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Options for Addressing Leakage in California's Climate Policy

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I. What is Leakage? What Causes It? Why is It a Concern?

With the passage of the Global Warming Solutions Act of 2006 ("AB 32"), California became one of a growing number of political entities undertaking policy measures to reduce emissions of greenhouse gases ("GHGs"). Many other entities, including the United States, are actively considering similar policies.

A central concern of policymakers in the development of GHG reduction policies is the issue of "leakage." Leakage is the shift in emissions and economic activity from one region to another as the result of a difference in the regulatory costs faced by competitors in each region. If facilities in one region face higher regulatory costs than competitors in another region, then facilities in the more-regulated region risk losing sales to these outside competitors. When this occurs, the emissions from firms in the more-regulated region decline, while those from competitors in the less-regulated region rise. Emissions increases in the less-regulated region can partially, fully, or even more than fully offset emission reductions in the more-regulated region. The net effect depends upon many factors, including the relative emission rates of facilities in the regions.[1]

Leakage is not a problem unique to a particular type of regulatory policy. Leakage can occur with any climate policy that places an additional regulatory cost on economic activity, including a market-based policy, such as a cap-and-trade system or a carbon tax, or a traditional

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[1] For example, if the GHG intensity of production in the less-regulated region is greater than the GHG intensity of production in the more-regulated region, total emissions could increase.

regulatory approach, such as an emission standard. Any policy that increases the costs of producing goods and services can lead to leakage.[2]

Leakage raises several concerns for climate policy. First, leakage reduces the environmental integrity of climate policy. Emission reductions that are achieved within the more-regulated region are offset (to some degree) by emission increases outside the region. Under a cap-and-trade program, for example, even if the more-regulated region achieves its target emissions reductions and meets the cap, leakage leads to offsetting increases in emissions outside the region that reduces the environmental gains achieved by region's program.

Second, leakage can lead to reductions in economic activity within the regulated region. This can best be understood by considering the three ways in which leakage occurs. First, leakage occurs when imports from outside (less-regulated) regions displace production in the (more) regulated region.[3] Second, leakage occurs when exports from the regulated region decrease due to competition from producers outside the regulated region.[4] Third, leakage occurs when investment in production to supply increased future consumption shifts to other regions, as increased costs in the regulated region drive firms to expand elsewhere. In all these cases, producers in the regulated region produce less than they otherwise would, and at least some of this lost production is offset by increases in output elsewhere. In all three of these circumstances, economic output in the regulated region declines by more than it otherwise would, potentially reducing employment in the affected sectors. Thus, businesses and workers outside the regulated region gain at the expense of business and workers in the regulated region, while the accompanying environmental benefits in the regulated region diminish.

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[2] In the case of carbon dioxide (CO_2) emissions, there are two distinct pathways that bring about emissions leakage. One is the pathway described above, namely that, as a result of higher regulatory costs within a region, comparative advantage in the production of particular goods and services can shift to other regions that do not face similar regulatory costs. The other pathway, specific to CO_2, is that as a result of decreases in demand within the regulated region for carbon-intensive goods (e.g., coal), the world price of those goods can fall (if the regulated region is a sufficiently important part of the world market), with the result being that the use of those goods in other, unregulated regions would be expected to increase. We focus on the first pathway, because it is the important one in the context of AB 32.

[3] Throughout our discussions, we make the simplifying assumption that facilities outside the region implementing a climate policy do not face any such regulations, while recognizing that the important condition driving leakage is that outside regions impose less costly regulations, not necessarily no regulations at all.

[4] Note that the sources of leakage may extend beyond the directly affected industries. For example, shifts in production in a GHG-intensive industry may induce increases in economic activity outside the region as well as prompting household movements as labor shifts to regions with more economic activity.

When assessing leakage, it is important to recognize that changes in industry output arise not only from leakage but also from reduced demand for industry output, particularly for more carbon-intensive goods. Because production of more carbon-intensive goods is expected to decline, even absent leakage, assessments of leakage must distinguish between these leakage effects and effects on industry production due to reduced product demand and product substitution.

Leakage has been identified as a potentially undesirable and unintended outcome of the limited geographic scope of proposed regional and/or national climate policies. Empirical studies of leakage risks associated with particular policies provide some insights into the likely magnitude of leakage.[5] Several studies have examined the leakage implications of a nationwide cap-and-trade system that would likely be a key element of a federal climate policy.[6] One such study is by Aldy and Pizer (2009). Based on a statistical analysis of the historical relationship between energy prices and industry production, the authors find that a $15 price per ton of carbon will lead to a decline in total U.S. manufacturing production of 1.3 percent.[7] This reduction in U.S. production is the result of roughly equal proportions of leakage (0.7 percent) and reduced U.S. consumption (0.6 percent), representing a "leakage rate" of 57 percent.[8] In other words, the authors find that absolute levels of production leaking outside the United States are not large but that leakage accounts for more than half of these declines.

Just as important, the reduction in emissions integrity from leakage also has adverse consequences for the policy's cost-effectiveness. The Aldy and Pizer analysis suggests that, if emissions reductions are roughly proportional to changes in production, for each 100 tons of CO_2 emissions reduced from a decline in U.S. manufacturing sector output, there is an induced increase of 57 tons of emissions in other countries. This means that much less is accomplished

[5] For example, two reports examine leakage in the context of the European Union Emissions Trading System (EU ETS): McKinsey and Company and Ecofys (2006), "Report on International Competitiveness," Report for the European Commission, Directorate General for the Environment; and Reinaud, Julia, (2005), "Industrial Competitiveness Under the European Union Emissions Trading Scheme," International Energy Agency. We do not assess these studies for a variety of reasons, including the potential non-comparability of industry cost structures and trade exposure between the EU and the United States and the inclusion of free allowance allocations within leakage assessments.

[6] The effect of an economy-wide carbon prices on leakage and related competitiveness concerns are likely to differ from the effects of prior environmental regulation due to factors such as the nature of regulatory costs (i.e., variable costs versus capital costs), the uniformity of regulation across the United States, facility size and other criteria affecting the applicability of regulations, certainty over regulatory costs, and, potentially, the magnitude of such costs.

[7] The authors, however, caution against extrapolating their results to higher levels of allowance prices.

[8] Aldy, Joseph E. and William A. Pizer, "The Competitiveness Impacts of Climate Change Mitigation Policies," Pew Center on Global Climate Change, May 2009.

in terms of net emissions reductions (only 43 tons in this example) than anticipated. The result is that the true cost-effectiveness of the policy (total cost divided by actual emissions reduction) would be reduced.

Estimated impacts for more energy-intensive industries are larger than suggested by Aldy and Pizer's estimated industry-wide impacts, with total reductions in output of over three percent for many industries and output reductions from leakage of nearly two percent for the most affected industries. Ho, Morgenstern, and Shih (2008) find similar results, although with a lower economy-wide leakage rate of 26 percent.[9] They indicate that these results are consistent with estimates of economy-wide leakage rates from other studies, although these vary widely.[10]

These studies of leakage from a national cap-and-trade system provide some insights into potential leakage that could arise from the implementation of AB 32 due to *international* trade competitiveness. However, because these studies analyze national policies that would affect all states equally, they do not account for leakage from *interstate* trade competitiveness that would arise from a state-level policy such as AB 32. Potential and actual leakage arising from the regulation of the electricity sector under state or regional climate policies has received substantial attention due, in part, to particular susceptibility of electricity markets to leakage.[11] However, we are unaware of any empirical assessments of potential leakage risks for other sectors arising from climate policies implemented at the state or regional level. Analyses of existing, non-climate environmental policies within the United States find that differences in the

[9] Ho, Mun S., Richard Morgenstern, and Jhih-Shyang Shih (2008), "Impact of Carbon Price Policies on U.S. Industry," Resources for the Future Discussion Paper 08-37. In addition to these studies examining multiple industries, industry-level studies have also been performed. For example, EnSys Energy (2009) concludes that there would be substantial leakage from the refining sector under a U.S. cap-and-trade program such as the one included in Waxman-Markey. EnSys projects that Waxman-Markey will result in a reduction in emissions from U.S. refining of 30 million metric tons of carbon dioxide-equivalent ("CO_2e") in 2020 but an increase in emissions from non-U.S. refining of 17 million metric tons CO_2e – a leakage rate of 57 percent. EnSys Energy, "Waxman-Markey (H.R. 2454) Refining Sector Impact Assessment," October 2009.

[10] Ho, Morgenstern, and Shih (2008), pp. 36-37.

[11] Within California's electricity sector, emissions leakage could occur through "contract reshuffling" in which GHG emissions reductions are achieved on paper – but not in reality – by swapping contracts for power with high GHG emissions for those with low GHG emissions. Contract shuffling alone could potentially allow California's electricity purchasers to meet a 1990 emissions target for the sector. Bushnell, James, Carla Peterman, and Catherine Wolfram, "California's Greenhouse Gas Policies: Local Solutions to a Global Problem?" Center for the Study of Energy Markets, Working Paper 166, April 2007. Emission leakage from the Regional Greenhouse Gas Initiative (RGGI), a GHG cap-and-trade system covering large stationary sources in ten Northeastern and Mid-Atlantic states, has been extensively analyzed, as well. For example, *see*, Sue Wing, Ian and Marek Kolodziej (2008), "The Regional Greenhouse Gas Initiative: Emission Leakage and the Effectiveness of Interstate Border Adjustments."

stringency of regulation between regions has led to systematic impacts on industry output, employment, and capital stocks across regions.[12]

Sub-national impacts are likely to differ from international impacts due to a number of factors. First, labor costs, political risks, tax rates, and other factors affecting production economics vary less across states than across countries. Second, while transportation costs remain an important factor for many energy-intensive industries, locational advantages are diminished if output can be shifted to a nearby region or state as opposed to a nearby country. As a result of these differences, a state's economy may be more integrated with neighboring states (and other countries) than the nation as a whole is to the international economy. If this is the case, the state would be more prone to leakage. Finally, given differences in trade patterns at the state level, there are likely differences in the degree of trade exposure of industrial sectors in California relative to the trade exposure of those same industries when viewed at the national level.

In response to these concerns, recently enacted and proposed climate policies include requirements to develop policies to address leakage. For example, AB 32 instructs the California Air Resources Board ("CARB") to "minimize leakage."[13] One of the Western Climate Initiative's ("WCI") design recommendations for its proposed cap-and-trade system is to "minimize[] the potential for leakage."[14] The American Clean Energy and Security Act (hereafter "Waxman-Markey"), passed by the U.S. House of Representatives in June 2009, proposes a program to address leakage from trade-sensitive sectors.[15] Similarly, the European Union ("EU") authorizes its member nations to adopt measures to address leakage from the Emissions Trading Scheme ("ETS"),[16] and Australia's proposed Carbon Pollution Reduction Scheme ("CPRS") includes an "emissions-intensive trade-exposed assistance program" to do the same.[17]

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[12] Greenstone, Michael (2002), "The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufacturers," *Journal of Political Economy* 110(6), pp. 1175-1219; Becker, Randy and Vernon Henderson (2000), "Effects of Air Quality Regulations on Polluting Industries," *Journal of Political Economy* 108, pp. 379-421.

[13] California Health and Safety Code Section 38562(b).

[14] Western Climate Initiative, "Design Recommendations for the WCI Regional Cap-and-Trade Program," September 23, 2008, corrected version issued March 13, 2009, p. 53.

[15] See Title IV, Subtitle A, Section 401, which adds to the Clean Air Act a program, the "Emission Allowance Rebate Program," to address leakage.

[16] "Directive 2003/87/EC of the European Parliament and of the Council," amended, Article 10a.

[17] Carbon Pollution Reduction Scheme Bill 2009, Part 8, The Parliament of the Commonwealth of Australia, House of Representatives.

The remainder of this white paper will identify and assess the policy alternatives for addressing leakage under California's climate policy. In particular, we will discuss three key policies to address leakage:

- Broad-based, global commitments to reduce GHG emissions;
- Cost-containment measures; and
- Policies aimed at identifying sectors potentially vulnerable to leakage and addressing the competitive disadvantage faced by these sectors.

In discussing these options, we consider California's unique circumstances, evolving policy developments at the regional, national, and international levels, and the experiences and approaches of cap-and-trade programs throughout the world.

II. Reducing Leakage through Multi-National, Harmonized Commitments to Climate Policy

The ultimate solution to concerns about leakage – and a necessary condition for achievement of meaningful reductions in global GHG emissions – is the development of multi-national commitments to climate policy. Commitments by all key nations to achievement of broad-based reductions in GHG emissions would reduce leakage because industries in these nations would be subject to climate regulations, thus limiting the number of competitors in countries that do not take on these obligations. Note that just 17 of some 190 nations in the world together account for approximately 90 percent of global CO_2 emissions. Commitments to reducing emissions made by just these nations could substantially reduce potential leakage arising from multinational GHG commitments

Differences in the regulatory costs of climate regulation across nations could be further reduced if all economic activity were regulated under a harmonized set of GHG commitments that normalized the regulatory costs faced by industries. Such normalization can be achieved as a part of multinational climate agreements or – in principle – by linking national and multinational cap-and-trade systems. Thus, as more nations take on GHG commitments, harmonize carbon regulatory requirements, and link their trading systems, leakage may become less of a concern.

Just as internationally harmonized climate regulations would reduce leakage from national programs, a federal climate policy can reduce leakage arising from state climate policies undertaken in the absence of corresponding commitments by other states. Thus, progress in Washington on developing a nationwide cap-and-trade system to control GHG emissions could substantially affect the need for policies at the state level to address leakage. For example, the need for action by California to address state-level leakage would be eliminated if California's cap-and-trade system were to be pre-empted by a federal system

(although this would not necessarily eliminate the need for policies to address leakage at the federal level.) We consider the implications of impending federal actions on California's options in regard to leakage in detail in Section VI.

III. Reducing Leakage Through Cost-containment Mechanisms

Absent global, harmonized commitments to climate policy, individual countries or regions can address leakage through measures designed to contain the costs of their own climate policies and thereby reduce the competitive disadvantage faced by facilities operating under such policies. For example, in the development of its cap-and-trade program, California could implement mechanisms to reduce the costs of obtaining emission allowances and complying with climate policy. These various mechanisms would not only reduce the economic burden on households and the economy but would also reduce the potential for leakage from vulnerable industrial sectors.

Typical cost-containment mechanisms in cap-and-trade systems include:

- **Banking**: The ability for a regulated entity to save emission allowances for use in a future period.
- **Borrowing**: The ability of a regulated entity to use emission allowances from a future period to satisfy current allowance obligations.
- **Offsets**: Credits for GHG emission reductions that occur outside the scope of the cap-and-trade program that regulated entities can use for compliance with GHG requirements.
- **Price Caps, Prices Collars, and Strategic Reserves**: A price cap sets an upper limit on the price of emission allowances. It is usually implemented by allowing additional allowance purchases at the price cap. These purchases may be unlimited or limited to a "strategic reserve" which borrows allowances from future periods. A price collar sets a price floor, in addition to a price cap, to ensure a minimum price for GHG allowances.

The EU ETS, Australia's proposed CPRS, and U.S. Congressional proposals including Waxman-Markey include various combinations of these cost-containment mechanisms. In addition to mechanisms aimed at containing the costs of achieving GHG targets, leakage may be reduced by designing policies to ease the transition faced by industries subject to new climate regulations.

IV. Targeting Leakage in Vulnerable Sectors

While effective cost-containment measures can reduce the extent of leakage, they are unlikely to eliminate it. A cap-and-trade system or other climate policy will continue to impose incremental costs that firms in other regions may not have to bear, even if that price is lower

than it otherwise would be absent cost-containment measures. Hence, some sectors may still be vulnerable to leakage.

Cap-and-trade programs can include provisions to address these remaining leakage concerns. Such efforts typically involve a two-step process. In the first step, those sectors most vulnerable to leakage are identified. In the second step, measures are implemented to help facilities in identified sectors address the cost disadvantage they face due to climate policy. Existing and proposed GHG cap-and-trade programs consider various ways to carry out each of these steps. We review these approaches in the remainder of this section. Then, in Section V, we discuss particular issues arising in the implementation of these approaches in California should CARB decide to pursue them.

Our discussion of the design of mechanisms to target industries potentially vulnerable to leakage focuses primarily upon the tradeoffs posed by options to effectively targeting leakage. However, there may be other considerations that enter into policy decisions to address leakage that we do not address. In particular, we do not address legal and diplomatic issues related to current and future multinational trade agreements, and the implications of leakage measures for the likelihood of successfully developing multinational commitments to addressing atmospheric GHG concentrations.[18]

A. Identifying Sectors Vulnerable to Leakage

The first step in addressing leakage in specific industrial sectors is to identify the most vulnerable sectors. For a cap-and-trade system, this assessment should, in principle, identify those sectors expected to experience declines in production that reflect *shifts* in production to outside regions, rather than decreases in demand for their products. In practice, however, developing a regulatory mechanism that accurately forecasts shifts in production and corresponding levels of leakage is difficult. Although various statistical and data-intensive

[18] For example, *see,* Aldy, Joseph E. and Robert N. Stavins, *Post-Kyoto International Climate Policy: Summary for Policymakers.* Cambridge, UK: Cambridge University Press, 2009; Frankel, Jeffrey, "Global Environment and Trade Policy," pp. 493-529, Aldy, Joseph E. and Robert N. Stavins, eds., *Post-Kyoto International Climate Policy: Implementing Architectures for Agreement*, Cambridge, UK: Cambridge University Press, 2010; "Addressing Competitiveness in U.S. Climate Change Policy," Pew Center on Global Climate Change, Congressional Policy Brief, Fall 2008, pp. 8-9; and Bordoff, Jason (2008), "International Trade Law and the Economics of Climate Policy: Evaluating the Legality and Effectiveness of Proposals to Address Competitiveness and Leakage Concerns," prepared for Brookings Forum: "Climate Change, Trade and Competitiveness: Is a Collision Inevitable?"

methods have been developed to accomplish these tasks,[19] these techniques may be difficult for CARB or any regulatory authority to use in practice.

Faced with practical limitations on the use of complex economic models to develop regulatory determinations regarding leakage, existing and proposed cap-and-trade programs use simpler approaches to identifying vulnerable sectors. These approaches typically rely on the calculation of metrics for the two key factors affecting the extent to which a particular sector is vulnerable to leakage: the sector's GHG intensity and the sector's trade intensity.

The first metric for measuring potential vulnerability to leakage is a sector's GHG intensity. This metric seeks to measure how costly carbon regulation will be on average for firms in the sector. Firms in a sector that is particularly GHG intensive will have to bear higher costs as a result of climate policy. In some cases, should GHG intensity be difficult to measure, energy intensity may be used as a proxy for the consequences of climate policy on the economic competitiveness of individual sectors of the economy, although it is likely to be a less accurate measure of the impact of a cap-and-trade system.[20]

Measures of GHG intensity typically identify the incremental cost of proposed GHG regulations on an industry relative to some measure of economic activity in that sector. An economy-wide cap-and-trade system can create both direct and indirect costs for firms. Direct costs reflect costs associated with GHG emissions arising from production processes. If facilities are directly regulated, GHG allowances would have to be surrendered to cover these direct emissions.[21] If GHG emissions are regulated upstream at fuel producers, refiners, or suppliers, facilities would face higher prices for regulated fuels used as inputs in production processes. In addition, indirect costs can arise if climate regulation raises the cost of non-fuel

[19] For example, Aldy and Pizer (2009) estimate statistical supply and demand models for over 400 industries, and, using these results, simulate the effects of a $15 per ton carbon price. Ho, Morgenstern, and Shih (2008) model the implications of a $10 per ton carbon price on output and leakage using partial and general equilibrium models of the U.S. economy calibrated using parameters from 2002.

[20] Waxman-Markey includes an energy intensity criterion, which considers the "cost of purchased electricity and fuel costs of the sector." Title IV, Subtitle A, Section 401, H.R. 2454, American Clean Energy and Security Act of 2009.

[21] Irrespective of whether firms receive allowances for free or whether allowances are purchased through an auction, the need to surrender allowances to regulators imposes an opportunity cost on firms. Even if allowances are provided for free, firms give up potential revenue if allowances are used to cover their emissions instead of selling them to other firms.

inputs to production. In particular, increases in electricity prices due to imposition of GHG regulations on electricity producers can lead to indirect costs.[22]

When measuring GHG intensity, metrics should accurately account for the scope of the GHG policy. For example, a cap-and-trade system limited to large, stationary sources would impose costs only upon sectors with large industrial facilities and those highly reliant on electric power, while other economic activities may not face costs if their energy uses are not covered by the policy. Failure to capture these different sources of GHG-related costs can lead to metrics that fail to compare sectors on an equal basis.

The second metric for measuring potential vulnerability to leakage is the trade intensity of the sector. Measures of trade intensity seek to capture the degree of competition firms in the regulated region face from competitors outside the region. This competition can arise as imports compete for sales to customers in the regulated region and/or as outside producers compete with the region's exports to other parts of the world. Metrics of trade intensity typically rely upon measures of current import and export volume relative to overall economic activity in the sector. The reliability of such a measure of trade intensity at identifying potentially vulnerable sectors rests upon the assumption that sectors with higher levels of current trade activity are more likely to lose domestic sales to imports or lose export sales to competitors outside of the region. However, such a measure may not account for many factors that could make a particular sector more or less vulnerable to leakage, such as if fringe suppliers could expand market share given an incremental cost advantage.

Table 1 summarizes the proposed mechanisms used to identify sectors vulnerable to leakage under three existing or proposed programs: Waxman-Markey, Phase III of the EU ETS, and Australia's CPRS. Although the programs are broadly similar in the way they seek to identify vulnerable sectors, their approaches differ in important respects. These differences illustrate the variety of considerations facing California as it seeks to develop its own mechanisms to limit leakage under AB 32:

- **Level of aggregation**: Each program defines vulnerable production processes and sectors at a different level of aggregation. The EU ETS classifies sectors at the three- or four-digit NACE level, Waxman-Markey at the more detailed six-digit NAICS level, and Australia's CPRS at the even more detailed "activity" level.[23] These policies all aim to assess leakage at a high level of disaggregation.[24]

[22] Climate regulations would raise the costs of not only electricity, but, for the most part, all goods and services in the economy. These cost increases, however, are typically not considered in measures of GHG intensity.

[23] The North American Industrial Classification System ("NAICS") comprises nearly twice as many categories (1,170) as the Nomenclature des Activities Economiques ("NACE") classification system

The level of aggregation can affect whether a particular sector qualifies as vulnerable to leakage, as there is significant variation in both the GHG and trade intensities of the many individual sectors within broad industry categories. For example, energy costs of the overall Pulp and Paper sector (a four-digit NAICS group) were approximately 7 percent of shipment value in 2002, whereas the energy costs of the subsector Pulp Mills (a six-digit NAICS industry) were over 21 percent of shipment value in 2002.[25]

Identifying leakage at a more disaggregated level can lead to more targeted assistance to facilities most vulnerable to leakage and helps ensure that the most GHG intensive or trade intensive production within broader industrial classifications are not overlooked. Using disaggregated industry designations can also support the implementation of certain mechanisms (see below) for reducing leakage by increasing product homogeneity. For example, greater product homogeneity may simplify the design of output-based updating mechanisms by reducing the number of outputs for which allowance allocations must be determined. In practice, the availability of data for the particular region implementing the climate policy may limit the extent of disaggregation that can be used. Implementing new data collection efforts to support leakage programs could impose incremental and costly administrative burdens.

- **Thresholds based on GHG intensity, trade intensity, or both**: Under Australia's CPRS, a sector must establish that it is *both* emissions intensive *and* exposed to international trade. By contrast, under Waxman-Markey, a sector can qualify as vulnerable to leakage if it is very highly GHG (or energy) intensive, *even if* it is not particularly trade intensive. Similarly, under the EU ETS, a sector can qualify as vulnerable to leakage if it is very highly trade intensive, *even if* it is not particularly GHG (or energy) intensive. Separate GHG and trade criteria may capture industries that are, for example, particularly GHG intensive, although not highly trade intensive.

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(615). The Australian Government's White Paper on the CPRS defines an activity as "the chemical or physical transformation of inputs to produce a given set of outputs."

[24] For example, Australia's CPRS specifically designates zinc smelting as an activity vulnerable to leakage. Zinc smelting, however, is only one component of a six-digit NAICS industry and a four-digit NACE sector and thus may only be designated as a vulnerable to leakage under Waxman-Markey or EU ETS if its entire sector were as well.

[25] Similarly, Houser et al. calculate that the energy costs of the overall Chemical Manufacturing sector (a three-digit NAICS subsector) were just over 4 percent of value in 2002, while the energy costs of the component Alkalies and Chlorine Manufacturing (a six-digit NAICS industry) were over 31 percent of value in 2002. Houser Trevor et al. (2008), *Leveling the Carbon Playing Field: International Competition and US Climate Policy Design*, Washington: Peterson Institute for International Economics and World Resources Institute. *See also,* Ho, Mun S., Richard Morgenstern, and Jhih-Shyang Shih (2008), "Impact of Carbon Price Policies on U.S. Industry," Resources for the Future Discussion Paper 08-37, pp. 29-30.

- **Economic metrics against which to measure GHG costs or trade volume**: When calculating the GHG intensity and trade intensity of a sector, the level of GHG costs and trade volume are typically measured relative to either value of shipments, which is essentially revenue, or gross value added, which accounts for the value of inputs to production.

  Because the relative size of the value of shipments and the gross value added can differ significantly across sectors, the choice of which economic measure to use can affect sectors' eligibility for leakage-related assistance. For example, as shown in Table 2, value added is 57 percent of value of shipments for mining industries in the United States but only 12 percent for petroleum and coal products. If GHG and trade intensity criteria are based on value of shipments, those sectors with high ratios of value added to value of shipments are more likely to qualify. By contrast, if GHG and trade intensity criteria are based on value added, those sectors with low ratios of value added to value of shipments may be more likely to qualify.

Table 1
Criteria Used to Identify Sectors Vulnerable to Leakage

	Waxman-Markey	EU ETS Phase III	Australia CPRS
Single Criteria: Must meet either GHG- or trade-intensity criteria			
GHG intensity criterion (GHG costs)	20% of Value of Shipments (assuming $20 per $MTCO_2$-e) *or* 20% Electricity and Fuel Costs relative to Value of Shipments	30% of Gross Value Added (assuming average carbon price of EUR 30 per $MTCO_2$-e)	No standalone GHG cost criterion
Trade intensity criterion (Value of Imports + Exports)	No standalone trade intensity criterion	30% of Value of Turnover and Imports	No standalone trade intensity criterion
Dual Criteria: Must meet both criteria			
GHG intensity criterion (GHG costs)	5% of Value of Shipments (assuming $20 per $MTCO_2$-e) *or* 5% Electricity and Fuel Costs relative to Value of Shipments	5% of Gross Value Added (assuming average carbon price of EUR 30 per $MTCO_2$-e)	3% of Revenue (assuming $30 per $MTCO_2$-e) *or* 9% of Value Added (assuming $30 per $MTCO_2$-e)
Trade intensity criterion (Value of Imports + Exports)	15% of Value of Shipments and Imports	10% of Value of Turnover and Imports	10% of Value of Domestic Production

Sources

Title IV, Subtitle A, Section 401, H.R. 2454, American Clean Energy and Security Act of 2009.

Directive 2003/87/EC of the European Parliament and of the Council, October 13, 2003, as amended, Article 10(a).

Commission of the European Communities, "Commission Decision Determining a List of Sectors and Subsectors Which are Deemed to be Exposed to a Significant Risk of Carbon Leakage Pursuant to Article 10a (13) of Directive 2003/87/EC: Impact Assessment," September 4, 2009.

Australian Government, "Carbon Pollution Reduction Scheme: Australia's Low Pollution Future," White Paper, December 2008, Executive Summary and Chapter 12.

Table 2
Value Added and Value of Shipments
Selected Industries, 2007

Sector	Value Added (Billions)	Value of Shipments (Billions)	Ratio of Value Added to Value of Shipments
Oil and gas extraction	$ 164.7	$ 273.1	0.60
Mining, except oil and gas	45.3	78.6	0.58
Mining	275.0	479.0	0.57
Nonmetallic mineral products	54.4	117.9	0.46
Fabricated metal products	140.4	319.9	0.44
Chemical products	249.2	637.8	0.39
Paper products	50.7	165.8	0.31
Primary metals	62.4	236.4	0.26
Petroleum and coal products	70.4	579.0	0.12

Source

Bureau of Economic Analysis, "Gross-Domestic-Product-by-Industry Accounts, 1947-2008," http://www.bea.gov/industry/gpotables/gpo_list.cfm?anon=229222&registered=0.

Because GHG- and trade-related metrics do not provide a perfect measure of an industry's vulnerability to leakage, some cap-and-trade programs propose that regulators may consider factors other than the formulas and conditions shown in Table 1 to identify vulnerable sectors. Under the EU ETS, the list of sectors "deemed to be exposed to a significant risk of carbon leakage" may be supplemented by taking into account the extent to which individual facilities can reduce GHG emissions or electricity use, future projections of market conditions, and firms' profit margins.[26] In Australia's Carbon Pollution Reduction Scheme, sectors may apply for assistance by arguing that they have "a demonstrated lack of capacity to pass through costs due to the potential for international competition."[27]

[26] Directive 2003/87/EC of the European Parliament and of the Council, as amended, October 13, 2003, Article 10a(17).

[27] Australian Government, "Establishing the Eligibility of Activities Under the Emissions-Intensive Trade-Exposed Assistance Program," June 2009, Section 4.2, p. 24; see also, Australian Government, "Carbon Pollution Reduction Scheme: Australia's Low Pollution Future," Policy position 12.6, p. 12-31, http://www.climatechange.gov.au/publications/cprs/white-paper/cprs-whitepaper.aspx.

The resulting list of industries potentially vulnerable to leakage varies across programs due to a variety of factors, including industrial classifications and data sources, details of the calculation of GHG, energy or trade intensity, and eligibility criteria. Houser has compiled a list of U.S. industrial sectors that would appear to qualify as sectors vulnerable to leakage and thus eligible for assistance under the conditions in Waxman-Markey.[28] That list is provided in Appendix Table A. [29] The European Commission recently published a list of 146 industrial sectors "deemed to be exposed to a significant risk of carbon leakage."[30] The list includes a number of sectors that are highly trade intensive but not particularly energy intensive (e.g., manufacturers of knitted and crocheted fabrics) and sectors that are considered both energy and trade intensive (e.g., manufacturers of pulp and paper and manufacturers of cement).[31] The list is provided in Appendix Table B.

Similarly, the Australian Government has initially identified eight activities that would be eligible for free allowances under its emissions-intensive trade-exposed assistance program. These eight activities are found in Appendix Table C. The Government has identified 24 additional activities, including petroleum refining, that will be evaluated for eligibility for leakage-related assistance. These additional activities are found in Appendix Table D.

[28] Houser, Trevor, "Ensuring US Competitiveness and International Participation," Testimony before the Committee on Energy and Commerce, U.S. House of Representatives, April 23, 2009.

[29] Houser et al.'s calculations rely on the 2002 Manufacturing Energy Consumption Survey from the U.S. Department of Energy, Energy Information Administration. Waxman-Markey, however, instructs the Administrator to use data from the U.S. Census Annual Survey of Manufacturers from 2004, 2005, and 2006 or data from the 2006 Manufacturing Energy Consumption Survey before using the data Houser et al. used. As a result, the Administrator may come to different conclusions regarding sectors' energy and GHG intensities than those arrived at by Houser et al.

[30] The draft Commission report examined 258 sectors. 146 met the criteria for vulnerability to leakage. Commission of the European Communities, "Draft Commission Staff Working Document: Document Accompanying the Commission Decision Determining a List of Sectors and Subsectors Which are Deemed to be Exposed to a Significant Risk of Carbon Leakage Pursuant to Article 10a (13) of Directive 2003/87/EC: Impact Assessment," September 4, 2009. See also Bergman, Hans, "Sectors Deemed to Be Exposed to a Significant Risk of Carbon Leakage – Outcome of the Assessment," presentation, WG 3 Meeting, September 18, 2009.

[31] The Commission's draft assessment concludes that the manufacture of refined petroleum products will have GHG costs of 11.7 percent of gross value added and has a trade intensity of 16.1 percent. Therefore, the manufacture of refined petroleum products appears on the preliminary list of eligible sectors. Commission of the European Communities, "Draft Commission Staff Working Document: Document Accompanying the Commission Decision Determining a List of Sectors and Subsectors Which are Deemed to be Exposed to a Significant Risk of Carbon Leakage Pursuant to Article 10a (13) of Directive 2003/87/EC: Impact Assessment," September 4, 2009, p. 39.

B. Assisting Sectors Vulnerable to Leakage

Once sectors vulnerable to leakage have been identified, governments have several options for addressing leakage in these sectors. One approach is simply to exempt vulnerable sectors from compliance with cap-and-trade and other climate policies. This approach would ensure that these sectors face no new direct regulatory costs arising from the cap-and-trade system. However, these industries would still face indirect costs from increases in other inputs to production, including electric power, unless there are specific provisions to provide rebates for such costs. And, exemptions will likely reduce the environmental effectiveness of the climate policy, since firms in exempted sectors will not face limits on GHG emissions. Unless the overall cap is tightened to account for the higher expected emissions from exempted sectors, the overall level of emissions will increase. Moreover, exempting sectors will likely raise the overall cost of meeting a given emissions target, since any lower-cost emissions reductions in those sectors that could contribute to meeting emission reduction goals would most likely not be pursued.[32] These lower-cost emissions reductions would have to be replaced by higher-cost reductions from sectors under the cap, which would increase the total costs of achieving emission targets. None of the programs evaluated (Waxman-Markey, Phase III of EU ETS, Australia's CPRS) exempt sectors as a way of addressing leakage.

A second way to address leakage in vulnerable sectors is to implement so-called border adjustments. Border adjustments can apply to both imports and exports. Import adjustments would reduce or eliminate any competitive advantage for importers into California by requiring that importers of designated goods obtain and surrender allowances or pay "tariffs" to cover the goods' embodied GHG emissions. Export adjustments would help level the playing field for California producers' exports to markets outside California by granting allowance refunds to exporters of designated goods corresponding to the carbon costs associated with production of the goods (including potentially both direct and indirect emission costs). Waxman-Markey, for example, authorizes border adjustments if a sufficient number of other nations do not adopt similar climate policies by a specified deadline.[33] By imposing a cost on imports into the region associated with products' embodied GHG emissions, border adjustments provide a GHG price signal to downstream users to encourage reductions in the use of GHG-intensive goods. However, accurate measurement of the GHG intensity of imported products may be difficult due to uncertainties about emission rates in product production and distribution.

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[32] One way that low-cost emissions reductions from exempted sectors could be available is as part of an offsets policy that effectively allows regulated entities to fund emission cuts from sources not under the cap. Offsets are typically discussed as a way to take advantage of emission-reduction opportunities in regions or countries that are not covered by the cap-and-trade program. They can just as readily be used, however, within the regulated region in sectors not covered by the program.

[33] See the sections entitled "Presidential Reports and Determinations" and "International Reserve Allowance Program" in Title IV, Subtitle A, Section 401, H.R. 2454, American Clean Energy and Security Act of 2009.

Implementation of border adjustments requires administrative systems to monitor the flow of all designated goods across the relevant regional boundaries. Such systems may be impractical and/or costly for many goods. In addition, implementation of border adjustments at either the federal or the state level could raise legal issues associated with interstate trade (i.e., the Commerce Clause) or international trade laws.

A third way to address leakage in vulnerable sectors is to provide free emission allowances to firms in those sectors. There are two general approaches to freely allocating allowances: updating allocations and fixed allocations. Under so-called updating allocations, allowances are allocated on a rolling basis with each eligible firm receiving an annual (or periodic) allocation based on some recent measure of the firm's activity and an "allowance factor," which is the number of allowances to be allocated per unit of activity. These measures can include output levels, emissions levels, input levels, or a combination of these measures. The key feature of updating allocations is that, as an eligible firm increases the level of the activity being measured, the number of allowances it receives increases.

Although updating allocations can be based on any measure of firm activity (e.g., inputs or emissions), the most common proposal is to allocate allowances based on an eligible facility's recent economic production or output. This approach is referred to as an "output-based updating allocation." An output-based updating allocation effectively provides a production subsidy to each facility receiving this assistance, since the allocation directly offsets a portion of facility's marginal production costs. By subsidizing the facility's output and lowering its marginal costs, the facility can remain more competitive with outside firms that do not face similar carbon costs. The impact of output-based updating allocations on facilities' production decisions will depend on many factors, including the number of allowances provided per unit of output (i.e., the allowance factor), the delay between output levels and receipt of allowances, and the various factors affecting the product market equilibrium, including the industry's cost and market structure. However, assuming these allocations reduce the facilities' marginal costs, they should raise production and thereby reduce leakage.

While updating allocations provide an option to help reduce leakage, other considerations may affect decisions regarding their use. In particular, updating allocations will raise the cost of achieving GHG emission reductions necessary to meeting GHG targets by encouraging output in GHG-intensive industries, thus requiring that more costly GHG emission reductions be undertaken in other sectors.

The other type of free allocation mechanism that has been proposed to address leakage is fixed allocations. Under fixed allocations, the number of allowances provided to each eligible facility is determined prior to the implementation of the policy. Thus, in comparison to updating allocations, the quantity of allowances each eligible facility receives through a fixed allocation approach does not vary with its output or other aspects of its operations. The size of the allocation to each eligible facility is typically based on historical activity, such as the

facility's past emissions, or the emission rate for an industry "benchmark" facility (e.g., a facility meeting particular engineering or technological criteria).

Fixed allocations can offset the financial impacts of climate policy on asset values (or profits), but fixed allocations are poorly suited to addressing leakage. While fixed allocations may provide facilities with credit and/or capital support, they do not affect their marginal costs of production – their supply functions – which is what affects their competitiveness and drives leakage. Because facilities face the same additional costs of carbon regulation *on the margin* regardless of whether they receive a fixed allocation of allowances or not, providing them with free allowances through a fixed allocation approach does not eliminate the cost disadvantage they face from the climate policy.[34]

Table 3 summarizes the approaches proposed in several cap-and-trade programs to assist firms in sectors deemed vulnerable to leakage. Both Waxman-Markey and Australia's CPRS propose updating allocations in which each the quantity of allowances received by each each facility is based on its recent output level. By contrast, the EU ETS provides fixed allocations based on each facility's historical output. Thus, the allocation to a specific facility under Waxman-Markey and CPRS proposals would continually update to reflect the facility's most recent output, whereas allocations under the proposed EU ETS assistance program would be established prior to the onset of the program.

In most – but not all – circumstances, the use of updating or fixed allocations will have no impact upon a facility's incentive to make investments in efficiency or take other actions to reduce its emissions rate (i.e., GHG emissions per unit of output). A facility will continue to have an incentive to reduce its emissions rate so long as the mechanisms for determining the quantity of allowances received do not affect the facility's compliance cost. Aside from certain exceptions, which we discuss below, this is true. On the one hand, compliance cost is based on a facility's *actual* emission rate. On the other hand, in most cases, allowances allocations are determined by factors independent of the actual emission rate: with fixed allocations, allocations are pre-determined and fixed, while with updating allocations, allocations are based on the allowance factor.[35] Thus, a firm with low costs of reducing its emissions rate may find it profitable to reduce this rate to lower its compliance costs, since doing so will not affect the quantity of allowances it receives in that year or future years.

[34] As noted earlier, because firms can either earn revenues through the sale of allowances or use revenues to cover their emissions, decisions regarding allowance use impose an opportunity cost regardless of how those allowances are received. Because firms cannot affect the number of allowances they receive under a fixed allocation, they have no incentive to alter their production decisions as they do under an updating allocation.

[35] As we discuss below, there are certain circumstances in which a facility can potentially affect the level of the allowance factor, in which case the actual emission rate may not be independent of the allowance factor.

Table 3
Summary of Allowance Allocation Assistance to Sectors Vulnerable to Leakage

	Waxman-Markey	EU ETS Phase III	Australia CPRS
Type of Allowance Allocation	Updating	Fixed	Updating
Primary Determinants of Allocations	Updating facility-level output Updating GHG intensity of electricity purchases Updating sector average direct GHG intensity Updating sector average electricity intensity	Historical facility-level output Historical benchmarks based on most efficient facilities	Updating facility-level output Historical sector average direct GHG intensity Historical sector average electricity intensity Historical sector average natural gas intensity
Other Factors Affecting Allocations	Number of available allowances may not be enough to meet eligible sectors' needs	Formulas not yet established	Two tiers of assistance -- More emissions-intensive activities receive more allowances
Duration of Assistance	Through at least 2034	Through at least the end of Phase III (2020)	Indefinite -- Reviewed every five years

Sources

Title IV, Subtitle A, Section 401, H.R. 2454, American Clean Energy and Security Act of 2009.

Directive 2003/87/EC of the European Parliament and of the Council, October 13, 2003, as amended, Article 10(a).

Commission of the European Communities, "Commission Decision Determining a List of Sectors and Subsectors Which are Deemed to be Exposed to a Significant Risk of Carbon Leakage Pursuant to Article 10a (13) of Directive 2003/87/EC: Impact Assessment," September 4, 2009.

European Commission, "Carbon Leakage: Background," http://ec.europa.eu/environment/climat/emission/carbon_en.htm.

Australian Government, "Carbon Pollution Reduction Scheme: Australia's Low Pollution Future," White Paper, December 2008, Executive Summary and Chapter 12.

When designing an updating allocation, a key element is the allowance factor, which determines the number of allowances received for each unit of output (or chosen measurement of activity). A variety of considerations arise in determining allowance factors:

- **Basis for the Allowance Factor**: Allowance factors can reflect historical sector-level or facility-level emissions rates, emissions rates for a particular "benchmark" technology, or other factors. Allocations factors in Waxman-Markey and CPRS are based on average sector-level emissions rates per unit of output, whereas the EU ETS proposes allowance factors based on the emissions rates of the most efficient facilities in each sector.[36] Allowance factors based on sector-level average emissions rates would, on average, provide eligible facilities with roughly enough assistance to cover the direct and indirect allowance obligations from the GHG content of their energy use.[37] A facility with a higher-than-average emissions rate would receive fewer allowances than needed to meet direct and indirect allowance obligations, while a facility with a lower-than-average emission rate would receive more allowances than needed to meet direct and indirect allowance obligations. Thus, an allowance factor based on a sector's average emission rate confers a competitive advantage on facilities with lower-than-average emission rates. By contrast, an allowance factor based on a facility-specific emission rate eliminates any competitive advantage across facilities.

  Allocation mechanisms can also differ in how they treat direct and indirect emissions. For example, although both Waxman-Markey and CPRS propose free allocations to cover indirect emissions from electricity generation (which raises electricity costs), the allocation under Waxman-Markey depends upon the GHG intensity of the mix of electricity generation the facility actually purchases, whereas the allocation proposed under CPRS does not.

  Allowance factors must also take into account whether industries produce multiple outputs with varying levels of GHG intensity. In this case, allowance factors should reflect differences in the GHG intensity of these products. If there is variation across facilities in the GHG intensities of these products, however, facilities may have an

[36] The relevant EU ETS Directive specifies that, "[i]n defining the principles for setting ex-ante benchmarks in individual sectors or subsectors, the starting point shall be the average performance of the 10% most efficient installations in a sector or subsector in the Community in the years 2007-2008." See Article 10(a)(2).

[37] This is true holding all other things constant and assuming no changes in emission rates. Facilities that lower their emissions rates can, of course, sell any excess allowances they receive.

incentive to reconfigure the output at multi-product facilities in an effort to increase allowances allocations.[38]

- **Full or partial offset of competitive disadvantage**: Allowance factors can differ in the degree to which they are intended to offset the competitive disadvantage faced by firms subject to climate policy. For example, although Waxman-Markey and CPRS propose allowance factors based on sector-average emission rates, CPRS discounts allocations by an "assistance rate" that is less than one. Thus, while the proposal in Waxman-Markey is intended to fully offset the cost to a facility that has sector-average emissions rates for the incremental costs of cap-and-trade, the CPRS explicitly does not.[39] In addition, other factors can limit the magnitude of assistance directed to vulnerable industries, particularly if the total quantity of allowances devoted to leakage programs is capped or limited in some manner. In this case, decisions must be made about how to allocate allowance across various sectors potentially vulnerable to leakage.[40]
- **Changes over time in allowance factors**: Allowance factors may be *fixed* indefinitely or *periodically revised* based upon more recent information on emission rates, electricity consumption or other factors used in determining allowance factors.[41] The CPRS proposal uses allowance factors that are fixed and based on historical data on sector-average emissions rates, whereas Waxman-Markey would periodically revise allowance factors.[42] Thus, under Waxman-Markey, if facilities in a sector become less GHG or electricity intensive on average, total allocations to that sector will decline.

[38] A facility will have an incentive to produce more of an output where the difference between the allowance factor for that output and its particular GHG emissions intensity for the production of that output is the greatest. Such reconfigurations of output across facilities may increase allowance allocations to these facilities but have an ambiguous effect on total emissions.

[39] Specifically, CPRS proposes two tiers of assistance, one for "highly emissions-intensive" activities and one for "moderately emissions-intensive" activities. In 2011, the assistance rate will be 94.5 percent for highly emissions-intensive activities and 66.0 percent for moderately emissions-intensive activities.

[40] For example, under Waxman-Markey, the total allocations available to address leakage will likely be insufficient in some years to fully offset costs to facilities if they maintain their recent levels of emissions and energy consumption. As the overall cap on economy-wide emissions declines, the number of available allowances for vulnerable sectors will also decline, given requirements regarding how allowances are to be distributed across various competing uses.

[41] Although some policies may fix allowance factors, if the duration of these policies is finite in duration (e.g., the first phase of the EU ETS) and rules regarding initial allowance allocations are not specified for subsequent phases, then allowance factors might be revised between policy stages.

[42] Waxman-Markey specifies that the sector average GHG intensity factor should be recalculated every four years, and suggests that sector average electricity intensity factors should be recalculated annually.

As noted above, in most – but not all – circumstances, the size of the allowance factor and the mechanisms used to determine the factor will have no impact upon a facility's incentive to invest in energy efficiency or undertake other measures to reduce its emissions rate. So long as a facility's decisions about its emission rate do not affect the size of the allowance factor in future periods, its incentive to reduce its emission rate is unaffected. However, there are two circumstances in which decisions affecting a facility's emission rate could affect the future level of the allowance factor. The first is when allowance factors are (a) periodically revised *and* (b) revised based upon *facility-specific* emission rates. In this case, each facility would face a substantial disincentive to reduce its emissions rate because a facility's reduction in its own emission rate would reduce the allowance factor in future periods and thereby reduce the quantity of allowances it will receive in the future.[43] The second case is when (a) allowance factors are periodically revised, (b) initial allowance factors and subsequent revisions are based on *sector-average* emissions rates, *and* (c) the facility represents a large portion of the sector's total emissions. In this case, reductions in the facility's own emission rate could meaningfully reduce the sector-average emission rate and thereby the level of the allowance factor in the future. Thus, large facilities may face some disincentive to reducing their emission rates. However, in most industries, the majority of (if not all) firms are likely to be small enough that the effect of their own actions on the sector-average emission rate will be minimal, so that any disincentive to reducing emission rates would also likely be minimal.

Any disincentive to reducing emission rates can be further mitigated by revising allowance factors infrequently and/or revising allowance factors based on lagged measurements (i.e., several years in the past) of activity levels. For example, allowance factors could be based on a three-year industry average, but taken from a period lagged three years in the past (e.g., allowances in 2015 based on activity levels from 2010 to 2012). In such a case, the benefits of reducing emissions rates in a given year would be immediate (in the form of reduced compliance costs) while any impact on allowance allocations – if it occurs – would not appear for three years.

At the extreme, if the allowance factors are fixed indefinitely and never revised, then a facility's own actions to reduce its emission rate will have no effect on the size of the allowance factor then or in the future. Thus, the size of the allowance factor and the formula used to determine the factor will have no impact upon the facility's incentive to reduce its emissions rate.

[43] While periodically revising facility-specific allowance factors would diminish incentives to reduce the facility's own emissions, facility-specific allowance factors for the indirect GHG emissions from electric power generation have no effect on the incentives to reduce emissions rates *in the generation of electricity* because the facilities receiving assistance generally have no influence over the GHG intensity of the electric power they purchase.

- **Differentiation in support based on vulnerability**: Allowance factors can also differ depending upon the degree of vulnerability faced by the sector. CPRS proposes two tiers of allocation assistance based on the emissions intensity of the eligible activities. "Highly emissions-intensive" activities would receive more allowances than otherwise comparable "moderately emissions-intensive" activities.[44] By contrast, Waxman-Markey and the EU ETS would apply the same allocation formulas to all eligible sectors.

Proposals also differ in the duration of their assistance programs and the mechanisms for phasing out the programs. Waxman-Markey includes the most explicit phase-out mechanism. Allowance assistance is scheduled to phase out between 2026 and 2035 so long as a sufficient percentage of imports for that sector originate in countries with similar climate policies. Assistance under EU ETS proposal would be provided through the end of Phase III in 2020. Plans for assistance under policies after 2020 have not been discussed. Assistance under the CPRS is indefinite but will be reviewed every five years and may be discontinued if other countries have introduced comparable climate policies.[45]

V. How should California approach and address leakage concerns?

As noted in Section I, leakage from a state-level climate policy may differ substantially from leakage from a federal policy. Leakage in California will be driven not only by trade between California and other countries but also by trade between California and other states. Further, decisions to shift production to other states involve a qualitatively different set of tradeoffs than opportunities to shift production to other countries. Not only are incremental transportation costs likely to be smaller, but differences in regulatory requirements, political risks, and other factors are also likely to be less pronounced. As suggested by the observed changes in economic activity arising from differences in existing state-level environmental requirements (see Section I), impediments to shifting production to neighboring states may be smaller than those facing the shift of production to other countries. Given that each sector's trade exposure will reflect competition from firms in other states, as well as other countries, industry exposure at the state level may be greater than that at the national level.

[44] "Moderately emissions-intensive activities" are those for which GHG intensities are between 1,000 tons CO_2e and 1,999 tons CO_2e per million dollars in revenue or between 3,000 tons CO_2e and 5,999 tons CO_2e per million dollars in value added. "Highly emissions-intensive activities" are those for which GHG intensities are at least 2,000 tons CO_2e per million dollars in value added or at least 6,000 tons CO_2e per million dollars in value added. See Australian Government White Paper, p. 12-44.

[45] Australian Government White Paper Executive Summary, p. xxxviii.

In Sections II, III, and IV, we identified options for addressing leakage. In this section, we discuss how such options could be used in California and the particular issues that may arise in implementing them at the state level.

A. Broadening the Scope of Climate Policy and Linkages

The most effective approach to limiting leakage is through the harmonization of climate policies across competing economies. As a first step, the development of a nationwide cap-and-trade system as a part of federal climate policy would greatly reduce leakage by eliminating differences in regulatory costs between California and other states. Subsequent steps to reduce leakage would entail the development of multi-national climate commitments and harmonization of regulations across global economies to achieve such commitments. Because such commitments are necessary for meaningful actions to address climate change, along with addressing leakage, California should encourage efforts to develop carbon policies worldwide.

Given these opportunities, ongoing efforts to enact federal climate legislation raise several potential issues for California's efforts to limit leakage as it designs its own climate policies. First, if California seeks to implement its own cap-and-trade system after enactment of a federal system (in addition to or as a "carve out" from such a federal system), then leakage could continue to be a concern that CARB might need to address through design of its state policy. By contrast, pre-emption of a California system would eliminate inter-state leakage and avoid the need to design measures to address such leakage.[46] Second, if California's system is to be pre-empted but there is a delay between the enactment of California and federal policies, then CARB would need to consider whether it would be worthwhile to implement the state program for the interim period until the federal system is in place. Potential leakage risks during this period and the administrative costs of developing measures to address such leakage are important factors for CARB to consider.

In the event California's cap-and-trade system is not pre-empted by the federal system, California should aim to coordinate with federal officials to ensure consistency in the identification of and support to sectors vulnerable to leakage in both the state and federal systems. Absent such consistency, facilities in California could be given a competitive advantage if they receive allowances that facilities outside California do not (or vice versa.)[47] If California chooses to layer its state system on top of a federal system (in spite of the failure of such an incremental system to achieve *any* additional emission reductions), then California may

[46] Stavins, Robert N., Jonathan Borck, and Todd Schatzki, "Next Steps for California with Federal Cap-and-Trade Policy on the Horizon," White Paper, July 2009.

[47] Such federal-state coordination could recognize that the leakage risks faced by facilities within California (or other states) might differ from those faced in the rest of the country. However, coordination could avoid potentially more damaging shifts in competitiveness between facilities within the country.

want to consider whether it wants to provide assistance to vulnerable industries within the state, although such assistance would have no effect on inter-state emissions leakage.

B. Options for cost containment under AB 32

If California decides to move forward with its cap-and-trade program or other provisions of AB 32, it should take advantage of the benefits provided by cost-containment measures, which can not only lower the costs of climate policy, but also, by reducing allowance prices faced by industries, help reduce leakage. CARB's draft cap-and-trade regulation includes certain cost-containment measures, including three-year compliance periods, banking, and the use of offset credits.[48] The current preliminary draft regulation does not include other cost-containment mechanisms that might also help to reduce leakage, such as allowance borrowing, price caps or collars, and strategic allowance reserves. Further, the proposed design of certain cost-containment measures included in the draft regulation may not take full advantage of the potential for those measures to reduce the costs of climate policy. For example, proposed regulations of offset use would cap the number of allowances any regulated entity could use at four percent of their total compliance obligations.[49]

C. Options for identifying and targeting potentially vulnerable sectors

In addition to implementing cost-containment measures, CARB could also address leakage through measures targeting specific sectors vulnerable to leakage. Such policies could mitigate the environmental and economic consequences of leakage, particularly in light of the possibility that California's cap-and-trade system is only implemented for an interim period until Congress establishes a nationwide system. Along with helping to preserve the environmental integrity of a California-only system, measures adopted for this interim period would avoid economic impacts to California's economy that might not be completely reversible once a federal program harmonizes regulatory costs across states.

As described above, three types of efforts to assist vulnerable sectors are exemptions, border adjustments, and free allowance allocations. Exempting sectors from a cap-and-trade program receives less policy attention because of, among other things, the consequences of exemptions for environmental effectiveness. We do not consider them further as a policy for addressing leakage in California.

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[48] California Air Resources Board, "Preliminary Draft Regulation for a California Cap-and-Trade System," November 24, 2009.

[49] California Air Resources Board, "Preliminary Draft Regulation for a California Cap-and-Trade System," November 24, 2009, Section 95970, p. 15.

For many industries, the use of border adjustments for California would require development of new administrative functions to track all trade into and out of the state. Border adjustments may be feasible for sectors in which trade is already tracked, including the electricity sector and liquid fuels. Border adjustments would also require accurate measurement of the GHG emissions embodied in products that may originate from different facilities with different emission rates. As mentioned previously, such adjustments may raise legal issues that would preclude use of such adjustments and potentially delay policy implementation due to legal challenges.

The third option available to CARB to address leakage through directly targeting potentially vulnerable industrial sectors is the free allocation of GHG allowances to those sectors. In designing a system to freely allocate allowances to assist sectors vulnerable to leakage, California policymakers face a number of design choices. In addition to these general decisions that must be made in establishing any sort of allowance allocation program for vulnerable sectors, California policymakers will need to address a number of issues unique to the development of such allocations at the state level. We discuss these choices and issues below.

Identification of sectors vulnerable to leakage

As described in Section IV, all programs that target sectors potentially vulnerable to leakage rely to some extent on metrics of GHG intensity and/or trade intensity to identify sectors that would be eligible for free allowance allocations. The design of such metrics requires the consideration of the following issues, which were addressed in Section IV in greater detail:

- **Level of industry aggregation**: Eligibility criteria can be defined at varying levels of industry aggregation. Use of disaggregated industrial categories supports more precise targeting of leakage support and reduces product heterogeneity, thus simplifying the calculation of allowance allocations. However, data availability may limit the degree of disaggregation possible, particularly given the significant administrative costs that would arise from any new requirements to monitor trade flows.
- **Single or dual requirements for eligibility**: Eligibility criteria can require that sectors meet *either* a GHG-intensive or a trade-intensive criterion or that sectors meet *both* GHG-intensive and trade-intensive criteria.
- **Measuring GHG and trade intensities**: When calculating metrics, GHG costs and trade activity must be measured relative to some level of economic activity. Value of shipments and value added are the two most commonly used metrics.

As discussed in Section IV, all of these decisions have potential implications for which industries will be eligible for free allowances. For example, the choice to require that industries meet both GHG and trade criteria may fail to identify sectors that are vulnerable to leakage

because they are either particularly GHG intensive or particularly trade intensive. Because the use of these GHG and trade intensity metrics is inherently an imperfect approach to identifying sectors potentially vulnerable to leakage, regulators will need to decide how best to use the flexibility offered in specifying these criteria to account for this uncertainty.

The availability of data on California sectors' GHG intensities and trade exposures will also affect these decisions. An administratively simple approach to calculating these metrics would be to use national-level data sources such as those proposed in Waxman-Markey.[50] National-level data, however, will not reflect California-specific conditions. Consequently, metrics of GHG intensity and trade intensity that can reliably be used to identify a comprehensive list of sectors vulnerable to leakage at the state level will be best developed through state-level data.

Of the two metrics, GHG intensities for individual industries will likely be easier to calculate at the state level than trade intensities, because CARB's GHG Inventory has already identified industry-specific GHG emissions. Information on electricity use may not be readily available but might be supplemented through requests to the state's electric utilities. The federal Census of Manufacturers or other data sources can provide corresponding measures of economic output (e.g., value of shipments or value added) for the state's industries.

Trade intensities may be more difficult to measure at the state level, particularly at a level of industry disaggregation necessary to identify specific sectors that are trade exposed. While data is available on international imports and exports, limited options are available to measure trade intensity at the state level.[51] Data on many six-digit NAICS sectors' imports, exports, and production levels would be necessary to calculate trade-intensity metrics such as those proposed in Waxman-Markey, the EU ETS, and Australia's CPRS. Development of new administrative procedures to collect data on trade with other states would likely be very costly. Alternatives – such as using data at a higher level of industry aggregation or relying on national-level data – would be less costly but would not be expected to identify a comprehensive list of specific sectors vulnerable to leakage at the state level.

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[50] These include data from the U.S. Census Annual Survey of Manufacturers, the Energy Information Agency's Manufacturing Energy Consumption Survey, the Economic Census of the United States, and the U.S. International Trade Commission.

[51] The U.S. Department of Transportation (DOT) performs a periodic Commodity Flow Survey (CFS). This survey estimates commodity flows for the universe of approximately 750,000 business establishments in the United States based on data collected from approximately 100,000 establishments over a limited period of time. The DOT reports commodity flows from the 2007 CFS by industry, but it does not currently report these estimates at sufficient geographic disaggregation to determine commodity flows from and into California. U.S. Department of Transportation, *2002 Commodity Flow Survey, State Summaries*, July 2005.

Another option is to consider sectors' vulnerability to leakage through supplemental assessments in addition to identification through the formulaic criteria described above. Supplemental assessments could reflect both quantitative and qualitative information about a sector or activity's vulnerability that might better capture leakage risks for industries in unique circumstances, such as emerging competition that is not yet reflected in existing trade data.[52] Use of such assessments typically requires clear and well-defined criteria and methodologies and transparent procedures for review to ensure that determinations are consistent across sectors, reflect objective, independent analysis and reflect true industry vulnerability. Ensuring adequate procedural safeguards can place an additional administrative burden on the program. Despite these complications, such assessments may be warranted if data limitations reduce the reliability of available metrics for measuring GHG- or trade-intensity at the state level.

Allowance allocations to sectors vulnerable to leakage

Should CARB decide to provide assistance to sectors vulnerable to leakage, it could do so through free allowance allocations, which could be based on fixed allocations, updating allocations, or a combination of the two. As discussed above, updating allocations are superior in addressing leakage concerns. Under any approach, the quantity of allowances would most likely be calculated using predetermined formulas. A number of decisions must be made in the design of such formulas, including:

- **Basis for allowance factor**: There are two key decisions in determining the quantity of allowances provided per unit output (i.e., the "allowance factor"). The first is the empirical basis for allowance factors, with sector-average emissions or "best practices" as common bases. The second decision is whether the allowance factors will be fixed based on historical data or periodically revised based on more recent data. In most – but not all – cases, the size and methods used to determine the allowance factors will have little or no effect on facilities' incentives to reduce their emissions.
- **Degree of offset of competitive disadvantage**: Eligible facilities can (on average) be fully or partially compensated for the direct and indirect costs of climate policy. This decision could be affected in part by whether California chooses to limit the number of allowances designated to address leakage. Such limitations may be considered because, while there are many potential uses for allowance value, there is only a limited number of allowances under the fixed emissions target (which declines over time).
- **Differentiation in support based on vulnerability**: A standard allocation formula can be used for all eligible facilities or the formulas can be tiered to reflect each sector's (or

[52] The Australian Government has proposed such assessments in the CPRS. The Australian Government has proposed allowing activities to be considered for assistance if the firms undertaking them can demonstrate the *potential* for international competition, even if such competition does not have a significant presence given current market conditions.

facility's) degree of GHG or trade intensity. Adjusting the formulas to the degree of vulnerability may provide policymakers with flexibility to target the most vulnerable sectors if the total quantity of allowances designated to address leakage is limited.

Finally, California must decide when and how to phase out any assistance program. For example, regulators could establish quantitative tests or qualitative criteria that, if met, would trigger a gradual end to free allocations.

VI. Conclusion

Assessments of potential leakage arising from national (e.g., United States) or even multinational (e.g, European Union) climate policies have raised concerns about potential leakage from certain energy-intensive, trade-exposed sectors that could diminish the environmental effectiveness and reduce the cost effectiveness of regional climate policies. Concerns about leakage are expected to be just as severe, if not more so, for an aggressive state program implemented without corresponding obligations from other states.

California regulators and policymakers have a number of options to address these leakage issues and can draw upon a number of models from existing and proposed cap-and-trade systems throughout the world. The first steps toward limiting leakage should be broadening the scope of climate commitments to include other U.S. states, through federal legislation, or to include other nations, through multinational commitments. Harmonizing the regulations used to achieve these commitments across states and across nations would further reduce leakage by eliminating differences in regulations faced by different industries in different countries that could lead to competitive advantages.

The next steps to reducing leakage is the development of climate regulations aimed at cost-effectively achieving GHG targets, including the implementation of effective cost-containment mechanisms within a cap-and-trade system. By limiting the cost of climate policy, these measures can limit the extent of any competitive disadvantage created when an economy takes on GHG regulations that are not reciprocated by economic competitors.

After these steps are taken, California will need to weigh its options for targeting particularly vulnerable sectors. Free allowance allocations and border adjustments are options that can be potentially used to assist such industries. The choice between these mechanisms should reflect a balance of considerations, not only in terms of environmental effectiveness and cost effectiveness, but in terms of administrative burdens and legal complications, which could potentially delay implementation of AB 32 policies.

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APPENDIX

Appendix Table A
Sectors Eligible for Assitance Under Waxman-Markey
As Reported by Houser (2009)

	Energy Intensity (energy costs / shipment value)	GHG Intensity (GHG costs / shipment value)	Trade Intensity (exports + imports) / (production + imports)
Alkalies and chlorine manufacturing	27.5%	8.8%	28.5%
Alumina refining and primary aluminum production	19.4%	19.3%	67.0%
Iron ore mining	17.3%	3.3%	26.9%
Flat glass manufacturing	17.2%	4.2%	47.9%
Cement manufacturing	15.0%	23.6%	15.5%
Glass container manufacturing	14.6%	3.5%	18.5%
Nitrogenous fertilizer manufacturing	14.2%	29.2%	85.5%
Other pressed and blown glass and glassware manufacturi	11.6%	3.9%	58.2%
Wet corn milling	11.3%	5.7%	18.8%
Copper, nickel, lead, and zinc mining	11.2%	2.2%	25.1%
Other nonmetallic mineral mining and quarrying	10.8%	2.2%	36.7%
Other structural clay product manufacturing	10.6%	3.6%	25.1%
Tobacco farming	8.9%	1.6%	91.0%
Gold, silver, and other metal ore mining	8.8%	1.7%	20.7%
Mineral wool manufacturing	8.5%	2.2%	16.8%
Fishing	8.5%	1.4%	96.7%
Paper and newspring mills	8.3%	2.5%	29.5%
Pulp mills	8.3%	2.5%	92.3%
All other basic inorganic chemical manufacturing	8.3%	4.5%	58.1%
Carbon black manufacturing	8.3%	10.5%	23.0%
Cotton farming	8.0%	1.5%	62.1%
Ceramic wall and floor tile manufacturing	7.6%	2.5%	63.1%
Petroleum refining *	7.4%	--	~ 20%
Reconstituted wood product manufacturing	7.3%	1.9%	30.2%
Iron and steel mills and ferroalloy manufacturing	6.6%	6.0%	35.7%
Grain farming	6.3%	1.2%	36.3%
Artificial and synthetic fibers and filaments manufacturing	6.2%	1.8%	40.4%
Other basic organic chemical manufacturing	6.1%	3.2%	51.9%
Primary nonferrous metal (except copper and aluminum)	6.1%	2.5%	128.7%
Synthetic dye and pigment manufacturing	5.7%	1.3%	46.7%
Synthetic rubber manufacturing	5.6%	1.2%	59.9%
Carbon and graphite product maufacturing	5.5%	1.5%	50.1%
Tree nut farming	5.3%	1.1%	68.0%
Petrochemical manufacturing	5.1%	1.3%	15.3%
Refractory manufacturing	5.0%	1.7%	37.1%
Pottery, ceramics, and plumbing fixture manufacturing	5.0%	1.7%	63.0%

Notes

* Houser (2009) does not include petroleum refining in his discussion of energy-intensive, trade-exposed sectors. Data for the petroleum refining sector shown in this table are from Houser et al. (2008).

Sources

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Appendix Table B
Preliminary List of Sectors
Eligible for Assistance Under EU ETS Phase III

NACE	Sector Description
1010	Mining and agglomeration of hard coal
1430	Mining of chemical and fertilizer minerals
1597	Manufacture of malt
1711	Preparation and spinning of cotton-type fibres
1810	Manufacture of leather clothes
2310	Manufacture of coke oven products
2413	Manufacture of other inorganic basic chemicals
2414	Manufacture of other organic basic chemicals
2415	Manufacture of fertilizers and nitrogen compounds
2417	Manufacture of synthetic rubber in primary forms
2710	Manufacture of basic iron and steel and of ferro-alloys
2731	Cold drawing
2742	Aluminium production
2744	Copper production
2745	Other non-ferrous metal production
2931	Manufacture of agricultural tractors
1562	Manufacture of starches and starch products
1583	Manufacture of sugar
1595	Manufacture of other non-distilled fermented beverages
1592	Production of ethyl alcohol from fermented materials
2112	Manufacture of paper and paperboard
2320	Manufacture of refined petroleum products
2611	Manufacture of flat glass
2613	Manufacture of hollow glass
2630	Manufacture of ceramic tiles and flags
2721	Manufacture of cast iron tubes
2743	Lead, zinc and tin production
2651	Manufacture of cement
2652	Manufacture of lime
1110	Extraction of crude petroleum and natural gas
1310	Mining of iron ores
1320	Mining of non-ferrous metal ores, except uranium and thorium ores
1411	Quarrying of ornamental and building stone
1422	Mining of clays and kaolin
1450	Other mining and quarrying n.e.c
1520	Processing and preserving of fish and fish products
1541	Manufacture of crude oils and fats
1591	Manufacture of distilled potable alcoholic beverages
1593	Manufacture of wines
1712	Preparation and spinning of woollen-type fibres
1713	Preparation and spinning of worsted-type fibres
1714	Preparation and spinning of flax-type fibres
1715	Throwing and preparation of silk, including from noils, and … [1]
1716	Manufacture of sewing threads
1717	Preparation and spinning of other textile fibres
1721	Cotton-type weaving
1722	Woollen-type weaving
1723	Worsted-type weaving
1724	Silk-type weaving
1725	Other textile weaving
1740	Manufacture of made-up textile articles, except apparel
1751	Manufacture of carpets and rugs
1752	Manufacture of cordage, rope, twine and netting
1753	Manufacture of non-wovens and articles made from non-wovens, except apparel
1754	Manufacture of other textiles n.e.c.
1760	Manufacture of knitted and crocheted fabrics

Appendix Table B (Continued)
Preliminary List of Sectors
Eligible for Assistance Under EU ETS Phase III

NACE	Sector Description
1771	Manufacture of knitted and crocheted hosiery
1772	Manufacture of knitted and crocheted pullovers, cardigans and similar articles
1821	Manufacture of workwear
1822	Manufacture of other outerwear
1823	Manufacture of underwear
1824	Manufacture of other wearing apparel and accessories n.e.c.
1830	Dressing and dyeing of fur; manufacture of articles of fur
1910	Tanning and dressing of leather
1920	Manufacture of luggage, handbags and the like, saddlery and harness
1930	Manufacture of footwear
2010	Sawmilling and planing of wood; impregnation of wood
2052	Manufacture of articles of cork, straw and plaiting materials
2111	Manufacture of pulp
2124	Manufacture of wallpaper
2215	Other publishing
2330	Processing of nuclear fuel
2412	Manufacture of dyes and pigments
2420	Manufacture of pesticides and other agro-chemical products
2441	Manufacture of basic pharmaceutical products
2442	Manufacture of pharmaceutical preparations
2452	Manufacture of perfumes and toilet preparations
2463	Manufacture of essential oils
2464	Manufacture of photographic chemical material
2465	Manufacture of prepared unrecorded media
2466	Manufacture of other chemical products n.e.c.
2470	Manufacture of man-made fibres
2511	Manufacture of rubber tyres and tubes
2615	Manufacture and processing of other glass, including technical glassware
2621	Manufacture of ceramic household and ornamental articles
2622	Manufacture of ceramic sanitary fixtures
2623	Manufacture of ceramic insulators and insulating fittings
2624	Manufacture of other technical ceramic products
2625	Manufacture of other ceramic products
2626	Manufacture of refractory ceramic products
2681	Production of abrasive products
2722	Manufacture of steel tubes
2741	Precious metals production
2861	Manufacture of cutlery
2862	Manufacture of tools
2874	Manufacture of fasteners, screw machine products, chain and springs
2875	Manufacture of other fabricated metal products n.e.c.
2911	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
2912	Manufacture of pumps and compressors
2913	Manufacture of taps and valves
2914	Manufacture of bearings, gears, gearing and driving elements
2921	Manufacture of furnaces and furnace burners
2923	Manufacture of non-domestic cooling and ventilation equipment
2924	Manufacture of other general purpose machinery n.e.c.
2932	Manufacture of other agricultural and forestry machinery
2941	Manufacture of portable hand held power tools
2942	Manufacture of other metalworking machine tools
2943	Manufacture of other machine tools n.e.c.
2951	Manufacture of machinery for metallurgy
2952	Manufacture of machinery for mining, quarrying and construction
2953	Manufacture of machinery for food, beverage and tobacco processing
2954	Manufacture of machinery for textile, apparel and leather production

Appendix Table B (Continued)
Preliminary List of Sectors
Eligible for Assistance Under EU ETS Phase III

NACE	Sector Description
2955	Manufacture of machinery for paper and paperboard production
2956	Manufacture of other special purpose machinery n.e.c.
2960	Manufacture of weapons and ammunition
2971	Manufacture of electric domestic appliances
3001	Manufacture of office machinery
3002	Manufacture of computers and other information processing equipment
3110	Manufacture of electric motors, generators and transformers
3120	Manufacture of electricity distribution and control apparatus
3130	Manufacture of insulated wire and cable
3140	Manufacture of accumulators, primary cells and primary batteries
3150	Manufacture of lighting equipment and electric lamps
3162	Manufacture of other electrical equipment n.e.c.
3210	Manufacture of electronic valves and tubes and other electronic components
3220	Manufacture of television and radio transmitters and apparatus … [2]
3230	Manufacture of television and radio receivers, sound or video recording … [3]
3310	Manufacture of medical and surgical equipment and orthopaedic appliances
3320	Manufacture of instruments and appliances for measuring, checking, … [4]
3340	Manufacture of optical instruments and photographic equipment
3350	Manufacture of watches and clocks
3511	Building and repairing of ships
3512	Building and repairing of pleasure and sporting boats
3530	Manufacture of aircraft and spacecraft
3541	Manufacture of motorcycles
3542	Manufacture of bicycles
3543	Manufacture of invalid carriages
3550	Manufacture of other transport equipment n.e.c.
3621	Striking of coins
3622	Manufacture of jewellery and related articles n.e.c.
3630	Manufacture of musical instruments
3640	Manufacture of sports goods
3650	Manufacture of games and toys
3661	Manufacture of imitation jewellery
3662	Manufacture of brooms and brushes
3663	Other manufacturing n.e.c.

Notes

1. Full sector description is "Throwing and preparation of silk, including from noils, and throwing and texturing of synthetic or artificial filament yarns."
2. Full sector description is "Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy."
3. Full sector description is "Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods."
4. Full sector description is "Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment."

Source

Commission of the European Communities, "Commission Decision Determining a List of Sectors and Subsectors Which are Deemed to be Exposed to a Significant Risk of Carbon Leakage Pursuant to Article 10a (13) of Directive 2003/87/EC: Impact Assessment," September 4, 2009.

Appendix Table C
Activities Eligible for Assistance
Under Australia's Energy-Intensive Trade-Exposed Assistance Program

Activities Eligible for Assistance	Emissions Intensity
Production of carbon black	High
Production of glass containers	Moderate
Production of bulk flat glass	High
Production of methanol	High
Manufacture of newsprint	High
Production of silicon	High
Production of white titanium dioxide pigment	Moderate
Smelting zinc	High

Sources

Australian Government, "Carbon Pollution Reduction Scheme Regulations 2009," Part 8.

Australian Government, "Establishing the Eligibility of Activities Under the Emissions-Intensive Trade-Exposed Assistance Program," June 2009.

Appendix Table D
Additional Activities to be Evaluated for Assistance
Under Australia's Energy-Intensive Trade-Exposed Assistance Program

Alumina refining	Integrated lead and zinc production
Aluminum smelting	Integrated iron and steel
Carbamide (urea) production	Iron ore pellets
Cartonboard manufacturing	Lime production
Carbon steel from cold ferrous feed	Magnesia production
Chlorine gas and soldium hydroxide production	Packaging and industrial paper manufacturing
Clinker	Petroleum refining
Dry pulp manufacturing	Pig iron production
Fused alumina production	Printing and writing paper manufacturing
Fused zirconia production	Soda ash production
High purity ethanol production	Synthetic rutile production
Hydrogen peroxide	Tissue paper manufacturing

Source

Australian Government, Department of Climate Change, "Activity Definitions," http://www.climatechange.gov.au/government/initiatives/cprs/eite/eite-activity-definitions.aspx.