# ENERGY DEMAND AND CARBON EMISSIONS REDUCITION POTENTIONAL OF DYNAMIC PRICING OF ELECTRICITY: SYSTEMATIC REVIEW AND META-ANALYSIS OF EXPERIMENTAL EVIDENCE.

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## Overview

Demand response has been recognized as a critical element in transition to low carbon energy systems[1]. It is hoped that shifting demand through price incentives can reduce energy consumption and facilitate electrification of heat and transport[2]. However, a rigorous assessment of the existing evidence from field trials that use time-of-use pricing, critical peak pricing, real time pricing or rebates to influence energy use in households is missing. Previous reviews have also relied on evidence from utility reports in the United States and Canada and evidence from pricing experiments in Europe, East Asia and developing Asia has not been accounted[3].

## Methods

Here, we address this gap by employing a machine learning-assisted systematic review and meta-analysis of experimental and quasi-experimental pilots aimed at shifting or reducing energy demand of households during peak and off-peak hours. We extract over 400 individual effect sizes from 40 research studies and 50 utility reports in 12 countries that we make available for further research. Embedding the results from the meta-analysis into a production cost optimization model of the electricity sector for Germany, we try and estimate the reduction in carbon emissions from peak-shifting brought about by time of use pricing.

## Results

We estimate that monetary incentives can reduce overall energy consumption by 6-7% and peak energy demand by 14-16%. For time-of-use experiments both the absolute and the relative (peak to off-peak price ratio) size of the monetary incentive, and the general level of electricity prices determines effectiveness.

## Conclusions

Climate mitigation benefits of dynamic pricing can occur in three dimensions. First, customers reduce their overall demand to avoid peak prices, second through changes in the electricity generation mix as more electricity is generated using low carbon emissions technologies, and third, dynamic pricing can facilitate renewable energy integration. Our meta-analysis evidences that the mean reduction in overall energy demand is greater is statistically and substantially significant. This can be increased further by employing dynamic pricing in conjunction with other behavioral interventions. Dynamic pricing can effectively shift energy demand depending on the size of the monetary incentive. The impact of demand shifting on carbon emissions and renewables integration can go both directions: for instance, demand could be shifted away from an inefficient open cycle natural gas peaking plant either towards renewables energy (reduced carbon footprint) or towards a coal plant as marginal unit (increased carbon footprint). Using marginal carbon emissions factors of the electricity grid from Germany, we estimate a reduction in carbon emissions of the electricity grid by up to 20% with the current system at certain times of the year.

## References


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