

Impacts of Market-Based Greenhouse Gas Emission Reduction Policies on U.S. Manufacturing Competitiveness

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Executive Summary

The recently completed Kyoto Protocol requires that total emissions of greenhouse gases (GHG) from Annex I countries be at least 5 percent below 1990 levels by the 2008 - 2012 period.¹ Non-Annex I countries are not bound by the treaty. In the first phase, the U.S. would be required to reduce emissions of carbon dioxide, methane and nitrous oxide by 7 percent below 1990 levels by this time period. For carbon dioxide, this translates into a 31 percent emissions reduction from what it would have been in 2010 absent a treaty, based upon the latest projections by the Economic Information Administration, DOE.

Market-based approaches are proscribed by the Clinton Administration to meet the U.S. emission targets set by the treaty. While the administration has distanced itself from proposing new taxes, its call for a system of tradeable permits will impact the economy in much the same way as new taxes. A tax increase directly raises the price of products, tradeable permits ration the quantity of products thereby indirectly raising prices. The impact on the economy is similar for a given emissions target.

This paper informs on the impacts that such market-based mitigation policies could have on U.S. manufacturing competitiveness. More specifically, given that the treaty calls for mandatory emission reductions from Annex I countries only, U.S. manufacturing cost impacts are examined vis-a-vis those of both member and non-member countries. As an illustration of the former, cost impacts on U.S. energy-intensive goods are compared to those that would accrue to comparable Canadian goods assuming both countries are subject to mandatory emission controls. In the latter, U.S. competitiveness is assessed assuming that the production costs of industries in non-Annex I countries would not change. Finally, the report assesses the potential within-country regional impacts of market-based GHG mitigation policies. Such impacts are likely to be significant given the geographic variability of natural resource endowments, e.g., the abundance of hydro-power in the Northwestern U.S. and Canada, and the prominence of coal-generated electricity in the Midwestern States and Prairie Provinces.

While coverage is not geographically comprehensive, such a focus does allow for a detailed examination of the primary determinants that would drive relative cost changes. These determinants, illustrated in Figure ES-1, include relative energy intensities, carbon contents of fuels, and emission reduction targets (reflected in the magnitude of the market-based instruments). The cost impacts presented herein are based upon estimates of these determinants, developed in detail in the following chapters.

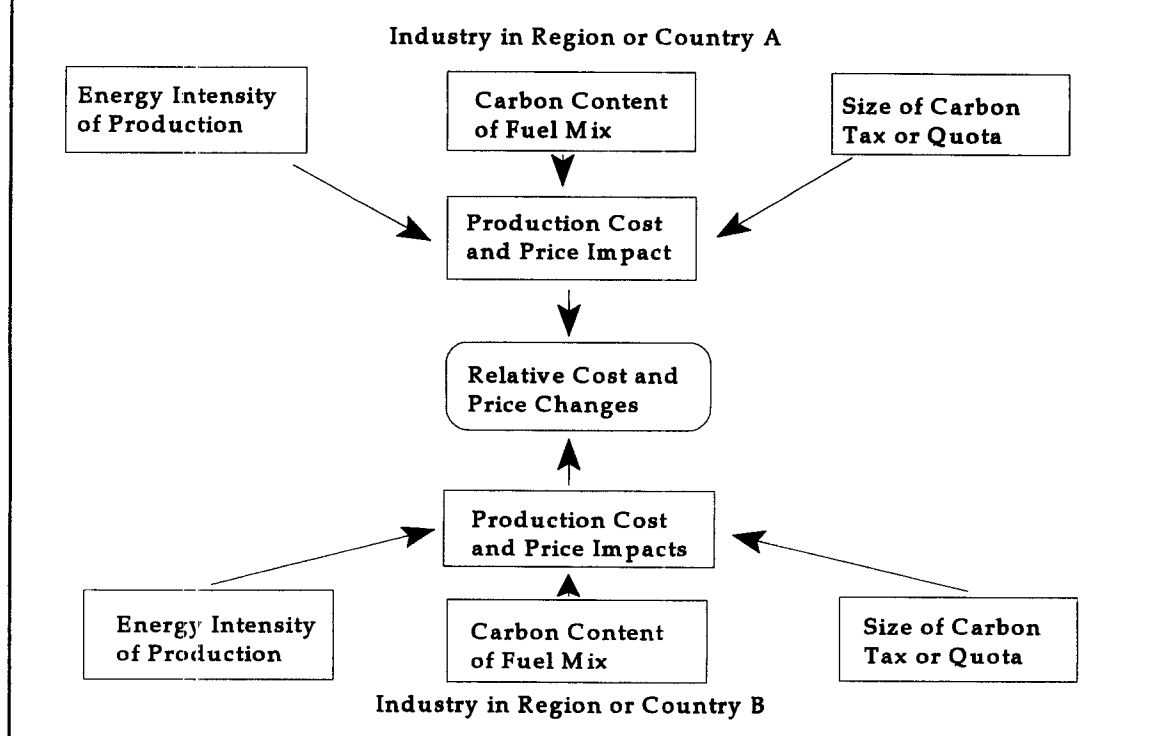
Such detail on industry energy use is often missing from large scale general equilibrium- and macro-model analyses of global warming initiatives. Though broader in scope than the analysis undertaken here, they typically employ a higher degree of sectoral aggregation, and hence exhibit a relative paucity of industry detail, particularly with respect to energy use and regional variability. As such, the transparent and detailed nature of this analysis serves to complement analyses stemming from larger models, and provides useful information on a timely issue given the increasing attention to issues of global warming and the growing importance of trade to economic growth.

Two emission targets are considered in this report, basing their tax rates upon those cited in the literature. In the first, a \$139 per metric ton (tonne) carbon tax (\$1994) is chosen as a representative estimate of the average annual tax rate over the 2000-2020 period required to stabilize carbon dioxide emissions at 1990 levels by the year 2020.² In the second scenario, a \$205 per tonne carbon tax is taken as a representative estimate of the average annual tax rate over the same time period required to reduce emissions 20 percent below 1990 levels by 2020. Importantly, all cost estimates in this report based upon the above stated emissions stabilization target are likely to understate the cost impacts that would result from the implementation of the recently completed Kyoto Treaty given that they are derived from a less stringent

¹Annex I countries include OECD countries as of 1991 plus member countries of the former Soviet Union.

²The economic impacts of policies to address emissions other than carbon dioxide, e.g., methane and nitrous oxide, though not considered here, are important. American agriculture generates roughly 40 percent of the annual U.S. emissions of methane and nitrous oxide. Emissions of these gases are slated to meet the same target as carbon dioxide under the Kyoto Protocol.

Figure ES-1 Primary Determinants of Production Cost Impacts of Market-Based Greenhouse Gas Emission Reduction Policies



emissions target.

Unit production cost impacts are estimated as the product of the energy intensity of production (quantity of energy per unit of output), the carbon content of the fuel mix used in production (quantity of carbon per unit of energy) and the magnitude of the carbon tax (monetary value per unit of carbon). These estimates should be interpreted as initial or near term since neither factor substitution nor rising prices of nonenergy intermediate goods are accounted for in the analysis.³ As such, they are intended to identify which industries would likely come under the most competitive pressure to dampen production cost impacts resulting from the implementation of mandatory emission reduction policies (e.g., through new capital investment). The industries examined include electricity, pulp and paper, iron and steel, nonferrous metals, industrial metals, chemical

products, and petroleum refining.

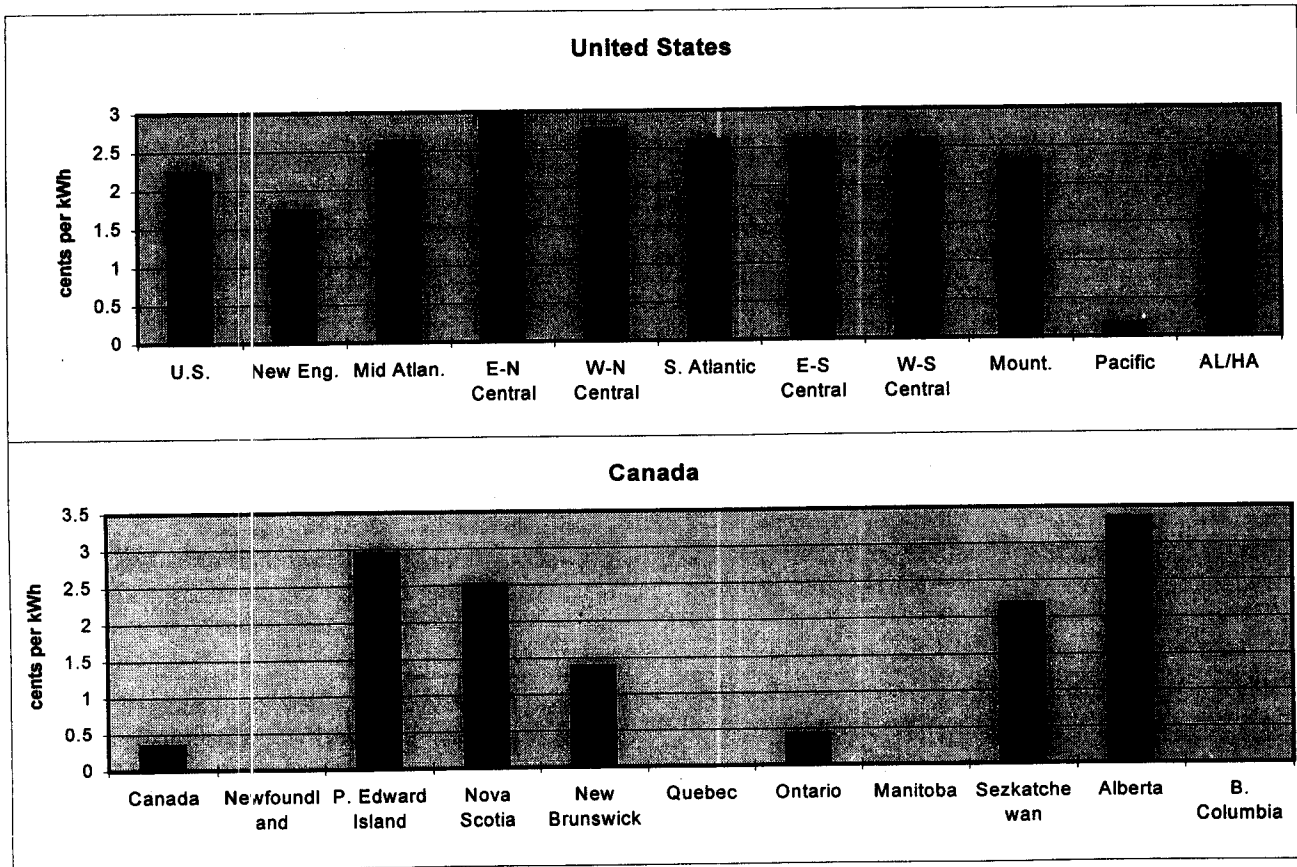
The average annual unit cost increases of electricity generation by region in the U.S. and Canada, given a market-based policy that returns emissions to 1990 levels by 2020, are illustrated in Figure ES-2. The national average U.S. rate increase is estimated to be 2.2 cents per kWh compared to a .3 cents per kWh increase in Canada. The large differential reflects Canada's relative abundance of hydro-power, and suggests one source of competitive disadvantage for U.S. industry, especially those which use electricity intensively such as aluminum or steel.⁴

Regional within-country variation in electricity rate increases would be significant in both countries, as well. The prominence of coal-fired utilities in the Midwestern U.S. and in the Prairie Provinces of Canada would result in rate increases between 2.5 to 3.3 cents per kWh. Regions with abundant hydro-power, i.e., the Pacific Northwest, British Columbia

³The two omissions work in opposite directions, i.e., not allowing for factor substitution results in an overstatement of cost impacts while not accounting for rising prices of nonenergy intermediate goods results in an understatement.

⁴Electricity rate increases are taken to equal estimated cost increases, i.e., full cost pass through is assumed.

Figure ES-2 Average U.S. and Canadian Electricity Rate Increases given a Market-Based Policy that Returns Emissions to 1990 Levels by 2020



Source: API calculations, 1997.

and Quebec, would face much smaller rate increases at less than .2 cents per kWh. Such variation illustrates a principal finding of this report, namely, that implementation of mandatory emission reduction policies will produce significant disparate impacts within as well as across national borders.

The cost impacts that would accrue to energy intense U.S. manufactured goods under the above described emissions stabilization policy, expressed in both absolute and percent of base price terms, are given in Table ES-1. The largest impacts in percentage terms would be faced by the lime and hydraulic cement industries, at 27 percent (\$17 per tonne) and 25 percent (\$15 per tonne) of base prices, respectively. Production costs of primary steel and primary aluminum are each estimated to increase by roughly 10 percent of their base prices, or \$60 per tonne and

\$138 per tonne, respectively. The cost of petroleum refining would increase by 6 percent of its base price, i.e., over \$9 per tonne or \$1 per barrel,⁵ and pulp and paper cost would increase by roughly 5 percent of its average base price assuming that self-generated fuels would not be taxed or rationed, or \$31 per tonne in absolute terms. Production cost increases of pulp and paper products would more than double if emissions from self-generated fuels were subject to control. Finally, the production cost of sawmill products is estimated to increase by roughly 3 percent of its average base price, or \$6 per cubic meter.

⁵The petroleum refining estimate accounts for only the increased cost of energy used in the refining process. Including the increased cost for the crude feedstock would greatly increase refining costs.

Table ES-1 Summary of Average Production Cost Increases on U.S. and Canadian Products from a Market-Based Policy Stabilizing Emissions at 1990 Levels by 2020 (USD per metric ton and percent of 1994 price, except where noted)

	U.S.	Canada	Relative Cost Impact (percent)
lime	17 (27.1%) ¹	18 (28.7%)	-6
hydraulic cement	15 (25.0%)	12 (20.0%)	25
primary steel	60 (10.8%)	43 (7.7%)	39
primary aluminum	138 (9.6%)	55 (3.8%)	152
petroleum refining	9 (6.1%)	8 (5.4%)	13
pulp&paper ²	31 (5.3%)	17 (2.9%)	83
sawmill products ³	6 (2.9 %)	2 (1.0%)	187

1. Numbers in parentheses are cost impacts as a percent of 1994 base prices.

2. Self-generated fuels and feedstocks not taxed.

3. Unit cost increased in USD per cubic meter.

Source: API calculations, 1997.

A detailed analysis of the chemical industry is undertaken in this report. As noted by the Argonne National Laboratory (1997), the U.S. chemical industry is currently very competitive on world markets due to its strong scientific and technical base, relatively low energy prices, access to large markets, and stable economic and political systems. This is reflected in the industry's \$16.9 billion in net exports in 1996, on par with net exports of food and feedstuff and exceeding that of civilian aircraft. Of concern in the global warming debate is whether its position as world leader could be put in jeopardy due to the implementation of a Kyoto type agreement that applies to Annex I countries only.

Discussion focuses on the cost impacts that would accrue to widely traded U.S. produced organic and inorganic chemicals. The results in Table ES-2 indicate that the largest cost increases, ranging from 4 to 15 percent of 1997 base prices, would accrue to various plastics (e.g. vinyl chloride, polystyrene), synthetic fibers (e.g., Nylon 6,6), chlorine, and agricultural fertilizers (e.g., anhydrous ammonia). The estimates assume that the major feedstocks used in the production process, i.e., natural gas, LPG, and crude oil, would not be subject to carbon taxes or market-based quotas.

Organic chemicals and plastics are major export components of the U.S. chemical industry. Organics comprised 27 percent of all chemical exports in 1995 while plastics comprised 17 percent (CMA, 1996). Estimates from the economic literature indicate that chemical market share is sensitive to price, i.e., producers face elastic demand on world markets (see, e.g., Shiells, Stern and Deardorff, 1986). Given the range of cost increases cited above (and assuming full

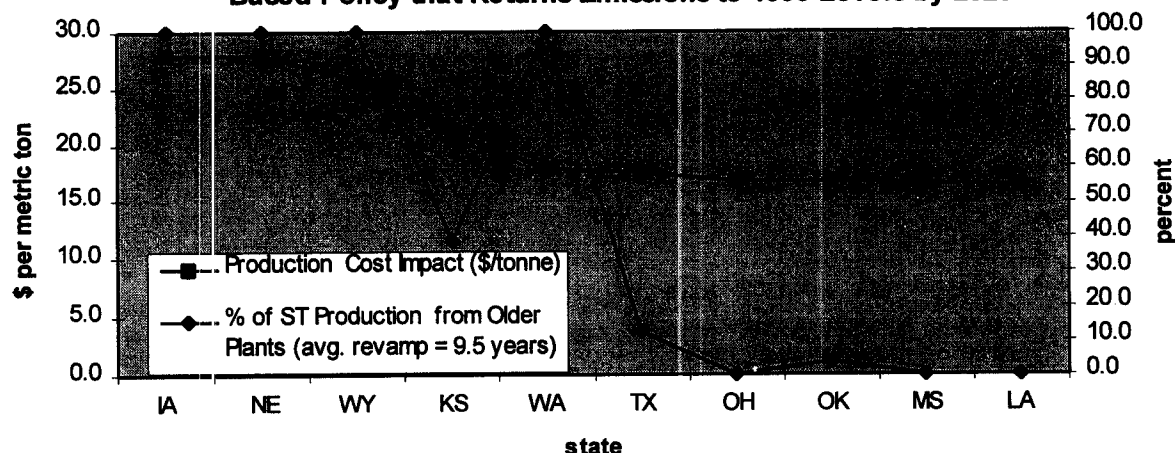
Table ES-2 Average Annual Production Cost Increases¹ on Selected U.S. Chemicals from a Market-Based Policy Stabilizing Emissions at 1990 Levels by 2020

	\$ per tonne	% of 1997 price
vinyl chloride	61	15.3
chlorine	34	12.1
Nylon 6,6	112	(n.a.)
anhydrous ammonia	19	7.4
polystyrene, GP	34	4.3
polyester resin	62	3.6

1. Feedstocks not taxed.

Source: API calculations, 1997.

Figure ES-3 Ammonia Production Cost Impacts by State given a Market-Based Policy that Returns Emissions to 1990 Levels by 2020



Sources: The Fertilizer Institute, 1997; API calculations, 1997.

cost pass through), a significant erosion in U.S. exports of organic chemicals and plastics could result. For example, estimates in this report suggest that exports of vinyl chloride, currently at 10.8 percent of national production, could shrink to 5.8 percent under a GHG mitigation target less stringent than that negotiated in Kyoto. The U.S. producers' share of the domestic chemical market could also be impacted. A rough estimate reveals that U.S. imports of anhydrous ammonia, primarily from Trinidad/Tobago, Canada, Mexico and Russia/Ukraine, could grow from 22 percent of domestic consumption to 27 percent.

Some regions would be hit harder than others, as illustrated for the case of agricultural fertilizer in Figure ES-3. Production cost increases of anhydrous ammonia would be highest in certain Midwest States, e.g., Iowa at \$28 per tonne, and lowest in the Gulf States, e.g., Louisiana at \$16 per tonne. Such differences reflect the greater fraction of older (and hence less energy efficient) plants in the Midwest compared to the Gulf Coast, as well as the relatively greater electricity rate increases that would be incurred there.

These results indicate that a significant relative cost advantage would accrue to producers of energy-intensive goods located in non-Annex I countries to the detriment of U.S. producers. The degree to which U.S.

producers could pass through costs to product prices would depend in part upon the scope of the greenhouse gas initiative. Cost pass through under the recently completed Kyoto Protocol would likely result in a loss of U.S. producers' market share to industries in non-Annex I countries. Equally unattractive, however, absorption of the cost increase by domestic industry could eventually result in a decline in investment within U.S. borders in response to declining profit margins in these industries.

As stated earlier, factor substitution was not accounted for in the analysis. Of relevance to the interpretation of the estimates is the extent to which cost impacts stemming from rising fuel prices could be mitigated through fuel substitution. As will be explained in greater detail in the main body of this report, data from the 1994 *Manufacturing Consumption of Energy* (DOE, 1997) indicate that the existing capability of industries to switch fuels, e.g., within 30 days without extensive equipment modifications and no interruption in production, is limited. Hence, in aggregate, the existing fuel switching capability of the U.S. manufacturing capital stock would likely not allow for a significant moderation in production cost impacts due to rising fossil fuel prices. Therefore, the industry cost estimates of this report are representative of the actual impacts that would be incurred given the implementation of market-based emission reduction

policies under the constraints of the existing capital stock. An implication is that U.S. investments in more energy efficient and less carbon using capital equipment and infrastructure would be required to achieve a significant dampening of the cost and market share impacts.

Policy makers are therefore correct to focus on the international trade impacts that could occur between Annex I countries and those not bound by the treaty. However, since two-thirds of U.S. international commerce is undertaken with other Annex I countries, it is also important to assess the potential trade impacts that could occur between Annex I countries themselves. Some have argued that the economic damage to the U.S. will be minor since other Annex I countries will also be making comparable emissions cuts. The results of this report run counter to such an assertion.

Production cost impacts of comparable Canadian manufactured goods are also given in Table ES-1. The results indicate that, with the exception of lime, U.S. production cost impacts would exceed those faced by Canadian producers given the implementation of an equal magnitude market-based policy on both sides of the border. This is a rather surprising result given that some U.S. industries appear to be more energy efficient than their Canadian counterparts, as will be seen in Chapter II. Part of the explanation is to be found in differences in the carbon contents of the fuel mixes combusted by industries in the respective countries. In addition, the electricity rate increases would be considerably smaller in Canada compared to the United States. A detailed industry accounting is given in the main body of this report.

The key results of this analysis suggest that due to unalterable differences in the natural resource endowments among countries, and barring some technological breakthrough or regulatory reform⁶ allowing for the provision of energy with carbon content approaching that of hydro-power at competitive prices...

- U.S. adoption of the Kyoto Protocol would unequivocally damage the competitiveness of U.S.

⁶ An example would be regulatory reform allowing for an increase in the share of nuclear power over the next several decades.

energy-intensive industries vis-a-vis those in non-Annex I countries. In addition, this report provides credible evidence that U.S. manufacturing competitiveness would decline relative to that in Canada;

- Significant disparate impacts would be created within as well as across national borders. Industries located in the Midwest would be hit particularly hard.

These results highlight the need for a thorough accounting of the trade impacts that could occur between the U.S. and its major Annex I trading partners before the U.S. commits to a Kyoto type agreement.

The key microeconomic parameters governing these results are differences in fuel carbon contents and energy intensities in the manufacturing and utility sectors by region at home and abroad. Both variables are functions of relative factor and output prices which in turn reflect consumer preferences, natural resource endowments, the technology set, and the existing regulatory environment.

Finally, achieving GHG emissions reductions by means other than market-based approaches, such as command and control or end-of-pipe abatement, would require investments and operating changes in a wide variety of industries. The costs of these alternative control strategies would likely be greater than those of market-based policies. Therefore, their associated aggregate trade impacts would be at least as large as (and most likely larger than) the aggregate impacts under market-based approaches for a given emissions target.

Disclaimer: For purposes of analysis and clarity of discussion, all price impacts estimated in this report are based upon the assumption of full cost pass through (which may or may not occur) and abstract from a discussion of transmission mechanisms connecting costs and prices. No pricing behavior on the part of any agent or industry is implied in the discussion.