

Energy Environment and Economic Studies

ISSN: 3149-8477

available at http: www.econjournals.com

Energy Environment and Economic Studies, 2026, 2(4), 16-20.

Asymmetric Effects of Carbon Pricing on Household Energy Poverty in Gulf Cooperation Council Economies

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Received: 07 August 2026 **Accepted:** 05 November 2026 **DOI:** https://doi.org/10.32479/eees.25361

ABSTRACT

Although there is a symmetric response in electricity prices to a symmetric change in the carbon price, carbon pricing can introduce asymmetric affordability challenges to households. A prospective expenditure-gap model is developed and the electricity component of the model is calibrated using the public generation data from Ember for all six Gulf Cooperation Council economies for 2026. A common observation year provides the benefit of not mixing national reporting years. Published emissions intensities are distinguished from assumed consumption, pass-through and affordability parameters in the analysis. Additional monthly electricity costs of USD 71.60-USD 135.37 are generated by a fully transmitted carbon-equivalent charge of USD 50 per tonne at 3,000 kWh/month in the UAE and Bahrain, respectively. At 10% expenditure benchmark, the income-frontier moves from USD 716.00 to USD 1,353.72. A positive-part expenditure gap yields asymmetric changes in the vicinity of its threshold, even if there does not need to be asymmetric price transmission. Results indicate conditional energy-poverty prevalence and compensation needs, not energy-poverty prevalence nationally. Before interpreting the observed asymmetry, policy design should differentiate between threshold effects and tariff decisions and household income distributions.

Keywords: Carbon Pricing, Energy Poverty, GCC, Electricity Affordability, Distributional Policy, Scenario Analysis
JEL Classifications: I32, Q43

1. INTRODUCTION

In the case of the Gulf economies, the issue of a carbon price's distributional impact on both the cost of providing energy services and on the reduction in emissions. Electricity costs are particularly significant when cooling is a regular household need. The retail bill is also an institutional outcome, rather than an indicator of the costs of generation, due to the presence of existing subsidies and eligibility rules. A carbon charge that is levied upstream does not have to be levied at the same rate on each household.

An asymmetric outcome in a household does not have to mean that suppliers are able to pass the price rises more quickly than the price cuts. If a household's expenditure falls into a shortfall due to a price increase, but no such shortfall occurs if the same size price decrease, then the household has also incurred an expenditure shortfall. The key analytical question explored here is how to differentiate this threshold mechanism from supplier behavior.

The study provides a prospective calibration for Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. The role it plays is to provide a numerical value for the electricity-cost exposure resulting from a generic carbon-equivalent charge, and to identify the income range in which an expenditure-gap measure becomes asymmetric. The comparison is done using an explicit scenario design as the current carbon pricing record doesn't offer a comparable history of implemented actions by the GCC countries for houses and poverty responses (World Bank, 2026).

Distributional research has recently been conducted and choices have been identified that are important for interpretation of carbon burdens. Shei et al. (2024) discuss the merits of income-based and

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expenditure-based evaluations, and Kang et al. (2026) explore the implications of expanding emissions coverage beyond CO_2. Household expenditure and sectoral carbon-intensity data for Ghana, Nigeria and Uganda are merged by Ayhan et al. (2025). The studies evoke interest in the dimensions of resources, emissions coverage and household consumption patterns. The present analysis focuses on a more specific question, namely the interactions between a given electricity-cost increment and an affordability threshold in the Gulf economies.

Evidence also suggests that there are disparities between the overall impact of a policy and the vulnerability of individual households, as seen in the Gulf. Darandary et al. (2024) assess the policies to reform the electricity prices in Saudi Arabia based on the regional demand and power-sector information. Based on the macro econometric framework, Hasanov et al. (2025) simulate hypothetical Saudi carbon prices. These studies explore the economy-wide effects and demand adjustment that are kept fixed by the present fixed service comparison exercise. Their findings provide a foundation for the importance of price reform for Gulf decarburization but they do not provide a six-country poverty response to the household. The smaller contribution here is to define an expenditure boundary that causes unequal shifts in an affordability gap due to otherwise symmetric cost shifts.

It is important to consider the service quantity as well. Mikayilov et al. (2026) establish the relationship between temperature and electricity consumption among the countries of the GCC region. Asif et al. (2026) infer that there are relationships between income and spending in Saudi Arabia at household level in relation to air-conditioning practices. These findings combined provide a warning that identical electricity consumptions are not necessarily the same needs nor the same welfare. This study is then a controlled comparison of their general level of use. It does not presume that low recorded cooling will be equal for all dwellings, nor does it presume that low recorded cooling equates adequate access to cooling.

2. MATERIALS AND METHODS

The electricity data is the public data of yearly electricity generation from Ember, which was extracted on September 25, 2026. The six country codes BHR, KWT, OMN, QAT, SAU and ARE are included as are the Total generation series and calendar year 2024. There are no observations from Bahrain and Qatar for 2025; hence a common year of 2024 is used for the same. No missing intensity is "filled in." The deleted records and calculations are kept in the research materials (Ember, 2026).

Ember's lifecycle greenhouse-gas intensity, which covers upstream and manufacturing, are reported in grams of carbon dioxide equivalent (CO_2e) per kWh. These values are not intended to be an inventory of emissions that will be included in a domestic carbon tax. Analysis therefore is conducted based on a carbon equivalent cost criterion. To translate the results into a statutory tax proposal would need the applicable emissions boundary, electricity-system losses and the applicable rule of regulatory incidence. There is also no national UAE intensity to determine the intensity of all emirates' electricity supplies.

A similar delineation is needed for "affordability" indicators. Vandyck et al. (2023) link a residential-energy expenditure threshold to a low-income threshold in their European assessment. The current frontier is the screening calculation that doesn't include the additional population classification, just electricity. It aims to pinpoint what resources are required to keep the share of expenditure at a given percentage of the national average, but does not resolve the question of national eligibility and the number of households affected. Comparing results at 5%, 10% and 15% does not set an appropriate minimum living standard for the GCC; rather it is a test of the consequence of the screening share selected.

Monthly consumption is fixed at 3,000 kWh in the central illustration. This is a scenario quantity, not an estimated representative household. Carbon-equivalent prices of USD 25, 50 and 100 per tonne and pass-through rates between zero and one provide transparent sensitivity cases. The central calculation uses full transmission. No household weights or national prevalence estimates are constructed.

$$C = \lambda\, q\, e\, \tau/1{,}000{,}000 \tag{1}$$

Here C denotes the additional monthly bill in USD, λ is pass-through, q is monthly kWh, e is the published intensity in gCO_2e/kWh and τ is USD per tonne. The conversion denominator converts grams into tonnes. Fixed consumption isolates the expenditure required to maintain the stated electricity service quantity; it is not a demand forecast.

$$G(\tau) = max\{B_0 + C(\tau) - \kappa Y, 0\} \tag{2}$$

G is the monthly expenditure gap above an affordability benchmark, B_0 the baseline electricity bill, Y monthly household income, and κ the expenditure share used for screening. The central κ equals 0.10. This electricity-only measure does not capture transport fuels, cooking fuels, inadequate cooling or multidimensional deprivation. The choice of 10% is an analytical benchmark rather than a validated GCC poverty line.

$$\Delta Y^* = C/\kappa \tag{3}$$

The income-frontier shift is the additional monthly income required to keep the same electricity expenditure share after the charge. Reporting a shift avoids assigning an unobserved baseline bill or household income distribution to a country. Different retail subsidies change the baseline frontier even when the incremental benchmark is identical.

$$A = G(\tau_0 + \delta) - 2G(\tau_0) + G(\tau_0 - \delta) \tag{4}$$

For a symmetric perturbation around an interior positive reference price, define z as baseline expenditure minus the permitted expenditure at that reference and a as the absolute bill change. Then A equals $\max(z+a,0) - 2\max(z,0) + \max(z-a,0)$. It is zero when z lies outside the interval from −a to a and equals $a - |z|$ inside it. This is an algebraic consequence of the convex positive-part function. It is not an estimated behavioural coefficient or a statistical test of price transmission.

Sensitivity calculations vary one parameter at a time while retaining the six published intensities. Half pass-through tests partial insulation of retail bills; doubling consumption represents a higher-service scenario; and the 15% benchmark tests a less restrictive expenditure share. These are policy and household scenarios, not confidence intervals. The model contains no sampling distribution from which statistical significance could be inferred. The calculations use unrounded intensity values, with monetary results rounded only for presentation. Tariff eligibility and baseline expenditure remain outside the incremental comparison.

3. RESULTS

Table 1 reports the direct extraction and computed central exposure. Differences reflect the reported national electricity intensities. They do not rank countries by household poverty or by the quality of their social protection systems.

Bahrain has the largest benchmark increment, USD 135.37 per month, followed by Saudi Arabia at USD 103.36, Kuwait at USD 95.29, Qatar at USD 87.26 and Oman at USD 81.43 (Figure 1). The UAE increment is USD 71.60. The ratio between the largest and smallest increments is approximately 1.89. This ratio holds consumption and pass-through constant and therefore isolates the intensity component of exposure.

The corresponding income-frontier shifts are ten times the bill increments under the 10% benchmark. Halving the carbon-equivalent price, consumption or pass-through halves every increment. Combining half pass-through with half consumption reduces exposure to one quarter of the central result. These proportional relationships are properties of the specified cost allocation and should not be interpreted as estimated household elasticities.

Asymmetry is concentrated near the affordability boundary. For example, Bahrain's intensity implies a USD 67.69 bill change for a USD 25 perturbation at the stated consumption. At a household exactly on the boundary at the reference price, an increase generates that expenditure gap, whereas an equal reduction leaves the gap at zero. The asymmetry measure is therefore USD 67.69. For a household sufficiently far above the boundary, both changes affect the existing gap linearly and A is zero. A large expenditure burden and a large asymmetry measure are consequently distinct outcomes (Figure 2).

Each column changes one central-scenario assumption. Half pass-through retains 3,000 kWh/month and USD 50/tCO_2e. The 6,000 kWh case retains full pass-through and the same carbon-equivalent price. The income-shift column retains the central bill increment but replaces the 10% screening share with 15%. Source: calculations from Ember (2026).

Table 2 shows that partial retail transmission reduces the monthly increment to USD 35.80-67.69, while a 6,000 kWh service quantity raises it to USD 143.20-270.74. At a 15% screening share, the income-frontier shift falls to USD 477.33-902.48. Under a 5% share, the same central cost requires an income increase of USD 1,432.00-2,707.43. The country order is unchanged under these common parameter changes. It can change if consumption or pass-through differs between countries; the intensity ranking alone is insufficient to rank actual household exposure.

Figure 1: Additional monthly electricity expenditure under the central scenario. Calculated from the six published national intensities; no population weighting is applied

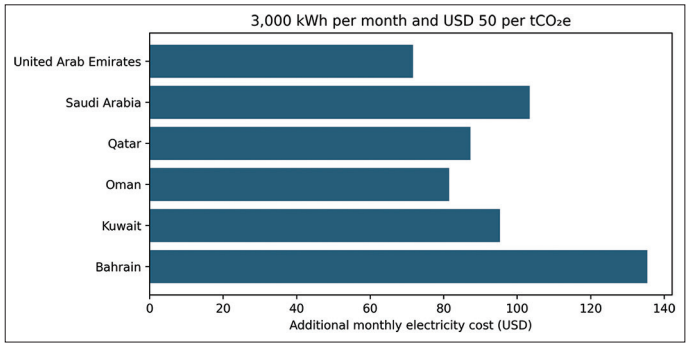


Table 1: Published intensity and calculated electricity-cost exposure

Economy	gCO_2e/kWh	Monthly cost USD	Income shift USD
Bahrain	902.477	135.37	1353.72
Kuwait	635.269	95.29	952.90
Oman	542.872	81.43	814.31
Qatar	581.704	87.26	872.56
Saudi Arabia	689.051	103.36	1033.58
United Arab Emirates	477.334	71.60	716.00

Source: Calculation from Ember (2026), observations for 2024. Scenario: 3,000 kWh/month, USD 50/tCO_2e, full pass-through and κ=0.10. Income shifts are conditional thresholds, not observed household incomes

Table 2: Sensitivity of monthly electricity exposure

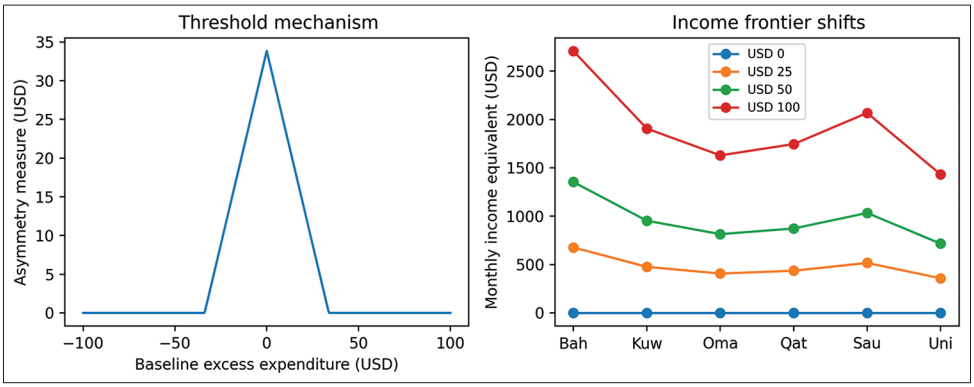
Economy	Half pass-through USD	6,000 kWh cost USD	Income shift at 15% USD
Bahrain	67.69	270.74	902.48
Kuwait	47.65	190.58	635.27
Oman	40.72	162.86	542.87
Qatar	43.63	174.51	581.70
Saudi Arabia	51.68	206.72	689.05
United Arab Emirates	35.80	143.20	477.33

The asymmetry interval can also be expressed in income terms. For a USD 25 perturbation at the stated consumption and full pass-through, households exhibit positive threshold asymmetry when their income lies within the bill change divided by the screening share on either side of the reference frontier. The interval's total width is USD 716.00 in the UAE and USD 1,353.72 in Bahrain at the 10% share. These widths describe where the model's kink matters. They do not indicate how many households occupy that interval, nor whether those households were initially deprived of adequate energy services.

4. DISCUSSION

The findings indicate that three decisions of carbon-pricing appraisal should be made separately. The emissions limit is the limit to which the carbon cost of electricity is applied. How much

Figure 2: Threshold asymmetry and policy sensitivity. Panel a illustrates the positive-part mechanism for an arbitrary bill perturbation of USD 33.832; its horizontal coordinate is a scenario variable. Panel b reports calculated income-frontier shifts under alternative carbon-equivalent prices using the six observed intensities



is delivered to the household is determined by retail regulation. Whether the ensuing bill causes an affordability problem is dependent on the income and current energy inputs. An increase in a poverty-gap measure is not necessarily larger than a decrease and doesn't, on its own, show which decision led to which result.

Under fixed consumption, the household's pre-charge cash position is restored to C with a compensation payment. That is a bookkeeping obligation, not one that the money that could be collected from the electricity sector should be spent on, so to speak, everyone. Fiscal appraisal should set coverage for collection, administration costs and subsidy expenditure and eligibility. Household compensation may also not capture the differences in cooling requirements and disposable income among households within a nationality or account category.

There is a need to separate distributional protection from political acceptance in transfer design. Vandyck et al. (2023) demonstrate that targeted revenue recycling can help mitigate energy-poverty risks, while suggesting that there are, however, constraints on generic transfers. In their systematic review and meta-analysis, Mohammadzadeh Valencia et al. (2024) discover that the fact that revenues are spent in a green way has a positive impact on public support, notably in their meta-regression analysis. Therefore, if a payment offsets a bill increment then the accounting result is not a sufficient condition for households to see the policy as fair. Communication should identify who receives support, its timing and the remaining purpose of the carbon-price signal.

Reducing the amount exposed to a carbon charge is an efficiency improvement, but a decrease in electricity use is not necessarily considered a welfare improvement. If cooling is inadequate, the amount of cooling experienced may lead to a smaller reduction in the bill and to poorer quality of life. Policies should differentiate between maintaining thermal comfort at a lower energy level, and between reducing by not providing necessary services. This is helpful for the distinction the fixed-service calculation provides but would need a building-level thermal model to determine the appropriate consumption.

Timing is also an element of the choice between immediate relief and investment. Mengesha and Roy (2025) examine the dynamic interaction among carbon pricing, technological adoption and redistribution in their model. Their results refer to structural adjustment and not this short-run expenditure identity. The current calculation can be kept as a practical appraisal for near-term cash exposure and efficiency investment can be assessed separately. A 20% decrease in the use as well as the intensity of electricity services results in a 36% decrease in the modelled cost, as the decreases are multiplicative. Such the conditional result is not a prediction of savings to be made or a reason not to support it until improvements are made.

A significant drawback is the lack of consistent distribution of the household sector between income, consumption, tariffs and dwelling attributes in the six economies. From these calculations, there is no national poverty incidence or confidence interval or causal coefficient. Lifecycle intensity also does not equal the tax-specific emissions factor. The increments reported should thus be considered equivalent carbon-equivalent exposures. The population impacts of each scenario could be estimated by a subsequent household study that substitutes the survey observations for each scenario's quantity and income and applies the actual tariff and transfer rules.

5. CONCLUSION

The exposure to conditional affordability is significantly different in each GCC economy for a base carbon-equivalent electricity charge. Under the central scenario, the extra monthly expenses range from USD 71.60 to USD 135.37. It also shows that there is a trade-off between asymmetric household outcomes and symmetric cost transmission, in the sense that an expenditure-gap threshold can induce such an outcome. Mechanical effect should be recognized in policy appraisal and not be blamed on household behavior or suppliers for being asymmetric. The second empirical condition is a linked household distribution which allows a comparison of actual burdens, eligibility for energy services and compensation.

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