

Sunspace Augmented Positive Input Ventilation of Buildings

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Abstract

A total of 16 positive input ventilation (PIV) units were installed in a new build housing development in west Scotland utilising a glazed sunspace on the south elevation of each dwelling to augment the energy saving potential of the installation. Data logging equipment was installed in each dwelling to enable assessment of the energy benefit to the property derived from the delivered air temperature, outside air temperature, delivery flowrate and occupant control setting. Additionally, an attempt was made to evaluate the system benefits relative to occupant comfort utilising monitoring equipment in the occupied zone of the dwellings with a questionnaire survey undertaken in support of this. Data collected over a 16 month period showed that using the sunspace in this configuration can save up to 15 % of the domestic heating requirements when compared with traditional infiltration ventilation, and more than doubled the energy benefit of that obtained by positive input only ventilation.

Keywords: Sunspace, Positive Input Ventilation

1. Introduction

A total of 16 NuAire 'Ecosmart' positive input ventilation (PIV) units were installed in a new build housing development in West Scotland utilising a glazed sunspace on the south elevation of each dwelling to augment the energy saving potential of the installation (Fig. 1).



Fig. 1. Sunspaces installed on south façade of dwellings

The Ecosmart units supply ventilation air to the dwelling with the air being drawn from the attic space, sunspace, or outside, depending on the user setting – typically the warmest source of either sunspace or attic during the heating season and cooler outside air during summer months. The Ecosmart units were located in the attic space and connected to the various supply sources using insulated flexible ductwork. Thermistor temperature sensors were installed in each of the inlet ducts and house to enable the system controller to select the appropriate ventilation source for the desired conditions.

2. Methodology

The original proposal was to install NuAire monitoring equipment in 8 no. dwellings which would enable assessment of the energy benefit to the property derived from the delivered air temperature, outside air temperature, delivery flowrate and occupant control setting.

It was proposed to establish two of these dwellings as 'controls' - disabling the sunspace solar collection element and operating the systems as normal positive input ventilation systems. Additionally, an attempt was made to evaluate the system benefits relative to occupant comfort; by installing additional monitoring equipment to monitor temperature and relative humidity in the occupied zone of three of the dwellings. A questionnaire survey was to be undertaken in support of this.

3. Data Collection

A total of 14 NuAire NiCM Link data loggers were eventually installed in the properties together with 3 additional Grant Squirrel temperature and relative humidity loggers. A software upgrade to each system delayed the start of the monitoring period until the 4th July 2003 after which commenced a one-year monitoring period.

Problems were experienced in a number of properties which resulted in incomplete data sets; this was mostly due to the tenants switching off the ventilation units and disabling the data collection system and one property experienced a change of tenant part way through the monitoring programme. In another dwelling the tenant reconfigured the ducting installation; negating the control configuration. However, high volumes of data, recorded at 10 minute intervals, were collected for subsequent analysis and the data monitoring was continued until November 2004 in selected properties.

Questionnaire survey forms were sent to all 16 residences on 9th July 2004 in conclusion to the main monitoring exercise.

3.1 System Performance

The onboard programmable interface control software and volatile memory enables each NuAire Ecosmart device to log up to 6 months temperature and activity data. This included:

- House Temperature
- Sunspace (Solar) Temperature
- Loft Temperature
- Outside Temperature
- Ecosmart Delivered Temperature
- User Demand (Target) Setting

A typical profile of this data is shown in Fig. 2 where the target setting is that obtained from a potentiometer dial located on the Occupant Ecosmart Control and can be set by the occupant

between cold and warm depending on comfort requirements. This is recognised as a signal measured between 5 (cold) and 50 (warm) on the graph.

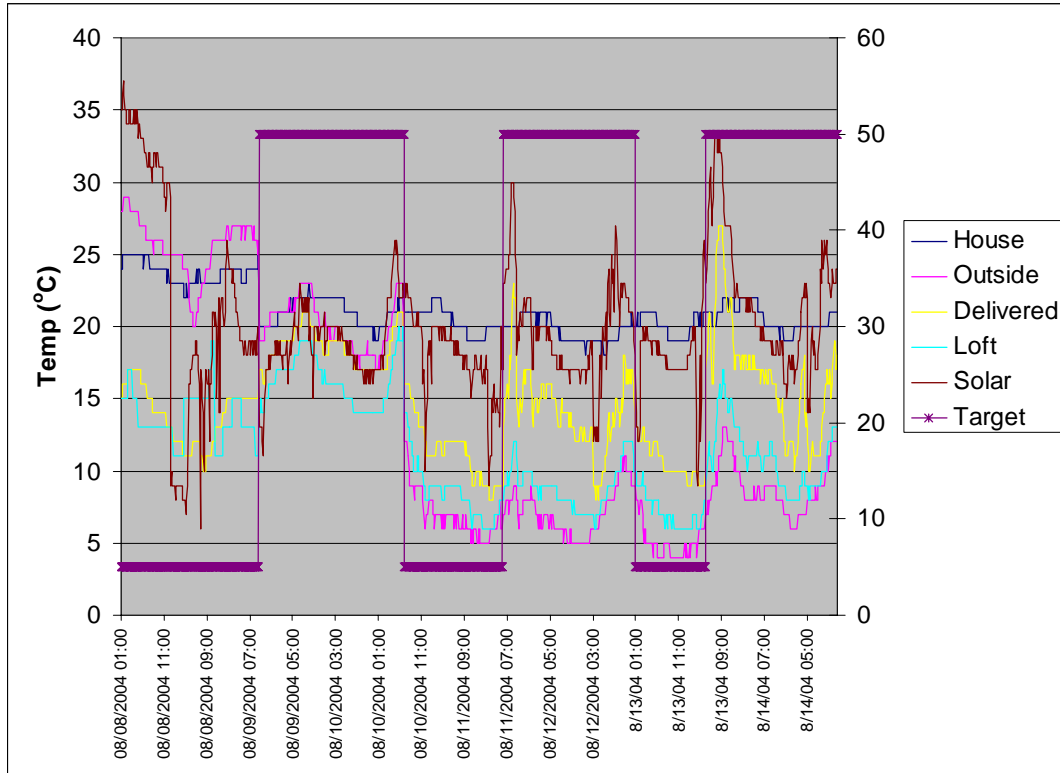


Fig. 2 Typical weekly data profile

3.2 Control

In order to establish 'control' houses the sunspace supply duct to the Ecosmart unit was disconnected with the sunspace temperature sensor left connected. This enabled the Ecosmart units to operate in a standard positive input ventilation mode. The energy benefits on the Drimaster positive input ventilation system had previously been validated by the Building Research Establishment (BRE) in their reports CR 106/99[1] and 379/99[2] as 550 kWh over a heating season

4. Data Analysis

4.1 Energy Performance

The energy benefit gained by using the sunspace to pre-heat the ventilation air was calculated from the supply volume (mass flowrate) multiplied by the specific heat capacity and time integral of the delivery/outside air temperature difference. This is illustrated in the daily temperature profile in Fig. 3 below where the energy benefit to the house of the positive input ventilation over infiltration ventilation is represented by the maroon shaded area.

It should be noted that the maximum energy benefit from the sunspace, represented by the yellow shaded area, is not being realised in this example and it is suspected that either a thermistor calibration problem or some leakage past the outside air/attic inlet damper may be causing this.

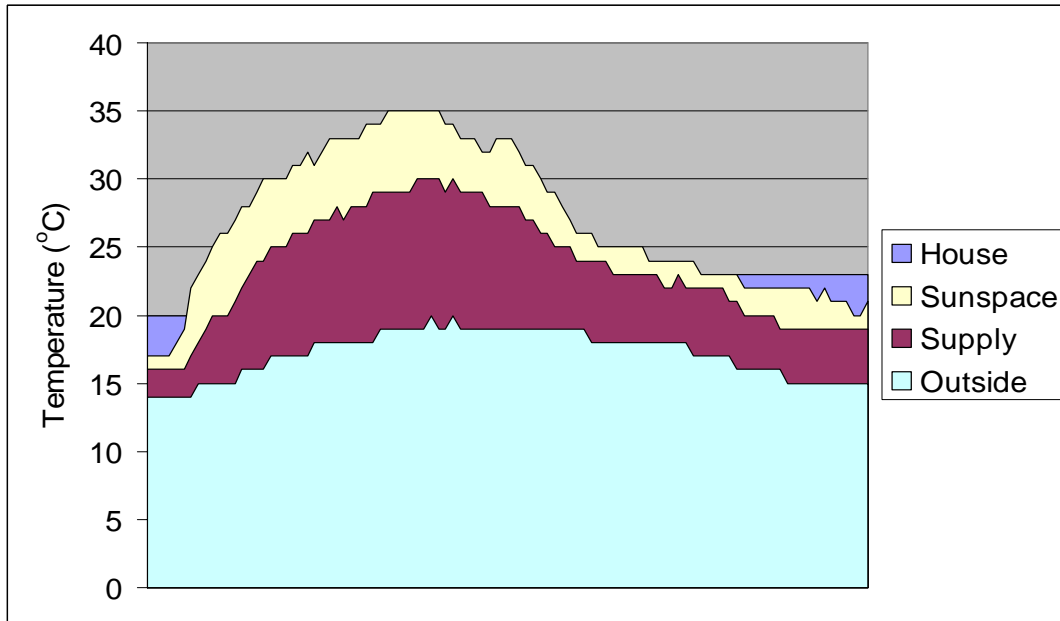


Fig.3. Typical daily temperature profile showing energy saving

For the control houses the energy gain was that obtained solely from the attic space, as the sunspace input to the system had been disconnected. A graph showing how the energy benefit was represented can be seen in Fig. 4 where the supply temperature very closely profiles the attic temperature; although much less than the sunspace augmented system an energy saving, represented by the maroon shaded area, is still evident.

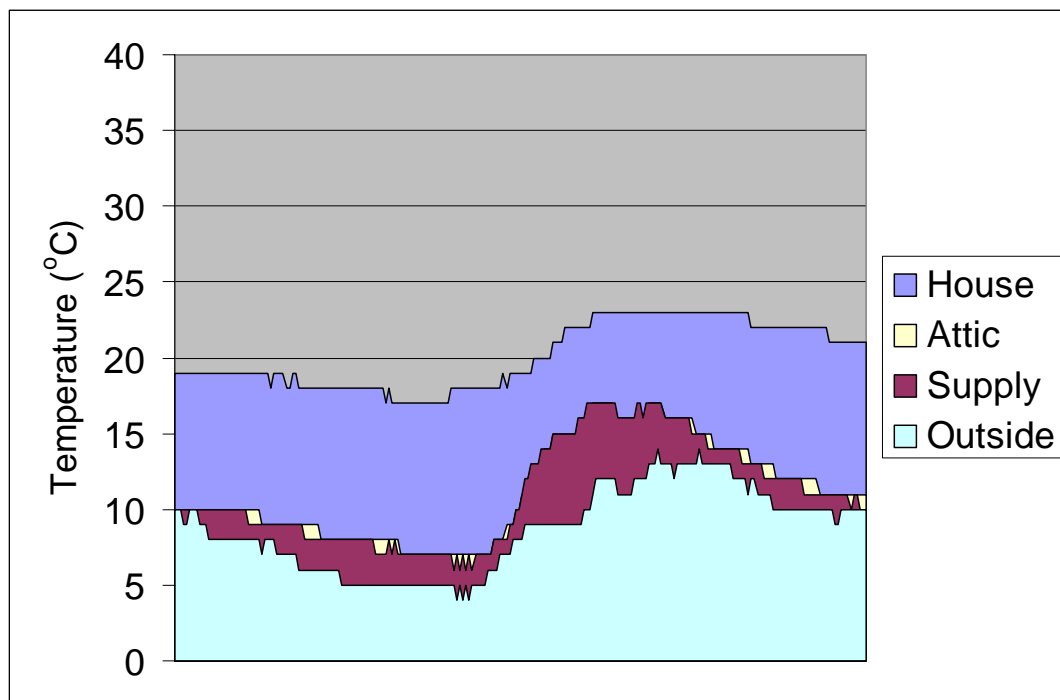


Fig.4. Typical daily profile showing energy saving from 'control' dwelling

The energy benefit was derived over a heating season for each dwelling and the results presented in Table 1 below. Due to the aforementioned problems some of the data sets were incomplete and the energy savings from the system could not be calculated. Where available, these are presented alongside the annual energy consumption for each dwelling taken from metered data. The average house temperatures recorded are included to give an indication of the levels of occupant comfort in each dwelling.

The average energy benefit gained through the installation of sunspace augmented positive input ventilation is of the order of 1500 kWh per annum over traditional infiltration / mechanical ventilation systems. This is more than double the energy savings available from the attic derived positive input ventilation (770 kWh) as delivered by the control house. Comparing this with the total energy consumption of the dwellings it accounts for a saving of 9.8 % and when compared to the average heating requirements the saving is 14.3 %.

| Dwelling Type | Annual Energy Usage (kWh) | Off-Peak Heating (kWh) | Energy Saving (kWh) | Average Temperature (°C) |
|-------------------------|---------------------------|------------------------|---------------------|--------------------------|
| 3 bedroom, asymmetric | 21,722 | 16,746 | 1561 | 23.8 |
| 3 bedroom, asymmetric | ** | ** | 1534 | 24.7 |
| 2 storey, 2 bedroom | 11,820 | 8,654 | 770 | 21.8 |
| 2 storey, 2 bedroom | 13,499 | 7,916 | 1172 | 19.4 |
| 2 storey, 2 bedroom | 15,766 | 9,817 | ** | ** |
| 2 storey, 2 bedroom | 14,246 | 9,600 | ** | 22.2 |
| 2 storey, 2 bedroom | 12,589 | 7,909 | ** | 21.3 |
| 3 bed wheelchair access | 18,286 | 13,142 | 1763 | 20.6 |
| Average | 15,418 | 10,541 | 1507 | 21.9 |

Table 1 Summary of Annual Energy Usage and Savings (** denotes incomplete or corrupted data sets)

4.2 Occupant Feedback

A questionnaire survey of all the occupants was conducted in order to obtain some user feedback regarding the operation of the ventilation system, together with some indication of improvements in general comfort and wellbeing since moving in to the property - most of the occupants had moved from older, less well insulated and energy efficient, dwellings.

The questionnaire comprised a mix of quantitative and qualitative responses and from a total of 19 questionnaires sent out 9 completed responses (47%) were returned. The responses are summarised below:

Whilst the majority of households (88%) understood how their heating system operated, an equivalent percentage (88%) indicated that they did not understand how the house ventilation system operated. This is interesting as the contacted installer explained the operation of the system at the time of installation; this information has either been forgotten or not passed on to other members of the household.

When asked about use of the ventilation system controls, 56% of the respondents indicated that they used the controls often, 22% sometimes and 22% never.

Semantic 5-point differential scaled questions were used to enquire about occupant comfort and effectiveness of the sunspace. Generally speaking, the occupants found the dwellings warmer (3.4) and fresher (3.1) than previous houses they had lived in although most (2.5) felt that the sunspace was less than effective. Comments received indicated that this was in-part due to leaks in the glazing causing water ingress and the fact that the space overheated in summertime. The ventilation system extracts heat from the sunspace only when it is warmer than the other two inlet supplies (attic & outside) and the user control is set for heating. During the summertime, when

the user control is set for cooling, air would not be drawn from the sunspace during daylight hours and this can result in high temperatures ($> 40^{\circ}\text{C}$) being experienced. The inclusion of an openable window at a high level within the sunspace would provide the occupant with control over such conditions.

The ventilation system incorporates G4 grade air filters which can arrest particle sizes down to about 5 microns; this includes for instance asbestos fibres, cement dust, plant spores and pollens and some bacteria. As the dwellings have the added benefit of being supplied with filtered air the study enquired whether there were any perceived health benefits noticed by occupants; particularly those who might suffer from respiratory problems e.g. asthma. Of the respondents, 56% indicated they had asthma sufferers in the family with 33% noting an improvement in their condition since moving into the house.

Condensation forming on windows overnight can often be associated with inadequate levels of heating and/or ventilation in the dwelling (assuming average rates of moisture evolution). Most of the respondents to this question (67%) indicated that no condensation was present. Of those that did notice condensation, on checking back through the data it was identified that these houses had switched off the ventilation systems at varying times throughout the year.

5. Conclusions

The installed ventilation systems were designed to enhance the already well-established system of positive input whole-house ventilation by use of a glazed sunspace to augment the heat recovery potential. The monitored data showed that using the sunspace in this configuration can save up to 15 % of the domestic heating requirements when compared with traditional infiltration ventilation, and more than doubled the energy benefit of that obtained by positive input only ventilation.

Occupant feedback suggested that the sunspace overheated in summertime and this is borne out by the monitored data; which shows temperatures in excess of 40°C being recorded in the sunspace. The inclusion of an openable window at a high level within the sunspace would provide the occupant with some control over such conditions.

Many of the occupants indicated a lack of understanding of how the ventilation systems operated. This resulted in many of the systems being switched off with the attendant problems this causes with moisture displacement, some tenants noticing condensation on windows, and in data collection. The ventilation systems have since been fully re-commissioned to ensure correct operation.

References

- [1] Building Research Establishment Technical Report CR 106/99 Monitoring and Evaluation of Domestic Supply Ventilation Systems, 1999.
- [2] Building Research Establishment Technical Report CR 379/99 Low Energy Positive Input Ventilation in Dwellings, 1999.