Institution: University of Nottingham

Unit of Assessment: 16

Title of case study: Use of natural lighting and ventilation to deliver energy savings and commercial benefits

1. Summary of the impact

University of Nottingham research into the use of natural lighting and ventilation in building design has resulted in the development, marketing and application of two new sister products (SunCatcher and Sola-Vent) by a leading supplier of low-carbon, low-energy solutions. Since 2008, 745 installations of Sola-Vent units have been carried out by Monodraught Ltd. Homes and commercial premises, both in the UK and overseas, have benefitted from the low energy demands of the system. As well as delivering economic benefits for the company, this work has had a positive impact on building owners and occupiers and the wider environment.

2. Underpinning research

Given the need to cut energy demand, Dr Li Shao (Reader in Architectural Environment Engineering, University of Nottingham 1993-2007) and his team investigated the possibility of using natural lighting and ventilation as a means to deliver low carbon solutions for lighting and ventilation, especially in places that are away from the façade of the building and can only be ventilated from above.

Light pipes were identified by the University of Nottingham (UoN) team as having great potential to address this challenge. In the late 1990s Dr Shao and Professor Riffat (Professor of Sustainable Energy, University of Nottingham 1992 - present) published research into sunpipes and solar chimneys, proposing the idea of integrating them into a single system. The hypothesis was that if a light pipe is put in a larger duct, the annular space surrounding the light pipe can facilitate natural ventilation. The reflective liner inside a light pipe usually has a high reflectance for visible light, but is less reflective in the infrared region of incoming solar radiation. Absorption of this infrared radiation by the wall of a light pipe will heat up the air in the annular space to cause a stack effect (buoyancy), like a solar chimney. This ventilation can also be driven by wind or by both wind and buoyancy. The proposed system would be particularly suitable for the deep interiors of large buildings and especially in schools, warehouses and other settings where security considerations might limit the availability and effectiveness of conventional forms of ventilation (e.g. windows).

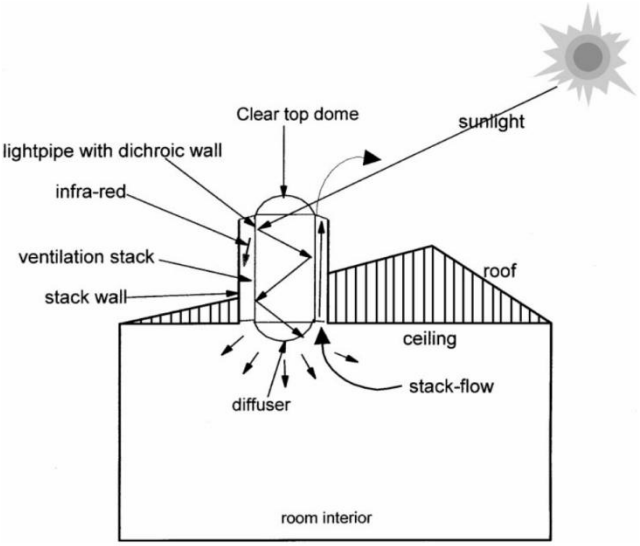

Figure 1: Illustration of Sola-Vent concept

Together with six European partners, Shao and Riffat secured EU funding to investigate the concept through the TRIPLESAVE project (G1). The resulting work, carried out from February 1998 to July 2000, led to the creation of an integrated light-vent pipe (LVP), with UoN responsible for the conceptual design and testing of the prototype. UoN demonstrated that the infrared part of the solar radiation could be absorbed by the surfaces of the stack, transferring heat to the adjacent now more buoyant air, thus facilitating natural ventilation extract while the visible light was transmitted into the room below. The successful prototype was commercialised by UK-based Monodraught Ltd, a recognised market leader in low-carbon, low-energy products such as natural lighting, ventilation and cooling systems; and was officially launched in 2002 as SunCatcher.

Building on this success, Shao and Riffat began to investigate the idea of incorporating additional artificial lighting and ventilation, powered by renewable resources, to produce a system that could be used in domestic buildings. This strand of research, which began in 2004, had two key aims: a) to use a photovoltaic-powered fan and spotlights, together with a back-up battery and relevant control electronics, to allow for controllable ventilation in hard-to-reach places where access to mains power would require a complex installation [2.1]; and b) to facilitate ventilation and lighting at night or in poor weather [2.2].

Key contributions to this work came from Riffat and Shao, who were involved in the design and selection of the photovoltaic panel system [2.3], and Dr Yuehong Su (Lecturer, 2005 - present), who developed an experimental method to assess the ventilation rate and other performance indicators through experimental and CFD studies [2.4].

Successful testing of a prototype system, developed with Monodraught and using a DC fan duct (to allow active ventilation) aligned with a sunpipe, led to subsequent commercialisation. Launched by Monodraught in 2005 as Sola-Vent, the system won the Best Interior Product award at the 2006 Interbuild show, a major annual event for the UK construction industry. Sola-Vent has received widespread uptake from 2008 onwards as described in Section 4.

3. References to the research

References (*Items marked with an asterisk indicate 3 most significant papers):*

2.1 *Oakley, G., Riffat, S.B. and Shao, L., 2000, Daylight Performance of Lightpipes, *Solar Energy*, vol. 69, no. 2, pp89-98 DOI: 10.1016/S0038-092X(00)00049-9

2.2 *Shao, L., Riffat, S.B. and Gan, G., 1998, Heat Recovery with Low Pressure Loss for Natural Ventilation, *Energy and Buildings*, vol. 28, no. 2, pp179-184 DOI: 10.1016/S0378-7788(98)00016-4

2.3 *Elmualim, A.A, Smith, S., Riffat, S.B. and Shao, L., 1999, Evaluation of Dichroic Material for Enhancing Lightpipe/Natural Ventilation and Daylighting in an Integrated System, *Applied Energy*, vol. 62, no. 4, pp253-266 DOI: 10.1016/S0306-2619(99)00014-8

2.4 Su, Y.,Riffat, S.B., Lin, Y.L. and Khan, N., 2008, Experimental and CFD Study of Ventilation Flow Rate of a Monodraught™ Windcatcher, *Energy and Buildings*, vol. 40, no. 6, pp1110-1116 DOI:10.1016/j.enbuild.2007.10.001

Grants:

- TRIPLESAVE – An Integrated System for Daylighting, Natural Ventilation and Solar Heating for Buildings (EU contract ref. JOR3-CT97-0172, 1998-2000), (PI Riffat)
- Heating/cooling/power generation system using PV concentration for integration in high-rise buildings (May 2003-Feb 2005), funded through Pilkington Energy Efficiency Trust (PEET), (PI Riffat)

4. Details of the impact

The technology developed as a result of the University of Nottingham's research into the use of natural lighting and ventilation has been employed in the design of low-carbon, low-energy buildings both in the UK and overseas, delivering economic, environmental and societal benefits. The technology developed by the University of Nottingham was licensed to Monodraught Ltd and 745 units of Sola-Vent were installed between 2008 and 2012 in domestic and commercial buildings in the UK [4.1].

For example, the Newcastle-Under-Lyme College (NUL) installed 21 Sola-Vent units as part of its £60M investment in a new Construction Skills and Technology Centre for its 3,000 A-Level students in 2008. This contributed to the college's "excellent" BREEAM rating. Michael Giblin, a

spokesman for NUL's facilities management team said, "the Monodraught natural ventilation strategy has been performing to expectations for three years with no problems and no evidence of solar gains in any areas of the college" and added that the "natural low maintenance, low cost, low energy ventilation solution ticks all the boxes, ensuring that schools meet BB101 requirements for ventilation rates and CO_2 levels" [4.2].

To indicate the energy saving credentials of the product, an energy performance evaluation was carried out by UoN on a supermarket and an annual lighting energy consumption saving of 22% was identified [4.1, 4.3, 4.4].

Riffat and his team have continued to work with Monodraught throughout the impact period, producing a number of reports into the feasibility and effectiveness of Sola-Vent and related products, so informing the firm's marketing efforts.

In 2012 collaboration on a KTP project to transfer the University of Nottingham's research expertise in building energy simulation to the company resulted in Monodraught's adoption of dynamic thermal modelling packages and daylighting simulation software in its quotation procedure for specific high-value contracts. As a result, Monodraught now has in-house dynamic thermal modelling capabilities and its own ventilation testing system to determine the performance of existing and new products [4.5, 4.6].

The software, named Performance Components was developed with Integrated Environmental Solutions Ltd, and delivers optimised energy savings in design. A team of 10 design engineers employed by Monodraught use this in house to perform energy saving calculations. The software has made their job easier and halved modelling time on complicated projects. [4.1]

This ongoing collaboration with the University of Nottingham has been crucial to the company's growing success in the market. Sola-Vent products have been installed in supermarkets, stores, schools and other buildings and have earned Monodraught an increased share in the sector throughout the impact period.

Figure 2: Sola-Vent demonstration unit

5. Sources to corroborate the impact

4.1 Nick Hopper, Technical Director, Monodraught Ltd. Statement available on request.
4.2 http://www.monodraught.com/news/5/monodraught-helps-awards-winning-newcastle-under-lyme-college-achieve-in-excellent-breeam-rating
4.3 Y Su, X Yu, L Zhang, M Karagianni, N Khan (2012) 'Energy-saving potential of Monodraught Sunpipes Installed in a Supermarket', *Energy Procedia*, 14, 578-583
4.4 S Riffat et al (2010) 'Assessment of Daylighting Design Using Monodraught Sunpipes for a Supermarket', *Proceedings of 9th International Conference on Sustainable Energy Technologies*, Shanghai, China, August 24-27
4.5 http://www.monodraught.com/building-simulation/
4.6 http://www.monodraught.com/news/10/monodraught-and-ies-demystify-the-art-of-wind-tower-natural-ventilation-at-ecobuild/