How does a carbon price impact electricity prices?

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The impact of carbon prices on electricity prices is a key question for utilities and policymakers seeking to decarbonize both electric and non-electric sectors. Previous EPRI research has demonstrated the impact of different carbon price policies on electrification outcomes and electric and non-electric sector CO_2 emissions[1]. In this analysis, we explore the mechanisms behind the differentiated responses using EPRI's U.S. Regional Economy, Greenhouse Gas, and Energy (US-REGEN) model[2]. Applying an economy-wide carbon price of \$43/tCO_2 price beginning in 2021 and rising at 4% per year for illustration (based on the 2019 Climate Leadership Council (CLC) proposal, excluding any potential impacts of revenue recycling), we find:

- A carbon price increases the generation price of electricity, but the impact is moderated by substitution of low-carbon technologies and impacts vary by region.
- Delivered electricity prices increase less proportionally than end use fossil fuel prices in response to an economy-wide carbon price, creating an additional incentive for electrification.

Imposing a carbon price on the electric sector, either through a cap, tax, fee, or similar policy, increases the costs of fossil fuels used for generation in proportion to their carbon content. If the generation mix were held constant, pricing carbon would translate directly to an increase in the electricity price (\$/MWh) equal to the carbon price (\$/tCO_2) multiplied by the average carbon intensity of generation (tCO_2/MWh). However, the increased cost for fossil-based technologies creates strong incentives to substitute other technologies, including wind, solar, nuclear, and carbon capture and storage. Thus, the equilibrium response to a carbon price in the electric sector includes reconfiguring the generation mix toward low-carbon technologies, effectively substituting capital for carbon, resulting in a lower price impact than that implied by hypothetically applying the carbon price to the reference carbon intensity. As the carbon price increases over time, this substitution effect lowers the carbon intensity of generation, effectively "decoupling" the electricity price from the carbon price.

The response of the electricity price to the carbon price varies by region depending on both the carbon intensity of the existing capacity mix and the potential for low-carbon resources, particularly the quality and availability of renewable resources.

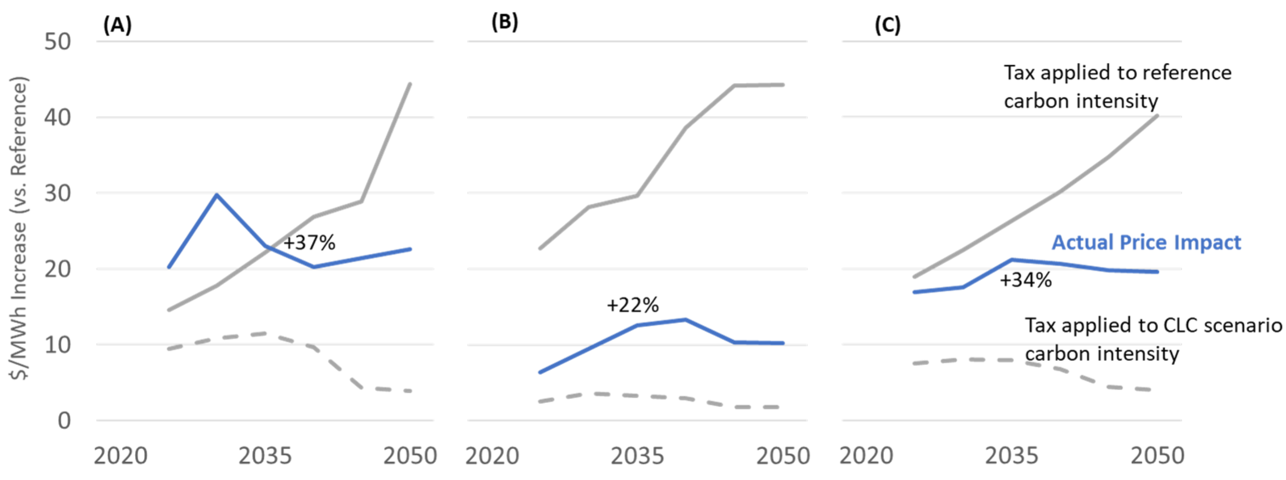

Figure 1. Impact on electricity generation price in CLC scenario shown as increase relative to reference in (A) a region with lower than average carbon intensity but low renewable potential; (B) a region with higher than average carbon intensity but high renewable potential; and (C) the U.S. national average. Electricity price impact is compared to a hypothetical application of the carbon tax to scenario carbon intensity. Percentage changes are shown for 2035.

In regions with high quality renewables (such as wind in the Great Plains or solar in the Southwest), the price impacts will be lower than in regions with less wind and solar potential, which will rely on more capital intensive low-carbon technologies, and/or continue to use or shift to natural gas in response to the carbon price. Figure 1 shows the modeled price impact compared to carbon intensity of generation for two regions as well as the U.S. national average under the CLC carbon price.

This carbon price path implies a roughly 34% increase in the national average generation price in 2035, and a roughly 17% increase in the average residential retail price, which includes transmission and distribution costs. Moreover, after an initial sharp increase reflecting a rapid retirement of existing capacity, this impact remains relatively flat over time as the electric sector decarbonizes.

By contrast, the impact of a carbon price on the end use of fossil fuels will scale directly with the carbon content of the fuel. A $100/tCO_2$ carbon price translates to roughly $5/mmbtu for natural gas and $7/mmbtu (or around $1 per gallon) for gasoline. Under the CLC carbon price, these impacts translate to an average 57% increase in the residential price of natural gas by 2050 and a roughly 36% increase in the price of gasoline (based on a reference price following AEO 2019). Figure 2 illustrates the impacts on both electricity and non-electric fuels for the two regions and the U.S. national average.

When a carbon price is applied economy-wide, the delivered price of electricity increases, but proportionally less than the delivered price of end-use fossil fuels, creating an incentive for additional electrification. Conversely, when the carbon price is applied only to the electric sector, the incentive for electrification is weakened. However, in both directions the effect of relative price changes induced by the carbon price on end-use technology adoption may be relatively modest, partly because of the relatively low share of energy costs in total service costs, but also because of behavioral and structural barriers to adoption. These barriers may be counteracted with additional policies or measures.

Contact Information

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Additional results are provided in EPRI Product #3002019005. Model documentation and related research can be found at http://esca.epri.com.

[1]Trade-offs in Emissions Reductions with a CO_2 Policy. Report #3002015050 and Back Pocket Insight.

[2]US-REGEN model documentation available at: https://esca.epri.com/models.html

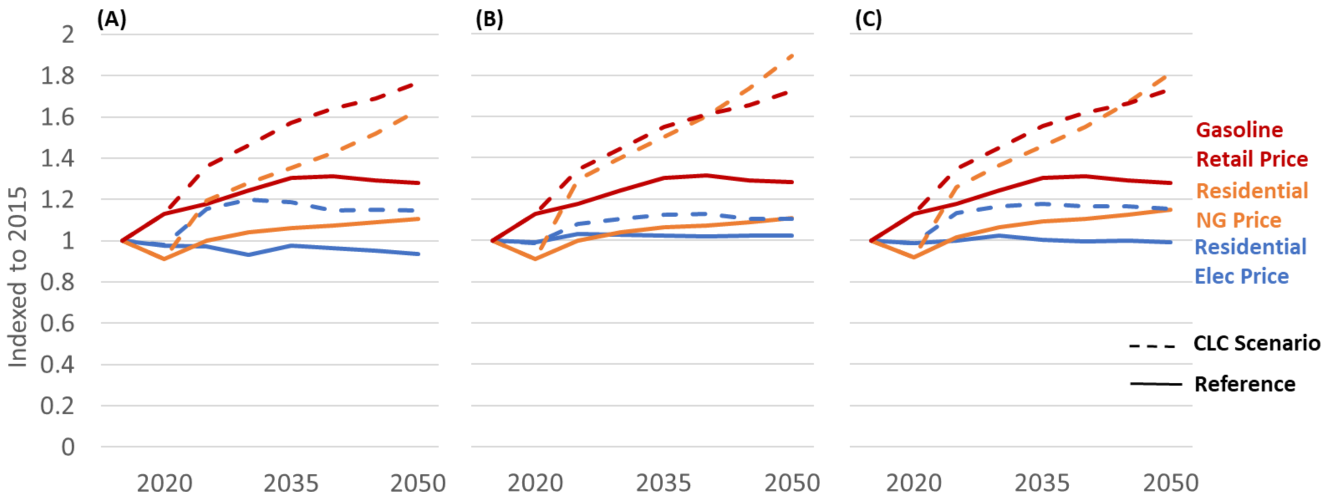

Figure 2. Indexed end-use fuel prices in Reference (solid lines) and CLC scenario (dashed lines) for (A) low renewable potential region; (B) high renewable potential region; and (C) U.S. national average.

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