Energy performance of modern conservatories

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Summary

Conservatories are a very popular home improvement. A decade or so ago, they were seen as a key element in the design of passive solar houses, but more recently, the accepted view seems to regard conservatories as energy liabilities[1]. Ironically, over that same period, the thermal performance of conservatories has improved significantly. The project on which this paper is based was aimed at trying to understand the energy performance of modern conservatories, and to develop guidance on the important parameters that influence energy performance.

Two aspects of the performance of conservatories are reported here. Firstly, winter performance, where the balance between passive solar benefit and the heating requirements for extended conservatory occupation is assessed, along with the effects of style, size, and heating setpoint. Secondly, the increased prevalence of portable domestic air conditioners has raised concerns over a possible trend towards active cooling of conservatories. Therefore, the relative effectiveness of different strategies for providing summer comfort is also reported.

Introduction

Conservatories are very popular spaces, because they provide high levels of natural light, offer excellent views into the garden and thereby create an attractive buffer space between house and garden. In 2001, approximately 170,000 new conservatories were built in the UK[2], and the market is expanding rapidly. The energy flows in conservatories are very complex (see example in Figure 1), involving the usual conduction and ventilation and heating system energy flows, coupled with very large variations in solar gain all within a light-weight structure. In common with most issues related to dwellings, the way the occupant uses the conservatory is very variable, and has a big impact on energy performance. The coupling between the conservatory and the house is also a significant effect, and therefore the insulation standards and heating regime in the attached house will also have an impact on overall performance.

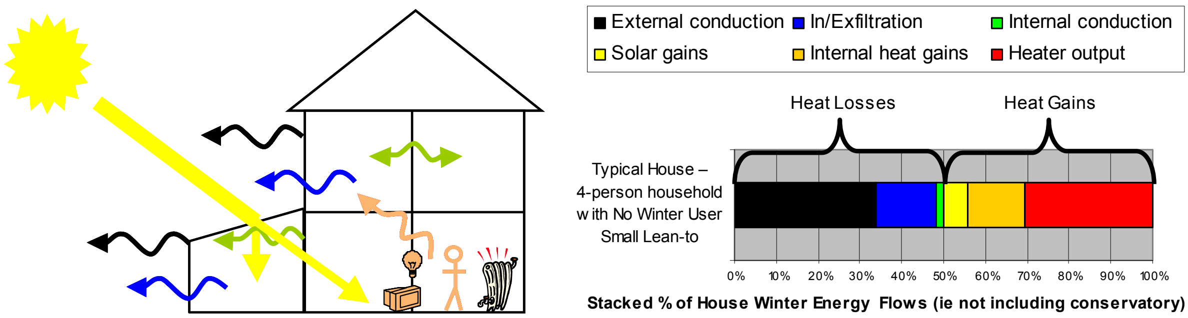


Figure 1 Energy flows in house and unoccupied conservatory

In the heating season, the ideal conservatory design will increase the capture of free renewable energy from the sun, whilst minimising heat loss by improving the insulation standards of the glazing. Unfortunately, in summer, maximising the capture of solar energy will result in overheating, with serious discomfort problems, and the temptation to install cooling systems (e.g. a portable air conditioner unit). To illustrate the effects, Figure 2 shows the energy rating[3] of different window units compared to a solid wall built to current Building Regulation standards. The energy rating accounts for both the benefits of solar gain and the heat loss via conduction – the higher the rating, the better the performance. Moving from single glazing to the double glazed units typically used in conservatories in 2003, leads to a 76% increase in the energy rating. Specifying windows that meet the standards laid down for house glazing in the current Building Regulations increases the rating by a further 15%. In fact this gives an energy rating very similar to a solid wall built to current Building Regulation standards.

Assessing energy performance

In order to assess the energy performance of modern conservatories, a number of standard designs attached to different house types have been analysed using dynamic thermal modelling[4]. Such modelling is able to capture the rapid dynamics of the energy flows and the interactions between the climate and the conservatory and the conservatory and the house. The pattern of occupation is perhaps the single most important factor that controls the energy used to heat a conservatory. A number of typical heating scenarios were developed based on a survey of user behaviour[5]. These scenarios are summarised as follows:

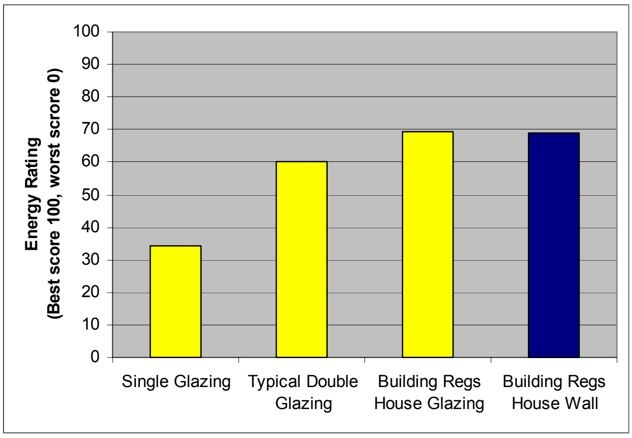


Figure 2 Energy rating of different constructions

- **"No winter user";** in this scenario, users shut up the conservatory during the winter months and no heating is ever used in the conservatory. The house itself is heated morning and evening five days a week, and also for the rest of the day at weekends.
- **"Weekend user";** in this scenario, users occupy and heat their conservatory for seven hours on each weekend day, but do not use or heat it on weekdays. When the conservatory is not used, the connecting doors linking it to the house are closed. The house is heated as per the "no winter user" scenario.
- **"Heavy user";** in this scenario, the users occupy and heat their conservatory seven hours per day seven days per week. As with the weekend user, the conservatory is closed off when not in use. The house is also heated longer, using the "no winter user" weekend heating regime for all seven days of the week.
- **"Opened" user;** in this scenario, the conservatory is permanently open to the house. During the seven hours the conservatory is occupied, the conservatory is heated to 21°C (in the previous scenarios it is only heated to 18°C). The house heating follows the "heavy user" scenario.
- **"Extension";** in this scenario, the conservatory is replaced by a conventional "brick and block" extension of the same size and shape. The extension is heated to 21°C for the same hours as the house in the "heavy user" scenario, and the heat is supplied by the house gas fired central heating system. In all the other cases, the conservatory heating is by electric panel heaters.

The figures given in the following sections focus on worst-case results for simulations based on the current CIBSE test reference year for London, i.e. heating requirements are shown for North-facing conservatories, overheating risk for South-facing. This means that a particular installation will, if anything, tend to perform slightly better than the results shown.

In Figure 3, the carbon emissions for heating the house and the conservatory/extension are shown for these scenarios, and compared to heating the relevant "house-only" scenario (i.e. no conservatory attached, with either a weekend or heavy user heating regime). In all cases, the house is well insulated, built to current new-build (ADL1 2002) standards.

A number of important points can be seen from this graph:

- Closing off the conservatory in winter and not heating will always reduce overall heating bills, because the insulation of that part of the house covered over by the conservatory has been improved. Although always beneficial, the effect is usually small, but the poorer the standard of the house, the bigger the benefit.
- Heating the conservatory for a few hours a day does increase heating costs and associated carbon emissions. However, the increase is relatively modest, provided the conservatory is isolated from the house and unheated when not in use.

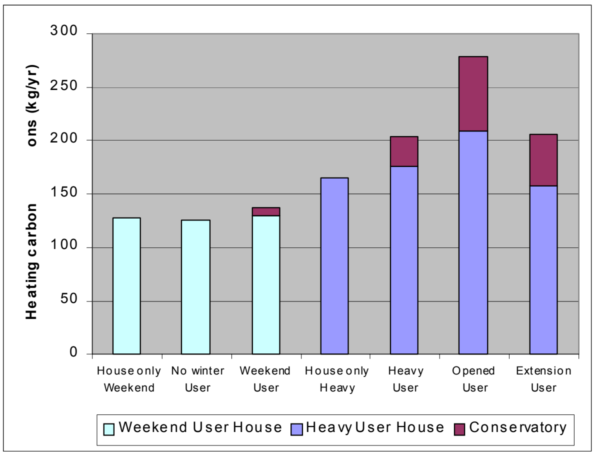
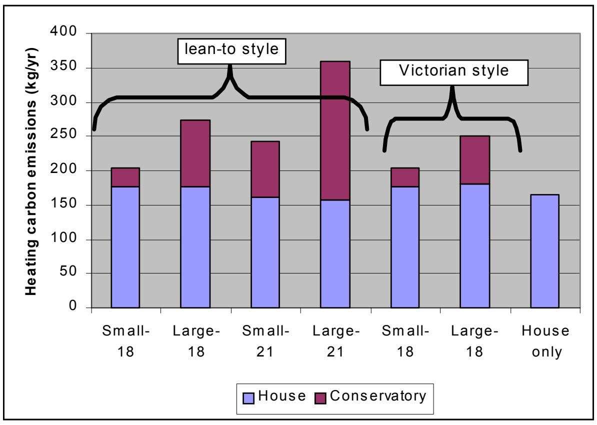


Figure 3 Heating carbon emissions for different N-facing small lean-to conservatories

- If the user wants to connect the additional space to the house via a permanent opening, then a conventional extension will use significantly less energy for heating, even when heated for longer.

The impact of style and size



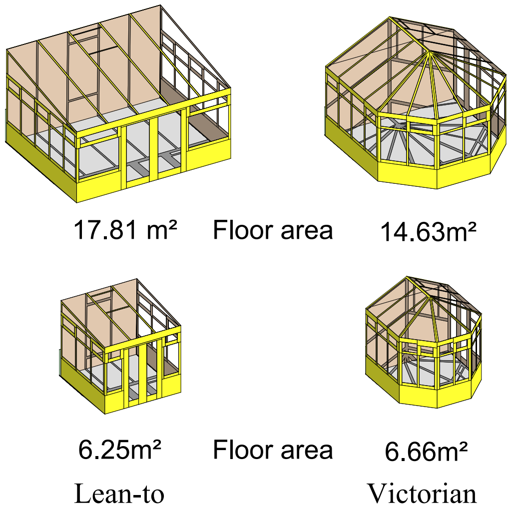


Figure 4 Effect of style, size and heating setpoint on N-facing conservatories

The studies looked at the two most popular styles of conservatory, the lean-to and the Victorian, with size varied from the small to the large end of the modular conservatory range (see visualisations in Figure 4). The effect of heating the lean-to conservatories to different temperatures was also examined, with the graph labels indicating the style, size and occupied hours heating temperature setpoint. A number of trends are clear from this data:

- When the graph is normalised for floor area, it shows that the energy needed to heat the conservatory increases in proportion to the size of the conservatory, and that style is relatively insignificant (the large Victorian is 18% smaller than the large lean-to).
- The energy used to heat the conservatory to 21°C is double that to heat it to 18°C. (In the 18°C reference case, a large proportion of the heating is provided "free" by the solar gains).

If the conservatory is heated using electricity, then the effect of size and heating setpoint are even more dramatic in cost terms. Depending on how well the house itself is insulated, the cost of heating the large conservatory to 21°C for seven hours a day in winter can be between 55% and over 300% of the cost of heating the rest of the house by gas!

Can insulation standards be improved?

There are a number of things that can be done to reduce the heat loss from a conservatory, although they will increase the installation cost a little. Firstly, ensuring that the base and the dwarf wall are built to the standards required by the Building Regulations will reduce heating energy demand by about 20% relative to an uninsulated equivalent.

The other way to improve insulation standards is to opt for better specification window units and roof system (see Figure 5). For the windows, this usually means specifying "hard coat low-e" glass (the ADL1 2002 minimum standard for house glazing). The roof can also be glazed, or more commonly, a polycarbonate system is used. Insulation standards for polycarbonate systems can be improved by specifying more layers or walls in the panel. The current market norm is for a 3-wall system, but four and even five wall systems are available. More advanced "soft coat low-e" glazing is available, but this often reduces solar gain as well as further improving insulation standards. Consequently, as the graph shows, using advanced glazing makes little additional difference to heating energy demand because the two effects tend to cancel each other out.

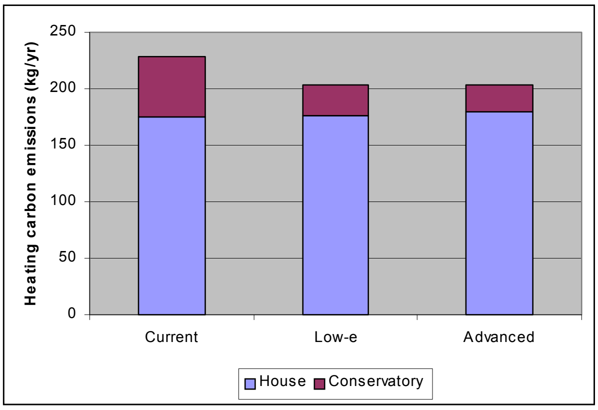


Figure 5 The effect of improved glazing specification on N-facing small lean-to

Summer performance

In summer, solar gains can result in high temperatures in the conservatory. This can mean that the conservatory gets too uncomfortable to sit in, resulting in a loss of amenity. In order to increase the usability of conservatories on peak summer days, two different approaches are possible:

- Reduce the solar gain into the conservatory by using solar control glazing systems and/or roof blinds.
- Install a portable air conditioning unit to cool the conservatory.

The air conditioning option should be avoided, because it is a significant consumer of energy. Calculations show that the carbon emissions from keeping the air temperature in the conservatory below 26°C in summer is roughly twice that needed to heat the same South-facing conservatory to 18°C in winter (see left hand side of Figure 6). As important, is the fact that air conditioning alone cannot provide very good comfort, since the occupant will still be experiencing high radiant temperatures and high levels of glare. That means that although air temperatures in the conservatory may be modest, the comfort temperature will still be high because of the extreme radiant effects (see right hand side of Figure 6). It is much better to solve the problem (excessive solar gain) than to try and reduce the symptoms (overheating). The solar control glazing or roof blind options (when coupled with high levels of passive ventilation from open external patio doors and toplight windows), deliver thermal comfort almost as good as the air conditioning option, but will simultaneously reduce glare and will not use any energy.

Solar control in the roof can be provided by specifying tinted polycarbonate systems (usually grey or bronze). The downside is that the level of daylight is reduced in proportion to the reduction in the solar gain. For glass roofs, "selective soft coatings" can be put on the glass. These coatings are colour-neutral, and do not reduce the daylight to anything like the same degree as the polycarbonate systems. Roof blinds can provide performance almost as good as a full solar control glazing system, but they have the added advantage of being retractable in winter to maximise the solar benefit to offset heating demand.

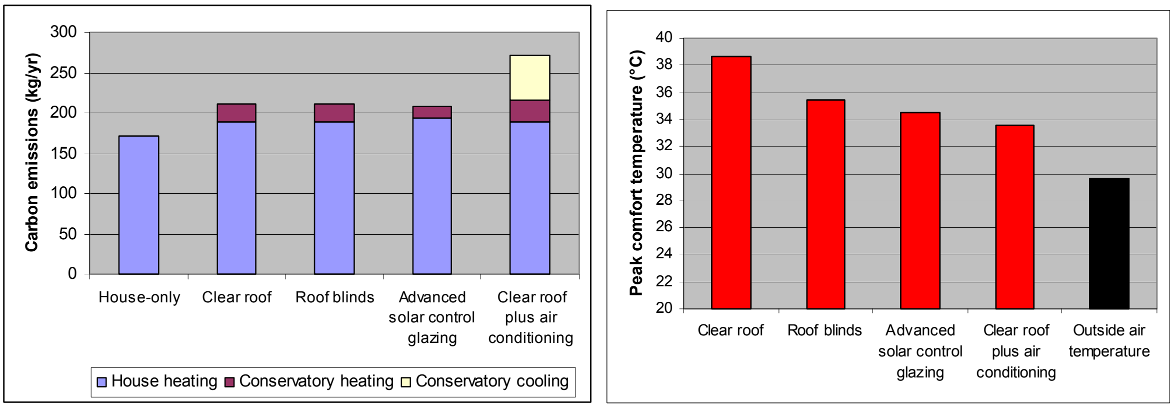


Figure 6 Effect of different overheating strategies on S-facing small lean-to conservatories

Summary

Conservatories provide very attractive space, and are therefore very popular with the homeowner. However, the threat of global warming is now an established fact, and so responsible citizens must take sensible measures to reduce their consumption of energy. This paper has tried to summarise the factors in conservatory design and use that influence energy demand. The main points are as follows –

- The conservatory should not be heated for longer periods or to a higher temperature than is really necessary.
- When the conservatory is not occupied it should always be thermally isolated from the house.
- If long hours of occupancy and a space open to the house are required, a conventional extension will be much less energy intensive.
- The bigger the conservatory, the more heating it will require. A large conservatory, even if it is only heated to 18°C, can cost more to heat than the well-insulated modern house it is attached to.
- Make sure that the dwarf walls and base are insulated, and consider the benefits of specifying low-e glass in the windows and an improved standard of roof system.
- Think about how to keep the conservatory comfortable in summer. Limit the solar gain using solar control glazing or roof blinds, and ensure that high rates of passive ventilation can be achieved.

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