U.S. DELIVERED ELECTRIC ENERGY INTENSITY: ARE 20-YEAR TRENDS SUSTAINABLE?

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Overview

Energy intensity, or the ratio of energy consumed per unit of economic activity, is often used as a proxy for energy efficiency. Many historical studies show that energy intensity decreases over time; however, energy intensity is often so aggregated that it is difficult to tease apart why energy intensity decreases. Many factors could explain why energy intensity decreases such as the growth of economic activity, structural change within the economy, weather factors, or efficiency gains. Additionally aggregate energy intensity masks intensity trends for different types of energy. During the 20th century, industrialized countries completed electrification thereby changing the mix of types of energy relied upon for economic activity. Developing countries are pursuing electrification now. Electric energy intensity in particular is a measure of great interest, since some of the largest economies – namely the United States and China – rely heavily upon coal to generate electricity. In the U.S., the electricity generation sector is the largest source of national carbon dioxide emissions, so trends in electric energy intensity bear implications for addressing climate change. This paper considers the case of delivered electric energy intensity in the U.S. among sectors with the largest electricity demand – industry, residential buildings, and commercial buildings – and documents trends from 1985-2004. It also investigates trends assumed by the Energy Information Administration in its reference case projections for delivered electricity demand to the industrial sector in the 2008 Annual Energy Outlook (AEO).

Methods

The U.S. Department of Energy office of Energy Efficiency and Renewable Energy (EERE) has compiled indices for U.S. energy intensity from 1985-2004. These indices are based upon the logarithmic-mean Divisia index (LMDI) method and have a nested structure where indices built at more detailed levels (level 3 is most detailed) are built up to more aggregated indices (units shown under Level 1) as follows:

Level 1	Level 2	Level 3
Residential buildings [Btu/square foot]	U.S. regions (Northeast, Midwest, South, West)	Housing types (single family attached, single family detached, mobile home, multi-family (2-4 units), multi-family (>4 units))
Industry [Btu/$1996 GDP]	Manufacturing, Non-manufacturing	21 NAICS sectors (manufacturing only)
Commercial buildings [Btu/square foot]	NA	NA

EERE indices have been calculated from a variety of energy perspectives (e.g. total, delivered, sectoral use). EERE indices are historical, but such indices could also be used for decomposing projections. The findings from the historical analyses of activity (e.g. GDP growth, population growth) and structure (e.g. structural shifts within manufacturing, population migration, changes in housing size) are compared to trends assumed in the 2008 AEO reference case.

Results

Overall findings are that activity (GDP growth, population growth, increased commercial floor space) is the largest contributor to energy use in all demand sectors. Efficiency gains in each demand sector vary substantially, and structural effects in the U.S. completely offset efficiency gains in the residential and commercial sectors from 1985-2004. Structural influences on aggregate industrial delivered electricity intensity were about equal to efficiency gains.

	Electricity use	Structural change	Component intensity (proxy measure for effect of efficiency gains on electricity use)
Industrial sector	+25%	-13%	-12%
Residential sector	+65%	+20%	+7%
Commercial buildings sector	+74%	-2%	+29%

Applying the same methods used in the historical EERE study to projections for industrial electricity demand from 2006-2030 in the AEO 2008 reference case, it was found that 20-year trends for structural change and efficiency improvements were assumed to be similar to those observed from 1985-2004. However much more modest assumptions for industrial activity in the AEO are what enable a low projection for industrial electricity demand of no greater than 8% above 2006 levels.

Conclusions

Compared to the many studies that have found decreasing trends for aggregate energy intensity, this study of U.S. delivered electric energy intensity finds that efficiency gains for electricity use are being equalized by structural factors or being completely offset. This underscores the need for structural policy interventions in addition to technological development. Additionally index decomposition methods applied to forecasts for the next 20 years can reveal important assumptions that are not obvious.

References

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