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Climate policy and energy-intensive manufacturing: A comprehensive analysis of the effectiveness of cost mitigation provisions in the American Energy and Security Act of 2009

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ABSTRACT

In response to the ongoing climate policy debates, this study examines the cost impacts of carbon-pricing legislation on selected US energy-intensive manufacturing industries. Specifically, it evaluates output-based rebate measures and the border adjustment provision specified in the bill, and tests the effectiveness of cost containment features of the policy, such as the international offsets, under various market assumptions. Results of the examination confirm that in all policy cases or industries, the output-based rebates would effectively mitigate the manufacturers' carbon-pricing costs in the short-to-medium term. However as the rebates decline after 2020, especially in a case where low-carbon electricity generation or international offsets are not readily available or implemented, these industries would suffer greater declines in profitability. At the same time, the study's findings were mixed concerning the effectiveness of the border adjustment measure in reducing cost impacts after 2020. While border adjustments could reduce costs to US manufacturing sectors, at least temporarily, they could create problems for domestic downstream producers and exports, under cost pass-along conditions. However at best, the output-based rebates, international offset, and border adjustment and measures primarily buy time for manufacturers. The only long-term solution is for EITE industries to invest in energy-saving and next-generation low-carbon technologies.

1. Introduction

Although it now seems unlikely that Congress will soon produce a climate and energy bill, debate over the potential economic impacts of policies aimed at limiting the use of carbon-based fuels, especially on manufacturing, is likely to continue. In June 2009, the US. House of Representatives passed H.R. 2454, the American Clean Energy and Energy Security Act (*ACESA*) (US Congress, 2009). The *ACESA*, and a similar bill introduced in the Senate, include cost containment and cost mitigation measures to either directly limit or offset after-the-fact the cost impacts of carbon-pricing to ease the transition for certain segments of the economy. Energy-intensive trade-exposed (EITE) manufacturing industries especially are vulnerable because of their heavy fossil-fuel reliance and their sensitivity to foreign competition. In the US, the manufacturing sector has lost more than 6 million workers and 57,000 establishments of all sizes since 1998, and the US continues to have record trade deficits in goods and manufacturing.

With these concerns, the *ACESA's* cost mitigation provisions aimed at the EITE sector – output-based rebates and border adjustment tariffs – were designed to:

(1) Protect US manufacturers from competitive disadvantages from carbon-pricing.
(2) Provide a temporary respite from cost impacts to better enable EITE industries to make the transition to low-carbon production.
(3) Prevent the "carbon leakage" resulting from GHG-intensive production moving to countries with less stringent emissions limits.
(4) Encourage other countries to adopt climate policies and join climate agreements, and argue for trade-related measures in the bills.

Motivated by industry, labor and Congressional concerns about the economic impacts of climate legislation on manufacturers, the present study was conducted to examine the costs impacts of climate policies on EITE industries and evaluate

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mechanisms for mitigating these costs, building on two prior studies. These two studies focused on the methodology and model developed to carry out the analysis (Bassi et al., 2009), and on the evaluation of the impacts of the *Lieberman–Warner Climate Security Act of 2007* (S. 2191) (Yudken and Bassi, 2009). Based upon these studies, that primarily focus on the allocation of free allowances – in the US and Europe – and their consequences of the cost structure of US manufacturing sectors and the broader consequences on world markets, the current study evaluated the output-based rebate measure, for basic and alternative *ACESA* policy assumptions that directly or indirectly affect the economic impacts of emissions allowances in the selected US EITE industries. It further examined the effectiveness of the controversial border adjustment measure specified in *ACESA* to mitigate EITE industry costs, as the rebates decline and emissions allowance costs grow. The EITE industries analyzed include iron and steel and ferroalloy products (331111), primary aluminum (331312), paper and paperboard mills (32212), petrochemicals (325110) and alkalies and chlorine (or chlor-alkalies) (325181).

Specifically, the study examined the following questions:

(1) How effective would the output-based rebate measures be in mitigating the costs incurred by EITE industries under the various scenarios?
(2) How effective will border adjustment fees be in mitigating the costs incurred by EITE industries from a climate policy, especially after the rebates begin to fade?

2. Literature review

Most of the discussions and analysis on the climate debate so far has been supported by general equilibrium studies, and limited to economy-wide impacts of climate legislation. The US EIA and many other studies, by environmentalists and academic economists, mostly use general equilibrium models to evaluate climate policy impacts on broad economic indicators, such as GDP, total consumer spending and industrial output (EIA, 2006, 2008a, b, 2009a, b, 2010; EPA, 2010; Paltsev et al., 2007). Some involves distributional effects on the industries, yet mainly at a high level of sector aggregation (Morgenstern et al., 2004). The observations on modest macroeconomic impacts of GHG policies and potential significant losses of output and jobs in domestic industries was a key reason that the US Government has not ratified the Kyoto Protocol (Scott, 1997; Standard & Poor's DRI, 1998). Internationally, research on rebates and border adjustment measures, and other cost and leakage mitigation in carbon-pricing policies, also are going on in the European Union, Japan and Canada (Fischer et al., 2010). Most research on these issues employs top-down computable general equilibrium models, which lack disaggregation and tend to be quite static.

There have been a relatively small number of studies that conduct in-depth examination on how climate policies influence manufacturing industries, and a set of these existing studies are largely qualitative (EPA, 2007; MGI, 2007; Houser et al., 2008). Another set of studies attempts to quantify the policy impacts through modeling tools, using econometrics, input–output frameworks and System Dynamics (Morgenstern et al., 2004, 2007; Morgenstern, 2009; Ho et al., 2008; McKinsey/Ecofys, 2006; Reinaud, 2005, 2008; Ruth et al., 2000a, b, 2002, 2004; Davidsdottir and Ruth, 2005; Aldy and Pizer, 2009; Choi et al., 2010). This includes the Resources for the Future (RFF) studies that measure the impacts of carbon-dioxide charges on industrial competitiveness—in terms of operating costs, profits and production output (Morgenstern et al., 2004, 2007; Morgenstern, 2009; Aldy and Pizer, 2009). In addition, two detailed studies of the European Union Emissions Trading Scheme (EU ETS) focus on the competitiveness of narrower and more energy-intensive industrial categories in EU than traditional economic studies usually evaluate (McKinsey/Ecofys, 2006; Reinaud/IEA, 2005, 2008).

As Morgenstern observes, "information concerning industry-level impacts associated with new carbon mitigation policies is quite limited" (Morgenstern et al., 2007). Thus, only a few studies over the past decade have applied dynamic modeling tools to evaluate climate policies and their implications on the manufacturing sector, especially on energy-intensive industries (Ruth et al., 2000a, b, 2002, 2004; Davidsdottir and Ruth, 2005). Adding to this small group, a series of studies conducted by HRS-MI (Bassi et al., 2009; Yudken and Bassi, 2009, 2010) attempts to quantify the cost impacts of climate policies and evaluate mechanisms for mitigating these costs on EITE industries. The first study of this series ("L-W EITE") (Bassi et al., 2009; Yudken and Bassi, 2009) analyzed the impacts of the *Lieberman–Warner Climate Security Act of 2007* (S. 2191) on energy-intensive manufacturing industries—in particular, the iron and steel and ferroalloy products, primary aluminum and secondary smelting of aluminum, paper and paperboard mills, petrochemicals, and alkalies and chlorine.

On top of the two previous studies, this study evaluates the costs of the Waxman–Markey bill on the six EITE industries in the first study, and the potential effectiveness of the output-based allowance rebate measure in the *ACESA* to mitigate these costs. While the prior study's impact estimates were based on energy price differences between a core climate case and a business-as-usual or *BAU* case, the new study directly calculated the costs that industries would incur from the purchase of carbon-emissions allowances, and then the cost mitigation impacts of the output-based allowance rebates, closely following the rules to calculate allowances and rebates stipulated in the *ACESA*. Further, this study examines alternative *ACESA* policy scenarios and a border adjustment mechanism and international offsets provisions as specified in Waxman–Markey and their effectiveness sin mitigating cost increases for the industries selected. The methodology employed is based on modified models for the selected industries, developed and employed in the prior studies. Two alternative policy scenarios, which are compared to the *ACESA Basic* case, are analyzed. The first one assumes that non-carbon sources (nuclear, thermal with CCS, biomass) substituting for carbon-intensive fuels in electricity generation would have higher costs than in the *Basic* case (the *High Cost (HC)* case), and a second scenario that assumes that the use of international offsets *ACESA* – important for cost containment – would be severely limited (*No International Offsets (NIO)* case).

3. Methodology and analytical issues

3.1. Output-based rebates

The models and methodology employed in the Lieberman–Warner study (Bassi et al., 2009; Yudken and Bassi, 2010) are the baseline for the models employed for this study. Updating the Integrated Industry Climate Policy Model (II-CPM) from the earlier study involved the following:

(1) Updating of the financial, energy, industry and other data used in the II-CPM models, and recalibration of the II-CPM using this data. This includes financial data (value of shipments, materials, capital, labor, energy purchases) from the US Census Bureau's (2009) Annual Survey of Manufacturers (ASM); production, supply and other data from industrial statistical tables (AISI, 2010; Aluminum Association, 2010; AF&PA, 2010; ACC, 2009); industrial energy consumption from the Energy Information Administration's (EIA) Manufacturing Energy

Consumption Survey (MECS) (EIA, 2009d); industry trade data from the US International Trade Commission (USITC) (2009); and, market price projections from IHS-Global Insight (Global Energy Services, 2005).

(2) Characterization of the Reference (business-as-usual or *BAU*) and *ACESA* policy cases. Energy price projections through 2030 from the EIA *Annual Energy Outlook for 2009 (AEO2009)* (EIA, 2009a) were used to characterize the BAU case. Price projections for certain energy fuels (natural gas, coal) from the EIA analysis of the *ACESA Basic* case (EIA, 2009b, c) were incorporated to partially account for the supply-demand dynamics of fossil fuels that would result from enactment of this policy.
Analyzing the *ACESA Basic* case entailed estimating the costs incurred on the selected EITE industries from the purchase of greenhouse gas (GHG) emission permits, and the cost mitigation impacts of the output-based allowance rebates, closely following the method to calculate allowances and rebates stipulated in *ACESA*. These included the following steps:
   - *Calculation of industry GHG (CO_2-equivalent) emissions for each industry*. This method directly converts energy consumed by the industries (from MECS) into GHG emissions—from fossil fuels (coal, coke, natural gas, residual and distillate fuel oils) directly combusted or used as feedstock in industrial processes, and the indirect emissions associated with electricity purchased by industrial enterprises (EIA, 2009d; Yudken and Bassi, 2009; IPCC, 2006).
   - *Calculation of production-based allowance costs for each industry*. These are the costs incurred by each industry from the purchase of GHG allowance permits to cover their GHG emissions for each year, as required by the *ACESA* policy. This entailed multiplying the industries' emissions levels by the emissions allowance prices generated by EIA analysis of the *ACESA Basic* case, using the National Energy Modeling System (NEMS) (EIA, 2009d).

(3) Calculation of the output-based rebate allocations for each industry. (This excludes the secondary aluminum industry, which under ACESA EITE eligibility requirements would not receive output-based rebates.) *ACESA* was designed to cover 100% of the production-based emissions allowance costs for each EITE industry in early years and then steadily fall off, covering a declining share of these costs over time, starting in 2014. It would provide a limited amount of free allowances each year to the EITE industries – up to 15% of all allowance permits in the economy. This number would begin to decline in 2021 – falling sharply after 2025 to zero by 2035. The II-CPM dynamically simulated the output-based rebates to each industry by calculating the yearly shares each would receive of this overall allocation, based on their shares of total emissions (direct and indirect) generated by EITE industries (EPA, 2009; Schipper, 2006).

(4) Industry simulations of *ACESA* impacts. The updated II-CPM simulated the impacts of the *ACESA Basic, High Cost* and *No International Offsets* cases (EIA, 2009a, b) on key economic variables (production costs, operating surplus) for the six industries. Only no cost pass-along (NCPA) scenarios were simulated. These reflect a worse – but also a more likely – case that these industries would experience with passage of the climate policy (Yudken and Bassi, 2009):
   - *The ACESA High Cost (HC)* case is similar to the *Basic* case except the costs of nuclear, fossil with CCS, and biomass generation are 50% higher (Yudken and Bassi, 2010).
   - The *ACESA No International Offsets (NIO)* case is similar to the *Basic* case but assumes the use of international offsets is severely limited by cost, regulation, and/or slow progress in reaching international agreements on offsets.

(5) Estimates of energy-efficiency requirements to offset cost impacts. Based on the simulation results, estimates were made of the energy-efficiency gains required to offset the added costs from *ACESA* relative to *BAU*, for each industry, on top of an assumed baseline 0.5% yearly energy efficiency improvement.

3.2. Border adjustments

3.2.1. Assumptions

The *ACESA*'s border adjustment (BA) measure would require importers of EITE goods from countries without GHG reduction polices comparable to the United State to pay fees on their carbon-intensive products to gain entry into US markets. However, because *ACESA* was somewhat vague in specifying the design and implementation of the BA measure, this study made several assumptions regarding key features in the provision:

(1) *The BA fees added to non-climate compliant country imports would be based on the carbon content of domestic products of covered industries.*
To simulate the most optimistic scenario, the HRS-MI models assumed that BA fees applied to imports would equal the *total* production-based emissions costs of US producers, not the *net* allowances that take into account rebates. Under this assumption, foreign importers could face higher added costs associated with the BA fees, compared to domestic manufacturers' added costs.

(2) *Only US EITE industries will be eligible for the protection of BAs applied to importing countries that fail to meet criteria specified in ACESA.*
The *ACESA* specifies that if *more* than 85% of US imports of covered goods were produced in countries that comply with criteria indicating they have a GHG mitigation policy as stringent as in the United States, the BA measure would not apply (H.R. 2454) (US Congress, 2009). According to these criteria, with some simplifying assumptions, for any eligible EITE industrial sector (see Table 1):
   - *Compliant countries* refer to importing countries that are assumed to meet one or more of the comparability criteria in *ACESA*. For analytical purposes, all Annex I countries were deemed comparable and Non-Annex I countries were deemed non-comparable, though in reality the actual breakdown might be different.
   - *Non-compliant countries* are nations that do not meet these criteria.
   - *Rest of the World (ROW) countries* include countries exempted from the BA requirements, aside from compliant countries, that according to *ACESA* qualify as least developed countries as identified by the United Nations.

(3) *The study modeled scenarios assuming the BAs would first be applied either in 2020 or in 2025* (H.R. 2454) (US Congress, 2009).

3.2.2. Policy cases

As different assumptions about the pass-along behaviors of the US. EITE industries would influence the impacts of BA measure, two scenarios are examined based on behavioral assumptions about these manufacturers' passing-along their emissions allowance costs to output market prices.

The scenarios modeled for each assumed starting year, 2020 and 2025 include (Table 2):

- *No Cost Pass-Along (NCPA BA) Scenario*: Assumes BA fees would be added to the prices of non-compliant country imports for an industry's products, but US, compliant country and ROW manufacturers do not raise their prices above the prevailing

Table 1
List of main compliant and non-compliant countries, and the shares of imports in each country group for selected EITE industries.

Industry	Primary aluminum	Iron & steel	Paper & paperboard	Petro-chemicals	Chlor-alkalies
Percent of imports [General imports—custom value ($) cumulative 2004–08]					
Compliant countries (%)	63.7	39.5	90.5	81.5	63.1
Non-compliant countries (%)	*35.1*	*52.9*	*8.6*	*14.4*	*32.8*
ROW (%)	1.2	7.6	0.9	4.1	4.1
Top importing countries					
Compliant countries	Australia, Canada, EU-15, New Zealand	Australia, Canada, EU-15, Japan	Australia, Canada, EU-15, Japan, Norway, Switzerland	Canada, EU-15, Norway,	Canada, EU-15, Japan
Non-compliant countries	Argentina, Bahrain, Brazil, China, Mexico, Russia, South Africa, UAE, Venezuela	Argentina, Brazil, China, India, Kazakhstan, Korea, Mexico, Russia, South Africa, Taiwan, Turkey, Ukraine, Venezuela	Brazil, China, Indonesia, Korea, Mexico	South Africa, Venezuela, Libya, Turkey, Nigeria, Brazil	China, Korea, Mexico, Romania, Taiwan

Data source: USITC.

Table 2
Summary of scenarios.

Output-based rebates, alternative policy scenarios:
BAU
ACESA Basic
with output-based rebate, no costs passed along
without output-based rebate, no costs passed along

ACESA High Cost (HC)
with output-based rebate, no costs passed along
without output-based rebate, no costs passed along
– Similar to the Basic case except the 50% higher power generation costs for nuclear, fossil with CCS, and biomass

ACESA No International Offsets (NIO)
with output-based rebate, no costs passed along
without output-based rebate, no costs passed along
– Similar to the Basic case but assumes very limited use of international offsets

Border adjustment measure:
No border adjustment measure, No cost pass-along (No BA, NCPA)
No cost pass-along (NCPA BA)
BA starting 2020
BA starting 2025

Cost pass-along (CPA USA BA)
BA starting 2020
BA starting 2025
– Non-compliant countries raise import prices (equal to BA fees based on the full production-based emissions allowance costs)
– US, ROW and compliant country industries do not raise prices above domestic market price

Cost pass-along (CPA USA BA)
BA starting 2020
BA starting 2025
– Non-compliant countries raise import prices (equal to BA fees based on the full production-based emissions allowance costs)
– US, ROW and compliant country industries raise prices (equal to total production-based allowance costs *less* output-based rebates)

domestic market price in a given year. The BA fees added to non-compliant country imports for each industry would be equal to the total production-based emissions allowance costs incurred by the industry for a given year.

- *Cost Pass-Along (CPA USA BA) Scenario*: Assumes that BA fees based on the full production-based emissions allowance costs would be added to non-compliant countries' import prices. In this case, each US industry would raise its prices equal to the net allowance allocations costs it incurs – total production-based allowance costs *less* output-based rebates calculated for a given year – according to the *ACESA*. Non-compliant importers would incur tariffs that increase their prices higher than US producers would raise their prices if they passed-through their allowance costs. Compliant countries and ROW countries would not raise their prices, however, in this scenario. It is worth mentioning that in reality the effect of the cost pass-along in the short term depends on the availability of domestic and imported substitutes and the aggregate income level, which will tend to increase demand for imported goods (comparatively cheaper), in the absence of a BA feature (Rathmann et al., 2010).

4. Summary of findings

4.1. Output-based rebates

4.1.1. Allowance rebates and cost mitigation

The simulations of the *ACESA Basic Case* impacts on EITE industries show that:

- Over the short-to-mid term, allowance rebates would substantially mitigate the costs of emissions permits on the production costs and operating surpluses of the industries.
- Cost mitigation would diminish as the allowance rebates start phasing out in 2020, with a sharp drop after 2025—paralleled by rising economic costs, though the extent and nature of these impacts would vary by industry.

Fig. 1 (and Table 3) illustrates the impacts of emissions allowance costs and rebates on the production costs structures of industries (for steel, in this case) through 2030. The additions at the top of the columns from 2012–2030, represent, (i) the impacts

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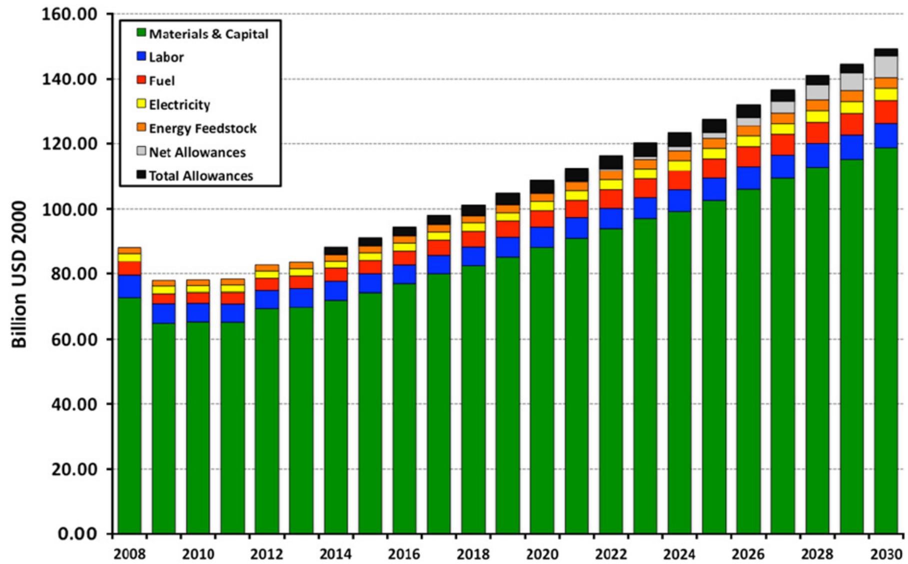

Fig. 1. Iron and steel industry cost structure (in billion US$2000).

Table 3
Summary of results—*Basic case*, with and without allowance rebates.

Industry [NAICS]	Energy cost share[a] (2008)	Primary energy sources	Emissions characteristics		Production costs (% above BAU)				Operating surplus (% above BAU)			
			Energy type	% Industry emissions (2012)	No allocation		Allocation		No allocation		Allocation	
					2020	2030	2020	2030	2020	2030	2020	2030
Primary aluminum [331312]	36.0%	NG, Petrocoke, RFO, Elect	Fuel Feedstock Electricity	4.3 44.3 51.4	10.8	18.3	−0.2	13.6	−23.8	−59.6	0.5	−44.0
Secondary aluminum [331314]	4.4%	NG, elect	Fuel Electricity	38.2 61.8	1.3	2.0	–	–	−5.0	−9.3	–	–
Iron & steel [33111]	10.0%	Coal, coke, NG, RFO, Elect	Fuel Feedstock Electricity	35.8 35.4 28.7	3.6	5.8	−0.1	4.3	−11.6	−18.4	0.3	−13.6
Paper & paperboard [32212.3]	13.1%	Coal, NG, RFO, Elect	Fuel Electricity	58.3 41.7	4.8	8.9	−0.2	6.5	−13.4	−36.9	0.5	−27.1
Petro-chemicals [325110]	19.0%	NG, LPG, RFO	Fuel Feedstock Electricity	15.5 76.7 7.9	3.5	6.9	−0.1	5.2	−4.2	−8.7	0.1	−6.5
Chlor-alkalies [325181]	45.9%	NG, coal, LPG, Elect	Fuel Electricity	57.3 42.7	9.2	13.4	−0.6	9.6	−18.9	−31.4	1.3	−22.4

Note: NG = Natural Gas; RFO = Residual Fuel Oil; LPG = Liquefied Petroleum Gas; Elect = Electricity; Petrocoke = Petroleum Coke.

[a] Energy share of production costs.

of an allocation rebate program in place (gray), and (ii) the full impacts of emissions permit costs without an allocation rebate, on the production costs (black + gray).

Fig. 2 compares production cost impacts relative to *BAU* for all the industries, from H.R. 2454 with the allocation (see also Table 3). The II-CPM projects 7 years of almost no impacts – the rebates completely cover emission costs – and then a steady rise, and subsequent acceleration in costs after 2025 assuming no significant energy efficiency is in place by that time. Primary aluminum would suffer the largest cost rises, followed by chlor-alkalies, and paper and paperboard. Iron and steel and petrochemicals would experience more modest impacts relative to *BAU*, according to II-CPM projection.

As with the production costs, in the II-CPM simulations show that the industries would suffer few cost impacts on their operating result for the first eight years (see Table 3). The industries' operating surpluses then would shrink from 2020 on, with larger drop-offs after 2025.

As summarized in Table 3, the varied impacts of *ACESA* on the industries reflect different market factors that influence market prices, input costs, and market demand and different patterns of energy consumption (fuels, electricity, and feedstock energy) and associated emissions. Fig. 3 illustrates the relationship between an industry's market price, which is a reflection of its overall market conditions, and production costs and resulting operating surplus trends, comparing the allocation and no-allocation policy scenarios to *BAU*. For industries whose market prices are projected to trend high or show only small declines relative to *BAU* production costs – possibly implying expectations of strong demand and markets – the operating surpluses will be larger and less easily weakened by rising policy-driven costs. Conversely, a

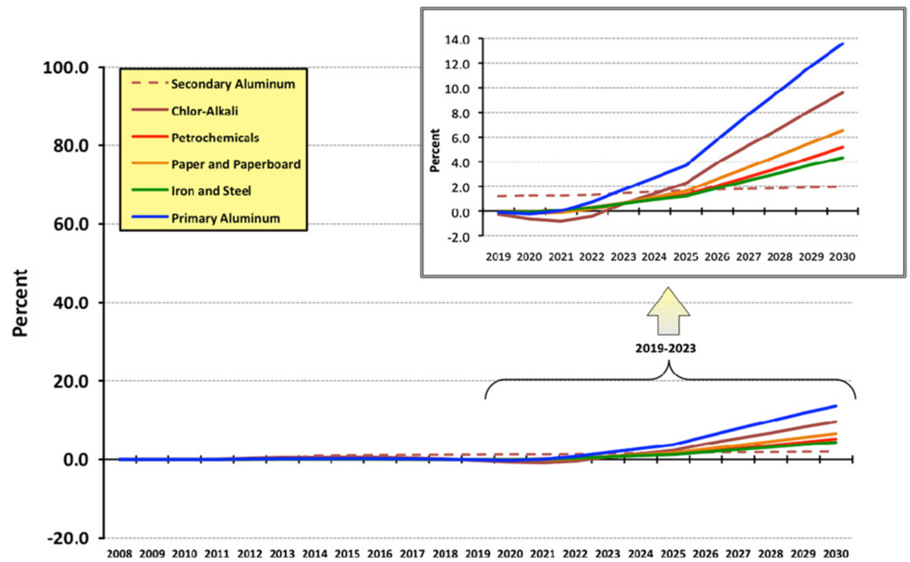

Fig. 2. Production costs above *BAU*—all industries, Allocation Scenario.

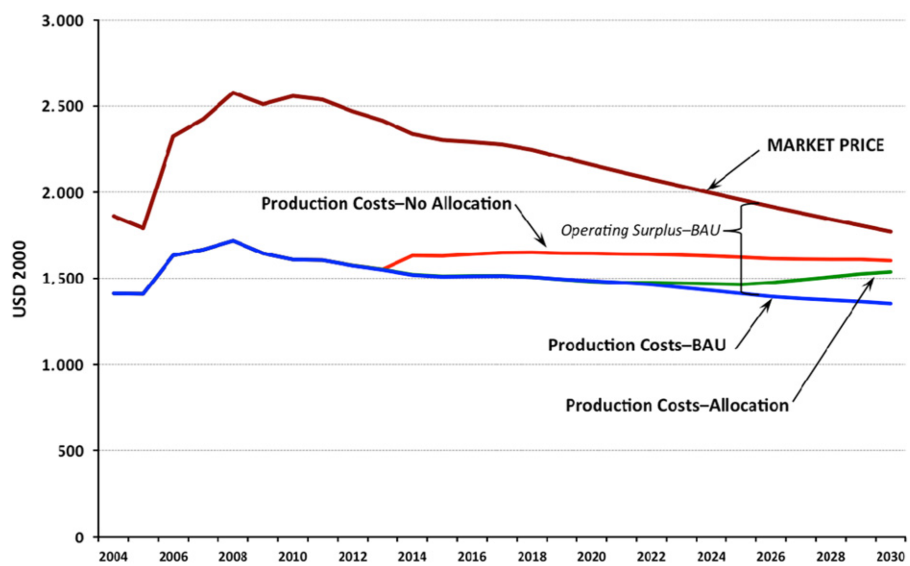

Fig. 3. Primary aluminum production costs and operating surplus.

declining market price relative to *BAU* costs – indicating weakening demand and perhaps supply overcapacity – would result in shrinking operating surpluses, which could be exacerbated by increased costs due to a climate policy. These results assume only standard energy efficiency gains of 0.5% per year.

Fig. 4 shows estimates of energy-efficiency gains that would be required, for a given year, to offset the added costs of *ACESA* from 2012–2030, for each industry (a breakdown of the gains required for the three main energy types—fuels (for heat and power), feedstock energy, and electricity (purchased, and source of indirect emissions) is applied). The method of calculation used estimates the energy-efficiency gains (percent of Btus reduced relative to *BAU*) required for a given year, for the energy types, assuming only minor yearly efficiency gains of 0.5% are made in prior years.

Fig. 5 provides a closer look, showing the efficiency gains required to offset the cost impacts from *ACESA*, for the allocation and no allocation scenarios for iron and steel. The no allocation requirements not surprisingly are somewhat larger than the allocation scenario requirements. Nearly zero efficiency gains would be needed through 2020 for the allocation case, and modest to large gains would be required for the no allocation scenario, depending on the industry. However, by 2030, because of the rapid decline of rebate coverage and growth of emissions costs, the no allocation requirements are only a little higher than for the allocation case.

The size of the requirement must be weighed against the baseline energy costs of an industry, however. For example, it appears that secondary aluminum would require large efficiency gains to offset the costs it would incur if it had to purchase emissions permits. However, its energy costs are under 5% of its production costs, and perhaps not until 2030 would the added costs be large enough to warrant the industry considering making significant investments in energy savings.

4.1.1.1. Alternative policy scenarios. As shown in Fig. 6a and b, which present results for an average of the industries (not including secondary aluminum, as it would not receive rebates) weighted by the industrial production outputs, the economic impacts of the alternative cases would begin to deviate from the

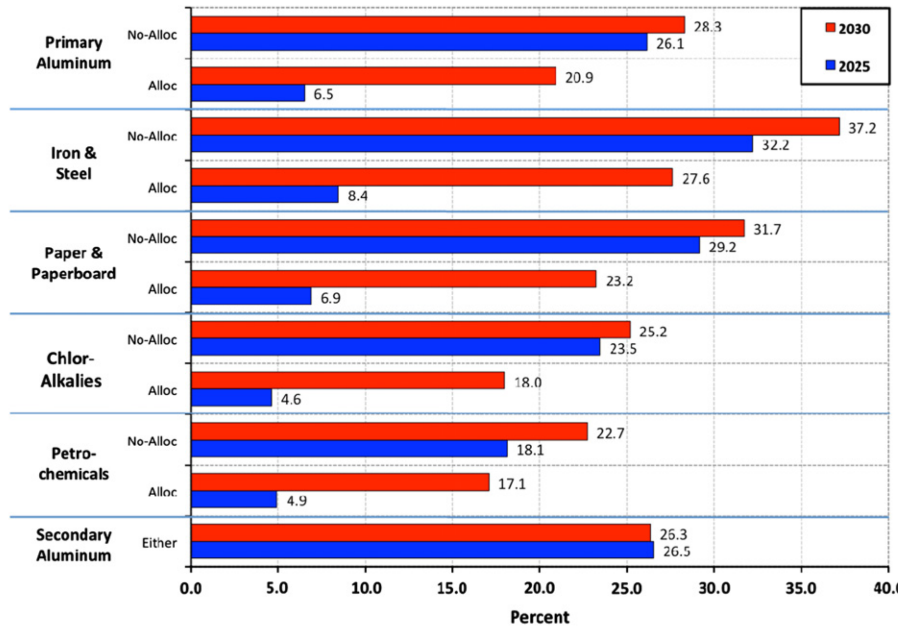

Fig. 4. Total energy efficiency gains required (percent).

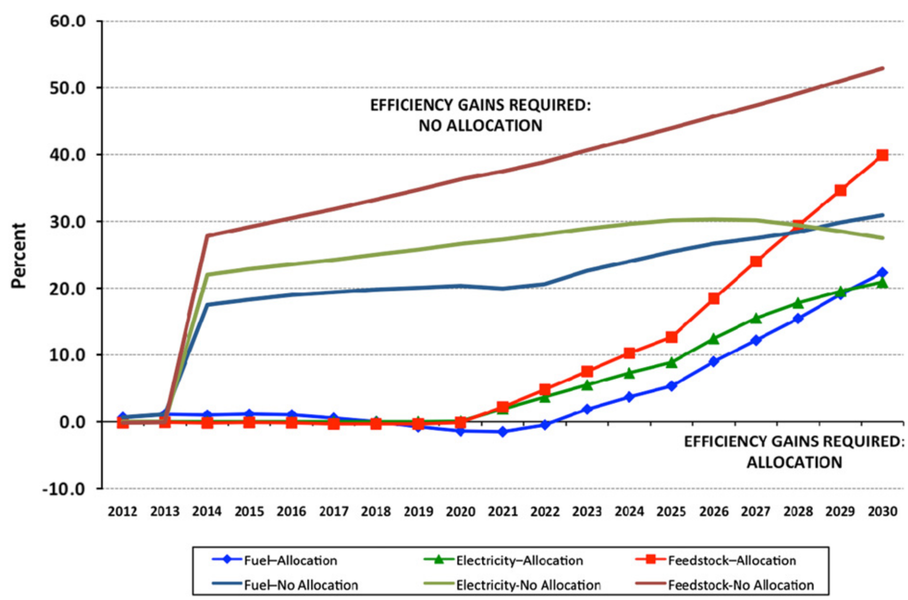

Fig. 5. Energy efficiency gains required, iron & steel industry, Allocation and No-Allocation Scenarios.

Basic case starting around 2020, as the rebates decline and cover less of the industries' emissions costs. The results indicate that if low-carbon electric power alternatives or international offsets were not readily available, the impacts would be greater than in the *Basic* case, especially after 2025. Specifically:

(1) Regardless of the policy case and EITE industry, *without rebates*, production costs would start growing – and operating surpluses would decline – in 2014 accelerating substantially by 2030, relative to *BAU*. The greatest impacts would occur in the *NIO* case, followed by the *HC* and *Basic* cases.

(2) *With rebates*, the EITE industries would be protected from significant emissions allowances costs until around 2020–2022, for all the cases:
   - The *HC* impacts would start growing, surpassing those of the *Basic* case, around 2020, rising at an even faster rate after 2025.
   - The *NIO* impacts would fall *below* those of the *HC* and *Basic* cases between 2020 and 2025 – production costs would dip below and operating surpluses would rise above *BAU*, 2020–2022 – before surpassing and growing beyond the *Basic* case and *HC* case impacts in 2025 or after.

The impacts on the individual industries would follow a similar pattern, reflecting the affect of allowance prices associated with the different cases, emissions levels, and energy costs and prices associated with the fuels consumed by each industry:

- The *NIO* impacts would be greater for industries with high direct emissions (and allowance costs), such as steel, petrochemicals, and paper and paperboard.
- The *HC* impacts would be largest for electricity-reliant industries—coal-powered electricity, and therefore emissions, are greatest in the *HC* case.

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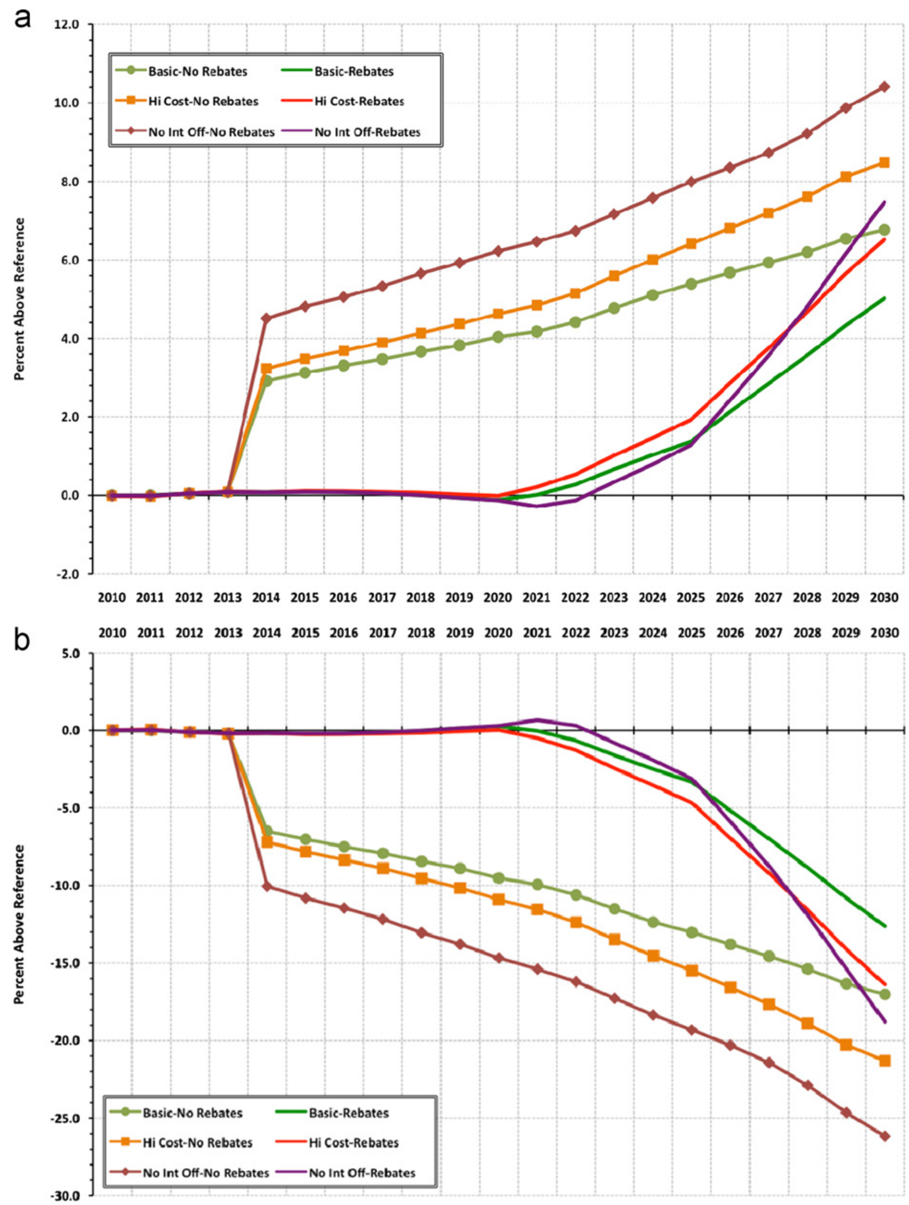

Fig. 6. (a) EITE industries (5-industry weighted average) production costs, percent above BAU, all policy cases. (b) EITE industries (5-industry weighted average) operating surplus, percent above BAU, all policy cases.

These different results under the policy cases primarily reflect three factors affecting the impacts of policies on the US. EITE industries: the allowance prices associated with the different cases, the emissions produced and the energy costs associated with the fuels consumed by each industry. The latter, in turn, are affected by projected fossil-fuel prices, especially those of coal and natural gas.

4.1.1.2. Allowance price impacts. For the weighted mean of the selected *EITE* industries, *NIO* production costs would grow at a faster rate – and *NIO* operating surpluses would rapidly fall – compared to the *Basic* and *HC* cases after 2025, reflecting the relatively higher allowance price trend for the *NIO* case relative to those of the other cases. Similarly, the *HC* impacts would start to grow relative to the *Basic* case in 2020, and spike upwards from 2025 on – though, for some industries, faster than the *NIO* case as well – *because* of high allowance prices.

4.1.1.3. Emission cost impacts. The amount and sources of emissions from each industry's production naturally influences the modeling results, especially after 2025. The emissions – and related allowance costs – associated with electricity generation for example, would diminish under any of the climate policies, as fossil fuel (coal, natural gas, oil)-generated electric power are replaced by non-carbon sources (renewables, nuclear power). In the *NIO* case, coal use for electricity would be dramatically reduced compared to the other cases, and *BAU*. This would be true, to a lesser extent, for the *Basic* case, as well. For all the industries, coal-generated electricity emissions therefore would be higher in the *HC* case relative to the *Basic* case, which in turn would be higher relative to the *NIO* case.

The biggest changes would be apparent in the electricity-reliant primary aluminum and chlor-alkalies industries, whose indirect emissions – generated by the electricity consumed in their production (for smelting and electrolysis, respectively) – represent the major portion of their total emissions—55% and 44%, respectively, in 2008. By 2030, however, electricity emissions in the *NIO* case would fall to only 14% and 11% of total emissions, respectively, substantially lower than *BAU* in both industries.

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In the *HC* cases, by contrast, the electric power share of emissions for the two industries would be 41% and 33%, respectively. As a result, *total* emissions for the two industries in the *NIO* case would be 56% and 36% *less* than *BAU,* respectively, in 2030, but in the *HC* case, *total* emissions would fall by only 18% and 15%, respectively, relative to *BAU*. The same pattern would be replicated for all the industries, though not to the same degree.

In short, the production costs and operating surpluses after 2025, for each industry, would depend on the combined effects of the relative allowance prices and emissions levels of the different cases. Allowance prices would be substantially higher and rise with time in the *NIO* case relative to the *HC* case, whose prices in turn are greater than for the *Basic* case. However, emissions levels would move in the opposite direction across the cases, falling substantially in the *NIO* case relative to the *Basic* case, which in turn would be lower than those in the *HC* case.

For example, in primary aluminum, production impacts in the *NIO* case would not catch up with those in the *HC* case (at least by 2030) reflecting the large reduction in coal-generated electricity emissions in the former case compared to the latter, which would not be offset by the higher allowance prices of the *NIO* case. In the iron and steel industry, on the other hand, the drop in coal-based emissions associated with electric power would not be as great, and high allowance prices would push the *NIO* impacts higher than the *HC* impacts in 2027 (Fig. 7).

4.1.1.4. Fuel mix and energy price impacts. Between 2020 and 2025, the fuel mix and fuel prices would strongly influence the relative impacts of the policy cases. Both coal and natural gas prices would vary with the demand and supply fluctuations of the two fuels across the economy. Over time, both sets of prices would decline in the policy cases, as coal and natural gas consumption for electric power generation, in particular, would fall due to substitution by non-carbon fuel sources—the extent of which, however, would vary by policy case. As a result, energy costs in each of the policy cases would *fall* relative to *BAU* especially after 2020, which when combined with the allowance costs would produce a small negative blip between 2020 and 2023 in the *NIO* case. The smaller energy costs for the policy cases relative to *BAU*, especially in the *NIO* and *Basic* cases, bring down the costs curves relative to the *HC* case, and to *BAU*, though the large, growing net allocation costs (as the rebates shrink) swamp energy price affects after 2025.

4.2. Border adjustments

While the ACESA I analysis of the output-based rebate provision (Yudken and Bassi, 2010) showed that the economic impacts on the EITE sector would be effectively mitigated through at least 2020 in all the policy cases, the study's findings are decidedly mixed concerning the effectiveness of the border adjustment (BA) measure (the International Reserve Allowance program) in reducing cost impacts after 2020.

4.2.1. Results of the border adjustment measures

Not surprisingly, the results show different cost mitigation impacts from starting the BA program in 2020, as rebates would begin to scale-down, and in 2025 when rebates would start to decline rapidly and allowance costs accelerate for the industries. However, cost-pass along behavior of US manufacturers in response to the BA measure would result in greater differences in cost mitigation impacts for the EITE industries. More specifically:

Regardless of the industry and behavioral assumptions, if the measure went into effect in 2020 than in 2025, the cost mitigation effects from the BA measure would be greater—smaller reduction in operating surplus and higher gains of domestic market share. However, the differences also would be noticeably greater for the cost pass-along (*CPA USA BA*) than the no cost pass-along (*NCPA BA*) scenarios (see Table 4).

- In the no cost pass-along (*NCPA BA*) scenarios, the cost mitigation impacts after 2020 would be very modest, swamped by cost increases after 2025, as rebate offsets diminish and production-based allowance costs grow.
- These impacts only would be noticeable for the iron and steel industry (Fig. 8) – which would enjoy an additional two years of cost mitigation in the scenario starting 2020 – and to a lesser extent primary aluminum, reflecting the non-complaint nations' high share of domestic imports (see Table 1).
- If the US industries passed along their costs (*CPA USA BA*), all except primary aluminum would have positive operating surpluses by 2030. Chlor-alkalies would see the largest operating surplus gain, of over 5%, followed by paper and paperboard, with 2% above *BAU* (Table 4, Fig. 9).

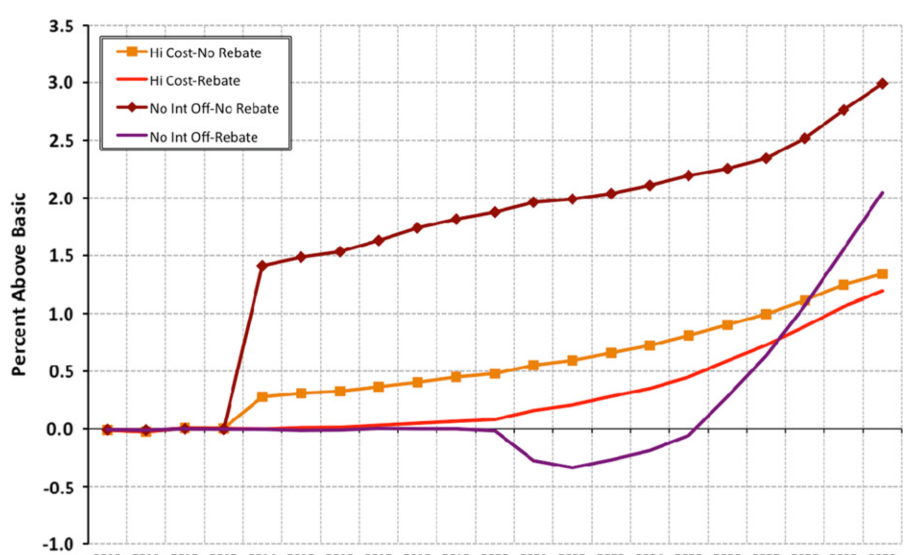

Fig. 7. Iron and steel production costs, percent above basic case, HC and NIO cases.

- Domestic market share gains in the *CPA USA BA* scenario would be smaller than in the *NCPA BA* scenario; except for iron and steel, the industries would see declines after 2025, and by 2030 they would suffer small market share losses (see Table 4).

4.2.2. Caveats and issues of BA findings

However, there are several caveats and issues that must be considered in interpreting these findings:

(1) *Compliant country import shares*. The high import shares of compliant countries compared to the non-compliant countries for the US EITE industries would limit the cost mitigation effects of the BA measure in the NCPA scenarios.

(2) *Future non-compliant country imports*. If non-compliant major developing countries' import shares – e.g., China, India and Brazil – grow in coming years, the BA measure could produce greater benefits under the NCPA assumption than projected by the models. On the other hand, the results do not account for the possibility that today's major non-compliant countries may become compliant later.

(3) *BA tariff calculations*. In the models for this study, the BA tariffs on non-compliant country imports would equal the *total* amount of US emissions costs, while US EITE manufacturers would incur smaller cost increases equal to *net* emissions costs, increasing US domestic market shares relative to non-compliant countries. If the non-complaint country BA fees equaled the *net* allowance costs of US producers, US and non-compliant producers would maintain their market shares, though compliant country importers (Canada, EU, Japan) would gain shares from both.

(4) *Export market impacts*. The HRS-MI models did not estimate policy impacts on US export markets. In the cost pass-along scenarios, US manufacturers would have to decide whether to pass through their costs to their exports in international markets, where low-cost foreign competition is strong. If they do not pass through costs, they may in the short run preserve their market shares, but would suffer from rising costs cutting into their operating surpluses and profits. In short, any gains from the BA adjustment could be offset by losses in export markets. Further, global trade rules may engender trade dispute and possible retaliation.

(5) *Downstream industry impacts*. The study did not examine potential impacts on downstream customers of the EITE industries, which could see costs increases in cost pass-along scenarios. If they in turn pass along the carbon-related costs from EITE suppliers, they could find themselves at a significant competitive disadvantage in export markets against low-cost foreign importers not subject to carbon-pricing policies, encouraging some firms to move offshore to remain competitive.

(6) *Elasticities of import substitution*. In the modeling of cost pass-along behavior, there is uncertainty about the elasticities of substitution between domestic and foreign goods in US domestic markets. While the models may be based on

Table 4
Summary of Results—*Basic* case with rebates: border adjustment scenarios.

Industry sector	No BA, NCPA	NCPA BA—starting 2020	NCPA BA—starting 2025	CPA BA—starting 2020	CPA BA—starting 2025
Operating surplus (%) above BAU—2025					
Primary aluminum	−9.8	−8.2	−9.8	2.2	1.6
Iron & steel	−3.9	−1.9	−3.9	2.2	0.7
Paper & paperboard	−5.2	−5.2	−5.2	1.3	1.6
Petrochemicals	−1.6	−1.6	−1.6	0.2	0.2
Chlor-alkalies	−4.8	−4.7	−4.8	3.2	3.1
Domestic market share (%) above BAU—2025					
Primary aluminum	0.0	1.3	0.0	0.5	0.0
Iron & steel	0.0	1.7	0.0	1.2	0.0
Paper & paperboard	0.0	0.2	0.0	−0.1	0.0
Petrochemicals	0.0	0.1	0.0	0.1	0.0
Chlor-alkalies	0.0	0.3	0.0	0.2	0.0
Operating surplus (%) above BAU—2030					
Primary aluminum	−44.9	−43.2	−43.3	−0.3	−0.4
Iron & steel	−13.6	−11.2	−11.2	1.6	1.5
Paper & paperboard	−27.0	−26.9	−26.9	1.9	2.1
Petrochemicals	−6.5	−6.5	−6.5	0.2	0.2
Chlor-alkalies	−22.4	−22.1	−22.2	5.4	5.4
Domestic market share (%) above BAU—2030					
Primary aluminum	0.0	2.0	1.7	−1.9	−1.9
Iron & steel	0.0	2.2	2.2	0.2	0.2
Paper & paperboard	0.0	0.4	0.3	−1.5	−1.4
Petrochemicals	0.0	0.1	0.1	−0.2	−0.2
Chlor-alkalies	0.0	0.5	0.4	−0.1	−0.1

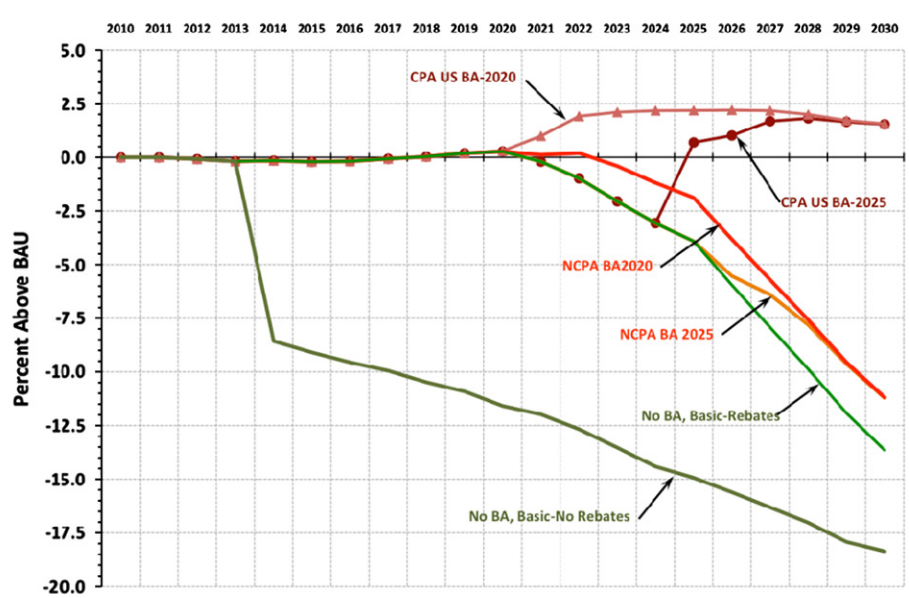

Fig. 8. Iron and steel operating surplus (percent Above BAU), BA Scenarios.

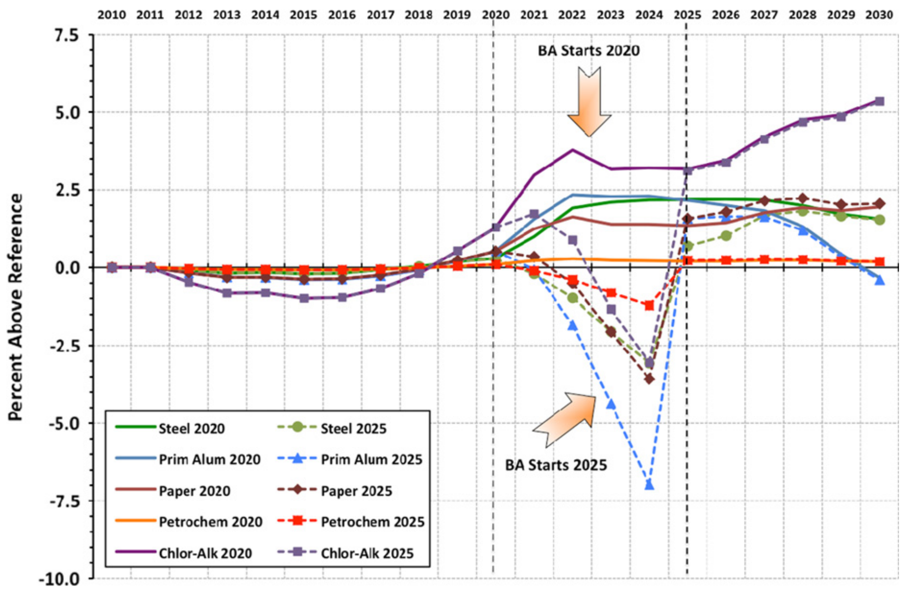

Fig. 9. EITE industries operating surplus (percent above *BAU*), CPA BA Scenarios from 2020 and 2025.

reasonable assumptions about goods substitution in normal markets, it may not fully capture the extent such substitution might occur if US producers are suddenly subject to policy-induced cost increases that foreign competitors are not.

(7) *Plausibility of BA provision.* Under Article II:2(a) of the General Agreement on Tariffs and Trade, a border-tax adjustment is permissible only when it constitutes "a charge equivalent to an internal tax … in respect of the like domestic product or in respect of an article from which the imported product has been manufactured or produced in whole or in part". Thus, does a tax on carbon emissions constitute a tax on an article from which a product "has been manufactured or produced in whole or in part"? This remains a difficult question to answer.

(8) *Carbon content of imports.* To accurately assess the embedded carbon content of a product (such as imported steel) it would be required to obtain specific plant-level information on the production process of the import from foreign countries. This is information is not currently available for all the imports to the US, and assumptions were made on the carbon content of imports from the industries studied.

5. Conclusions

This study evaluated the potential impacts of carbon-pricing on their costs, profits, and market shares, the effectiveness of cost containment and cost mitigation measures, and technology investment options and possibilities to reduce carbon emissions costs. It first focused on examining the output-based rebate measure in the *ACESA*, including alternative policy assumptions that directly (*NIO* case) or indirectly (*HC* case) affect the costs of emissions allowances in the economy—i.e., testing the effectiveness of cost containment in the bill. It then examined the effectiveness of the border adjustment (the International Reserve Allowance program) measure to mitigate EITE industry costs, as the rebates phase out and emissions allowance costs grow.

Therefore, the current study, along with the two prior HRS-MI studies, hopefully shed some light on the key issues concerning a set of recent climate legislation in the US—the Lieberman–Warner bill (S. 2191) (EIA, 2008b) the Waxman–Markey bill (H.R. 2454) (US Congress, 2009), and their implications on the EITE manufacturing industries and emissions mitigation in the US economy.

Overall, the study confirmed that regardless of the policy case or industrial sector, the output-based rebates would be an effective means for mitigating the costs of carbon-pricing for EITE industries, from the short-to-medium term, through 2020–2022.

Nevertheless, the analysis of the alternative policy scenarios (the *High Cost* and *No International Offsets* cases) showed that after 2021 and especially after 2025 – as the rebates start to phase out – economic impacts on the EITE industries would escalate more rapidly and to a somewhat higher level by 2030 than those in the *Basic* case. The *NIO* analysis, in particular, illustrated the important role that offsets might play in containing carbon-pricing costs for EITE industries. As noted, the alternative cases reflect assumptions that might be more realistic about carbon-fuel substitution (in *HC* case) and the availability and effectiveness of international offsets (in *NIO* case), than the *Basic* case. In short, care must be taken in interpreting the EIA analysis of the *ACESA*, as the predicted economic impacts in the *Basic* case analyses, could underestimate the actual impacts that EITE industries would experience if the *ACESA* were enacted.

The results of the analysis on the Border Adjustment measure were much more mixed, which reflect uncertainties about how the measure would be designed and applied, as well as modeled. For example, because countries that have complied with carbon reduction agreements account for the overwhelming largest share of US imports, the BA measure would not be especially effective in offsetting the rising allowance costs of US EITE manufacturers after the rebates start to fade. The iron and steel industry, whose imports include a large proportion from non-compliant countries compared to the other industries, would be the only sector with any observable benefit from the BA measure, assuming no cost-pass through.

On the other hand, the BA measure could make it less risky for US firms to pass through their emissions costs to their US customers. The prices of compliant country imports would not be affected, however, and they would increasingly replace both US and non-compliant country EITE goods in domestic markets. Eventually the US gains from BAs would diminish as allowance costs grow and compliant country imports increase their inroads in US markets. In addition, the BA measure would not alleviate the higher production costs of US EITE exports sold in international markets, and could force US downstream industrial consumers to bear higher US and non-compliant import prices, putting US manufacturers at a competitive disadvantage with foreign producers of downstream products.

Given these limitations and potential trade and legal issues that remain unresolved—e.g., WTO compliance, BAs may not be the most effective means for mitigating EITE industry costs from carbon-pricing, and limiting carbon leakage. Instead, a continuation of the output-based rebates – an option available under Presidential discretion – might be an easier, less encumbered and more effective mechanism for offsetting adverse impacts on US. EITE industrial competitiveness.

In the medium-to-long run, however, the only true solution is for US. EITE manufacturers to invest in energy-saving and next generation low-carbon production and process technologies. The rebate and BA measures only buy time for manufacturers, over the short-to-medium term. While the rebates might encourage some companies to make energy-saving investments, these inducements would not be enough to encourage the large-scale investments in the low-carbon technologies they would need to remain competitive in the face of high emissions costs incurred by 2030. Unfortunately, there have been few policy measures considered in the climate debate that provide genuine support and incentives for promoting innovation and adoption of advanced low-carbon technologies by the EITE industries. Yet such policies would result in substantial and permanent reductions in GHG emissions from industry and reduce the threat of carbon leakage, while strengthening and promoting the competitiveness of a critical industrial sector in the United States.

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