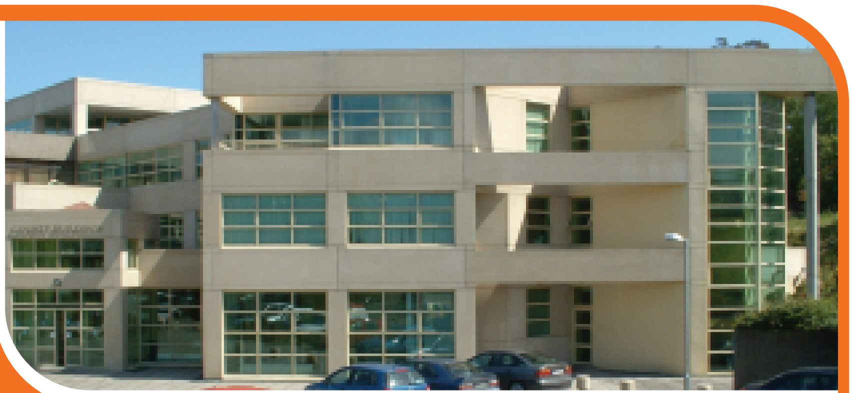
SUSTAINABLE ENERGY IRELAND



Wicklow County Council Offices

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Report prepared by:

Building Design Partnership
Blackhall Green
Dublin 7

t +353 1 474 0600
f +353 1 672 7536
e cm-croly@bdp.ie

Introduction

This report summarises the work carried out as part of the SEI Design Study on the Wicklow County Council Offices building. It will serve as a useful reference document for anyone who is embarking on the preparation of an energy evaluation report on an existing building as it illustrates the level of detail and calculation rigour that is required in order to identify potentially significant and cost-effective energy savings.

The building, which is located on Station Road, Wicklow, serves as the main offices for Wicklow County Council. It is also used by members of the public to access a number of Council services.

Covering a total area of approximately 4,000m^2 it contains a number of cellular offices. Other features include a large concourse area located beside the main entrance, a staff canteen and the Council chamber.

The original office building is quite old – an extension was added during the 1990s. Both structures are clearly visible in the photograph shown here, and are further identified in the areas highlighted in blue (existing) and green (new) on the simulation model also shown below.

All offices in the building are naturally ventilated. Radiator heating throughout is provided by means of an oil-fired system.

1 The Design Approach

1.1 Design study brief

A specific requirement of the design study brief was that a full energy evaluation of the building would have to be carried out.

An additional requirement was that the report prepared on foot of that evaluation should clearly identify and prioritise a number of appropriate energy-saving options, and provide details of their associated environmental benefits. Further, the report was to be designed in such a way that it could be used as a quick reference document for situations such as when planning changes were being implemented or when building refurbishment works were being carried out.

Occupant comfort and energy use are often closely related. In the case of the Wicklow County Council Offices building, occupants had reported experiencing some discomfort related to overheating in many of the office areas. An initial study commissioned by the Council suggested that air-conditioning would be required throughout the building in order to control internal air temperatures.

Obviously, air-conditioning would reduce internal temperatures. However, the Council was concerned about its many drawbacks including the significant energy consumption and associated environmental effects that result from the use of such systems. It was therefore eager to find an environmentally responsible solution to the overheating problem.

The Building Design Partnership (BDP), which has considerable experience in the design of naturally ventilated buildings, was appointed by the Council to determine whether it would be possible to devise a natural ventilation solution.

The design study findings show that it is possible to provide environmentally conscious solutions to potential overheating difficulties in offices with high internal heat gains.

1.2 Economic evaluation criteria and timescale

When carrying out an evaluation of potential energy-saving measures only those that offer a reasonable payback period should be considered as suitable for implementation. While energy-saving measures that offer a payback period of less than ten years are worth investigating, a payback period of less than five years is the ideal.

Evaluation reports must also provide realistic and accurate calculations of potential energy and carbon dioxide emissions reductions.

Finally, when evaluating the costs of implementing energy-saving measures within an existing building, it is important to take into account the fact that certain building elements and services may be approaching the end of their useful life and may therefore need to be replaced in the near future: such obsolescence considerations could improve the overall viability of a proposed energy-saving project.

1.3 Design study strategy

The following methods were used to carry out this design study.

Information gathering

Site visits

The BDP team made a total of three visits to the site. These were carried out in varying weather conditions and building operating conditions, and were designed to establish how effectively certain building services systems were functioning. They were also designed to assess staff members' reactions to conditions inside the building. Repeat visits were considered essential in order to spot any anomalies in the control strategy, such as the heating system being left on in areas of the building during warm weather.

As well as examining the building services systems, the team also carried out a detailed examination of the building's fabric and form – factors which are equally as important in the control of energy use as the systems installed within that building.

Consultation

During the site visits, discussions were held with the building's manager and maintenance staff to establish how the building was controlled and what operating systems and methods were being applied.

Discussions were also held with Council staff to elicit their views on environmental conditions within their own offices and to establish how they dealt with overheating.

Finally, the team contacted the specialist who was responsible for installing the building's controls system to clarify various aspects of the design and operation of that system.

Information
Drawings, energy consumption data, and details of the building fabric construction were obtained and confirmed with Council staff.

Monitoring
Temperature monitoring equipment was installed in several offices; data was gathered and analysed.

Calculations
When assessing the viability of the various options under consideration the BDP team did not rely on manufacturer's claims or rough estimates of potential energy savings – only accurate data was acceptable. In some instances it necessitated carrying out a full-year simulation exercise in order to determine the projected payback period of a particular energy-saving proposal.

Each of these energy-saving options was analysed in detail under headings including energy savings, energy cost reductions and reductions in carbon dioxide emissions.

Reporting
The completed design study report on the Wicklow County Council Offices comprises approximately 50 pages and provides a detailed analysis of the problem and the possible solutions available. The basis of the various calculations made, and any assumptions drawn from those calculations, are described in straightforward language. In addition, the report makes extensive use of photographs and other visual methods to describe concepts.

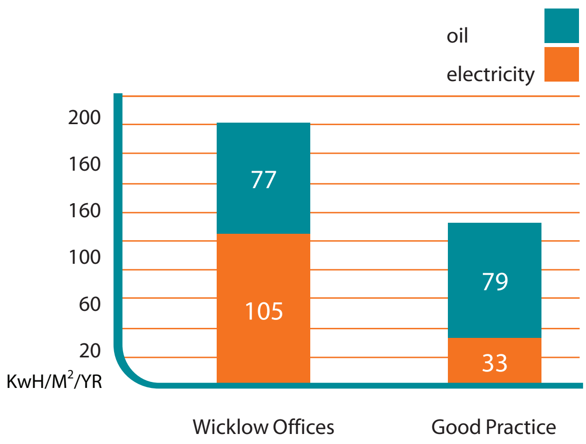
1.4 Building simulation

In order to determine whether the proposed overheating solutions would work, a detailed three-dimensional dynamic simulation model of the building was created.

A dynamic simulation is a complex, computer-based calculation capable of examining how a building would perform when subjected to a full year of typical weather conditions. It takes hourly weather data for a full year and calculates heat flow through the building for every hour of that year.

The first step in the simulation process involved the creation of a model representing the Wicklow County Council Offices building. The computer-based calculations were then compared with the monitored temperature results from designated offices within the building. When it was established that the model was accurately predicting existing conditions it was modified to reflect the various proposed energy-saving measures. This procedure allowed the effects of the proposed changes to be examined with a high degree of accuracy.

2 Building Energy Monitoring



The building's existing energy consumption was calculated using energy bills covering a two-year period. Readings were checked to make sure that they represented a typical year's energy consumption and were then compared with energy consumption in a good practice office.

The graph shows that the Council offices use considerably more electrical energy and slightly less fossil fuel (oil) than a good practice office.

There are a number of reasons for these differences. For example:

- In the Council offices, all water heating is provided by electrical energy; this increases the electrical load while reducing the oil load.
- In addition, the lighting system is relatively inefficient and contains no automatic switching controls.

It should be noted that the large electrical load is responsible for the low oil consumption figures; this is because heat gain from electrical fittings helps to heat the building; as a result, oil consumption is reduced. It is, however, neither cost-effective nor energy efficient to use electrical energy as a source of heat in the building. In addition, any electrical energy used during the summer produces no heating benefits; in fact it contributes to overheating.

It should also be noted that the overheating problems caused by poor ventilation in the offices actually reduce the energy spend on oil, but this is at the expense of comfort for the people working in these offices.

When the above factors are taken into consideration, the building's total energy consumption i.e. 183 kWh/m^2/yr is not excessive. More importantly, the figures suggest that it is the type of services that have been installed – rather than the way in which they are managed – that offers the greatest potential for generating energy savings.

3 Fabric and Form

While improving insulation may appear to be one of the most obvious ways to reduce energy consumption, it is often not the most cost-effective solution. Indeed, it can worsen overheating difficulties – particularly in offices that have large heat gains (caused by computers, lighting, human body heat and solar heat gain through glass).

One of the options considered by the BDP design team was to remove the glazing in the old section of the building and replace it with a modern double-glazed system. Detailed calculations were made to assess this energy-saving option and the results were as follows:

Reduction in primary energy usage	129,535 kWh/yr
Reductions in CO_2 emissions	36270 kg/yr
Reductions in running costs	€5,298/yr

While the projected payback period is approximately 35 years, the glazing replacement option delivers one additional benefit – the opportunity to improve ventilation in the old part of the building.

When considered in isolation, the benefit of installing double glazing does not deliver an acceptable payback period. Nevertheless, this option was recommended – particularly in the light of the age of the existing glazing system and the need to improve the ventilation system.

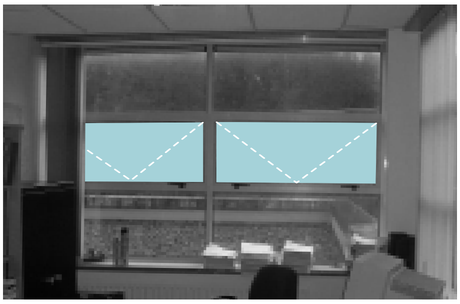
4 Building Ventilation and Overheating Control

Overheating was experienced in both the old and the new parts of the building. The analysis showed that the difficulties experienced within the old part of the building were related to two factors – the small area of openable sections in the existing windows, and the positioning of those sections.

While the windows in the new part of the building clearly had reasonable, openable window areas, and while the room depths were appropriate for naturally ventilated spaces, significant overheating was being experienced in many offices nonetheless.

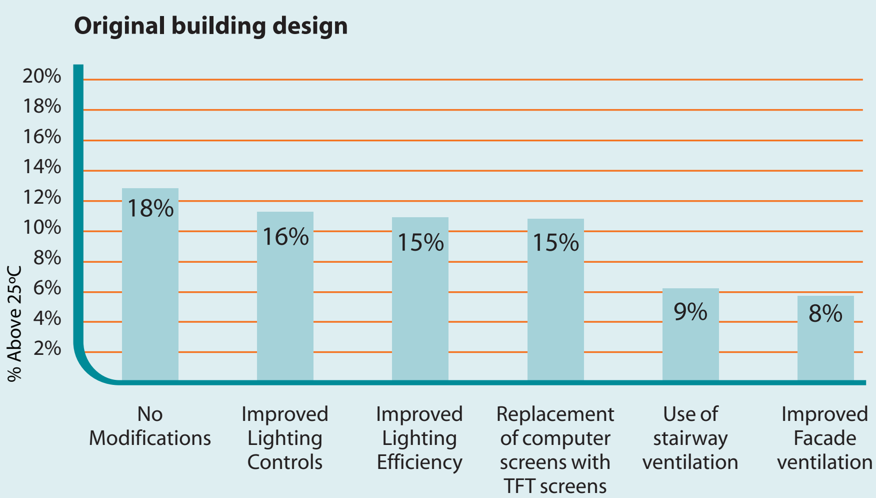
When designing a natural ventilation scheme, the location of the openable sections of the windows is just as important as the opening area itself. It is often necessary therefore to use advanced thermal simulation packages to prove that a proposed natural ventilation scheme will in fact be successful.

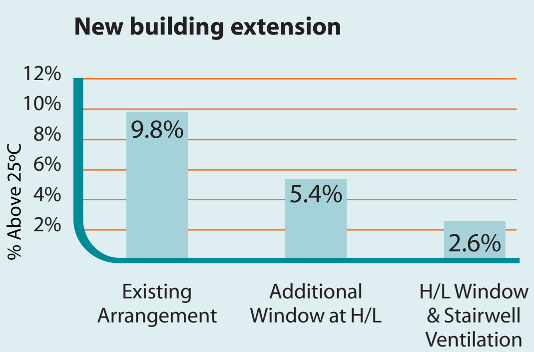
These windows do not support effective natural ventilation because there is no vertical separation between the air inlet and outlet paths. It is also necessary to provide window openings at different vertical heights in order to produce a driving force for the natural ventilation; however that has not been done in this case.



Opening sections on the windows

Location of the openable window section of the windows in the new part of the building.





A number of approaches were examined in detail with a view to both reducing the internal heat gains (i.e. heat from lighting and computers) and improving the natural ventilation provided.

The following graphs show the effects of each of the measures considered: these effects were created using the three-dimensional dynamic simulation model.

It should be noted that a figure close to 5% (see left hand scale on the graphs below) is considered to be ideal for natural ventilation; a slight increase above 5% would be acceptable for an existing building.

The percentage improvements shown on the first graph are not cumulative; they merely show the savings that would be achieved by each measure if it were to be implemented in isolation.

The simulations show that acceptable temperatures may be obtained in both sections of the building by using a combination of two temperature control measures.

5 Heating System

5.1 Existing system

The building's heating system is powered by three oil-fired boilers.

The control panel located inside the boiler house is fitted with three time clocks for each of three hot water circuits. While weather compensation is catered for, optimum start control is not.

Because seven-day time clocks have been installed, it is not possible to set them to accommodate extended holiday periods. Neither is it possible to accommodate the shut-down requirements of bank holidays and other holidays that occur out of the normal seven-day sequence.

5.2 Proposed energy savings

Conversion to gas
Calculations showed that converting the existing boilers from oil to gas and fitting them with modulating burners would produce significant improvements – both in terms of reduced energy costs and reduced carbon dioxide emissions. The projected payback period for the conversion to gas was shown to be less than one year.

Cost savings achieved from conversion to gas	€13,935/yr
Reductions in CO_2 emissions	110,569 kg/yr

Local controls
A significant amount of heating energy wastage is caused by lack of local controls in the old part of the building.

All rooms in the building are treated as a single zone and this can lead to both overheating and energy wastage. While older buildings are not usually provided with local room control, this can be added to an existing system with reasonable cost efficiency.

Weather compensation
The weather compensator is a control device used to measure external air temperature. The device sets the temperature of the heating system water, which is then distributed throughout the building.

During one of the BDP team visits to the Wicklow County Council Offices building on a warm day, the weather compensator appeared to be holding the flow temperature at a much higher temperature than was appropriate.

In this building, all three circuits are served by a single weather compensator whereas, ideally, three separate compensators should be provided in order to take account of the different building façade orientations.

Optimum start
An optimum start controller monitors the outside temperature during the morning and prevents the boilers from being turned on too early by the time clock if outside temperatures are warm.

When an optimum start controller is installed, the operator sets the clock for the time by which the building should be warm. The controls system then calculates how early the boilers should be turned on. This prevents energy wastage.

6 Hot Water Generation

6.1 Existing system

In this building, local electric water heaters are located at each toilet core.

While electric water heaters can be economical to install, they consume a relatively large amount of energy. Associated carbon dioxide emissions are also significant.

6.2 Proposed system and savings

As the toilet cores are located directly over one another, and as there is an existing, accessible services riser linking the two cores, the task of installing a centralised gas-fired hot water heating system would be reasonably straightforward. The cost savings and emissions reductions generated as a result of adopting this approach would be as follows:

Cost savings	€8,458
Reductions in CO_2 emissions	77,637 kg/yr

The conversion of the water heaters would have an eight-year payback period. However, because half the building's existing water heaters were approaching the end of their life and would have to be replaced at some time in their future, this further improved the viability of converting from electric water heaters to a centralised gas-fired hot water heating system.

7 Lighting

Office lighting consumes significant amounts of energy. This is particularly true of lighting in older offices, which tend to have old and inefficient light fittings.

Electrical energy that is used in this way has a large associated CO_2 penalty because it is generated inefficiently. In addition, inefficient lighting emits considerable heat and contributes to overheating in an office environment.

7.1 Natural daylight

The natural lighting levels in the existing building were measured with a light meter and calculations were carried out to determine if sufficiently adequate daylight was available in order for a natural lighting scheme to operate successfully.

A point-by-point daylight factor programme was used to determine the available daylight.

The calculations showed that the offices could be used for more than 80% of the time with their lights turned off.

Natural daylight availability on its own is not sufficient to save energy because office occupants will tend to leave lights on permanently – even when their use is clearly not necessary.

The advantage of automatic lighting control systems is that they can be used to turn off the lights when adequate daylight is available and/or when a room is unoccupied. In most cases, the controls can be retrofitted with reasonable ease. While the cost payback may in some cases not appear attractive initially, the benefits that they deliver in terms of preventing overheating must also be considered.

Old building

Replacement of existing light fittings and the installation of automatic lighting controls.

Cost saving	€13,871
Reductions in CO_2 emissions	79,707kg
Additional cost	€99,696
Payback period	7.2 years

New extension

Retrofitting of lighting controls

Cost saving	€4,657
Reductions in CO_2 emissions	26759kg
Additional cost	€25,900
Payback period	6 years

It should be noted that the cost saving is higher for the old building as the existing lights currently operate at a lower efficiency level.

7.2 Artificial lighting

Older office buildings and some more recently built office buildings will tend to contain low-frequency T8 type light fittings.

High-frequency T5 fittings have been available for a number of years. They consume less energy, generate less heat, and give a better light source at a relatively small additional cost.

While the use of high-frequency fittings is always cost-effective in new buildings, the cost of replacing existing fittings with high-efficiency frequency fittings is not cost-effective – unless the existing fittings are reaching the end of their useful life.

The recommendation for the Wicklow County Council Offices was that the lighting in the old part of the building should be replaced with high-frequency T5 fittings.

8 Environmental Management Plan

BDP recommended that an environmental management plan be drawn up. In particular, the plan should identify energy usage, energy targets, and a time-scale for the implementation of the proposed environmental improvement measures.

9 Conclusions

9.1 Summary of Findings

The following energy-saving measures (listed roughly in order of their cost-effectiveness) were identified as having a reasonable payback period:

- Clearly identify and document the correct settings for the heating system time schedules.
- Convert the building's heating system from oil to gas.
- Install local room heating controls (thermostatic radiator valves)
- Install light level and occupant detection controls on the lighting in the old building.
- Install light level and occupant detection controls on the lighting in the new building.
- Replace light fittings in the old building with high-frequency fittings.
- Convert water heating from a local electric to a centralised gas system.
- Replace old single glazing with double glazing.
- Each of proposed overheating solutions identified below has an associated energy saving when compared with the alternative option of installing air-conditioning.

  For example:
  - Install additional window opening sections in both the old and the new parts of the building, ensuring that there is a sufficient vertical distance between the openings to maximise the ventilation rate.
  - Install lighting controls (see above)

The following policy items were recommended for future implementation:

- Purchase flat-panel monitors when replacing computers, in order to reduce heat gains inside individual offices. The flat-panel monitors should also be located in the warmer rooms within the building.
- Install high-frequency lighting and lighting controls whenever refurbishment work is being carried out on the building.
- Produce an environmental management plan that details not only the Wicklow County Council Offices' energy consumption, but also the environmental purchasing policy, and waste strategies that are in place for the building.

9.2 Guidelines for designers

The following points should be considered by designers when undertaking design study reports or similar energy studies on an existing building. Many of these points will also be relevant to new building design studies:

- Carry out a thorough investigation of the building on a number of occasions, in order to witness how it is used under different conditions.
- Talk to both building managers and the occupants/end-users in order to determine how the building is utilised.
- Systematically consider each of the systems installed in the building and how they are run and determine if the potential exists for energy savings to be made.
- When making recommendations, consider not only the building's services but also the building fabric. Look for the most cost-effective solutions – even if they require the involvement of other disciplines.
- Concentrate on measures which are likely to have a reasonable payback period and produce the largest energy savings; this is preferable to focusing on renewable technologies – unless the building is particularly suited to their application and use.
- Carry out thorough calculations that accurately determine the energy savings provided by the proposed measures.
- If possible, carry out an in-house computer-based simulation exercise, as this allows continuous reference throughout the design process and also allows further checks to be carried out during construction.
- Be realistic when making energy savings based on comparisons. If, for example, your brief is the production of a new naturally ventilated building, do not compare the proposed energy-saving measures with an air-conditioned building. Rather, they should be compared with a good practice naturally ventilated building.
- Prioritise savings and consider how the cumulative measures will affect each other. For example, a combined heat and power (CHP) unit may appear to be cost-effective when installed in a building with a high heat loss, but it may be more cost-effective to consider options that address the building heat loss issue.
- Advise the client of future changes that should be made during routine refurbishment work. Changes might include items such as the replacement of boilers or lighting with high-efficiency alternatives.

Sustainable Energy Ireland
Glasnevin
Dublin 9
Ireland
t +353 1 8369080
f +353 1 8372848
e info@sei.ie
w www.sei.ie

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