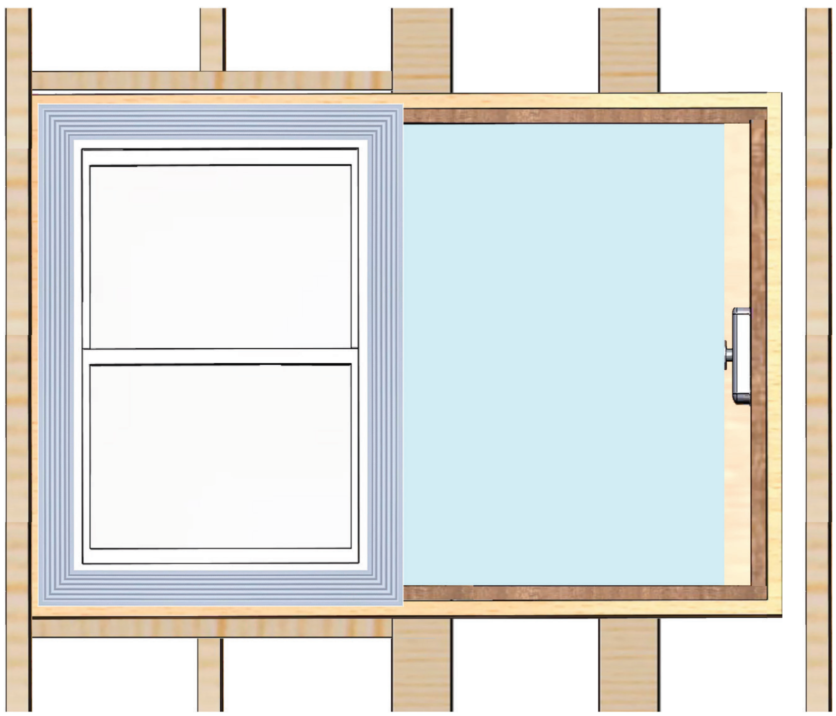
Window Thermal Cover

Every now and then a transformational innovation occurs that has a big impact on how we do things. An example is the LED light bulb that replaced the incandescent bulb and caused energy consumption to drop 7-fold. Before this occurred, no one could imagine this would happen, yet happen it did.

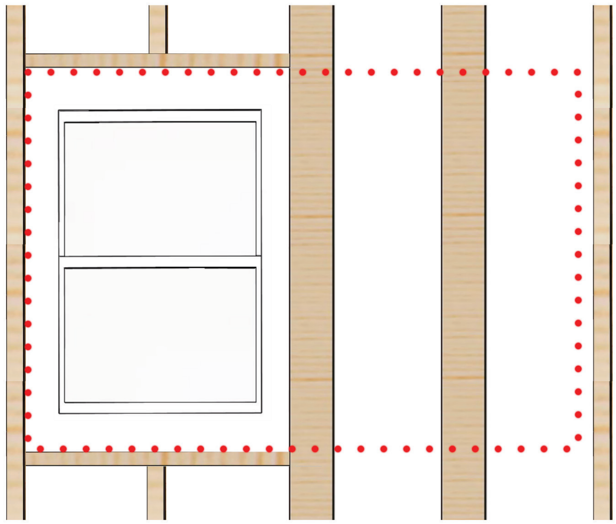
Approximately [25% to 30%](#) of residential heating/cooling energy consumption is due to loss through physical wall windows; and we have yet to see a transformational event at the window. Researchers explore standardized systems that could potentially change this. Below is one example approach.

Window Thermal Cover

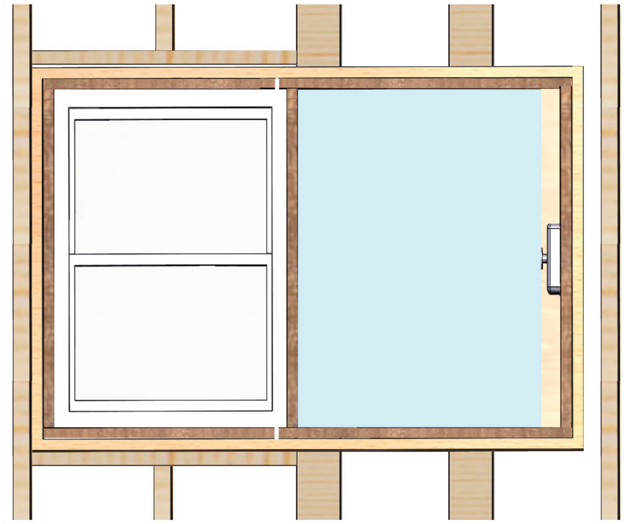
The average American home has an average wall insulation of R16 (amount of insulation). A typical window has an insulation of R3 (1/5th as much). In theory, one could *thermally* turn a window into a wall with a 5cm (2 inch) thick thermal cover (blue) embedded in the wall that automatically slides over the window when the room is not occupied; and thermally moves the R3 window to R16 wall, as illustrated below.



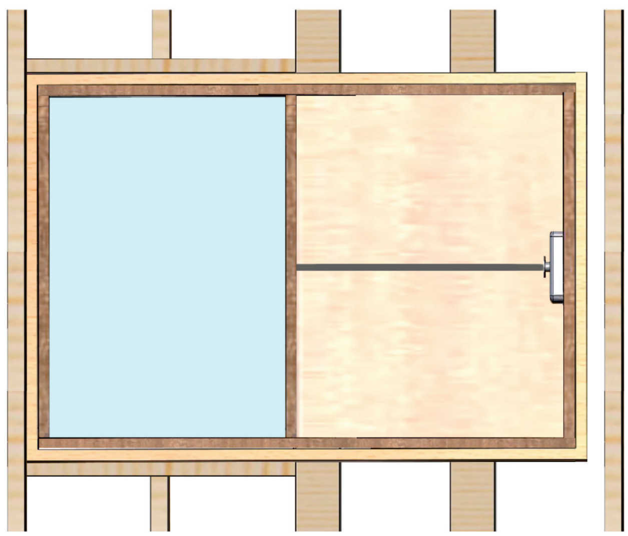
The below illustrations explain how this might work.



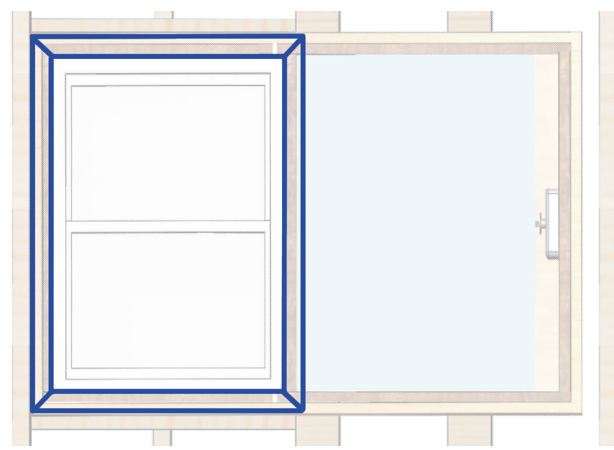
Shown above is wood framing (e.g. 2x6) and window without thermal cover. Framing bears load and is not effected by thermal cover, with the possible exception of rotating several breams by 90 degrees. Window must transfer load from hurricane force winds to framing. Alternatively, thermal cover assembly bears no load, and therefore does not increase framing costs.



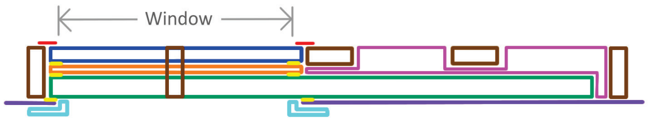
Motor and worm-drive moves thermal cover (blue) into stow position behind drywall and out of view. Thermal cover assembly is pressed against drywall while insulation resides between thermal cover and exterior plywood sheathing. Moveable cover is light and therefore involves little force, ensuring safety. Internally, it contains Styrofoam like insulation several inches thick.



Thermal cover (blue) seals airflow at perimeter via gaskets after being moved in front of window via mechanism. Shown here is worm drive, yet one could use alternative systems such as pulley/cable or linear gear.

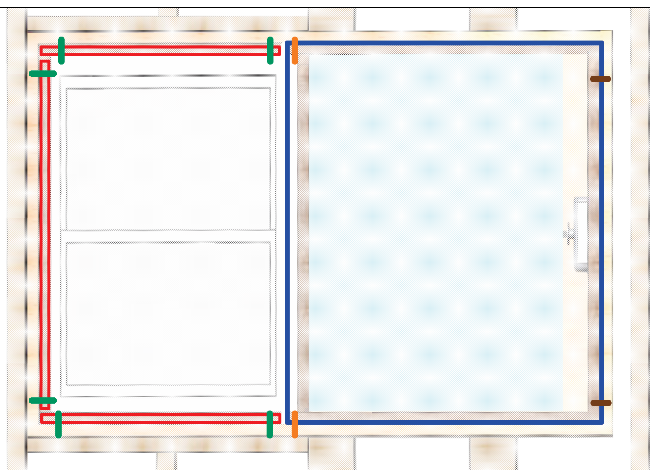


Molding (blue) is viewed by occupant and surrounds window opening in a traditional manner. Occupant sees drywall outside this molding.

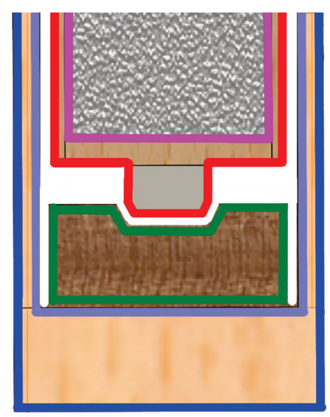


This top view shows window (blue) bonding to framing (brown) via metal plate (red). Thermal cover assembly (green) is pressed against drywall (purple) while insulation (violet) resides between assembly and external sheathing. Carpenter seals assembly via caulk (yellow) to stop airflow from inside wall. Carpenter also installs filler window casing (orange) between assembly and window, where casing thickness is determined by final wall thickness. Final wall thickness is determined by building requirements (e.g. amount of insulation).

Thermal cover assembly outer frame (red) permanently attaches to wall framing (e.g. 2x6) along two surfaces (blue) via fasteners (e.g. screws) and/or glue bond. Everything inside assembly is the "thermal cover product" and is responsibility of thermal cover manufacturer; whereas everything outside is the responsibility of architect and carpenter. Wall framing is accurate to ~1cm whereas windows and window covers are significantly more precise due to internal seals.



Replaceable plug-in module (blue) slides out after internal rails (red) are removed via bolts (green). Module (blue) is secured by bolts (orange) and pins (brown). Module contains components that will not last building lifetime. This includes moveable thermal cover, motor, worm-drive, electronics and gaskets. Standardization of module sizes ensures compatibility between different manufacturers; which increases access to replacement modules over building lifetime.



This is right side view of lower rail. Styrofoam-like insulation (violet) resides inside moveable cover (red). Thermal cover assembly (blue) and box inside assembly (purple) permanently attach to building. Plug-in module (green) houses cover and supports replacement. Carpenter seals permanent assembly (blue) to wall via caulk; and therefore prohibits airflow from inside wall to room.

Why Does This Not Exist?

Moveable embedded panels within walls are not new; however, we do not see them for several reasons:

1. There is a standard way to electrically attach your vacuum cleaner to your living room wall (110VAC outlet), and a standard way to attach your computer to your router (Ethernet); however, there is no standard way to electrically attach a window thermal cover to a building. And multiple proprietary methods are costly for a variety of reasons.
2. Mechanical components such as motors and sliding mechanisms typically fail every 10 to 30 years and need replacement; however, a building might last 100 years. And manufacturers are not likely to make a product for 100 years. Subsequently, replacement parts for a propriety system might become illusive over time. If a property is being sold and half the living room thermal covers are not working, and not being fixed, then buyers will consider it to be of less value. And developers, who fund and control the construction of a building, know this. Therefore, they will not embedded propriety gadgets in walls that periodically fail.
3. If one wants massive adoption then one would want the savings from reduced energy loss to pay for the thermal cover in a reasonable period of time. Proprietary products tend to not meet this requirement due to high price, especially if sales volume is low.

R&D Challenge #1: Identify Best Method to Electrically Attach To Building

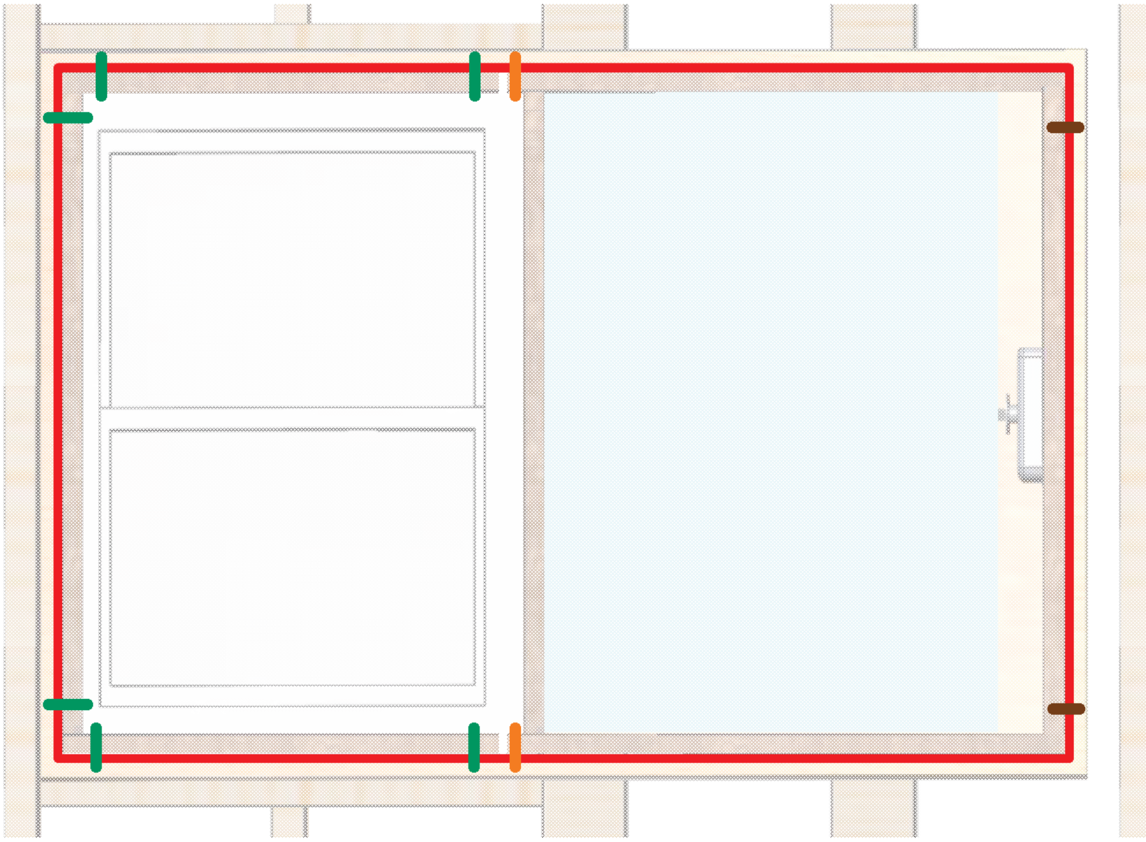
The "Smart Building" initiative discussed previously would provide a standard way to electrically attach a window thermal cover to a building; and solve Problem #1

R&D Challenge #2: Develop Plug-In Module That Supports Replacement

A standardized plug-in module would help solve Problem #2. The design illustrated previously has a removable plug-in module embedded in the wall that contains a moveable thermal cover, motor, mechanism, and electronics. A standards body could establish standard sizes for these plug-in modules. For example, one might have sizes 3ft x 32" x 3", 4ft x 32" x 3", and 5ft x 32" x 3". Architects would then have the option of pairing with common window sizes. The beauty of mechanical standardization is it addresses both Problem #2 and Problem #3. The disadvantage is it pushes architects to consider fewer window size options.

Example Proposed Standard

The above design supports standardization by specifying several parameters for each of several sizes: assembly frame thickness, assembly frame internal height/width (red), placement of bolts that secure internal removable rails (green), placement of bolts that secure plug-in module (orange), and placement of pins that secure module to right side (brown).



This means any product that meets these requirements will plug-and-play into an existing frame. Replacement gear consist of one plug-in module and three removable rails. Subsequently, manufacturers control: entire contents of module, gaskets, mechanics, motor, electronics, and different thermal designs.

Manufacturers might offer different levels of quality at different prices.

Over time, thermal properties might improve due to innovation. For example, one might utilize vacuum insulation to provide high thermal insulation at low thickness. Theoretically, internal electronics could power a small pump.

R&D Challenge #3: Reduce Cost

If we look at the amount of material within a window thermal cover, we see much less relative to the typical window, since the typical window needs to resist hurricane force winds, and must seal airflow under high wind pressure. Alternatively, an internal cover can be made of light materials that involve little force. Internally the thermal cover contains Styrofoam-like insulation, it seals on all four sides with gaskets similar to a window, and it includes shiny metal surfaces on both sides that reflects radiation.

Mechanical standardization drives down price via commoditization since it entails multiple companies with low R&D costs who compete on price.

In order to gain mass adoption, one would want parts and labor costs to be paid for with energy savings over a reasonable period of time. This is a bit complicated, since energy costs vary from region to region, and over time.

R&D Challenge #4: Block Visible Light, Infrared Radiation and Heat Radiation

If one places a frypan on a stove, heats it, holds it in air with one hand, and places the other hand *below* the pan five inches away, they will feel heat against the lower hand. This is not due to convection air currents, which is what you feel with your hand *above* the pan, since heat rises. The heat you feel below is called "heat radiation" or "black body radiation", and is an import component of energy loss through windows.

If you place your hand in the sun and feel warmth, then approximately half is from visible light radiation and the other half is from infrared radiation. These are similar, yet differ in frequency.

If you place your hand in front of a camp fire and feel warmth, you are mostly feeling infrared radiation.

The thermal cover's job is to block all three of these, since they are all energy. A shiny metal surface, such as aluminum foil, reflects visible, infrared and heat radiation. One would want shiny metal on both external and internal thermal cover surfaces to minimize energy loss.

Styrofoam-like insulation has ~R6 insulation per inch of thickness, and a typical window has ~R3 total. If you want your covered window to be the same as the average American wall at R16, you would need your thermal cover to be ~2 inches thick (2 x 6 + 3 = 15).

Alternatively, one might consider a rolled cover above a window and embedded in the wall. This could move down over the window like a rolled blind. However, it would only support thin material and sealing airflow at edges might be illusive in a gravity fed system.

R&D Challenge #5: Overcome Homeowner Resistance

It is probably impossible to satisfy a homeowner's sense of aesthetics with a thermal cover since they typically enjoy window views and outdoor light. The easy solution is to automatically retract when room is unoccupied. Subsequently, the homeowner is not forced to observe shiny metal panels in their living room.

Automation could cover windows during the winter provided the following conditions were met: room is unoccupied, outdoor temperature is colder than desired room temperature, and the sun is not shining on window. Or cover windows during the summer when the room is unoccupied and the outdoor temperature is warmer than set point.

Passive Heating

There is a technique called "passive heating" that entails sun shining through a window, heating the floor, and subsequently heating the building. However, this must contend with heat loss through glass when sun sets, and is therefore not popular. Window thermal covers could change this, and cause architects to rethink passive heating, especially in climates conducive to this technique.

Parameters That Characterize Thermal Cover System

Multiple parameters characterize each window thermal cover: embedded in new construction wall or external and supporting attachment to existing construction, building type, window type, cover is flat ridged panel or rollable, reflective or absorbing surface, thermal conduction R-factor, parts cost, and installation labor costs.

Design Problem

Assignment for researchers:

> *Develop multiple free and open window thermal cover systems, where each is characterized by above parameters. Propose mechanical plug-in standards that support replacement over building lifetime. Attach to building wiring and network via Smart Building initiative, described previously. Support plug-and-play to reduce installation and design costs. Calculate cost models, perform thermal analysis, and build simple prototypes. Propose standards that define how components plug-and-play together, including mechanics, electronics, and communications.*

Summary

In theory, window thermal covers in new construction should be economically feasible; however, we do face multiple obstacles. This includes mechanical plug-in module standardization, electrical interface cable standardization, and software standardization. In summary, we need to plug-and-play to reduce cost. The good news is developing several standards cost little money.

See Also

For an example of free and open window thermal cover research, click here.