Report on Emissions Leakage and Resource Shuffling

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1. Leakage

The global nature of climate change creates challenges for California climate policy, which covers only a small subset of the sources contributing to the problem. This creates the potential for "leakage", a concept that is most easily illustrated by example. Consider an industrial producer operating in California that is required to purchase GHG allowances to cover its emissions. As a consequence, suppose this producer becomes relatively less competitive in the global market and thus loses market share to its out-of-state competitors. This induces a shift or "leakage" of production—and associated emissions—from the California firm to its out-of-state competitors.

For the purposes of this report, it is useful to distinguish between different forms of leakage:

- "**Emissions leakage**" refers to any change in emissions from sources not covered by the GHG policy or program that is *caused* by the GHG emissions policy or program. It is worth noting that leakage is a potential issue under *any* state climate change policy that increases operating costs of regulated entities, not just cap-and-trade. Also, it is worth noting that leakage can also happen within California if there is excess capacity at in-state facilities that are exempt from the GHG regulations.

- "**Rent leakage**" refers to the transfer of profits from California entities to out-of-state producers that is induced by GHG regulations.

Minimizing emissions leakage caused by California's climate change policies is a statutory requirement of AB 32 and an important design objective of the cap-and-trade program. Economists have thought carefully about the various channels through which emissions leakage can occur. For the purposes of this report, it is useful to distinguish between two related but conceptually distinct leakage channels.[1]

- **Trade-competitiveness channel**: Policy-induced increases in operating costs can cause industrial production (and associated emissions) to move to jurisdictions outside the reach of the regulation via trade flows.

[1] The economics literature has also identified additional leakage channels via income effects and technology spillovers from induced innovation that can potentially induce "negative leakage" (see, for example, Gerlagh and Kuik 2014).

- **Fuel price channel**: If emissions regulations in a large open economy reduces demand for carbon-intensive inputs (e.g., fossil fuels), global input prices will fall and stimulate demand for these inputs in unregulated regions.

The conceptual distinction between these two channels is important for the assessment of leakage mitigation alternatives. Measures such as output-based permit allocations and border adjustments are designed to counteract the first channel. The second channel is much more difficult to mitigate or address.

Concerns about leakage loom large, so it is essential that California's cap-and-trade program incorporate a meaningful response to this problem. It is important to acknowledge ARB's pioneering work in this area. The output-based approach developed by ARB, which involves allocating production subsidies in the form of free permit allocation to those sectors deemed to be at leakage risk, has set a policy design example that other jurisdictions are observing and following. That said, the current approach to determining the appropriate level of these subsidies is increasingly set by political arrangement, rather than data-based analysis. In what follows, we acknowledge some of the formidable challenges that complicate leakage mitigation in practice, and point to critical knowledge gaps that could be usefully narrowed with additional data collection and analysis.

1.1 Assessing leakage risk

Correctly identifying the kinds of economic activities most at risk of carbon leakage is a critical first step in the design of effective risk mitigation (Fowlie and Reguant, 2018). Here, we will focus on emissions leakage as this, along with "transition assistance", is the justification of free permit allocations to emissions-intensive industries.

There is a growing body of research in economics that assesses the potential for leakage risk across a range of sectors and contexts. One methodological approach uses multi-sector and multi-region computable general equilibrium models calibrated to represent global trade linkages and energy flows. This approach can capture multiple leakage channels, but results can be very sensitive to assumptions about key parameters, such as trade elasticities.

An alternative, partial equilibrium approach involves empirically estimating parameters that determine the extent of leakage potential via the trade/competitiveness channel (see, for example, Fowlie et al., 2016). Intuitively, emissions leakage in a particular industry via the trade/competitiveness channel can be defined as the change in out-of-state production that is induced by California GHG policies multiplied by the emissions intensity of that foreign production:

$$\text{Emissions leakage} = GHG_{out} \times \Delta Q_{out}$$

$\mathbf{GHG_{out}}$ (units: GHG emissions per unit of value of production) is the marginal emissions intensity of the out-of-state production that responds to a change in relative operating costs. As we explain in Fowlie and Reguant (2018), these marginal emissions intensity parameters are difficult to estimate empirically.

- Reliable data measuring the carbon intensity of out-of-state production can be very difficult to obtain.
- Even if we can obtain a reasonable estimate of the average emissions intensity for a given industry and trading partner, this average could significantly over or under-estimate the marginal rate. Past work has documented tremendous variation in emissions intensities across producers in the same industry (Lyubich et al, 2018).
- Marginal emissions rates in a given sector/jurisdiction can change over time as out-of-state producers respond to changing terms of trade and factor prices. A marginal emissions intensity estimate constructed prior to the introduction of a policy need not apply once the policy takes effect.

Researchers are actively collecting data on the emissions intensity of industrial production in various jurisdictions outside California. A concerted effort to gather these data and assess their credibility would help inform leakage risk assessment efforts in California and beyond.

$\boldsymbol{\Delta Q_{out}}$ (units: value of production) captures the responsiveness of out-of-state production to the introduction of GHG regulations in California. This industry-specific responsiveness parameter will in turn be determined by a number of factors, including the elasticity of the supply of imports to California, the elasticity of demand for exports from California, and the elasticity of production within California to policy-induced increases in operating costs. These elasticities are difficult to estimate empirically.

- One limiting factor pertains to data availability. For example, data on intra-national, interstate trade is very limited, making it next to impossible to assess how these trade flows might be impacted by changes in relative operating costs.
- A second complication concerns the identification of underlying elasticity parameters. It can be very difficult to disentangle the impacts of California climate change policies from the effects of other time varying factors.

These complications notwithstanding, careful work that seeks to evaluate how in-state production, imports, and exports are responding to policy-induced increases in operating costs can help inform our understanding of leakage potential across affected sectors.

1.2 Emissions leakage mitigation

California (along with other jurisdictions implementing GHG cap-and-trade programs) has been experimenting with using production subsidies to mitigate leakage in sectors deemed to be exposed to leakage risk. Under this approach, emitters are required to purchase cap-and-trade allowances to cover their emissions. But these same firms are freely allocated permits based on output levels. Thus, the economic effect of this approach is that the producer sees both an emissions tax (via the market-based value for allowances, which provides an incentive to reduce emissions) and a production incentive (which helps to 'level the carbon playing field' with respect to unregulated out-of-state producers).

This output-based free allowance allocation approach can, in theory, be used to strike a balance between incentivizing emissions abatement and mitigating leakage. However, it is important to stress that this strategy comes with side effects. First, an opportunity cost is incurred when allowances are freely allocated. If allowances were not freely allocated to industry to protect against leakage risks, they could be sold at auction and their revenue used to fund climate mitigation expenditures, cut taxes, or provide direct rebates to consumers. Second, output-based rebating dilutes the carbon price signal in those industries that receive implicit subsidies. This shifts more of the overall abatement cost burden onto producers who are subject to the cap-and-trade program, but ineligible for these subsidies. Thus, the use of output-based subsidies to mitigate leakage will generally increase the total abatement costs incurred within California to achieve a given level of abatement.

In sum, because output-based free allocation has potentially significant implications for both the costs of abatement and the distribution of who bears these costs, these interventions should be judiciously calibrated and targeted. To strike the right balance between incentivizing emissions reductions within California and mitigating emissions leakage out of state, subsidy levels should ideally reflect the GHG emissions in external jurisdictions that are avoided when production activities remain within California.

Allocating valuable subsidies is an inherently political process, so there is a pragmatic need for a systematic approach that can be applied consistently and transparently across sectors. The current approach to calibrating output-based subsidies is quite ad hoc. In particular, there is no attempt to rationalize the recent increase in industry-specific allocation factors in terms of factors that determine emissions leakage risk (namely foreign emissions intensity and the responsiveness of out-of-state production to changes in relative operating costs). As we acknowledge above, estimating these parameters is a challenging and imprecise exercise. These complications notwithstanding, more could be done to ensure that production-based subsidies conferred to industry reflect true leakage risk.

As California's GHG policies increase in stringency and ambition, the efficiency and distributional implications of any mis-calibration of subsidies will become more significant. Additional data collection (e.g., on intra-national, inter-state trade flows) and analysis is needed to refine and improve the current approach to calibrating and conferring leakage mitigation compensation.

2. Resource shuffling

Resource shuffling is a specific type of leakage that can occur in energy markets. It is most commonly discussed in the context of electricity markets, but it can also occur in other energy markets, such as those for transportation fuels. The idea is most easily illustrated by example.

Suppose a utility once imported power from carbon-intensive coal plants prior to the cap-and-trade program's existence. In response to the new carbon price, the utility might decide to divest its contract with the coal plant and replace it with natural gas-fired electricity. While this swap will reduce the carbon intensity of the utility's imports, and therefore reduce its compliance obligations under the cap-and-trade program, it may not reduce net greenhouse gas emissions if the divested coal-fired electricity is purchased by a utility outside of the cap-and-trade program.

Much of the progress California has made in reducing its greenhouse gas emissions in the electricity sector has been attributed to reductions in emissions from imports (ARB, 2018a: Figures 7-8). This underscores the importance of assessing the potential for electricity resource shuffling. Under California's cap-and-trade program, electricity importers are responsible for submitting compliance instruments to cover the greenhouse gas emissions associated with all imports.[2] As a result, electricity importers have a financial incentive to divest imports from high-carbon resources and replace them with low-carbon resources.

2.1 Resource shuffling in the cap-and-trade program

Energy modeling studies, including those conducted by ARB's former economic advisers, have identified a significant potential for resource shuffling in the electricity sector (Chen et al., 2011; Bushnell and Chen, 2012; Bushnell et al., 2014; Borenstein et al., 2014). Resource shuffling can occur via spot market or other short-term bilateral trades; or it could manifest via the systematic divestment of California utilities' legacy ownership positions in, and long-term contracts with, out-of-state coal-fired facilities (Cullenward & Weiskopf, 2013).

Although ARB's regulations nominally prohibit resource shuffling,[3] ARB decided to exempt a range of so-called "safe harbor" practices—first via an informal guidance document in late 2012 (Cullenward, 2014a) and subsequently via formal rulemaking completed in 2014.[4] Among the exempted "safe harbor" practices are any trades affecting legacy coal contracts subject to the provisions of SB 1018's Greenhouse Gas Emissions Performance Standard[5] and transactions in the day-ahead and real-time electricity markets operated by the California Independent System Operator (CAISO).[6] For a deeper discussion of how these safe harbors might operate in practice, see Cullenward & Weiskopf (2013: 21-26).

After ARB released its safe harbor exemptions to the prohibition on resource shuffling, California load-serving entities divested several major legacy coal contracts (Cullenward, 2014b). These divestitures reduced GHG emissions as reported in California's cap-and-trade program and GHG inventory. To the extent that these affected coal plants continued to operate

2 Cal. Code Regs., title 17, § 95852(b).
3 *Id*. at § 95852(b)(2).
4 *Id*. at § 95852(b)(2)(A).
5 *I*d. at §§ 95852(b)(2)(A)(2), (7).
6 *Id*. at §§ 95852(b)(2)(A)(2)(10).

and supply out-of-state electricity customers afterwards, there is potential for resource shuffling and associated emissions leakage.

To rigorously identify or measure the extent of resource shuffling, one would need to construct a credible counterfactual scenario against which to measure the market outcomes we actually observe (as was done for RGGI by Fell & Maniloff, 2018). More precisely, we need detailed estimates of the electricity production activity we would have observed across WECC had California climate policies not been in place. The task is complicated by the fact that economic fundamentals (such as natural gas prices, renewable energy costs, and load-serving entities' demand profiles) look much different today than they did at the time prospective analysis of resource shuffling risks were conducted. These complications notwithstanding, a careful analysis of how electricity dispatch has changed with the introduction of California climate policies could help inform our understanding of the extent to which reshuffling has—or has not—occurred.

The subcommittee notes that there may be additional concern about resource shuffling as California electricity load migrates from investor-owned utilities to community choice aggregators (CCAs) (CPUC, 2018). According to one projection, by the mid-2020s, CCAs and direct access customers could be responsible for 85% of retail load in California investor owned utilities' service territories (CPUC, 2017: 3). Many CCAs contract with existing out-of-state electricity resources, particularly in service of high-renewable energy retail choice programs. If the increase in California load supplied by CCAs reduces demand for relatively emissions intensive out-of-state resources, these resources may continue to supply customers outside of California. There is some preliminary evidence that CCA procurement may be leading to this form of resource shuffling (Rivard, 2018). Given the growing role played by CCAs, we see the potential for resources shuffling in the CCA context as a topic worthy of further investigation.

2.2 State-level greenhouse gas and electricity accounting

In order to track resource shuffling and evaluate greenhouse gas reductions from the cap-and-trade program, it is essential to have high-quality data on electricity imports into California and their associated greenhouse gas emissions.

One issue that merits attention is the role of unspecified power in the cap-and-trade program. Under the regulations, electricity imports from specific power plants receive source-specific greenhouse gas emissions factors. But many California utilities import significant quantities of electricity from unspecified sources. These resources are assigned a default emissions factor of 0.428 tCO_2e per MWh.[7] This method was developed in 2010 and was based on the average western grid supplies from the years 2006 through 2008 (Kaatz & Anders, 2016). Using this as the default, there is the potential for coal-fired generation to be classified as unspecified power for delivery to California at a substantially lower cost than it would face if made as a specified transfer.

7 *Id.* at § 95852(b)(1)(C) (citing *id*. at § 95111(b)(1) (specifying the default unspecified emissions factor)).

Calibrating this unspecified emissions factor to accurately reflect the emissions intensity of unspecified imports is challenging for two reasons.

First, the choice of default emissions factor changes the incentive market participants face when determining whether or not to reveal the source-specific emissions of their electricity imports. In other words, the composition of unspecified imports will depend in part on how the default emissions factor is calibrated. Electricity resources that are more GHG-intensive than the default factor may prefer transactional arrangements that are reported as unspecified imports, whereas those resources that are less GHG-intensive than the default factor may prefer to find transactional arrangements that reveal them as specified sources. The default factor should be chosen with this supply-response in mind.

A second, related challenge stems from the significant heterogeneity in the emissions intensity of sources supplying the California electricity market. The average emissions intensity of generators that comprise unspecified imports can be very different from the average emissions intensity across all suppliers. It can thus be very challenging to identify the marginal resources that ramp up in response to increased demand for California imports.

We note that electricity import data from ARB and the California Energy Commission appear to be diverging, especially with respect to unspecified power (see ARB, 2018c; CEC, 2018). Additional analysis could be helpful to understand the causes of these differences and what, if anything, they mean for accuracy in tracking electricity emissions. There is nothing inherently problematic with different definitions of unspecified power that are used for different purposes. However, differences in data reporting may enable analysts to evaluate whether a default emissions factor is altering market participants' behavior in response to the incentives created by the choice of default emissions factor.

2.3 Greenhouse gas accounting in regional electricity markets

Concerns have also been raised about resource shuffling in the context of the CAISO Energy Imbalance Market (EIM), a voluntary regional electricity market. In the CAISO EIM, out-of-state power plants are dispatched to CAISO if and only if they elect to become subject to the cap-and-trade program and submit a "GHG Bid Adder." As a result, the carbon price affects the EIM operator's dispatch order such that lower-carbon resources are preferentially dispatched to serve California load.

ARB and CAISO have discussed the concern that the CAISO EIM results in resource shuffling (ARB, 2018b: 70-73; CAISO, 2018). The issue arises because low- and zero-carbon resources outside of California have an incentive to opt in the EIM to serve CAISO load. However, if these relatively clean out-of-state resources are preferentially dispatched to serve California load, higher-carbon resources may be reallocated to serve non-California EIM load. The dispatch of higher-carbon resources to serve non-California EIM load is sometimes called "backfilling" or "secondary dispatch."

CAISO, ARB, and other stakeholders have been investigating the problem for several years. Until recently, CAISO was testing what it called a "two-pass solution" where the EIM market algorithm would be run twice: once without the carbon price, and again with the carbon price included from entities' bids. By comparing these two real-time optimization results, CAISO hoped to identify resources that were merely being re-allocated across state borders in response to the carbon price and reduce incentives for backfilling. However, some observers criticized the method for potentially enabling gaming of electricity market bidding strategies (Hogan, 2017). CAISO cited these concerns in moving away from the two-pass approach.

More recently, CAISO developed an alternative approach to mitigating leakage in the EIM (CAISO, 2018) and filed for EIM tariff amendments with the Federal Energy Regulatory Commission in August 2018.

3. Leakage-related matters in ARB's proposed regulations

Based on the very limited window of time in which the IEMAC was able to review ARB's proposed regulations, we have identified two key issues in the proposed regulations where issues related to leakage arise. We offer initial reactions to these issues here.

3.1 Accounting for CAISO EIM emissions

In the current cap-and-trade regulations, ARB developed what it calls a "bridge solution" to address emissions leakage in the EIM market. Under this bridge solution, ARB must first estimate emissions leakage that has occurred. Then, ARB will retire allowances to account for outstanding EIM obligations from the pool of allowances that remain unsold from the 2016-17 auction collapse. In the new proposal, ARB proposes to retire allowances from future program budget years to account for estimated emissions leakage associated with EIM transactions in 2018 and Q1 2019, rather than retiring allowances from the pool of temporarily unsold allowances from undersubscribed auctions (ARB, 2018b: 73).[8]

Beginning in Q2 2019, ARB proposes to calculate an EIM-wide leakage factor and assign new compliance obligations to EIM importers on a basis that is proportional to their share of total EIM electricity imports (ARB, 2018b: 72). From this point forward, there would be no need to retire allowances to account for leakage in the EIM because the calculated leakage would be assigned to EIM importers on an ongoing basis. The leakage is calculated based on the difference between the source-specific emissions from power that CAISO deems delivered to California and the unspecified emissions rate, which is taken as the "true" emissions profile of EIM imports. Under the proposal, EIM importers would face compliance obligations that are equal to the emissions associated with source-specific imports that CAISO deems to be delivered to California plus a proportional leakage factor (ARB, 2018b: 72-73).

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8 Such a change may be necessary because the pool of unsold allowances from undersubscribed auctions is temporary and may not be available on an ongoing basis. See the Managing Allowance Supply subcommittee report for more details.

Based on a preliminary review, retiring allowances to account for emissions leakage from resource shuffling is a reasonable approach to preserving the environmental integrity of the cap-and-trade program, provided that this leakage can be credibly estimated. ARB's proposal to retire allowances first from the pool of unsold allowances, and later, directly from future budget years, is a sensible way to accomplish these ends. However, allowance retirement shifts the costs of mitigating leakage from electricity importers, who are directly responsible for the leakage, to the market as a whole. We note that it may not be administratively feasible to assign leakage mitigation responsibility to historical electricity importers, which suggests that there may be relatively few alternatives to addressing leakage that has already occurred.

From an economic perspective, the concept behind ARB's new proposal for Q2 2019 and beyond changes electricity market incentives and likely distributional outcomes that will be important to study and monitor going forward. The current "bridge solution" retires allowances that would otherwise be made available for sale to the entire market, reducing market-wide supplies and increasing the market-wide cost of program compliance to account for leakage. Under this approach—whether allowances are retired from the pool of temporarily unsold allowances from undersubscribed auctions, or future allowance budget years—the cost of mitigating leakage in the electricity sector is borne by all market participants.

In contrast, the proposal for Q2 2019 and beyond would impose the costs of mitigating leakage in the electricity sector on the electricity importers directly, rather than across all sectors in the cap-and-trade program. This could increase the costs of purchasing electricity imports via the EIM, which could in turn affect electricity importing decisions more broadly. It is possible that these effects would induce importers to switch away from EIM imports, where the "true" emissions are assessed at the unspecified emissions factor rate, and instead prefer bilateral contracts with the same low-carbon resources, which would be eligible for source-specific emissions accounting outside of the EIM and without mitigating leakage.

The subcommittee has not had sufficient time to review ARB's proposed methods in detail and therefore cannot express a final view on these important matters. Careful analysis of the incentives and distributional impacts of ARB's proposal is warranted.

Meanwhile, we note that under both the status quo and the proposed regulatory changes, leakage in the EIM is calculated based on the assumption that the "true" EIM emissions are captured by ARB's unspecified emissions factor. Therefore, the effectiveness of this approach depends on the relevance and accuracy of ARB's unspecified emissions factor. As discussed in Section 2.2, the unspecified emissions factor has two important shortcomings. First, it is based on older data that may no longer be representative of actual average WECC-wide emissions. Second, it is an estimate of average emissions, not an estimate of the marginal emissions that result from the effect of California's climate policies on electricity imports. The subcommittee believes that further analysis of these issues is warranted.

3.2 Increase in Industry Assistance Factors in third compliance period

AB 32 and AB 398 require that ARB act to reduce GHG emissions while minimizing emissions leakage. To this end, free allowances are allocated to industrial emitters on the basis of their industrial output and leakage risk. As we note above, emissions-leakage-mitigating subsidy levels should ideally reflect the GHG emissions in external jurisdictions that are avoided when production activities remain within California.

ARB categorizes covered industrial sectors operating under specific NAICS codes as either high, medium, or low leakage risk. To calibrate the output-based subsidy, ARB uses the product of an industry-specific emissions benchmark and an "industry assistance factor" (IAF) to determine the number of permits allocated per unit of production. The IAF assigned to high, medium, and low risk industries has changed over time (see Table 1).

Table 1: Industry assistance factors in ARB regulations

Leakage risk	**First Period (2013-2014)**	**Second Period (2015-2017)**	**Third Period (2018-2020)**	**Fourth Period (2021-2023)**
2010 Regulation (Original rules) (ARB, 2011: Table 8-1)				
High	100%	100%	100%	N/A
Medium	100%	75%	50%	N/A
Low	100%	50%	30%	N/A
2013 Regulation (Current rules) (ARB, 2014: Table 8-1)				
High	100%	100%	100%	N/A
Medium	100%	100%	75%	N/A
Low	100%	100%	50%	N/A
2018 Regulation (Proposed rules) (ARB, 2018b: 59-64)				
High	100%	100%	100%	100%
Medium	100%	100%	100%	100%
Low	100%	100%	100%	100%
Legal authority:	ARB determines how to minimize leakage risks pursuant to AB 32			AB 398 requirement

The IAF values established in the original 2010 Regulation began at 100% and were initially scheduled to decrease in each new multi-year compliance period through 2020. However, during the 2013 regulatory amendment process, in an abundance of caution, staff delayed the scheduled reduction in the IAFs by one compliance period (ARB, 2014: Table 8-1). This delay allowed for the completion of research commissioned by ARB at the request of the Board to re-evaluate leakage risk for all industrial sectors covered by the Program and to inform updating industrial assistance factors. The 2013 cap-and-trade amendments constitute the current state of the cap-and-trade regulation with respect to IAFs.

The recent cap-and-trade extension bill, AB 398, changed the legal basis for ARB's determination of IAFs. Through 2020, ARB's authority to develop IAFs derives from AB 32's requirement to minimize leakage in the cap-and-trade regulations. Beginning in 2021, however, AB 398 requires ARB to use 100% IAFs for all industries, regardless of leakage risk classification.

The aforementioned data limitations—including, but not limited to, missing data on interstate trade transactions—have complicated a data-driven assessment of leakage risk to date. Citing limitations of the data and methods used in the commissioned studies, ARB now proposes to retroactively increase the IAF for affected industries in 2018 and avoid the reduction in the years 2019 and 2020 (ARB, 2018b: 59-64).

As we note above, output-based permit allocation to targeted industries shifts abatement cost burdens to unsubsidized sectors and increases the costs incurred within California to meet California's GHG reduction goals. Given these side effects, production subsidies should be judiciously targeted. If the legal requirement is to mitigate varying degrees of emissions leakage risk, changes to the calibration of IAFs should ideally be justified on the basis of analysis and empirical evidence on foreign emissions intensities and trade responsiveness within targeted sectors (see Section 1.1 of this report). In our judgment, the analysis offered in the proposed regulations does not explicitly provide such a justification. If instead the proposed change in free allocation is also intended to serve broader re-distributional purposes, a broader set of considerations may guide the targeting of production subsidies, including policy judgments that lie outside of this subcommittee's scope. In either case, the subcommittee believes that the benefits of conferring subsidies in the form of free allowance allocation should be weighed against the potentially significant costs.

4. Recommendations

We make several recommendations with regard to the monitoring and mitigation of emissions leakage in the context of its cap-and-trade program:

4.1 **Intra-national trade data.** In order to estimate emissions leakage potential for specific sectors in California, one needs data on intra-national, interstate trade transactions over time. Research to date has not fully leveraged the available data. Additional data sources could be used to construct a more complete picture of interstate trade in EITE industries. ARB could leverage the ongoing efforts of academic researchers to collect and analyze these data.

4.2 **Emissions intensity of out-of-state suppliers.** A critical determinant of emissions leakage is the marginal emissions intensity of out-of-state suppliers. Researchers are actively collecting data on the emissions intensity of industrial production in various jurisdictions outside California. A concerted effort to collect these data and assess their credibility would substantively inform leakage risk assessment efforts in California and other jurisdictions.

4.3 **Evidence-based decision making.** Rigorous empirical assessments of leakage risk are complicated by data limitations and identification challenges, as discussed in this subcommittee report. To date, these complications have limited the extent to which commissioned research informs California's approach to leakage mitigation. The subcommittee notes that the current abundance of caution has potentially important implications for abatement costs and the distribution of those costs. Methodological challenges notwithstanding, ARB should continue to work with the research community to strengthen the link between empirical evidence on leakage risk and the calibration of compensating subsidies.

4.4 **Resource shuffling.** The leakage subcommittee believes that the research and policy communities could benefit from further study of the extent to which emissions leakage caused by resource shuffling may have occurred in response to the cap-and-trade program's carbon price signal, including with respect to divestment of legacy coal contracts and ownership interests pursuant to SB 1368.

4.5 **EIM leakage.** ARB should report its calculation of GHG emission obligations in the CAISO Energy Imbalance Market, including both the outstanding GHG emission obligations related to ARB's "bridge solution" for 2017, 2018, and Q1 2019, as well as for the new compliance obligations that will be imposed on EIM importers beginning in Q2 2019. ARB's analysis of these obligations should be transparent and publicly accessible.

4.6 **Unspecified emissions factor.** ARB should evaluate the unspecified emissions factor and consider updating it. The current factor is based on outdated data and may no longer be representative of unspecified imports in the current market environment. Additionally, ARB should evaluate whether a default parameter that is calculated as an average is a reasonable proxy for the marginal emissions associated with electricity imports.

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