
# GREEN POWER

## CHANNELLING LIGHT TO DARK PLACES

**EXTENDED RENEWABLE ENERGY CASE STUDY**

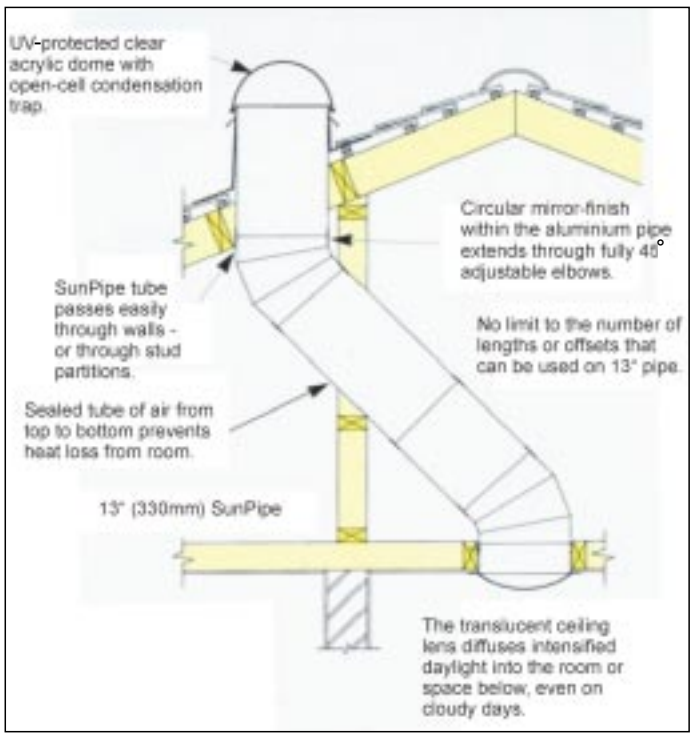



**Diagram of a SunPipe**

### INTRODUCTION

Passive solar energy is simply the energy from the sun that is absorbed by buildings. All buildings receive passive solar energy in two main forms: solar heat gain and daylight gain. By regulating these gains, energy demands can be reduced and comfort levels increased.

Many studies have found that natural light provides healthier working conditions than artificial light - and it is free. Large modern buildings often have small surface area to volume ratios, which is good for thermal efficiencies, but leads to many areas being starved of natural light. Therefore the challenge is to channel natural light to areas without windows. This can be achieved by a number of different methods, including light wells, optical fibres and light ducts.

Measures to control both thermal and daylight gains are best incorporated in new-build projects, rather than through refurbishment. By so doing, the project cost is absorbed into the cost of the building, resulting in near-zero costs. However, due to the high cost of electric lighting, it is often economical to retrofit measures to maximise natural lighting in existing buildings.

### LOCATION

Judge Meadow Secondary School, Leicester.

### BACKGROUND

Judge Meadow is a large comprehensive school to the east of Leicester city centre with approximately 1200 pupils and 80 teachers. It was built in the 1970s and, although a number of other buildings have been added since then, the main school is still a 3-storey block with 65 classrooms (total floor area 7724m$^2$). The large size of the main block means that there are a number of rooms with very little natural light, and one (the computer resource room) with none at all. This lack of natural light means that fluorescent tubes are used for lighting which, when combined with the light given off by the computers, creates a very unhealthy environment for the pupils. After a site visit, it was clear that the health of the room could best be improved by bringing in natural lighting, which would have the added benefit of reducing energy consumption. However, as the nearest exterior surface to the computer room was through a loft space 1m high, a method was needed to channel light to the room without losing too much quality or intensity.

DTI New & Renewable Energy Programme

dti
Department of Trade and Industry

**First issued May 2000**

*The project described in this publication is a current example of an operating renewable energy scheme, but may not represent best practice in all respects.*

### BACKGROUND ON LEICESTER

Leicester is a city of 280,000 inhabitants in the East Midlands. The City Council is the local authority for the city and surrounding areas, a total of 115,000 dwellings. It has a very strong environmental record: since Leicester became the UK's first "environment city" in 1990, it has gone on to develop the Leicester Energy Strategy in 1994 and the Blueprint for Sustainable Development in 1996.

**CLIMATIC DATA (1999)**

Degree Days (Basis 15.5°C): 2063

Annual Mean Temperature: 10.6°C

Annual Total Sunshine Hours: 1572

## TECHNOLOGY

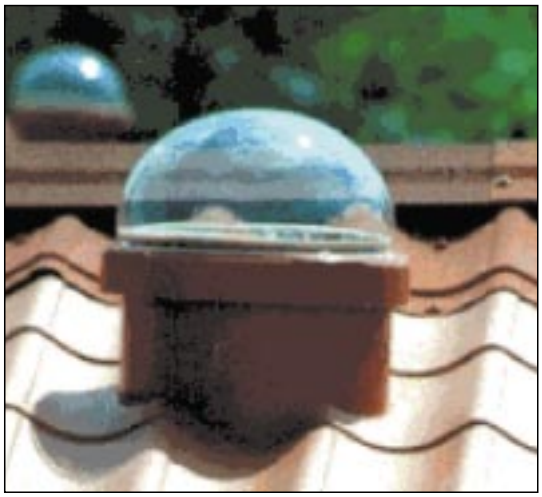
In 1998 Monodraught visited Leicester City Council's Energy Centre to deliver a presentation on a technology called the SunPipe. The staff were very impressed by the technology and, as part of the package, Monodraught agreed to carry out some free site assessments, together with an experimental installation to prove that the technology worked.

The Energy Centre has experience of working with Leicester's schools, through utility purchasing and monitoring at all schools and the implementation of energy efficiency schemes at some schools, one of which is Judge Meadow. The Principal (Mr David Powell) was therefore very happy to have his school assessed and when the computer room came out as one of the most suitable sites, he agreed to the installation of a SunPipe, funded through the school's payback fund (see below).

### HOW SUNPIPES WORK

The SunPipe is a new design in skylights that actively channels light to exactly where it is needed. Instead of the traditional large, flat, open skylight, this gathers light through a clear acrylic dome, which projects just above the surface of the roof. Light is then intensified as it passes down the super-reflective mirror-finish sealed tube. This light is diffused through a translucent ceiling lens into the room space below.
The system offers many benefits over traditional skylights, one of the greatest being its flexibility. The tube is narrow, allowing it to fit easily through roof spaces, and is not limited by either length or number of bends. Additionally, the unit is simple to install and its sealed nature means that it does not suffer heat loss in winter or gain in summer.

In November 1998, a single N° 1 Monodraught SunPipe 500 was installed in the computer resource room at Judge Meadow School. The room measures approximately 2.6m x 5.3m x 3m high and, before installation, received no daylight whatsoever. The lighting was previously provided by four 58W fluorescent lights, which had to be run continuously whenever the room was occupied. The SunPipe has been specified to provide 450 lumens of light to an area of approximately 14m$^2$ under full summer sun, and up to 250 lumens in sunny winter conditions. As the room measures 13.75m$^2$, and the requirement for office work is approximately 200-250 lumens, the system is able to replace lighting completely for much of the year. The lights are controlled by separate switches so, even in dull conditions, the level of lighting needed is reduced.



## COSTS AND BENEFITS

The total project cost was just £540, which breaks down into a £320 cost for the SunPipe and £220 for installation. This was financed in 1998 through the £83,000 "payback fund", as part of a major lighting upgrade package in Judge Meadows. This fund was set up by Leicester City Council to finance energy efficiency improvements in public buildings, especially schools, by providing a loan to pay for projects approved by the Energy Centre. All projects that are considered are assessed for their likely annual savings - if they have a payback of less than 5 years the project is approved - and the loan is then paid back at these rates. Therefore, the scheme is financially neutral for the organisation receiving the improvements until the loan is repaid, after which savings will be made year on year. Additionally, as each loan is paid back, there is a continuous injection of cash into the fund, which therefore allows new projects to go ahead every year. The reaction to this scheme has been very good, especially from organisations that have already worked with the Energy Centre, as it provides a simple means for any organisation to achieve risk-free energy savings, without any need for them to provide up-front payments.

The computer room has a very high occupancy level, typically being used for approximately 2040 hours per year. Prior to the installation of the SunPipe the cost of lighting using four 58W fluorescents was £31 per year. The initial assessment indicated that, with the installation of the SunPipe, the lights would only be needed for 720 hours per year, cutting the cost to just £11 per year - a saving of £20. This would give a simple payback of 27 years, with further unquantifiable health benefits for the pupils.

However, since the SunPipe has no mechanical or electrical parts, its lifetime will be that of the building, which could be said to be 30-50 years. Over that time period the

## The Roots of Leicester's Sustainable Commitment

Leicester City Council is the first unitary local authority in the UK to have achieved full Environmental Management Audit Scheme (EMAS) certification. This has been made possible due to a comprehensive and holistic approach to environmental policy. Energy awareness has been central to Leicester's environmental policy since the municipality of Leicester was granted the status of first "environment city" in 1990. This commitment to energy has been reflected since then by the continuing publication of reports and targets, together with the Council's status as one of the first Energy Efficiency Advice Centres (EEACs) to be launched in the UK (in 1993). This record is set to continue and expand as the Council bids for European Objective II funding to incorporate new and renewable energy into homes, schools and businesses in the area.

One of the key commitments Leicester gave when bidding to become firsr "environment city" was the reduction of energy use within the city to 50% of 1990 levels by 2025. This target is enhanced by the vision of meeting 20% of the city's energy needs from renewable sources by 2020. To help to meet these challenging targets, the City Council is actively promoting energy efficiency and renewable energy through the EEAC, housing associations and Article 10 regeneration projects, and, most importantly, is taking the lead itself, through the implementation of energy efficiency measures and the integration of renewable energy into council buildings.

The Council's commitment to sustainable energy use starts at the very top level, with the Chief Executive making a Corporate Commitment in 1992 to embed consideration of energy consumption into all decision-making. This means that all equipment now purchased must conform to a certain standard of energy efficiency; all new-build projects must actively seek to incorporate new and renewable energy and energy-efficient technologies. All the monitoring and purchasing of energy is now handled centrally at the Energy Centre, so that best value can be obtained and any anomalies can be spotted and rectified easily. It is this commitment at all levels that has allowed Leicester to set such ambitious energy targets.

following costs would be offset by the SunPipe:

1. The four fluorescents would be replaced every two years and the fittings cleaned at a cost of £18.50 each including labour. This would represent an annual cost of £37.

2. Within an average of 15 years the fittings would have been replaced at a cost of £200 each or £800 in total. This represents an annual cost of approximately £53.

Therefore, a total annual cost of £110 would be offset due to the installation of the SunPipe:

| Area of savings | £ |
|---|---|
| Electricity savings | 20 |
| Tube replacement and luminaire cleaning | 37 |
| Replacement of luminaire | 53 |
| Total | 110 |

This gives a payback of 4.9 years which is within the requirements of the payback fund.

In fact, since the SunPipe has been in use, it has saved more in electricity than expected (£27 per annum compared with the £20 estimated). This has reduced the payback period to 4.6 years.

Although the quoted payback for the SunPipe is within the requirements of the payback fund, by considering it as part of the whole lighting upgrade package (where inefficient lighting was changed to high-efficiency lighting, controlled by occupancy and daylight sensors) the payback period is even shorterr. This is an example of using an holistic sustainable energy approach where longer paybacks of some measures can be compensated for by the shorter paybacks of others, giving the entire installation an acceptable payback. In fact, since installation, the lights have been used even less than predicted, cutting the simple payback time to just 3.6 years. Mr. Powell has been so pleased with the installation, both in terms of financial savings and the improved learning environment, that he now wants to install SunPipes into the darker ends of all the top-floor classrooms.

Another way of looking at the cost would be to compare it with the cost of installing a traditional rooflight. To achieve the same effect would cost £1867, so in real terms the SunPipe represents an initial saving of £1327 as well as a revenue saving of £110 per year.

## GUIDELINES ON INSTALLING SUNPIPES

Below are some general guidelines on when and where best to install SunPipes. Firstly, the best times to install SunPipes are:

### 1. New-Build

This is the best time to install SunPipes. The installation cost is reduced because they are built into the fabric of the building, with consequent savings on other roofing materials and the labour involved with preparing the existing roof for the SunPipes. SunPipes are

particularly good for new-build projects as they can be designed into the building to allow large, thermally efficient blocks to be built, with SunPipes to channel natural light to windowless areas.

**2. Major Refurbishment**
In the same way as for new-build, any major refurbishment of a building that involves replacing a roof offers an ideal time to install SunPipes. This has the major bonus of allowing existing problems to be rectified, instead of attempting to second guess where the problems will occur with new-build. However, the SunPipes will only be able to serve the top floor, immediately below the roof.

**3. Part of Lighting Scheme**
As in this study, if a building is undergoing a major lighting overhaul, it is possible to specify SunPipes to supplement lighting in some areas. However, because they will be installed in parts of the roof that would otherwise not be touched, their cost increases, although it is possible to offset this against some of the benefits that the other more efficient lights will bring. They are best installed as part of a lighting scheme for specific problem areas, with daylight sensors to allow the supplementary lighting to be switched off automatically when not needed.

**4. As a Lighting Solution**
Retrofitted SunPipes not installed as part of a scheme will only be justifiable in certain cases. There will be no chances to offset the costs against any other installation, so the paybacks will be very long. Therefore, they are really only suitable for rooms that would otherwise receive no natural light and, even then, ones that have high daytime occupation. The best reason to install them would be for health reasons.

Secondly, the location for these pipes should ideally be:

**1. Close to the Roof**
This may appear obvious, but is worth stating. SunPipes are capable of stretching for lengths of up to 30 feet, but longer tubes will diminish the light available at the end. Additionally, the pipes will take up more room: not a problem in loft-space, but certainly worth considering in a room.

**2. Not Overshadowed**
Any overshadowing of the tubes, by either vegetation or buildings, will reduce the light output at the end of the tubes.

**3. Vertically Above the Area to be Lit**
SunPipes are capable of bending around corners but, as with increasing length, the more bends there are, the less light there is at the end of the tube.

**4. In a Permanent Roof**
SunPipes are given a lifetime in excess of 20 years and therefore should not be installed in a roof which is likely to need a major overhaul within 5 years.


## BENEFITS

- **Healthier working environment.**
- **Reduced energy consumption, therefore a simple payback of 20 years.**
- **A good demonstration model, to be used in other Leicester City Council buildings.**

## FURTHER INFORMATION

For information on this project, and others in Leicester, please contact:

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## NEW REVIEW

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