected to increase by about 15% from 2020 to 2030, reaching 242 trillion Btu at $11/MMBtu in 2030. In contrast, the supply of urban wood waste, mill residues and forestry residues are anticipated to remain unchanged between 2020 and 2030 (Fig. 5).

4. GT-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 (EIA, 2009a). By incorporating the impacts of the worldwide economic downturn, this version of NEMS recognizes that the forest products industry experienced sharp drops in demand, impacted by declining home construction, steep drops in advertising that led to declines in the demand for printed paper, and lower overall economic activity (Agenda 2020 Technology Alliance, 2010). We named the modified model GT-NEMS in order to emphasize that energy projections from the GT-NEMS are different from projections from the original NEMS.

4.1. *Renewable electricity standard*

While the nominal target for the national RES is 25% of total electricity sales by 2025, the effective target could vary depending on how renewables are defined and what service providers are regulated. Exempting small retailers from the RES mandates could lower the effective target to 22%. The effective target could be lowered further to 21% when the generation from hydroelectric power and municipal solid waste is excluded from the sales baseline. In addition, if the national RES allows the use of energy efficiency credits for compliance, the effective share could drop to 17% (EIA, 2009b). We modeled the nominal RES target (25%), and two effective targets with and without energy efficiency credits (17% and 21%) in GT-NEMS.

NEMS forecasts that biomass prices would increase significantly reaching $5.7 per million Btu under the scenario with the nominal target (25%); $3.2 with an effective target of 21%; and $2.7 with another effective target of 17%, assuming that energy efficiency credits are fully used for compliance (Fig. 6). Thus, with a national RES, wood and agricultural residues would become a more valuable commodity in the renewable energy market in the near future.[3]

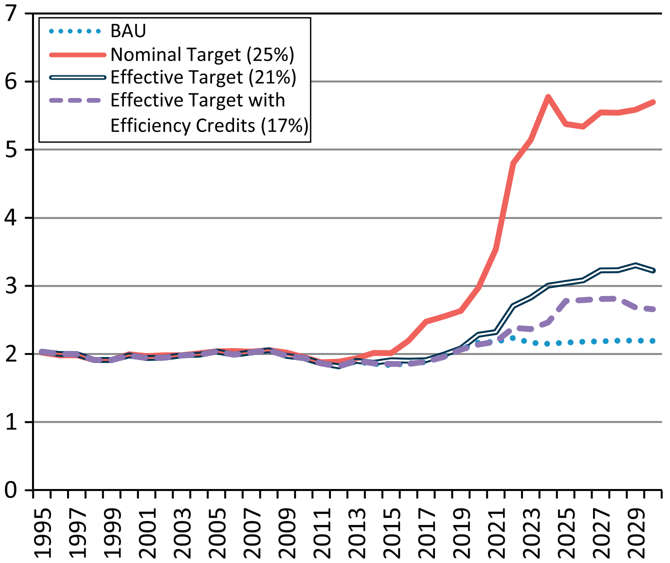

Fig. 6. Biomass price projections in the electric power sector under various RES scenarios (2007 dollars per million Btu).

The RES would not affect industrial electricity prices significantly – a finding that has been replicated by others. For example, 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 NREL's analysis, all 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%. The impacts on the electricity price estimated by the GT-NEMS model are similar to the results in the NREL's study. The changes in electricity prices estimated in this study are within a band of ±5%.

As the mandated share of renewable electricity to the total sales increases, the electricity generation from renewable resources is anticipated to grow. The majority of the growth in renewable electricity is attributed to the growth in electricity generated from wood and other biomass (Fig. 7). The dominance of biomass is due to the relatively low capital and operating costs it requires to generate electricity, compared to other renewable resources. Wood chips and agricultural residues can be mingled with coal and be fed into boilers with only minimal additional capital investments.

At the same time, the U.S. could avoid 9% of its CO_2 emissions from the electricity generation sector in 2030 (see Fig. 8).

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[3] 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.

4.2. *Carbon cap and trade system*

GT-NEMS suggests that the U.S. could expect to avoid 11% of CO_2 emissions from the electric power sector in 2020, increasing to 32% in 2030, by implementing a national policy of carbon constraints as specified in this analysis. A total of 16% could be reduced from all sectors in 2030 (see Fig. 9).

Industrial electricity prices are projected to be higher by 10% in 2020 and by 20% in 2030 under the carbon cap and trade policy than under the business-as-usual (BAU) scenario. This price inflation is considerably higher than the price increases under the renewable electricity standard (see Fig. 10).

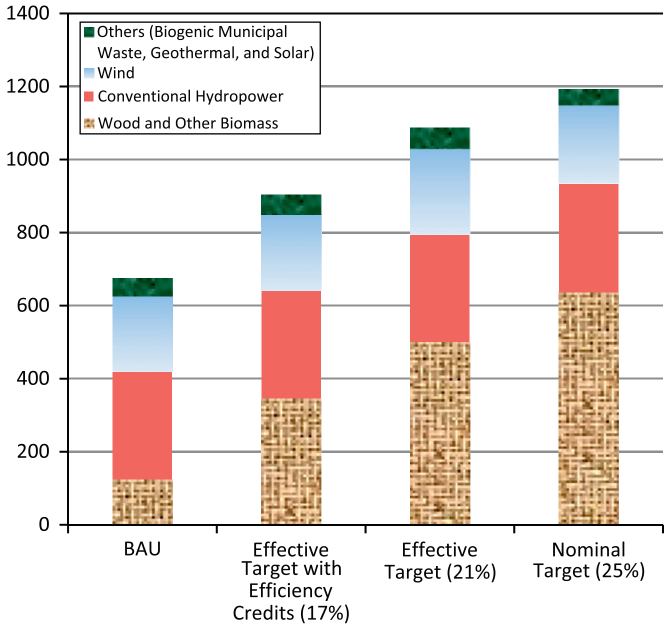

Fig. 7. Renewable electricity generation in 2030 under various RES scenarios (Billion kWh).

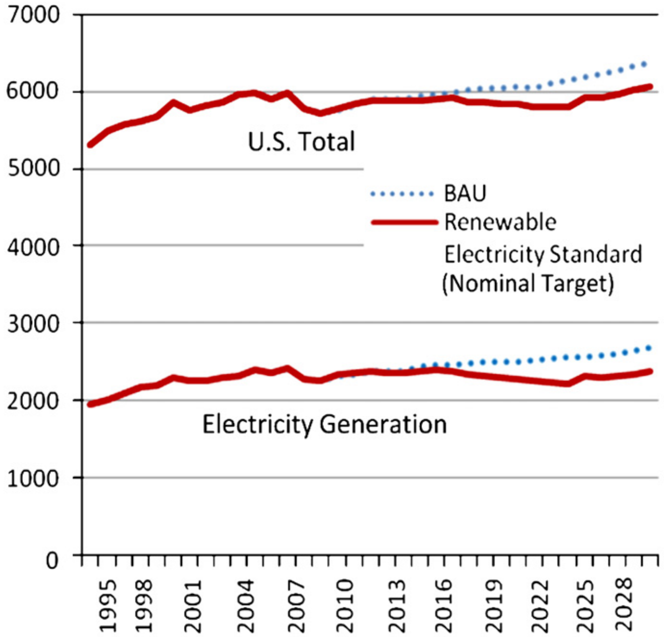

Fig. 8. Carbon dioxide emissions under the RES scenario (million metric tons carbon dioxide equivalent).

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. On the other hand, total industrial energy consumption decreases only slightly under the policy of carbon constraints comopared with the BAU forecast.

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 estimating the expected energy savings from the assessment programs, we entered a matrix of changed energy intensities and of technology possibility curves for all industrial subsectors modeled by GT-NEMS. To assess the magnitude of achievable energy-efficiency improvements from the proliferation of CHP systems, we assumed implementation of a set of transformative

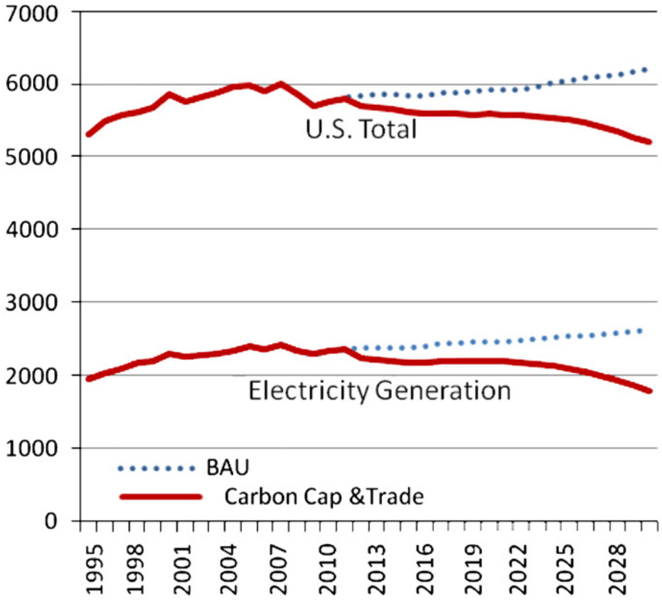

Fig. 9. Carbon dioxide emissions under the carbon cap and trade scenario (million metric tons carbon dioxide equivalent).

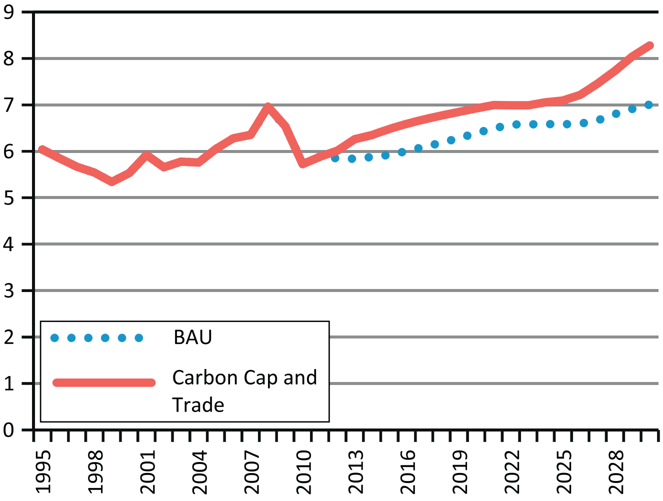

Fig. 10. Industrial Electricity Price Projections (2007 cents per kilowatthour).

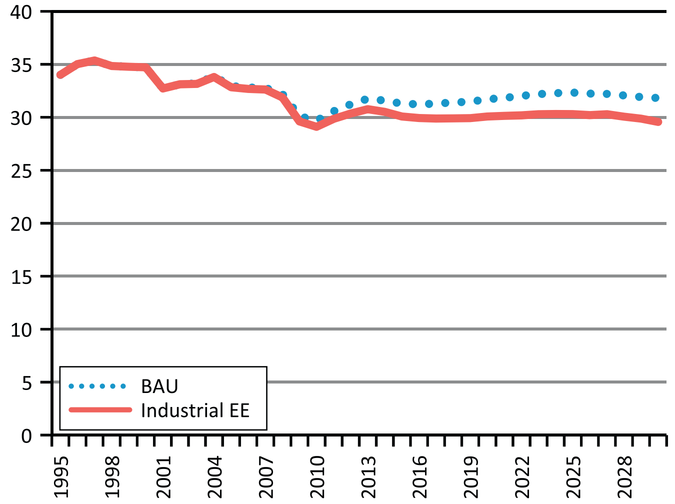

Fig. 11. Total Industrial Energy Consumption (quadrillion Btu, unless otherwise noted).

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 improved process 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 constraints, the industrial energy efficiency policies modeled here would be relatively small contributors to CO_2 mitigation. They would have minimal effect on electricity and biomass prices, as well. Nevertheless, these policies would contribute to reducing industrial energy consumption by 5% in 2020 and 7% in 2030 – reducing energy consumption by 2.2 quads (see Fig.11).[4] 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, 2007; National Academy of Sciences, 2010).

4.4. *The combined policies*

Using GT-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. In contrast, the combined policies could lower the CO_2 emissions from electricity generation by almost 41% in 2030, bringing emissions to well below 1995 levels (Fig. 12). The largest reductions are associated with implementation of a policy of carbon constraints. Total U.S. CO_2 emissions also decline significantly, dipping below 1995 levels by 2030.

Tables 1 and 2 show that the markets for biopower (electricity generated with wood and other biomass) and biofuel would grow faster under the renewable electricity standard and the carbon-constrained scenarios compared to the business-as-usual forecast or the industrial energy efficiency future, which are quite similar to one another. The combination of all three policies could grow biopower to 8% of total electricity in 2020 and 12% in 2030, compared with market shares of 2% and 2.5% under BAU forecast. Biofuels do not expand significantly in the policy scenarios in 2020, but by 2030, the combination of all three policies could grow the market share from 5.7% in BAU to 7.9% of total transportation fuels consumption.

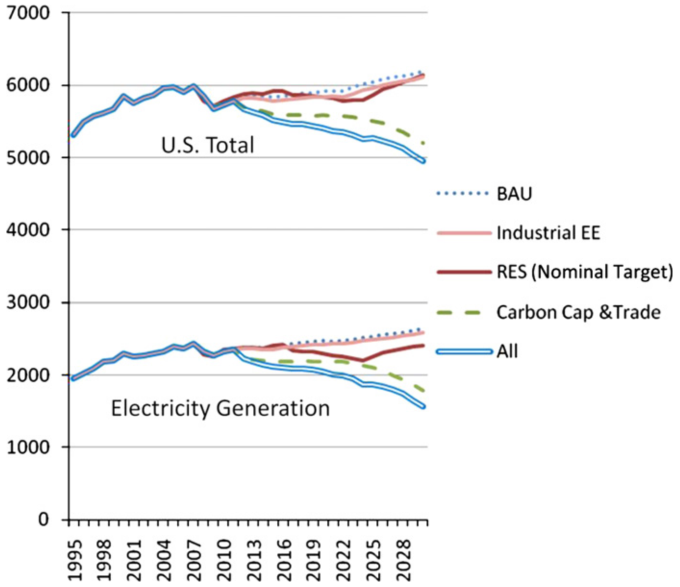

Fig. 12. Carbon dioxide emissions (million metric tons carbon dioxide equivalent).

The increased biomass price in the electric power sector and the expanded market size could motivate pulp and paper mills to increase their profits by selling their wastes. However, an additional competition between the paper industry and the biofuels industry in purchasing raw materials would also be inevitable.

5. 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 influence on the U.S. pulp and paper industry. Table 3 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 scenario reduces CO_2 emissions over time, compared to the business-as-usual forecast, with the carbon constrained policy producing the largest decline. As a package, the three policies together could cut CO_2 emissions from the electricity sector by an estimated 41% by 2030.

The carbon constrained policy would result in a 10 to 20% increase in the price of industrial electricity in 2030. However, this increase could be moderated by expanding industrial energy efficiency programs as “complementary policies.” When the energy efficiency policy is implemented, a significant amount of electricity surplus generated from CHP systems would sell back to the national grid and could increase the supply of retail electricity without requiring additional fuels or contributing to carbon dioxide emissions. The increased supply is anticipated to dampen the electricity price increases in the future. In addition, the reduced electricity consumption caused by the policy would lead to a drop in retail electricity prices. Similarly, our GT-NEMS analysis indicates that the RES and carbon cap and trade policies would increase the price of timber and other forest-based

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[4] The sale of CHP electricity to the national grid could increase the revenues of firms in the U.S. industrial sector. The total industrial sector could produce an electricity surplus of 24 TWh in 2020 and 35 TWh in 2030, respectively when the industrial energy efficiency policy is implemented. The amount of on-site electricity that the pulp and paper industry could sell back to the grid is estimated to be 3.9 TWh in 2020 and 5.7 TWh in 2030, an increase of 26% and 51%, respectively.

Table 1
Biopower supply changes in 2020 and 2030.

	BAU	Federal renewable electricity standard (nominal target)	National policy of carbon constraints	Industrial energy efficiency policies	All (three policies combined)
Biopower supply (billion kWh)	92 (2020) 124 (2030)	382 (2020) 637 (2030)	232 (2020) 282 (2030)	92 (2020) 116 (2030)	359 (2020) 565 (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) 2.34% (2030)	8.00% (2020) 11.92% (2030)

Table 2
Biofuel demand changes in 2020 and 2030.

	BAU	Federal renewable electricity standard (nominal target)	National policy of carbon constraints	Industrial energy efficiency policies	All (three policies combined)
E85 demand (quadrillion Btu)	0.71 (2020) 1.79 (2030)	0.81 (2020) 2.22 (2030)	0.69 (2020) 2.55 (2030)	0.75 (2020) 1.70 (2030)	0.66 (2020) 2.40 (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) 5.50% (2030)	2.31% (2020) 7.87% (2030)

Table 3
Summary of energy and climate policy impacts: estimated percentage changes in 2020 and 2030.

Policy	**National renewable electricity standard (RES)**		**National policy of carbon constraints**	**Industrial energy efficiency policies**	**All (Three policies combined)**
Point of impact	Electricity suppliers		Mostly “upstream” GHG sources	Industrial sector energy end-users	Upstream through downstream
	Nominal target (25%)	Effective target (17%)			
CO_2 Emissions from electricity generation	−7% (2020) −9% (2030)	−2% (2020) −7% (2030)	−11% (2020) 32% (2030)	−2% (2020) −2% (2030)	−17% to −13% (2020) −41% to −35% (2030)
Industrial electricity price	+3% (2020) +4% (2030)	0% (2020) +1% (2030)	+10% (2020) +20% (2030)	−3% (2020) −4% (2030)	+5–7% (2020) +17% (2030)
Biomass price in electric power sector	+37% (2020) +160% (2030)	−1% (2020) +21% (2030)	+4% (2020) +28% (2030)	−1% (2020) −1% (2030)	+3–15% (2020) +27–58% (2030)
Total industrial energy consumption	−5% (2020) +1% (2030)	0% (2020) −1% (2030)	−1% (2020) −1% (2030)	−5% (2020) −7% (2030)	−7% to −5% (2020) −9% to −5% (2030)
Sales of CHP electricity to grid[a]				+26% (2020) +51% (2030)	

[a] The sales of CHP electricity to the national grid could increase the revenues of firms in the U.S. industrial sector. The total industrial sector could have the electricity surplus of 24 TWh in 2020 and 35 TWh in 2030 when the industrial energy efficiency policy is implemented. The amount of on-site electricity that the pulp and paper industry could sell back to the grid is 3.9 TWh in 2020 and 5.7 TWh in 2030.

biomass inputs to the electric power sector, relative to a business as usual scenario. However, when all three policies are implemented concurrently, this increase drops significantly primarily because of the industrial energy efficiency policy, which reduces energy consumption and therefore subdues the growth in electricity prices.

The results underscore the value of implementing a well-designed portfolio of energy and climate policies. While the RES and carbon constrained policies contribute significantly to energy security and climate change goals, without also reducing the demand for energy with efficiency improvements, the escalation of electricity and biomass prices would be costly. We have illustrated how a combination of policies can strengthen energy security and reduce CO_2 emissions while moderating energy and biomass price escalation by including a strong energy efficiency initiative.

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