RFF REPORT

Lessons from Integrated Resource Planning and Carbon Trading for Integrating Carbon Adders into Wholesale Electricity Markets

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1. Introduction

In the absence of a comprehensive national climate policy, proposals have emerged for the use of a placeholder or shadow price in electricity sector planning and operations to account for an estimate of the social damage resulting from carbon emissions. The electricity sector stands out as the context for these proposals for at least three reasons. One is that the sector accounts for more than 30 percent of national emissions—coming from a relatively small number of point sources—and is the sector where the greatest emissions reductions can be achieved quickly. Second, because investments in the sector are long-lived, many advocates believe those decisions should be forward looking in expectation of future climate policy. Third, the sector is heavily regulated through various institutions, and public utility commissions and the governance structure of the organized markets provide institutional settings to address these issues.

Policies singling out the electricity sector for environmental accountability are not new. In the 1990s utility regulators in many states took steps to encourage the electric utilities that they regulated to incorporate environmental costs into the decision calculus for identifying least-cost investments. The quantified values of environmental costs were referred to as environmental “adders” because they were added to the private costs of generation to make the total cost of generation—the sum of private and environmental costs—the basis for identifying the least-cost resource. These values were shadow prices; they were not actually charged to companies or their customers. The objective at that time was to identify investment options that were expected to meet incremental new electricity demand at the lowest total cost when both private costs and costs that were external to the firm or decisionmaker were considered. Today, this approach of using adders to incorporate full social costs—the sum of private and external costs—into electricity sector operations and investment decisions is being revisited as utilities and wholesale electricity market operators seek ways to align markets with environmental policy objectives, particularly those focused on climate change. Further, the idea has broadened beyond the context of investment planning for a regulated utility to address the operation of existing resources in competitive wholesale markets.

Economists have long been advocates of using prices to discourage pollution in an efficient, low-cost manner. Although adders are not prices in the conventional economic sense because they are not actually charged in the marketplace, they nonetheless offer potential economic advantages over other environmental regulatory approaches that are more commonly used.

Climate policy in the electricity sector today is driven by state policies that address climate change concerns indirectly through mandates or subsidies for clean energy generation and energy efficiency. Twenty-nine states and the District of Columbia have renewable portfolio standards (RPS) requiring utilities to provide a certain percentage or quantity of renewable electricity. Technology-based policies like RPS have led to important technological innovation and market development, as well as carbon emissions reductions. They have other justifications as well, including local job creation, energy security, and air quality improvements. They also have the political attraction that they tend to increase the product price less than a direct emissions fee, and therefore may mitigate leakage or otherwise help a state maintain competitiveness.

However, technology policies have disadvantages compared with policies that price carbon. Policies that mandate or subsidize renewable energy resources can lead to generation investments and retirements that do not match what the market would yield if external costs were accounted for directly in production costs. This is because such policies may not properly balance the costs of clean energy and energy efficiency investments with the costs of other resource options, leading to inefficiencies in the electricity markets. In addition, the outcome of mandates or subsidy policies may be inconsistent with environmental goals if they cause other non-carbon-emitting resources to retire in response.

In contrast, economists argue that carbon pricing will lead to more efficient outcomes because it can better align market incentives with the social cost of carbon emissions and balance those costs with other resource costs. Over the past decade the federal government has put effort into estimating the social cost of carbon (SCC), and some states are already using the SCC to address carbon emissions in the electricity sector. New York's Zero-Emissions Credit (ZEC) program compensates nuclear energy resources for their carbon-free generation with payments based on the SCC, and a Minnesota judge ruled in 2016 that utilities must take the SCC into account in their long-term planning in order to comply with state regulations. Many electric utilities are incorporating carbon prices into their integrated resource plans in an effort to efficiently comply with existing policies and anticipate regulatory risks from future carbon policies. A recent report by RFF Visiting Fellow Joe Kruger (2017) outlines the actions that utilities are taking to incorporate carbon shadow prices in their planning and operations; it argues that state regulators can play an important role by providing guidance on carbon prices, as Minnesota is doing by requiring utilities to use the SCC.

Those state actions integrate the social cost of carbon emissions into electricity market resource planning decisions and are helping to maintain generation from low-emitting sources, including nuclear plants that are often not covered under renewable portfolio standards. Amid this accelerating interest in using carbon price-based policies to address climate change, some regional transmission organizations (RTOs) and independent system operators (ISOs) are now considering plans to incorporate the SCC or some other value tied to the cost of climate change as an adder for the electricity sector. Most notably, PJM and NYISO are considering proposals to implement adders as a method to incorporate state carbon policies into electricity markets.[1,2,3]

An environmental adder is generally described today as a within-sector tax equal to the marginal environmental damages from carbon emissions. As we note above, adders are not a new concept; however, the recently discussed environmental adders are not identical to those proposed in the 1990s, when the term referred

[1] PJM has published a straw proposal for a carbon pricing framework that could operate either regionally or subregionally. See http://pjm.com/~/media/library/reports-notices/special-reports/20170502-advancing-zero-emission-objectives-through-pjms-energy-markets.ashx.

[2] Newell et al. (2017) present an analysis of the effects of introducing a carbon charge in New York consistent with the carbon charge assumed in the state's ZEC program. See http://www.nyiso.com/public/webdocs/markets_operations/documents/Studies_and_Reports/Studies/Market_Studies/Pricing_Carbon_into_NYISOs_Wholesale_Energy_Market.pdf.

[3] These RTO-level discussions build on previous interest in using regional carbon adders as a method for compliance with the Clean Power Plan, an idea that was endorsed in 2015 by officials from PJM and MISO. See http://www.utilitydive.com/news/is-a-carbon-price-the-best-way-to-implement-the-epas-clean-power-plan/392504/.

primarily to the damages from criteria pollutants rather than carbon emissions.[4] Nevertheless, discussions from that decade about the architecture of the policies to implement environmental adders can inform the design of recently proposed carbon adder policies. Additionally, since adders today refer specifically to damages from carbon emissions, analyses of carbon pricing and carbon tax policy can provide guidance on incorporating the SCC into ISO- and RTO-operated electricity markets.

The carbon adders as recently proposed would apply only to the electricity sector and would be implemented at the state or regional level. They would provide incentives for investment in anticipation of a potential national, economy-wide carbon tax or emissions cap. An adder policy can be made compatible with existing expanded carbon taxes or emissions caps through adjustments to represent the difference between the carbon price and the state or region's preferred adder value.

It is important to note that although carbon adders are compatible with economy-wide climate policies, they are not a substitute. A carbon adder can provide incentives for efficient operation of existing resources and investment decisions, but under current proposals, the adder revenue would be kept within the electricity sector. As currently discussed, the revenue would be returned to load-serving entities (i.e., retail distribution companies) to offset the potential change in electricity prices, and hence it would not give consumers a clear price signal to substitute away from carbon-intensive uses of energy. A carbon price implemented through a tax or cap-and-trade scheme would be reflected directly in product prices, giving consumers an incentive to change consumption behavior. Further, a tax or emissions cap applying to the whole economy would have the additional benefit of driving decarbonization in other sectors, most critically in transportation.

2. Brief History of Environmental Adders and Carbon Pricing

Interest in environmental adders emerged fully in the early 1990s. Attention focused primarily on the use of environmental adders to address conventional air pollutants, but some proposals also targeted carbon emissions. Policymakers faced limitations in the implementation of environmental regulations at the state level for several reasons, including a general lack of technical expertise and authority. State policies generally deferred to federal legislation—mainly the Clean Air Act, which gave little attention to nitrogen oxide (NO_x) emissions, a precursor to ozone and fine particulates. Further, the Clean Air Act did not begin to address existing source emissions of sulfur dioxide (SO_2), another precursor of fine particulates, until implementation of emissions cap-and-trade began in 1995, and by then, the cap appeared loose, given the emerging

[4] "Damages" refers to the monetized value of the health and other environmental effects of an additional unit of pollution emissions. Measuring damages involves tracking emissions, modeling transport across space by prevailing winds, modeling the spatial deposition of pollutants, assessing chemical transformation in the atmosphere, measuring exposure to resulting pollutants, and then evaluating health and other effects on exposed populations. In most cases the largest portion of environmental damages comes from those components of emissions that have been associated with premature mortality.

estimates of health damages from fine particulates. Environmental advocates sought a way to influence the mix of generation resources, despite the policy limitations, in order to reduce air pollution. They turned to the administrative regulatory process run by state utility commissions for resource planning, which included the approval of proposed new facilities, to seek the approval of electricity tariffs.

The rate case proceedings and related regulatory proceedings associated with integrated resource planning provided a forum to introduce estimates of environmental costs—and more broadly, total social costs—as part of the cost calculation used to identify the least-cost resource plan for meeting future demand growth. This venue was a relatively transparent forum with an explicit role for public comment. Over time, these comments were incorporated into policies by a range of public utility commissions (PUCs). In several states PUCs effectively began to see energy planning and system operation as venues for promoting environmental policy goals. Environmental advocates at the state level used this forum to encourage demand-side management, energy efficiency, renewables, scrubbers on coal plants, and substitution from coal to natural gas. Perhaps as important, many advocates for the inclusion of environmental adders in the planning process were motivated by emerging science: some research on conventional air pollutants identified health damages that were not addressed by current air quality standards, and other findings indicated that greenhouse gas emissions were causing climate change. Advocates also argued this emerging science had potential ramifications to ratepayers from financial obligations associated with investments in new, long-lived infrastructure that might be affected under future environmental regulations.

By 1995, 25 states and the District of Columbia were considering the environmental externalities of energy generation through their PUCs. Of the 25 states, 16 considered externalities quantitatively with some form of adder, and the other 9 plus the District considered externalities qualitatively—for example, by using a subjective ranking system of generation sources based on anticipated environmental impacts (US GAO 1995). The focus of environmental adders at that time was on criteria pollutants.[5] However, by 1997 PUCs in 7 states required carbon adders, using a range of values from $1.10 per ton of carbon emissions in New York to $40 per ton in Oregon (Harrison and Nichols 1997). These environmental adders, for both criteria pollutants and carbon, focused on investment planning and were not aimed at operation of existing facilities, and they were not “charged out”—the adder value was used only for the purpose of ranking various resource investment options (Palmer and Dowlatabadi 1993).

In the late 1990s and early 2000s, as the shift toward competitive wholesale and, to a more limited degree, retail electricity markets began, interest in environmental adders declined because independent power producers could build generating units and bring power onto the grid without the approval of utility regulators. Coincidentally, the decline of natural gas prices led to an expansion in the construction of new natural gas combined-cycle units, which have substantially lower emissions than coal units.

[5] Criteria air pollutants, as defined by the US Environmental Protection Agency under the Clean Air Act, include ground-level ozone, particulate matter, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide.

State PUCs' Requirements for the Consideration of Environmental Externalities, 1995

			Quantitative			
	No Requirement	Qualitative	Not Specified	Percentage Adder	Dollars per Energy Unit Adder	Monetized Values for Emissions
Number of States	25	10	7	2	1	6

Source: US GAO 1995.

3. Observations from Past Research and Experience

Previous research on environmental adders and carbon pricing offers several lessons for the current discussion of electricity sector carbon adders. This body of research provides insight both to the valuation of environmental damages from energy production and to the appropriate implementation framework for adders.

3.1. Valuation of Damages

Estimating the damages from energy production and use is a developing art, and we continue to learn from advances in epidemiology, pollution modeling, and environmental economics. State-level interest in this topic helped spark major scientific and economic research initiatives in Europe and the United States. This research has focused both on the external costs of local air pollutants, which depend on the locational source of the pollutants, and on the external (social) cost of carbon emissions, which relates to the effects of climate change and does not depend on the location of emissions sources.

The empirical outcome of the ongoing development and improvement of damage estimation techniques is that these estimates have been increasing over time. The first comprehensive and multidisciplinary studies on the damages of emissions from electric utilities were published in the 1990s and mainly focused on location-specific damages from local pollutants (Krupnick and Burtraw 1997). These damage estimates, calculated separately for the various fuel cycles, tended to be relatively small and constituted only a small percentage of private generation costs, but in many cases these small values, if added to generation costs, would be sufficient to imply a change in the operation of existing resources or in the choice of new investments. The growth in this body of literature was catalyzed in part by the federal requirement (originally Executive Order 12291 in 1981, and updated since) for regulatory impact assessments for regulations that imposed major costs on the economy. Those assessments tabulated the benefits and costs of the regulations and created a political constituency for an improved scientific and economic basis for benefit-cost analysis.

One of the important contributions from comprehensive fuel cycle studies in the 1990s was the demonstration that environmental damages from conventional air pollutants (unrelated to climate change) are specific to source location (Hagler Bailly Consulting, Inc. 1995; Lee et al. 1995). This finding seems obvious in retrospect, but these studies spurred the development of rigorous methods and shed important light on the large differences in damages across locations. Taken together, the literature on this topic shows that the damages from pollutants can vary by an order of magnitude because of various factors, including atmospheric chemistry, wind direction, size and characteristics of exposed populations, and downwind ecological effects.

Another important contribution of this research was the explicit formulation of a method for developing monetary estimates of damages. At the time, many observers asserted that the marginal cost of controlling pollution under existing regulations should serve as an indication of society's willingness to pay to avoid injuries from pollution, but this had only an indirect relation to the injuries that occurred or the marginal cost of those injuries. For example, the marginal cost of abating SO_2 emissions as reflected in emissions allowance prices under the cap-and-trade program launched in 1995 was in the range of $100 to $200. However, contemporaneous studies on the damages from local pollutants found much higher values, and a general trend of increasing estimates over time is evident. A 1999 study estimated median mortality damages in the United States of $4,925 per ton of SO_2.[6] The 2011 MATS Regulatory Impact Analysis cited two studies that estimated mortality damages ranging from $8,300 to $73,000 per ton of SO_2.[7] Finally, it is noteworthy that another contribution was the quantification of external benefits associated with power plant investments that might counteract external costs. For example, a hydroelectric facility that might harm trout habitat might also create bass habitat, with associated recreational and ecological values for each.

The main research of interest for recent adder policy proposals concerns the valuation of damages from carbon emissions. These damages do not depend on the location of the source of the emissions because they relate to climate change effects. Although climate damages are not experienced equally across the globe, emissions of carbon dioxide from any location contribute equally to increased concentrations across the globe.

Innovations in climate and economic modeling have improved these estimates over time as well, as discussed in more detail in the section titled "Brief Discussion of the Federal SCC," below. Although estimates of the SCC typically focus on climate-related damages, policies that reduce carbon emissions have the co-benefit of reducing emissions of local pollutants through the shift away from fossil fuels. Based on recent estimates and depending on location, the damages from these local pollutants can be comparable in magnitude to the climate change damages of carbon emissions (Burtraw et al. 2014; US EPA 2015). Therefore, capturing the full range of environmental damages in a carbon adder could as much as double the price. The role for adders for conventional air pollution appears to still be relevant. The augmentation of adder values for climate damages with a fuller estimation of unpriced damages from conventional air pollutants would have significant implications for the effects of the adder policy, particularly as the gap between the private costs of low-carbon-intensity and high-carbon-intensity resources diminishes.

[6] Damages of $3,100 in 1990$ converted to 2007$ (Burtraw 1999).

[7] Damages expressed in 2007$ (US EPA 2011). Damages in the eastern United States are found to be nearly four times greater than damages in the West.

Brief Discussion of the Federal Estimate of the Social Cost of Carbon

Federal agencies are required to conduct regulatory impact analyses of major regulations that impose expected costs of $100 million or more on the US economy. When regulations affect any part of the energy sector, from appliance efficiency standards to CAFE regulations for cars, one of the benefits that is considered is reductions in CO_2 emissions and associated climate effects. In the past each agency used its own estimates to account for the benefits of reduced carbon emissions. In light of the broad range of research on quantifying the social cost of carbon, the US government formed an effort to establish a federal SCC that provides policymakers with a comprehensive estimate of the climate damages from carbon emissions based on peer reviewed scientific and economic research. The federal SCC effort was in large part motivated by a desire to establish a uniform social cost estimate to be used by all federal agencies. The federal SCC can also be used to inform the development of carbon adders for use in the electricity sector. The SCC represents an estimate of the monetized damages resulting from an incremental increase in carbon emissions in a given year. In 2010 the federal Interagency Working Group on Social Cost of Carbon (IWG) began estimating the SCC and continued updating these estimates until the group was disbanded in March 2017.

The damages accounted for in the federal SCC include changes in net agricultural productivity, human health, property damages from increased flood risk, and ecosystem services due to climate change. The IWG did not produce a single SCC value; rather it estimated annual SCC values for years 2010-2050 using discount rates of 2.5, 3 and 5 percent. It also provided annual SCC values based on the 95th percentile SCC estimates at the 3 percent discount rate, in order to represent a scenario with higher-than-expected impacts.

The IWG put effort into consistently updating its estimation methodology to incorporate innovations in scientific and economic modeling. This effort has resulted in SCC estimates that have evolved over time. As an example of this evolution, the 2010 IWG report estimated the 2020 SCC with a 3 percent discount rate to be $26.30—the 2016 report estimated it to be $42.[1] These types of revisions can be expected to continue. The National Academy of Sciences (NAS) reviewed the SCC estimation methodology at the request of the federal government, and in January 2017 released its review and provided a number of recommendations for updating the methodology. Going forward, RFF is leading a research initiative to advance the NAS recommendations and update the SCC estimates in order to continue providing policymakers with an SCC that reflects the best available science. Given the anticipated methodology updates and consistent innovation in relevant scientific and economic research, SCC estimates will continue evolving with each new assessment. Carbon adder policies should be designed to accommodate periodically updated SCC measures.

[1]Values expressed in 2007 dollars per metric ton of CO2. (Interagency Working Group on the Social Cost of Carbon 2010, 2016).

3.2. Implementation of Adders

An important contribution from past research is guidance on efficient policy implementation. This guidance falls into two general areas: mapping estimates of external costs into an efficient value for the emissions adder, and the design of policy to implement an adder in the electricity industry.

3.2.1. From External Cost to Adder Value

An efficient carbon adder should not always be equal to the marginal damages of carbon emissions. Instead, adders should reflect externalities, and marginal damages and externalities are not necessarily the same. The difference between damages and externalities depends on whether climate policies are in place. For example, if there were a small carbon tax of $2 per ton and the SCC was determined to be $42, then the adder would be adjusted to $40, representing the portion of external costs not already reflected in private costs. When such price-based policies exist, regulated entities are already internalizing at least a portion of their marginal emissions damages. Adders should then focus on any externalities that remain, based on the difference between the social cost of carbon and the emissions price.

In contrast, technology-based policies like (non-tradable) new source performance standards have no mechanism for internalizing the marginal damages of carbon emissions. In this case, an efficient adder would equal the full marginal damages captured by the SCC, which applies to the residual emissions that occur after investments have been made to comply with the standard. The same is true if no climate policies are in place.

An emissions cap provides a special dilemma. If the cap is binding—that is, if the price of a tradable emissions allowance is not zero—then any adder implemented on an emitting facility will not yield additional emissions reductions. At best, if it resulted in fewer emissions at the affected facility, it would lower the price of emissions allowances, providing a financial benefit to other emitting facilities covered by the emissions cap. This effect has been termed the waterbed effect. Somewhat perversely, in this case the efficient value of an adder would be zero in the short run. On the other hand, if the trading program has a price floor and the allowance price falls to the floor, then the adder could result in real emissions reductions. Each of the four carbon trading programs in North America—California, the Regional Greenhouse Gas Initiative (RGGI), Quebec, and Ontario—has a price floor, and all have had prices persistently near or at the price floor.[8] Moreover, in the long run the influence of the adder in reducing the demand for emissions allowances and pushing down their price is likely to result in a review of the trading program and a tightening of the cap, as occurred in the RGGI 2012 Program Review, or a reduction in emissions to the point where the existing cap is not binding, as occurred with the Title IV Acid Rain Program (the SO_2 trading program). Hence, a long-run perspective argues for applying the adder to a program that already has an emissions cap.

Finally, other preexisting regulations may informally internalize environmental damages. Renewable portfolio standards are a prime

[8] In 2021, RGGI will implement an additional element, an emissions containment reserve, that will make the supply of emissions allowances responsive to the allowance price even when the price is above the price floor (Burtraw et al. 2017a).

example. Depending on the stringency of the standard and the available resource mix, the cost of carbon emissions avoided can be up to $225 per ton, at least in the short run. Although that might suggest that no additional adder be applied, there are multiple justifications for an RPS, including air quality, energy security and independence, regional economic development and jobs, and the long-term vision of driving down costs for the identified technologies. Similar considerations apply to tradable performance standards. Policymakers will want to consider the function and purpose of these types of policies in deciding how to map the estimate of marginal damages into the adder value.

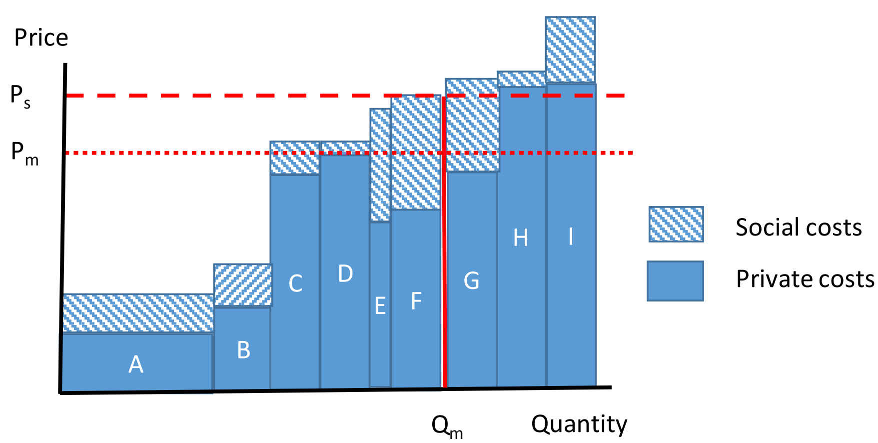
Additional implementation lessons pertain to cost-of-service regulated markets, where the price of electricity is based on the average cost. In this setting an adder could be adjusted to reflect the difference between the electricity price and the marginal cost of supplying that unit of electricity. In addition, adders in regulated markets have been used only for new source resource planning. This implementation could create a bias against new sources and thus grandfathered sources with high social costs might remain in use longer than they otherwise would. Applying adders to a side-by-side comparison of new and existing resources as part of the integrated resource planning exercise could avoid such an outcome.

Consumers' opportunities to bypass the electricity system also affect the efficient use of adders. Since adders apply only to utility-sourced electricity, consumers have an incentive to bypass utilities through self-generation, switching to other fossil fuels for particular energy services, or locating out of the range of coverage. Previous research has shown that it is possible to adjust the adder to account for these dynamics if the right information is known about the demand effects of electricity prices and the likelihood of fuel switching away from electricity (Burtraw et al. 1995, 1997).

3.2.2. Designing an Adder Policy

In the 1990s, adders were used to rank resource investment options based on the sum of private costs plus the "virtual" shadow price reflected in the adder. Adders were not used to affect the operation of existing resources—that is, they were not added to private costs in the ranking of facilities by cost in the production (dispatch) decision. However, adders could be used to affect the operation of existing resources (Burtraw et al. 1997). This approach would affect investment decisions as well as system operation because investors would anticipate the utilization of facilities once they were brought into service.

FIGURE 1: PRIVATE AND SOCIAL COST MERIT ORDER



As illustrated in Figure 1, this approach could have an unusual effect because the reordering of marginal costs for operation of the electricity system could lead to an infra-marginal plant with a higher private variable cost than the marginal plant. The supply schedule in the figure is ordered on the basis of the sum of private and external costs (P_s), and market demand (Q_m) is satisfied with utilization of resources A–F. The private costs of these resources are less than the social costs, and in particular the private costs of E and F are less than D, which sets the market price (P_m). In this case, the market-clearing price would need to equal the highest private variable cost of any plant that was dispatched, or that plant would have no incentive to operate. Note further that the private cost of G, which is not utilized, is less than the private cost of D. Electricity prices would increase based on the difference between the variable cost of the infra-marginal plant and the marginal plant, but they still would not incorporate the actual value of the carbon adder. This approach would affect the revenue for all plants, and those costs would be passed on to consumers. But because the price does not include the value of the social cost adder, it would have a smaller effect on the electricity prices ultimately faced by consumers than would a carbon tax or cap-and-trade program, as previously noted.[9]

A third approach, which is an element in the recent proposals for addressing the SCC, is charging out adders so that they essentially operate as a within-sector tax on carbon. Under a policy regime in which adders were charged out, that revenue could be recycled in various ways—to further environmental goals, for example, or to enhance fairness by reducing the burden of higher electricity prices on low-income households. The most-discussed option is returning the revenue to load-serving entities. That could minimize the increase in retail electricity prices but affect resource utilization and investment. The load-serving entity might decide to direct the adder revenue in ways consistent with the environmental goals of the adder policy, such as by funding energy efficiency programs.[10]

If adders were implemented in some states and not in others, opportunities for emissions leakage would arise in regional electricity markets. If adder value were returned to load-serving entities and added to the rate base to soften the change in retail prices, it would help maintain consumption levels but leave generation in the state or region at a disadvantage compared with generation from outside the adder region (Burtraw et al. 2017b).

Another approach would be to use the revenue to increase production in the adder region and avoid leakage to unregulated sources outside the region. Regulators have raised concern, most notably regarding PJM's straw carbon adder proposal, that such a production incentive undermines the environmental goals of the adder policy.[11] However, the production incentive might be targeted toward non-emitting resources like renewables or nuclear energy, which would be likely to reinforce environmental goals. Or the revenue could be returned as an unbiased production incentive to all sources in the adder region, based on an equal dollars per MWh

[9] If electricity demand is price responsive (not perfectly inelastic), finding an equilibrium between supply and demand would be complicated under this virtual adder approach, since demand at a higher infra-marginal price based on private costs may be lower than demand at the private cost of the marginal generator.

[10] Collectively, the RGGI states invest a substantial portion of the revenue from allowance auctions into energy efficiency measures.

[11] http://pjm.com/~/media/library/reports-notices/special-reports/20170502-advancing-zero-emission-objectives-through-pjms-energy-markets.ashx.

rate. The net effect of this production incentive would be to favor low-carbon-intensive resources in the adder region while encouraging production in the overall carbon-regulated region, thereby reinforcing the effectiveness of the adder policy (Burtraw et al. 2017b). Such an approach could actually lead to negative leakage—that is, a reduction in net imports to the region (Burtraw et al. 2015). It would also have the virtue of embodying legal and policy neutrality, which might be valuable for building coalitions of support.

Applying an adder to an entire ISO electricity market might diminish leakage, but interconnection with other regions still raises leakage concerns. An important legal question is whether and how imported power might be priced. Using a version of the California first jurisdictional deliverer approach is a feasible option if the electricity from renewable energy is always bundled with renewable energy credits and is therefore assignable to a specific power generation facility. Nuclear and hydropower would also have to be assignable. In this situation, a default emissions rate equivalent to the natural gas combined-cycle emissions rate could be applied to all unassigned imports for purposes of identifying the appropriate adder cost per MWh. This designation would still advantage imported power, typically a mix of natural gas and coal, but it would lessen the leakage challenge. Similar methods could be applied if states have different policies within a particular wholesale electricity market.

One issue that arises when adders are applied to power imports into a region is the potential for shuffling of contracts, such that cleaner power sources sell to the region with the adder and higher-emitting sources sell to the region with no adder. This shuffling could largely offset or negate the anticipated emissions reductions of imposing an adder on imports. To mitigate this incentive, both the California ISO (in its implementation of the regional energy imbalance market) and PJM (which contemplates carbon pricing in a subset of states) are considering use of a two-part dispatch approach.[12,13]

The two-part approach enables both estimating the size of potential contract shuffling and limiting the benefits of shuffling. In the first stage, resources within the carbon adder and the non-carbon adder regions are dispatched separately, without the potential for power trading, and those resources that serve native load in the region with no adders are identified. The generation identified as the source of supply for domestic demand in the non-carbon adder region is assumed not available as a source of power exports to the carbon adder region in the second, more integrated dispatch, thus providing an estimate of the increment of resource or generation shuffling. This approach limits the financial rewards to clean generators from selling power into a carbon adder region.

4. Ten Considerations for Carbon Adders in ISO Electricity Markets

The previous research and policy experience discussed above offer several insights for using carbon adders in today's ISO electricity markets.

[12] For a presentation of the California proposal, see California ISO (2017) at https://www.caiso.com/Documents/RevisedDraftFinalProposal-EnergyImbalanceMarketGreenhouseGasEnhancements.pdf.

[13] The PJM proposal is presented in PJM (2017) and also available at http://pjm.com/~/media/library/reports-notices/special-reports/20170502-advancing-zero-emission-objectives-through-pjms-energy-markets.ashx.

1. Carbon adders should be based on the social cost of carbon emissions and should maintain the flexibility to accommodate inevitable updates to the SCC.
2. Carbon adders are optimally placed in short-term energy markets. If they are relevant to decisions in short-term markets, then the same incentives will propagate to long-term investment planning. Using adders only in capacity markets does not induce utilities to take the SCC into account in dispatch decisions.
3. Carbon adders should net out the effects of carbon prices that affected generators face in order to best account for the externalities from carbon emissions. Such adjustments are fairly straightforward in the case of a carbon tax, where the price is fixed for a period of time.
4. However, if there is a preexisting emissions cap under a cap-and-trade system, a carbon adder would not yield additional emissions reductions unless the allowance price is driven down to the price floor. A carbon adder policy should address this explicitly. More careful consideration should be given in the case of preexisting cap-and-trade programs, where the carbon adder might not lead to any emissions change, at least in the short run. The motivation for a carbon adder on top of an existing cap-and-trade program should be to effect a long-term transformation in the electricity sector that might not be accomplished by the existing cap-and-trade program. Under one approach, carbon adder revenues could be used to purchase and cancel or retire emissions allowances. Alternatively, the existing cap-and-trade systems could incorporate a price-responsive supply of emissions allowances rather than a fixed pot of allowances (Burtraw et al. 2017a).
5. Adders could be implemented as a shadow price instead of a real price and thus not be passed on to electricity purchasers. This approach would have a smaller effect on electricity prices and would not raise revenue.
6. Current proposals focus on carbon adders that are charged out within the power system, and under such a regime the options for recycling the revenue include returning it to load-serving entities, spending it on programs consistent with environmentgoals, and using it as a production incentive. Decisions on the use of revenues should depend on the objectives of the program.
7. Even when carbon adders are applied to entire ISO electricity markets, interconnection with other regions raises additional leakage concerns that require a decision on how to price imported power. One feasible option is using a version of the California first jurisdictional approach.
8. A border adjustment between states that implement a carbon adder and states that do not can reduce carbon leakage. An unbiased production incentive can also serve this purpose, and previous research suggests that it would not undermine the goals of the policy.
9. The PJM carbon adder proposal illustrates a border adjustment that works to remove the carbon adder for exported power.[14] This policy design has not been previously seen in climate policies like RGGI or the California cap-and-trade system, but it could be an option that regions would want to explore further.

[14] http://pjm.com/~/media/library/reports-notices/special-reports/20170502-advancing-zero-emission-objectives-through-pjms-energy-markets.ashx.

10. Under a carbon adder policy, demand-side management and energy efficiency resources should be treated as zero-carbon resources.

5. Conclusion

Carbon adders are an incomplete approach to accounting for external costs of energy supply. However, their appeal reflects a familiar policy evolution. Many environmental regulations have begun as exclusively prescriptive and migrated over time toward greater reliance on incentives. Such a policy evolution reflects the contribution of the economic paradigm. Although many economists argue exclusively for the first-best approach of “getting the prices right” through the introduction of taxes, in reality other considerations—such as leakage, equity, economic development, technology learning, and energy security—enter the calculus of policymakers. Victory from an economic perspective is likely to take the form of policy with (a) greater accounting of full social costs and (b) incremental infusion of incentives that reflect social costs. Adders are an incremental policy. Are they efficiency enhancing? Are they practical? Are they legal? Are they a dead end, or might they be the pathway toward a more efficient electricity system that reflects all social costs?

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