The installation of energy efficiency measures in residential buildings reduces energy consumption. However, the research evidence is limited and the risk of bias of the studies included in this systematic review is often high. More high-quality impact evaluations in the field are needed.

What is this review about?
The residential sector releases around 17% of global greenhouse gas emissions. Hence, a key way to mitigate climate change is by improving household energy efficiency.

Engineering modeling indicates that residential energy consumption could be significantly reduced by installing residential energy efficiency measure (EEM) interventions. These include new windows, attic insulation and upgrading of heating and cooling systems, such as air conditioners. Yet, studies that examine the actual impact of EEMs often find these models too optimistic about reductions in consumption.

This systematic review synthesises impact evaluations to estimate the average effects of installing different EEMs on energy consumption, and examines how that effect differs across contexts and population subgroups.

What studies are included?
The review includes studies with an experimental or quasi-experimental design that estimate the effect of installing EEMs on relevant outcomes. The study summarises findings from 16 studies, most of which were implemented in high-income countries, in particular the USA and the EU.

What are the main findings of this review?

What is the effect of installing EEMs on energy consumption?
Installing EEM bundles significantly reduces energy consumption. Installing individual EEMs generally causes smaller reductions in consumption, but a few studies estimate larger or negligible changes and one study found an increase in consumption.
The results were similar when focusing on the five low risk of bias studies. High-quality evidence examining any EEMs is limited to one or two studies. There is not enough evidence available to formally rate EEMs effectiveness, as only one or two low risk of bias studies examine each EEM. The effectiveness of each EEM depends on many contextual factors, such as implementation or specific EEM features, and existing studies do not rigorously compare EEMs to each other.

What is the available evidence on funding mechanisms and costs?

All the interventions were fully or partially funded by governments, universities, or both. Eight studies conducted some type of cost analysis such as cost-benefit or cost-effectiveness analysis. Whilst some studies found that the energy saved by EEM installations was greater than the installation cost, other studies identified small or even negative cost-effectiveness.

Among the two low risk of bias studies, one found a small negative rate of return from installing an EEM bundle – primarily because the reductions in energy consumption were much smaller than expected – and the second found a large positive rate of return from installing attic insulation.

What do the findings of this review mean?

The results suggest that the installation of EEMs is effective, but the available rigorous evidence is limited. Careful consideration of EEM features and context is important, as studies indicate that the same EEMs implemented in different ways can cause different impacts. EEMs’ impacts on energy consumption are not always straightforward, as households might use some EEMs to increase indoor comfort or shift from one energy source to another, resulting in more energy consumed.

EEM funders and installers should use empirical findings to improve forecasting of how EEMs and programmes actually impact energy consumption.

Future studies might look at how factors such as pre-installation audits or government regulations moderate EEMs’ impact.

To understand and compare impacts, studies must precisely describe baseline conditions and implemented interventions, such as the amount of insulation installed and the efficiency ratings of original and replacement boilers.

Finally, studies should examine EEMs’ impact in more diverse contexts such as Asia, Africa, South America or Southern Europe.