High performance bubble-glazing

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Whenever financial aspects take precedence - availability of resources seems a disincentive for progress in sustainability and conservation. When we can afford more – we simply waste more, without even admitting for consideration that Earth is a system of limited resources.

The opposite direction on the other hand – aiming to improve quality of life while accepting severe limits to every resource including money – seems to be one of the greatest incentives for creativity and innovation. I guess it is a part of human nature – we don't even begin to invent things unless we really need them and we don't think about ways of conserving resources unless their supply becomes limited.

Maintaining winter comfort

Interior temperature in winter is a result of a balance between two things: the heat (energy) that we deliver to it and heat (energy) losses. It means that in order to maintain comfortable interior temperature in winter we need to deliver enough energy to compensate for all energy losses.

When it becomes colder outside – heat losses increase. One way to maintain the comfortable interior temperature in such a situation is to deliver more heat (energy) inside by using more firewood or more heat from some other source. The other way is to reduce heat losses.

Using more firewood leads not only to increased (and ongoing) cost and planetary pollution, but also to more work that takes more time (a resource that I do not have too much of). Finding, transporting and preparing the firewood are all quite time consuming activities. Using the grid electricity is even less appealing, because the efficiency of electricity generation from fossil fuels is about 20%, which means that for every 1kWh of electrical energy that we use, 4kWh escape via various chimneys to the atmosphere and contribute to the planetary overheating.

Reducing home heat losses on the other hand can be a once-only activity that results in a lasting win-win situation for the environment and for us. When we reduce heat losses - they stay reduced all winter. We simply need less energy to keep ourselves warm and cozy everyday - for many winters to come…

Home heat losses

The greatest heat losses in home interiors occur due to various gaps and air leaks. This is because convection (air mass transfer) is far more efficient heat carrier than heat conduction. Hence, our first step should be sealing and controlling gaps and leaks.

The second most significant heat loss occurs through windows, especially if they are large. Glass is a very poor heat insulator and heat can escape through it quite easily. Make a simple test: place a palm of your hand on a glass surface of a window. The cooler the surface is to touch – the more heat escapes through it.

A well-known method of reducing the amount of heat that escapes through windows is so-called double (or triple) glazing. This method has a few serious disadvantages, for example:

1. Heat loss through double glazed windows is still large in comparison to heat loss through normally insulated walls and ceilings
2. Double-glazing doubles the weight of window frames
3. Double glazing is costly and laborious to install and to replace

Disadvantage 1 simply means that double-glazing is not a good value-for-money performer. Even if you find the money to do

it, energy saving effects can be disappointingly small. Disadvantage 2 can prevent double-glazing for glass doors and any moving window parts, simply because when they become heavy their frames eventually skew and distort in time. Since my house has 5 outside glass doors this disadvantage really kept me thinking in alternative directions.

What I sought was a glass surface treatment that

- Would match the thermal performance of double and triple glazing
- Would not increase the weight of windows and glass doors
- Would be inexpensive ($2 per window?) and simple to install/replace so that I can afford to improve thermal performance of all windows I choose including those in the shed workshop.
- Would be easily removable if necessary (important for people who rent their homes)
- Would allow all the light through (after all, transmitting light is the main function of windows and glass doors)
- Would look good from all directions day and night

When I looked at the above list of wishes my first thought was that I was an incurable dreamer. However, when I actually tested my bubble-glazing idea - to my surprise I found that it met all my requirements and expectations.

Bubble-glazing

One of the best-known heat insulators is air. However, for air to work as an insulator its motion needs to be prevented – it needs to be trapped in small bubbles. One of the widely available products that traps air bubbles is a disposable polyethylene bubble-wrap used for packaging, which finishes up in our landfills. I haven't heard of anyone using bubble wrap in the building industry, but its transparency and minimal weight prompted me to try a window glazing experiment.

The only real problem I found with bubble-glazing was to decide the best way of attaching the bubble wrap to the window/door for a given situation. For best thermal performance, durability and best aesthetic appearance (flatness and transparency), the bubble wrap needs to be installed on the inside, as close to the glass as possible, with bubbles facing the glass and the "flat" surface of the bubble wrap facing the interior.

I considered the following ways of securing the bubble wrap in place:

1. Double sided sticky tape along the glass borders. Sticky tape technology is perhaps the fastest to implement, but has some serious weaknesses. When one attempts to remove the bubble wrap – it tears or distorts permanently and cannot be reused. Sticky tape attracts dust and yellows in the sun, each effect ruining the aesthetic appearance of the window. Cleaning glass covered by a sticky tape is a chore. The sticky tape method should not be dismissed however, because it may be the only practical bubble-glazing support for some windows - like some sliding windows for example.
2. Wooden battens. This is a sensible solution when the window frame has a sufficient depth to accommodate battens attached by screws parallel to the glass. Use of small screws rather than nails is important to facilitate easy removal or replacement of the bubble wrap setup. I used this method for some of my shed windows. Purchasing thin battens can be the most expensive part of the project. If your budget is restricted (like mine), the best is to find a friend who has a bench saw (I used my own Triton bench) to cut your own battens from second-hand or scrap wood or even plywood. Make sure that you pre-drill holes for each screw so that battens do not crack when screws go through them.
3. Aluminum angle channels. This is perhaps the most elegant and durable way to support bubble-glazing if you can find

a ready-made angle suitable for your window frame. In my glass doors I used 12x25x1.6mm angle attached by 6Gx10mm sheet metal screws to the wooden doorframe. I made the wider edge of the angle parallel to the glass, so that screws were perpendicular to the glass (and short enough not to reach the glass) for fast and easy installation.

4. Custom z-flashing bent from flat sheet strips to fit the window frame. If you have access to a sheet metal guillotine and bending machine, and can use strip off cuts this can be a very economical option that can provide a great flexibility to support bubble-glazing for various window designs. In my bubble-glazing applications I was able to use ready-made angles and self-made battens.
5. Using fly-screen frames. Bubble wrap can be fitted in made-to-size fly-screen frames, which are readily available in kit forms from many hardware stores. The bubble-wrap frames become portable for easy storage. The main weakness of this approach is that the thermal performance of the window is compromised, unless metal fly-screen frames that carry the bubble wrap are sealed to the glass so that the air flow between the bubble wrap and the glass is prevented.

Installing bubble-glazing is quite fast and easy, providing that all battens/aluminum angles are pre-cut to size and the installation begins with fixing the top edge of the bubble wrap followed by the bottom edge. The bubble wrap sheet needs to be cut larger than the glass and its excess trimmed with a sharp knife if necessary after all battens/angles are in place.

Results

My five bubble-glazed doors are parts of four large double-glazed window walls. Comparing the thermal performance of bubble-glazing versus double-glazing was easy – on a chilly day I put a palm of one hand on bubble-glazing and the palm of another hand on double-glazing. The difference was amazing, much greater than the difference between the single and double glazing that I observed before installing my bubble-glazing.

The bubble-glazed surface actually felt warm to touch, like triple-insulated timber walls in my house. In contrast, the double-glazed window glass felt quite chilly.

To measure the actual thermal performance of bubble-glazing I used an infrared (non-contact) thermometer. Measurements confirmed that the thermal performance of bubble-glazing nearly matches the thermal performance of double glazing.

The good news is that this high thermal performance is achievable to anyone for as little as $2 per window. (An optional aluminum channel may add another $10 to $20 or so, depending on the size of your window and the size of the channel you choose).

The looks

My greatest concern about bubble-glazing was the looks. I have nice views in all directions and greatly enjoy the green ambience of the garden and the forest nearby. I felt uneasy compromising it.

To my surprise I found my bubble-glazing looking much better than I expected. It diffuses light like a frost-glass does, but passes through surprisingly more visual details than I anticipated.

Looking through I can still distinguish all planks on the deck and the mesh details of the balustrade. The garden and the forest in the distance are blurred a little, but the green majesty of Nature outside seems undisturbed.

I feel no hesitation to embrace the bubble-glazing as a part of my energy-efficient and self-sufficient lifestyle. After all – it is a good thermal performer, isn't it?

Fig 1. Visual performance of the bubble-glazed balcony door observed from outside. Interior details some 18m away are still recognizable. The bubbles have 10mm diameter and the bubble-wrap sheet is supported along the inside glass edges using aluminum channels.

Fig 2. Bubble-glazed door in the southwestern bedroom window wall on a foggy winter day. It looks much like a frosted glass door, but its thermal performance is far superior. Unlike curtains, bubble-glazing transmits all incoming light that adds to the positive ambience of the room. Aluminum channels used to support the bubble-glazing do not reduce the size of the window. When bubble-glazing is removed for summer, aluminum channels will be stored in their best place: where they are needed in winter.