Generating electricity with decorative glazing

DOROTHY HARDY, research fellow in manufacturing of functional electronic textiles in the Advanced Textiles Research Group at **Nottingham Trent University,** explains how using solar cells in glazing designs can generate electricity.

Modern buildings should generate more energy than they use. All aspects of building design need to contribute to this, including the glazing. The availability of many types of glass and glazing systems now makes it possible for glazing to make a strong contribution towards temperature regulation of a building. For glass to become an energy generator requires the addition of solar cells. The best type of solar cells for this application are the same as those used in most roof-mounted solar panels used for electricity generation.

Each blue or black square within a panel is a single solar cell made from crystalline silicon. These cells can also be incorporated into glazing with wider spacing to allow light to enter through the gaps. Other types of solar cell are available or under development, but many still have very short lifetimes, and this is often coupled with low efficiencies at conversion of light to electricity. So standard, crystalline silicon solar cells are usually the best choice.

Opacity challenge

The opacity of crystalline silicon solar cells is a challenge when including them within glazing. Inclusion of straight rows of dark, square cells limits the places where this type of glazing can be installed. There is also a pay-off here: the solar cells have to absorb light in order to generate electricity. Large areas of glazing containing solar cells lead to less light entering a building interior. The rows of dark squares cause dappled shading inside a building.

Inventive design is required to ensure that building inhabitants can experience sufficient incoming light, adequate shading and adequate generation of electricity. The "industrial" appearance of the straight lines and strong contrast between light and dark is not appropriate in many settings. ***Please see Picture 1.***

Picture 1 – rows of solar cells provide shade whilst generating electricity at Solar Capture Technologies, Blythe.

"...the rich traditions of stained and decorative glass design offer many ways of working creatively with solar cells."

Inventive integration of solar cells into decorative glazing gives one way to add solar cells into architecture. It might seem counter-intuitive to put these dark, square shapes into windows that are designed to look good, but the rich traditions of stained and decorative glass design offer many ways of working creatively with solar cells. The completed glazing can be visually exciting and can become a useful, integral part of a building as well as a way of showing off an innovative approach to fulfilling requirements for green credentials.

Several glass artists have chosen to work with solar cells. Sarah Hall's work is some of the most well-known, with designs such as the "Lux Nova" solar art glass wind tower in Vancouver. This takes the straight rows of square solar cells and embeds them within pattern and colour that fit with the square cell shapes.

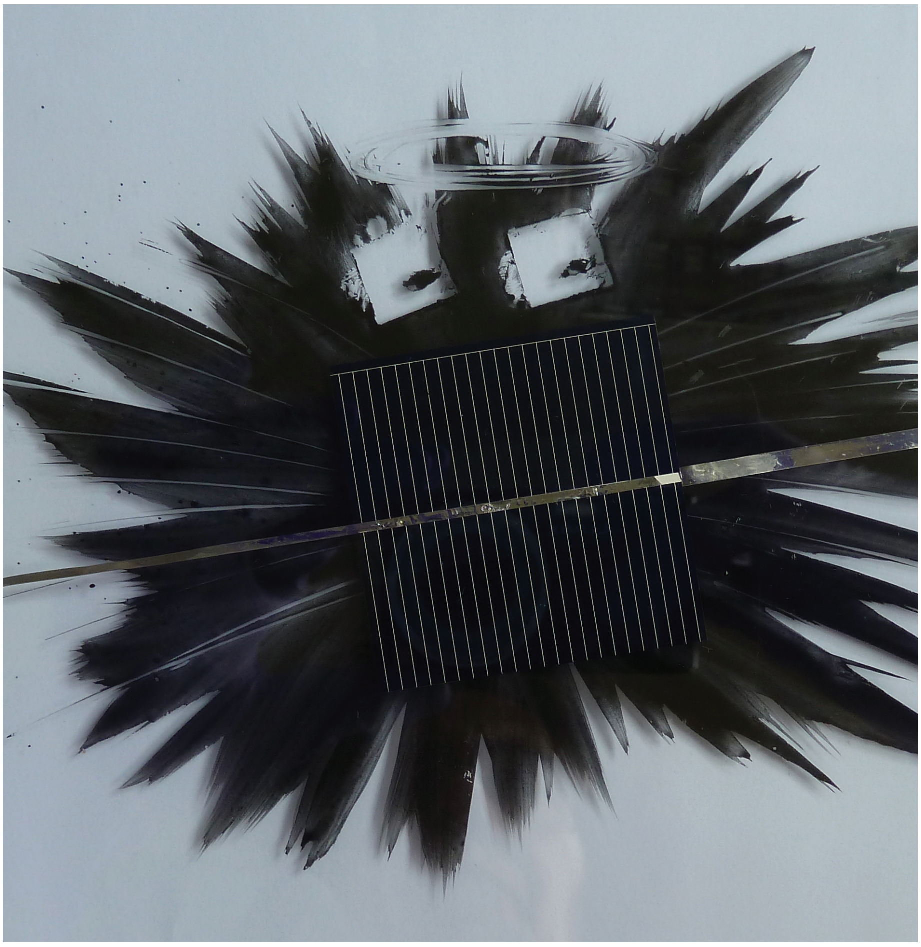
The limitation to creation of a wider range of designs is the strong contrast between dark, square solar cells and light-transmitting areas of glazing. One way to solve this problem is to place dark shapes around the solar cells, hiding the square silhouettes and opening up the potential for many types of design.

Please see Picture 2 which shows a single, square piece of solar cell surrounded by glass paint. The surrounding pattern is more noticeable than the rectilinear solar cell when the piece is viewed in transmitted light. This use of paint can work particularly well when viewing the glazing from a distance, as the details of the solar cell blend into the painted areas.

Electrical circuit

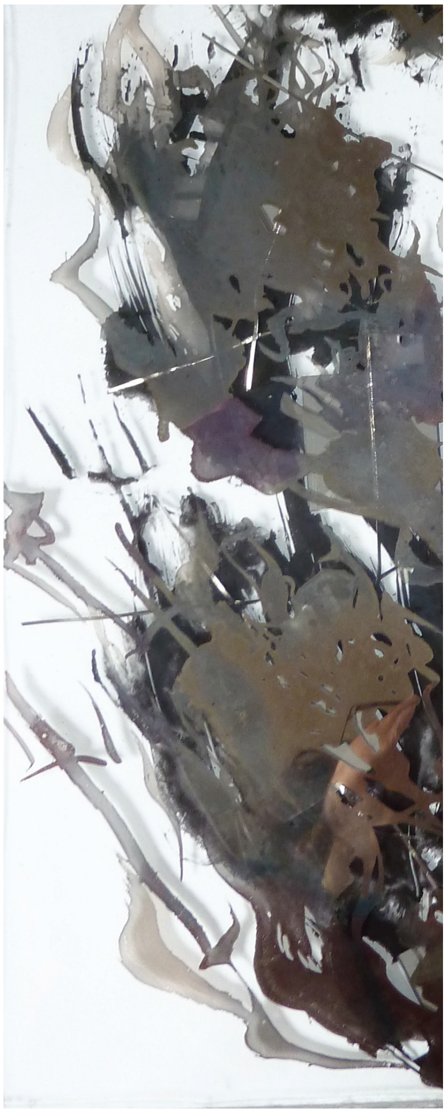
Solar cells have to be connected together to make an electrical circuit. Thin strips of metal are normally used, but the lines of connection do not need to be straight. Use of curved lines or sharp angles makes it possible to fit cells into many designs. Dark patterns can be used to disguise whole strings of solar cells, ***as shown in Picture 3*** with the cartoon of a crow design where the dark wings cover a string of solar cells fitted into a curve with uneven spacing between the cells that accommodates the design details.

Different types of solar cell require one, two or three metal strips to connect each cell to the next, so designs need to accommodate this. More than one string of solar cells can be included in a design, but the number of cells within each string need to match up to keep the electrical circuitry working well. ▶



Picture 2 – glass paint surrounds a solar cell, disguising the shape.

Picture 3 – cartoon showing a curved string of solar cells blending into a crow design.



Picture 4 – swirls of platinum paint cover the backs of solar cells on the inside of a glass-glass laminate containing solar cells.

There are some rules to consider when designing with these electrical power generators. The main aim is to ensure that the front of the design is best positioned to receive maximum amounts of light so that as much electricity as possible can be generated. Solar cells simply require light in order to work and can produce power on cloudy days.

Shading of some of the solar cells within a window needs to be avoided to prevent possible overheating of the solar cells when some are generating electricity and others are not, but circuitry can be put in place to minimise this problem if it is unavoidable.

Solar cells are best positioned to receive maximum amounts of light on the front surfaces. This means that the backs of the cells are usually visible from the interior of a building. The cell backs are not visually appealing, but fortunately these can be covered. Choosing a method of covering them gives new ways of adding to glazing schemes.

Please see Picture 4 where in the design platinum paint is used behind the solar cells. This covers the grey backs, but still allows some transmission of light through this translucent paint layer. The reflective platinum paint creates a changing view of the design, ▶

as movement and colour are reflected back to the viewer.

The window design in ***Picture 4*** contains two strings of solar cells with black paint on the front glass and platinum on the back. Spare pieces of connecting strip are used to add detail to the design. The piece gives an idea of what can be achieved with two colours of paint.

Decorative glazing

Colour is key to so much decorative glazing, so ways also need to be found to work with transmitted colour and with solar cells. There are options such as use of fluorescent dyes within the glues that hold the solar cells in place between sheets of glass.

Please see Picture 5 which shows the same type of design as before, but with red and yellow dye added to silicone that has been poured into place then left to dry.

The fluorescent dyes used in this test piece can increase the amount of light reaching the surface of the solar cells. They also show how colour can liven up a design. Unfortunately, the fluorescent dyes used in this piece can also fade quickly, bleaching away to nothing. Use of coloured glass, paints, films and decals gives other options, and these tend to have much better levels of permanence.

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They cannot be used in front of the solar cells without blocking light from them, but this is not normally an issue when solar cells face outward and are often viewed from a distance. This means that the full palette of colourful media that is normally available to glass artists and designers is still applicable when designing glazing schemes that contain solar cells.

Utilising power

Having a glazing scheme that generates electricity gives the opportunity to decide what is to be done with the power. This can be fed straight back into a standard electrical system. Glazing that is far from or difficult to connect into an electrical circuit can be given a new lease of life after sunset. Electricity generated during the day can be stored ready for use in lighting at night.

Creative use of the generated electrical power can include fans for air movement, or forms of interaction involving light, movement or sound. This does require careful consideration about the amount of power required and what can be generated by a given area of glazing. This can be a new skill to be added to the many already possessed by expert glaziers, or one to be delegated.

The siting of the solar cells need not be limited to the area of the glazing scheme.

Picture 5 – fluorescent dyes add colour to a painted glass-glass laminate containing solar cells.

Entire building exteriors provide potential areas over which solar cells can be placed, but glazing provides one area where retrofitting is relatively straightforward, giving the opportunity to add decoration and interest both within and on the exterior of buildings.

Maintenance requirements

Maintenance is required, as for other forms of glazing such as leaded glass. Crystalline silicon solar cells are normally guaranteed to be generating at least 80% of their guaranteed power after 20 years, so that replacement of the solar cells is required only infrequently. For installations that are intended to last more than two decades, one option is to apply solar cells to a single, interior sheet of glass that can then be replaced when required.

Inclusion of solar cells within glazing is a switch from glazing being a passive system to an active electricity generator, so some adjustments in design thinking are required. The appearance of the glazing scheme and amount of power that can be generated over time can work out well when weighed against the cost of traditional glazing schemes. The design task may become more complex, but the payoff is worthwhile if carried out inventively.

Provision of glazing in modern buildings can become an integral part of the architecture that supplements energy needs, moving on from being a net consumer of energy to becoming an integral part of the building and of its energy needs.

Design variations

Solar cells can be used in a great variety of glazing designs. Some design rules need to be borne in mind, but are worth learning to give opportunities for creation of decorative glazing schemes that can generate electricity. The power can then be used to enhance architecture with lighting or other effects, and to supplement a building's energy requirements.

(Many thanks to Peters Studios, Paderborn, Germany for ideas and for the opportunity to create the glass pieces shown in this article.)