

USING CLIMATE CHANGE POLICIES FOR U.S. PULP AND PAPER INDUSTRY EFFICIENCY

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A COMPUTER MODEL OF TECHNOLOGY CHOICE, ENERGY USE, AND CARBON EMISSIONS BY THE U.S. PULP AND PAPER INDUSTRY CAN SHOW THE EFFECT OF CLIMATE CHANGE POLICIES ON THE INDUSTRY RATE OF TECHNOLOGICAL IMPROVEMENT.

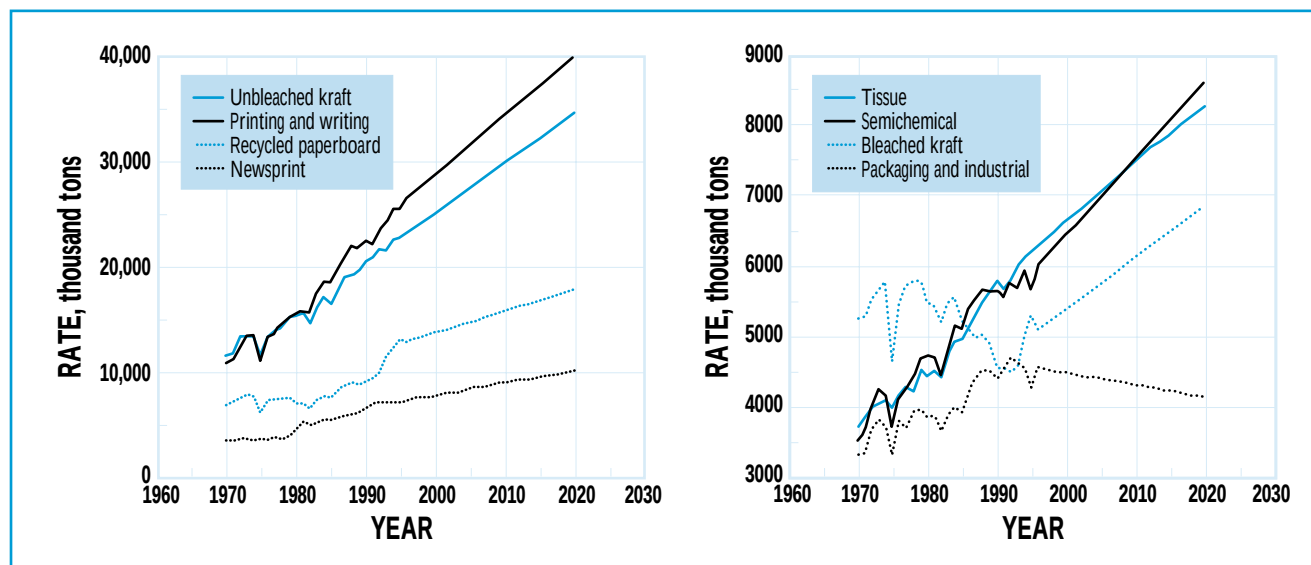
THE U.S. PULP AND PAPER INDUSTRY (SIC 26) IS A VERY energy intensive manufacturing industry. It consumes 12% of total manufacturing energy use. Pulp, paper, and paperboard mills use 95% of this. Energy efficiency improved 22% during the last two decades. Simultaneously, the demand for pulp and paper products rose to the highest per capita rates in the world. Further industry expansion should occur for the next two decades. Will this expected expansion mean higher energy use and greater carbon emissions from the industry? What will be the effect of climate change policies on the industry's rate of technological improvement?

DYNAMICS OF THE U.S. PULP AND PAPER INDUSTRY
To answer these questions, the authors developed a computer model of technology choice, energy use, and carbon emissions by the pulp and paper industry. An important feature of the model is its ability to track changes in energy efficiency through time and explore the dynamic changes of alternative policy scenarios. (For a copy of the model, software, and documentation, send an e-mail to mruth@bu.edu.) The model focuses on implications of increases in the cost of carbon and investment incentives for the pulp and paper industry's energy and carbon emission profiles until the year 2020. The model uses forecasts of production rates of four paper categories—newsprint, tissue, printing and writing, and packaging and industrial paper—and four paperboard categories—bleached kraft materials, unbleached kraft products, recycled products, and semichemical materials. Recognizing that a significant diversity exists, the model did

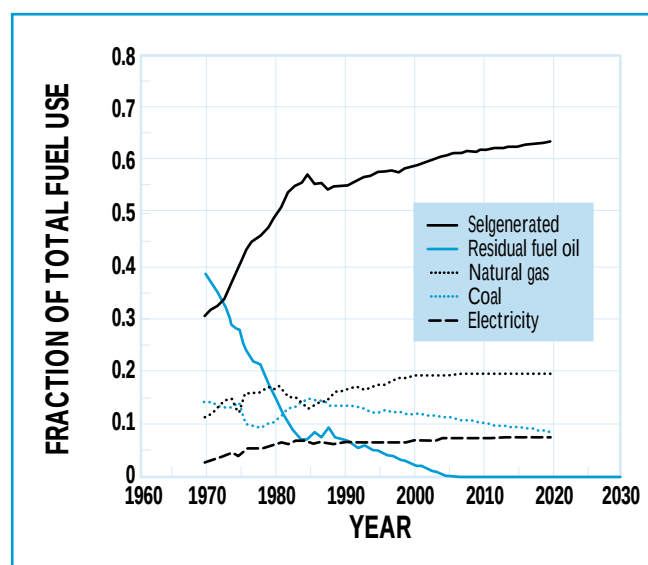
not intend to simulate an average pulp or paper mill. Instead, it explored energy use and the impacts of various climate change policies on the aggregate of the product categories listed above.

Changes in energy intensities measured in Btu per short ton of output are calculated as the result of collective improvements that occur at companies with implementation of new technologies and retirement of old ones. The drivers behind these changes are energy prices, learning-by-doing, and investment incentives. Absolute and relative energy prices influence fuel switching. Data for these analyses primarily come from “Annual Energy Outlook,” “Annual Energy Review,” and “Industrial Sector Demand Module of the National Energy Modeling System” of the Energy Information Administration, “Statistics of Paper, Paperboard, and Wood Pulp” of the American Forest and Paper Association, and engineering and scientific literature. The aggregate nature of the data does not enable distinctions between policy implications for integrated compared with nonintegrated firms.

Figure 1 show past and future production rates. Future average annual production growth rates vary between +1.7% for printing and writing grades and -0.34% for packaging and industrial paper. Aggregate pulp and paper industry output rises an average 1.65% per year. **Figure 2** shows corresponding energy use in the absence of any new policies. The authors expect a continued strong move toward use of self-generated energy primarily from recovered wastes—hogged fuel and spent liquor—and recovered paper to some extent. Use of natural gas and purchased electricity will also increase while the reliance on coal and residual fuel oil diminishes.



1. Historical and forecast production rate by product category



3. Energy use by source with no climate change policy

Assuming carbon emissions from self-generated energy to be neutral for the atmospheric carbon budget, investigating only carbon emissions from fossil fuels—defined as net carbon emissions—is sufficient. Compared with energy intensities, net carbon emissions per ton of industry output decline more rapidly because of continued fuel switching and expansion of self-generation as Fig. 3 shows.

IMPLEMENTATION OF CLIMATE CHANGE POLICIES

To evaluate the effects of increases in cost of carbon on energy efficiency, fuel mix, and net carbon emissions, the study assumes an increase in the price of each purchased fuel proportional to its carbon content. The work only en-

compasses the U.S. pulp and paper industry. Consequently, the scope of the study does not consider the impacts of greenhouse gas-reducing investments on the U.S. industry's international competitiveness. These impacts could possibly be severe if the costs were imposed on U.S. manufacturers but not on competing companies operating in countries outside the international framework for reducing greenhouse gases.

The study assumes that a cost of US\$ 50 per metric ton of carbon—perhaps in the form of payments for emissions permits—will occur in 2000. With the cost of carbon at US\$ 50 per ton for example, industrial energy prices would increase by about 20%–25%. Unlike the price shocks of the middle 1970s and early 1980s, the price increases assumed here would persist for 20 years. Since the carbon content per Btu of coal is highest among fossil fuels, the price of coal increases proportionally more than that of oil and gas. Higher prices for lower carbon fuels could result from increased demand for these fuels. This would reduce the attractiveness of switching to lower carbon fuels. To the extent that the pulp and paper industry might reduce total emissions through additional combined heat and power generation and export of excess power, electricity prices also greatly influence costs for these reductions.

The effect of the cost of carbon on electricity prices depends on the fuel mix in electricity generation. It fluctuates, as Table I shows. Table II gives detailed results for the fuel use, emissions, and energy costs for the pulp and paper industry. These results capture the effects of learning-by-doing, price-induced efficiency improvements, and price-induced fuel switching on energy use and net carbon emissions. By assumption, the pulp and paper industry behavior with climate change policy is qualitatively consistent with observed, historic behavior.

Fuel type US \$50/ton carbon

Electricity	2.39–2.59
Coal	1.28
Natural gas	0.72
Residual fuel oil	1.07

1. Cost of carbon for each fuel type in dollars per million Btu

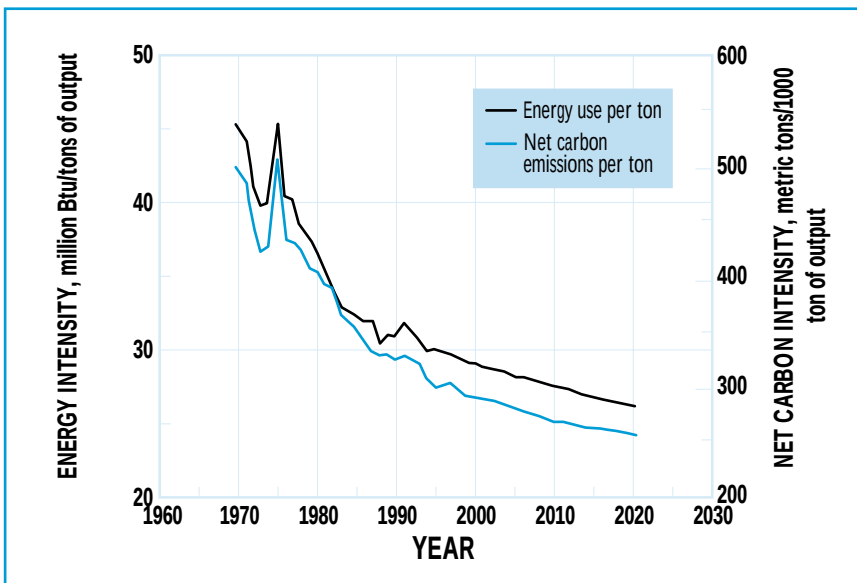
Specifically, equipment undergoes retirement or upgrading at “normal” rates.

Government policies that help disseminate technology information or provide incentives for faster technology adoption can help stimulate implementation of more environmentally benign production processes. Voluntary pulp and paper industry initiatives can also improve environmental performance. Such investment incentives can promote efficiency improvements beyond those that an energy price trigger can signal. Such policies might include allowing higher depreciation rates, providing investment incentives through tax credits, or providing regulatory flexibility by demonstrating new technologies for example.

How would investment incentives affect net carbon emissions by the pulp and paper industry if these incentives combined with a cost-of-carbon policy? To answer this question, the study used engineering-based assumptions about technological potential in the pulp and paper industry (1). Specifically, it assumed an efficiency gap between actual and best practices in 1995 of 20%. It also assumed the annual rate at which new technologies penetrate to close this gap is 10%. This rate is significantly more rapid than the average rates occurring in the pulp and paper industry over the last 20 years. Improvements of this magnitude might require the application of technologies not yet proven, such as black liquor gasification combined cycle technology. Pulp and paper industry personnel believe the availability of black liquor gasification technology may be able to replace as much as 80% of the significantly less efficient Tomlinson recovery boilers over the next 20 years.

The study assumed the capital recovery factor for the industry to be 15% rather than the more typical 33%. The study therefore assumes that public policies could reduce the profitability threshold for greenhouse gas-reducing investments to a capital recovery factor which is significantly lower than most companies now apply to investments in energy conservation.

Implementation of new technology will likely require capital investment whose opportunity costs are not explicitly part of a model. Since industry is under severe pressure to maximize return on invested capital, opportunity costs are an important element in capital allocation decisions.

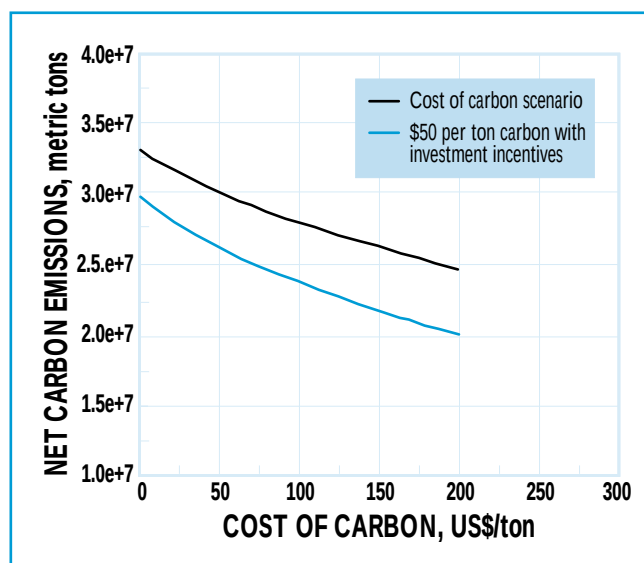


4. Net carbon emissions per ton of output and energy use per ton of output with no climate change policy

Item	No climate change policy	US\$ 50/ton carbon	Investment-led policy and \$50/ton carbon
Total energy use, % change from 1990 levels to 2020	39.67	38.38	20.38
Total purchased fuel use, % change from 1990 levels to 2020	33.24	15.86	0.36
Total self-generated energy, % change from 1990 levels to 2020	44.58	55.59	35.68
Energy intensity, energy use/output, % change from 1990 levels to 2020	-15.14	-15.92	-26.86
Years gained in efficiency improvement	-	3	17
Net carbon emissions, % change from 1990 levels to 2020	30.10	18.04	2.93
Carbon emissions from self-generated energy, % change from 1990 levels to 2020	44.58	55.59	35.68
Net carbon emissions per ton of output, % change from 1990 levels to 2020	-16.13	-23.90	-33.64
Energy expenditures in 2020, billion 1994 US\$	5.49	6.69	5.84
Cost of carbon payments in 2020, billion 1994 US\$	-	1.51	1.31

III. Summary of model results

1. Ross, M., Thimmapuram, P., Fisher, R., et al., Long-term Industrial Energy Forecasting (LIEF) Model (18 Sector Version), Argonne National Laboratory, Argonne, 1993, pp. 1-101.

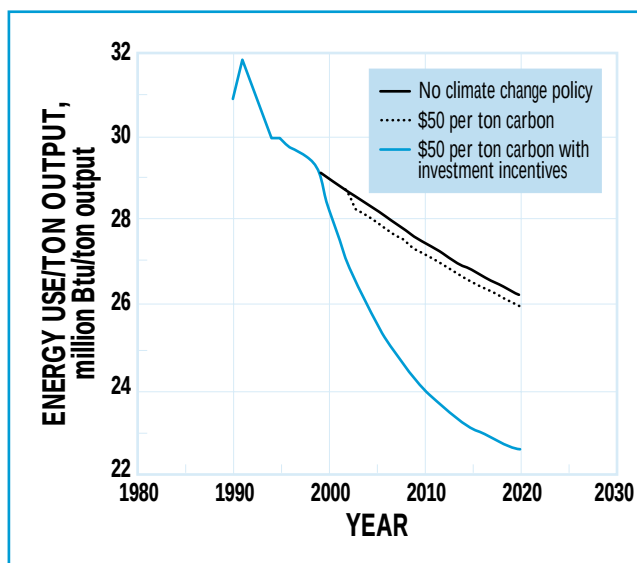


5. Rates of net carbon emissions in 2020 for alternative cost of carbon with and without investment incentives

Combined with a cost of US\$ 50 per ton carbon, investment incentives result in net carbon emission levels, as Table II and Fig. 4 show. Investment-led incentives can generate significant reductions in net carbon intensities over the gains stimulated by a cost-of-carbon policy. An increase in the cost of carbon by itself leads to significantly smaller energy savings and emissions reduction. The pulp and paper industry responses are time-delayed and follow “normal” procedures to retire and replace equipment.

Under the assumptions of an investment-led scenario that includes \$50/ton carbon—supported by an appropriate mix of incentives, information, and technical assistance, the same level of energy efficiency as that reached in the absence of climate change policies by the year 2020 is actually met 17 years earlier. Assuming only an increase in the cost of carbon without other investment incentives, efficiency gains accelerate by only three years. In all scenarios, total energy use increases in the long run because pulp and paper industry output rises at a rate that exceeds the rate of reduction in energy intensity, as Fig. 5 shows. In the investment-led policy scenario, total energy consumption temporarily declines. This is because the rate of energy efficiency improvement is greater than the growth in output.

Without climate change policies, energy expenditures will probably increase from US\$ 4.25 billion in 1990 to US\$ 5.49 billion in 2020. This implies that the pulp and paper industry will then spend US\$ 42.47 per ton of output on purchased energy. This is a decrease from US\$ 54.14 in 1990. All monetary values are in constant 1994 dollars. In comparison, a cost of US\$ 50 per ton carbon leads to total energy expenditures—less cost-of-carbon payments—in 2020 of US\$ 5.18 billion. This implies that



6. Total energy use per ton of output with and without climate change policies

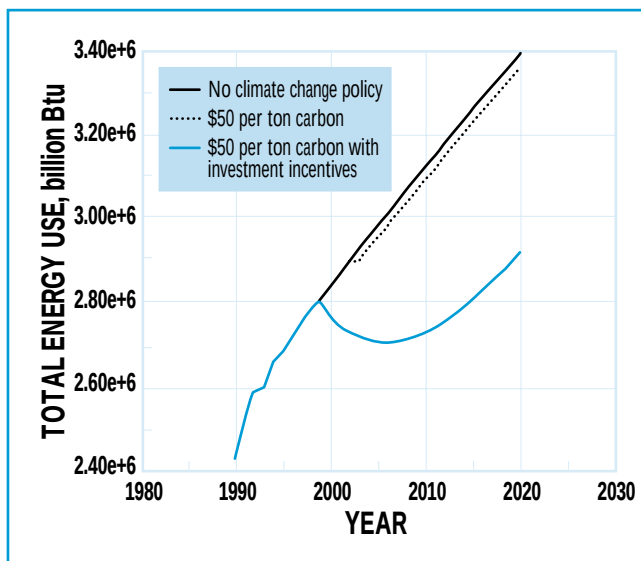
the pulp and paper industry will spend on energy US\$ 40.15 for each ton of output. If investment incentives are available with an increase in the cost of carbon by US\$ 50 per ton, total energy expenditures less cost-of-carbon payments in 2020 are US\$ 4.53 billion or US\$ 34.98 per ton of output.

Carbon emissions indicate trends similar to those energy intensities and total energy use, as Fig. 6 shows. Declines in carbon intensities in Fig. 7 in response to energy efficiency improvements and fuel switching are insufficient to balance increases in pulp and paper industry output. Figure 8 shows that total carbon emissions increase in the long run.

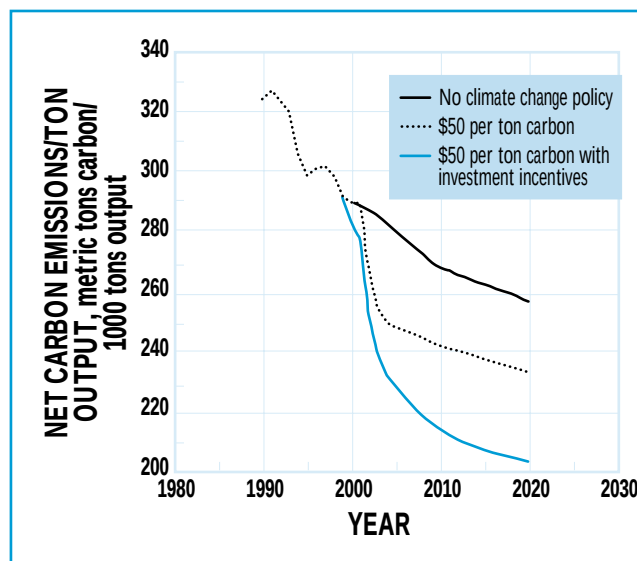
DISCUSSION

Climate change policy instruments such as an increased cost of carbon have frequently been proposed as tools to stimulate cost-effective reductions in industrial energy use and net carbon emissions. Simultaneously, a mix of investment incentives can noticeably increase adoption of efficient technologies to the benefit of both the pulp and paper industry and climate. This conclusion underscores the importance of including investment mechanisms that accelerate adoption of new technologies in any package of climate change policies.

A word of caution is important. Pulp and paper industry contributions to the atmospheric carbon budget will continue to increase if industrial production rises at rates that exceed the rates of technology improvement and carbon sequestration. The results of this study indicate that not implementing an investment-led climate policy would mean foregoing an opportunity to stimulate efficiency improvements in the pulp and paper industry and reduce net carbon emissions per ton of product. For example, the results show that an increase in the cost of



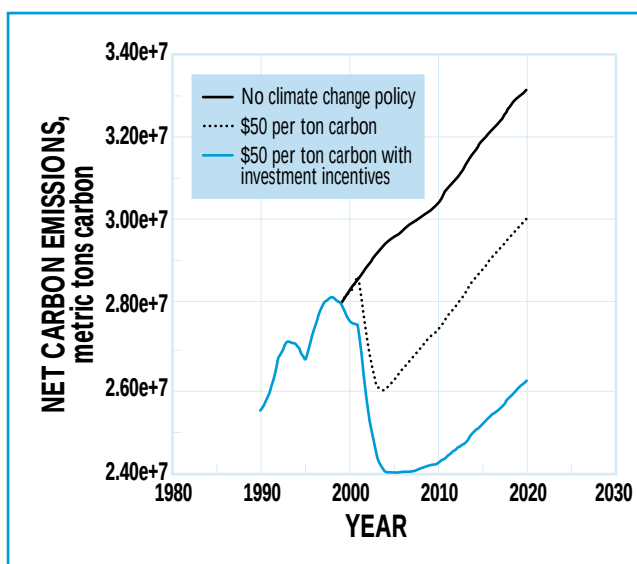
7. Total energy use with and without climate change policies



8. Net carbon emissions per ton of output with and without carbon change policies

carbon would leverage learning-by-doing in the industry and increase efficiency improvements.

In the absence of investment incentives, industrial responses occur most noticeably with a three to four year time lag following implementation of climate change policy. By 2020, efficiency improvements will be three years ahead of efficiency gains in the absence of new policies. With a series of “smart technology policies” to encourage investment in new technologies, industrial responses can be even quicker and stronger. An investment-led climate policy can lead to an accelerated technology gain by 17 years. Setting a policy sooner will therefore allow exploitation of previously unrealized efficiency potentials. Longer time to formulate and implement a policy will lead to generation of more uncertainty within industry about its optimum policy responses. Similarly, further delay in climate policy will increase the likelihood that the pulp and paper industry will become locked into an ultimately undesirable development trajectory. This will then require stronger policy incentives to meet a goal of stable or declining carbon emissions.^{TJ}



9. Net carbon emissions with and without climate change policies

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