# Carbon Pricing, Clean Energy Standards, and Zero Emission Subsidies on the Path to Net Zero

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**Extended Abstract**

Over the past decade, momentum has built behind policies targeting drastic reductions in greenhouse gas (GHG) emissions, perhaps all the way to zero. At the same time, there has been a lively debate between advocates of pricing carbon – through either a carbon tax or a cap and trade program – and proponents of setting standards across industries. This debate has been most evident in the electricity sector, where economists supporting carbon pricing have been widely dismissed as out of touch with political realities, while Clean Electricity Standards (CESs) have grown in favor. Regardless of which mechanism emerges, the goal now appears to be nearly complete elimination of GHG emissions from the electricity sector within 15 years.

Our research begins by studying the differences between a carbon price (CP) and a CES when the intended policy outcome of either is a reduction of emissions to nearly zero. In general, a CES differs from a CP in three ways, which have been documented in past work to varying degrees. First, a CES is an intensity standard. A CES would set a target for the *share* of electricity generation that should come from clean sources, and it would be implemented by a system of tradeable clean energy credits (known as "zero-emission credits" or ZECs) that would equalize compliance costs across load-serving entities (LSEs, *i.e.,* electric utilities or other retail electricity providers).[2] The economics of intensity standards has received attention recently in the context of electricity (Fischer, *Energy Journal*, 2010), low-carbon transportation fuels (Holland, Hughes and Knittel, *American Economic Journal: Economic Policy*, 2009 ), and fuel efficiency (see a review in Anderson and Sallee, *Annual Review of Resource Economics*, 2016). A central conclusion of this work is that intensity standards are inefficient relative to direct pricing of the externality because they implicitly subsidize production of low-emissions energy production, leading to an output price that is too low and hence to excessive output (absent other distortions such as emissions leakage or market power (Buchanan, *American Economic Review* 1969; Holland, *Journal of Environmental Economics and Management* 2012; Fowlie, Reguant, and Ryan, *Journal of Political Economy* 2016)).

Second, a CES simply categorizes generation into clean or dirty, assigning the clean designation to sources that produce extremely low levels of GHG emissions per unit of electricity generated. Thus, a CES does not punish coal-fired generation more than it punishes gas-fired generation, leading to an inefficiency because the CES's incentives are not well-targeted to sources with high emissions rates (Jacobsen, Knittel,

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[2]A Renewables Portfolio Standard (RPS) is a fraternal twin of a CES. The difference is that the term CES is used for programs that include generation sources not typically covered by an RPS, such as nuclear, large hydroelectric, and possibly fossil-fired generation with carbon capture and sequestration.

Sallee, and van Benthem, *Journal of Political Economy* forthcoming). Third, and finally, if the target share of a CES is met, it raises no revenue that could be used to offset other tax distortions, unlike a carbon tax or a cap-and-trade scheme with auctioned permits.

Previous evaluations of intensity standards have, however, only considered in passing the case of ambitious policies that target nearly 100% reductions in emissions. While intensity standards have well-known inefficiencies relative to applying a price directly on the pollutant of concern, there has been less study of how much less efficient the CES approach would be on the path to entirely eliminating GHG emissions from electricity.

Some introspection makes clear that a CES and CP are equivalent at 100% decarbonization. Both policies eliminate all GHG emissions, so that the CES's failure to specifically target high-emission sources is no longer a concern. In addition, both policies effectively act as full decarbonization mandates and lead to the same electricity quantity and price. And neither policy generates revenue at full decarbonization.

Still, along the pathway to decarbonization it is clear that the CP and CES approaches differ for the three reasons highlighted above. Our paper therefore evaluates the extent to which the emissions under a CES would be greater than those from a CP as decarbonization approaches 100%.[3] To begin, consider the neutrality of the CES's incentives to shut down generation across fossil-fired sources that have differing emissions rates per MWh produced. As the CES policy becomes more and more stringent, it drives the exit of fossil generation sources that have high private production costs (including both fuel costs and fixed operating and maintenance costs), ignoring their emissions rates. Carbon pricing, in contrast, targets generation sources with high total social costs: private generation costs including the tax levied on GHG emissions.

To assess these different incentives, we develop a model in which there is a distribution of generators, each of which is characterized by its private generation cost and its emissions rate per MWh. We use this model to show that the quantity of "excess emissions" from a CES – the difference in emissions between a CES and a CP policy that yield the same clean energy generation share – depends on the stringency of the policies and the correlation between generators' private costs and emissions rates. Policies that are sufficiently stringent to reduce emissions to zero will of course have no excess emissions when a CES is used. But along the path to zero emissions, we show that the excess emissions from the CES are smaller the larger is the correlation between generators' private costs and emissions rates. And if private and social costs are perfectly correlated across polluting plants, then a CES would cause retirement of these plants in the same order as a carbon price, and the policies would lead to equal emissions reductions as they became more stringent.

Following this theoretical analysis, we then explore the potential magnitude of the CES inefficiency by simulating the transition path from current to 100% zero-carbon generation under a CES and CP. We use a bivariate normal distribution of private costs and emissions that is calibrated to roughly reflect the current natural gas and coal-fired electricity generation fleets in the US. We then track the social cost under a CES

[3]This component of our analysis is closely related to Stock and Stuart's (NBER working paper, 2021) evaluation of power sector decarbonization under specific combinations of a CES, CP, and other policies.

and CP that achieve the same annual rates of clean energy penetration, up to 100%.

A key parameter in this analysis is the correlation of generators' private costs and GHG emissions, which is heavily dependent on the relative prices of natural gas and coal. These factors are difficult to forecast, as fuel price volatility over both the last decade and the last six months have illustrated. So we analyze the relative social costs for the CES versus CP policies for various levels of correlation. What we find was surprising to us: though a CES is more socially costly than a CP in terms of excess emissions, the difference is smaller than is often suggested in policy discussions. Our preliminary analysis suggests that even with zero correlation, a CES would be lead to only 14% more emissions than a CP along a path to decarbonization. With a correlation of $+0.5$ between private costs and emissions, the difference in emissions narrows further to 10%, while a negative correlation increases the difference.

The other way a CES differs from a CP is that it leads to lower wholesale electricity prices when decarbonization is incomplete. This difference in prices is even greater for a zero-emissions subsidy (ZES), a policy that operates in many ways like a CES but explicitly subsidizes clean generation without imposing an implicit penalty on dirty generation. This structure implies that for a given policy stringency, as measured by the resulting share of generation that is clean, a ZES will result in the same level of emissions as a CES (with a gap relative to a CP) but an even lower wholesale electricity price than a CES. Moreover, the difference in wholesale prices between a ZES and a CP will persist even under complete decarbonization.

The low electricity price under a CES, and especially under a ZES, raises the concern that as low wholesale prices are passed through to retail customers, these policies could lead to excess electricity consumption, as emphasized by Holland, Hughes and Knittel (2009) in the context of transportation fuels. This concern, however, is rooted in an assumption that retail electricity prices are not already distorted by large markups over wholesale prices. Recent work by Borenstein and Bushnell (Energy Institute at Haas Working Paper, 2021) suggests that these markups are actually quite large in most of the U.S. Retail electricity price markups even exceed 100% of the wholesale price in many areas, especially those that are most aggressively reducing GHG emissions. These markups are due largely to costs of early investment in low-carbon generation, climate adaptation programs (*e.g.,* grid hardening), paying for climate change damage (*e.g.,* wildfires), and many other social programs (*e.g.,* subsidies for low income households and households that install solar) that are paid for through volumetric electricity rates.

As a result of these large pre-existing retail price markups, it is possible that while a CES/ZES approach to decarbonizing electricity would increase the social cost of electricity generation via excess emissions along the transmission path, in some areas that loss could be partially or more than fully offset by increased efficiency in retail electricity pricing. That is, the under-pricing of electricity that a CES or ZES would cause in wholesale markets could lead to retail prices that are more closely aligned with social costs once retail markups are accounted for. We have not yet completed this analysis, but it will straightforward to do so given earlier work on the gap between retail prices and social marginal cost, and an assumed rate of wholesale electricity pass-through to retail prices.