U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

Pathway to Zero Energy Windows: Advancing Technologies and Market Adoption

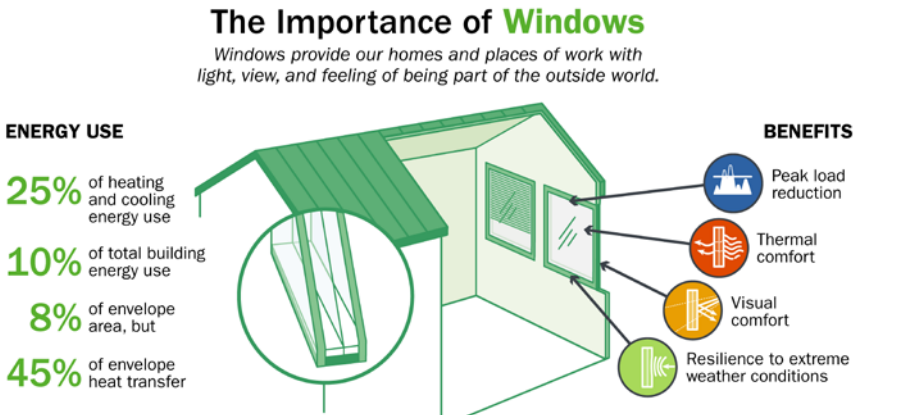


Figure by Cristen Farley, LBNL.

Improving the performance of windows has the potential to reduce U.S. annual energy use by 1.7% and CO_2 emissions by 1.9% in 2050.

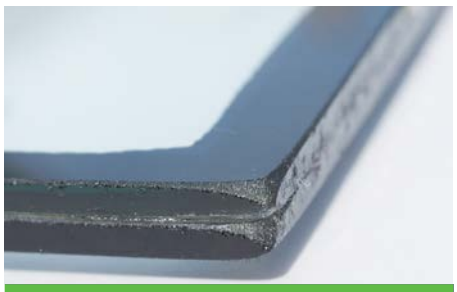
Beyond static windows, dynamic technologies could reduce U.S. annual energy use by 1.6 quads and CO_2 emissions by 68 million metric tons. In addition, the widespread adoption of static and dynamic technologies would substantially reduce peak electricity demand from buildings.

Beyond energy use and CO_2 emissions reductions, improving window performance will increase occupant comfort and well-being.

In a new report, *Pathway to Zero Energy Windows: Advancing Technologies and Market Adoption*, the U.S. Department of Energy (DOE) outlines multiple avenues for technology development, deployment, and adoption to increase the impact that windows can have on decarbonizing America's buildings.

Importance of Windows

By leveraging desirable external environmental conditions (e.g., fresh air and natural light) and mitigating the influence of undesirable conditions (e.g., moisture, hot or cold temperatures, wind), windows can reduce the need for space conditioning and electric light, and thus reduce energy use and CO_2 emissions.



Example of vacuum-insulated glazing. *Photo from LBNL.*

Overall, windows are responsible for 8.6% of energy use in buildings, and they influence multiple end uses, including heating, cooling, ventilation, and lighting. Although windows compose only 8% of building surface area, they represent 45% of thermal energy transmission through the building envelope.

Reducing the thermal load from windows reduces the size of HVAC equipment required to deliver needed heating and cooling, thereby reducing equipment cost and, crucially, the cost of switching to heat pumps for decarbonization.

Windows are also critical to creating indoor spaces that people enjoy. High-performance windows, daylighting, and shading systems that can substantially reduce undesirable heat transfer and air leakage compared to current typical systems have the potential to dramatically enhance occupant satisfaction.

Transforming Technologies

High-performance windows are crucial to achieving low-energy buildings. Modifications to the frame, advanced glazing packages, and subcomponents are essential to achieving window performance far beyond typical new windows. These include advanced glazing (e.g., thin triple or vacuum-insulated glazing), higher-performing inert gas fills (e.g., krypton), or replacing the fill with a transparent low-conductivity solid material, and developing highly insulating window spacers and frames.

Dynamic facades and glazing that respond to changes in heating and cooling demand, occupancy, and available daylight can reduce energy use and improve comfort. Novel approaches that rely on low-cost, high-throughput production methods could reduce costs and expand availability of systems. Self-powered systems (e.g., using photovoltaic [PV] cells, or transparent PV glazing) for automated attachments and dynamic glazing would reduce installation costs. Additionally, improved control methods (e.g., adaptive models using sensor inputs, user feedback, or machine learning algorithms) can be used to improve energy efficiency performance and user satisfaction.

Accelerating Market Adoption

Through a range of deployment and market transformation activities, DOE's Building Technologies Office seeks to accelerate the adoption of high-performance window technologies, especially retrofits of existing buildings, by increasing the number of retrofits each year, and converting all retrofits to take advantage of available high-performance window technologies. ■

Learn More

Technical Report: https://www.nrel.gov/docs/fy22osti/80171.pdf

For more information, visit: energy.gov/eere/buildings/windows

DOE/GO-102022-5735 · June 2022

Produced for the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, by the National Renewable Energy Laboratory (NREL).