

# Measuring Underlying Energy Efficiency in the GCC Using a Newly Constructed Energy Dataset

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## Overview

Economic development, population growth, and improvements in energy efficiency are key factors behind the evolution of energy demand. The Gulf Cooperation Council (GCC), an economic union that includes six countries, has experienced rapid economic and population growth over the last few decades. This has led to rapid growth in final energy consumption, which increased at an average annual rate of 6.8% between 2004 and 2014. Using a newly constructed dataset, we undertake a benchmarking exercise for energy efficiency in three sectors across the six GCC countries. With an energy demand framework, corrected ordinary least squares, an econometric approach, is used to estimate underlying energy efficiency trends for three key energy consuming sectors: residential electricity, road transport gasoline, and manufacturing aggregate energy. Our results reveal that relative underlying energy efficiency in the GCC countries has witnessed limited improvements, and has deteriorated in some cases. This has likely contributed to the region's rapid energy demand growth. However, recent implementation of energy efficiency standards and regulations, combined with energy price reform, should lead to considerable energy efficiency improvements in the future, which is likely to dampen the rapid growth rates in energy consumption that the region has witnessed over the last few decades.

## Methods

This paper uses COLS to estimate a relative measure of energy efficiency for the six GCC countries. We do this for residential electricity, road transport gasoline, and manufacturing aggregate energy demand. Once an energy demand equation is estimated, we use the residual terms to measure relative energy efficiency.

The first step in COLS is to shift the estimated energy demand equation so that only one residual (the most negative, that is, the most efficient) hangs on the function.

$$u_{it, COLS} = u_{it} - \min_{it} u_{it} \quad (1)$$

where  $u_{it}$  is the residual for country  $i$  in year  $t$  and  $u_{it, COLS}$  the corrected residual. (Note that this applies to the residuals from the estimated energy demand equations for all three sectors.) Equation (1) shows that the corrected minimum residual is equal to zero, implying the highest level of energy efficiency.

Underlying energy efficiency is then estimated by taking the exponential of the corrected residuals as follows:

$$UEE_{it} = \exp(u_{it, COLS}) \quad (2)$$

Therefore, the country in year  $t$  with an underlying energy efficiency equal to one is the most efficient country, and becomes the benchmark with which other points are compared. Values of underlying energy efficiency greater than one are thus indicative of energy inefficiency relative to the benchmark.

Given the lack of readily available, consistent data on GCC countries, we constructed a new dataset for estimating the energy demand equations for the residential, transport, and manufacturing sectors by combining numerous sources.

## Preliminary Results

For residential electricity, we find that underlying energy has improved in Kuwait, Bahrain, and Saudi Arabia by 18%, 11%, and 10%, respectively, while it deteriorated in Qatar, Oman, and the UAE by 34%, 15%, and 4%, respectively.

For road transport gasoline, we find that underlying energy efficiency has improved in Bahrain, Kuwait, Qatar, and Saudi Arabia by 21%, 17%, 7% and 7%, respectively, while it deteriorated in Oman and the UAE by 47% and 33%, respectively.

For manufacturing, we find that underlying energy efficiency has improved in Saudi Arabia and Bahrain by 31% and 6%, respectively. In contrast, underlying energy efficiency has deteriorated in Oman, UAE, Kuwait, and Qatar by 77%, 39%, 18%, and 8%, respectively.

Because of the difficulties associated with measuring energy efficiency, analysts often use simpler, indirect indicators to track progress in energy efficiency. For households, energy consumption per capita is often used. A fall in residential electricity consumption per capita, for example, is often believed to be associated with energy efficiency improvements. For firms, energy intensity (or its inverse, energy productivity) is often used. A fall in the energy intensity of manufacturing, for example, is often associated with improvements in energy efficiency. We compared these indirect indicators to our estimates of underlying energy efficiency for each country and sector, and found that they often do a good job at tracking progress in energy efficiency. But this was not always true. For example, in the residential electricity sector we find that Saudi Arabia's underlying energy efficiency has improved by 10% between 2004 and 2014. However, residential electricity consumption per capita has increased by 44% over the same period. This demonstrates that indirect indicators such as per capita energy consumption and energy intensity can be used to measure progress in energy efficiency to a certain extent, but are not perfect at doing so. In terms of cross-country comparisons, we found that the indirect indicators are less useful at comparing energy efficiency. For example, ranking the six GCC countries in terms of underlying energy efficiency reveals completely different outcomes when compared to ranking them in terms of energy intensity.

## Conclusions

Consumers in the GCC have enjoyed low energy prices for decades. This has had some unintended consequences. Low energy prices have encouraged rapid growth in energy consumption, which is not surprising given the pace of economic development and population growth in the region. Energy efficiency can often mitigate rapid consumption growth, but consumers see little incentive to invest in energy efficiency when energy prices are low.

In an environment of low energy prices, policy can play a big role. When consumers lack the incentive to invest in energy efficiency, policies such as minimum energy efficiency standards can be implemented instead. Countries in the GCC however had launched a limited number of policies around energy efficiency.

Low energy prices and a lack of policy around energy efficiency are believed to have inhibited energy efficiency in the GCC, contributing to the rapid growth in final energy consumption, which increased at an average annual rate of 6.8% between 2004 and 2014. Using corrected ordinary least squares (COLS), an econometric approach to estimating energy efficiency, we demonstrate that countries in the GCC witnessed limited improvements—and, in some cases, deteriorations—in energy efficiency in the residential, transport, and manufacturing sectors.

Nevertheless, given the recent waves of energy price reform in the GCC, there is likely to be greater improvements in energy efficiency over the next few years as prices encourage consumers to invest in more efficient capital. Higher energy prices will also incentivize less wasteful consumption of energy across the region. Furthermore, the increased attention given by governments in the GCC to energy efficiency standards and regulations will accelerate these expected improvements in energy efficiency. For these reasons, the growth patterns in energy consumption over the next decade will likely be exceedingly different to the patterns witnessed between 2004 and 2014, when energy efficiency played a limited role.

## References

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