The fabric of a building can also have a strong influence in how the relative humidity – and thus comfort levels, are controlled. Modern insulants and linings can be very hard and impervious, lacking the ability to absorb moisture in the air. Indeed vapour barriers are designed to ensure that vapour does not migrate into the wall structure where it could be at risk from condensation. However the fabric of a building is able to act as a hygroscopic lung, allowing changes in relative humidity to be taken up into the fabric and released when conditions are correct. The study team are recommending insulants, lining boards and plasters which allow this vapour permeability. Timber is also hygroscopic and can be used in a similar way.

4.3.7 Building Services

Throughout the design and construction process the final commissioning of systems must be considered in all aspects to ensure that the low energy design intentions can be realised at completion. Ensuring good quality control and monitoring procedures throughout the design and construction phases should ensure that the commissioning aspects of the project are fully achieved.

From the outset of the project the energy performance must become integral to the development and should be clearly defined within the brief and specifications. At handover stage the commissioning records and user operation guides should be explained to the end user to ensure that the internal environment and associated systems are effective for the end use.

4.3.7.1 Domestic Water

Fresh water is a very scarce global resource. Oceans, lakes, streams and rivers contain 98% of Earth's water. The remaining 2% is in the soil, the atmosphere, the bodies of living organisms or frozen in glaciers and ice caps. Only a tiny percentage is available for drinking.

The best strategy is to ensure water conservation measures are met first. If the decision is then made to install greywater recycling systems, the capital and running costs of such systems will be reduced and their effectiveness increased. (Water from flush toilets which is heavily polluted with pathogenic wastes is termed "blackwater". Greywater is the term used to describe the waste water from baths, showers, sinks and washing machines. The least polluted of these is usually the waste water from showers.)

Ecologically enthusiastic people may believe that greywater recycling is a must, but far greater savings, and for a lower cost, can be achieved through conservation measures, in the following order:

1) Develop awareness of use and change to water saving habits

2) Ensure new appliances are low on water use starting at the biggest water user – the WCs

3) Reduce dead legs on the hot water system

4) Harvest and use rainwater without special treatment

5) Recycle greywater

A rainwater recycling system to serve the building's WCs could be installed to reduce the water consumption from the public main supply. The system would collect the rainwater from the roof and connect the rainwater pipes at basement level to a storage tank. The water supply from the storage tank would then be pump boosted to distribute to the points of use. A filter would be installed on the supply to ensure the water transferred from the tank was suitable for purpose.

The installation cost of a system of this nature would be of the order of £2,000. This cost includes for the storage tank, filter and pump set but excludes the roof gutters, rainwater pipes and internal plumbing distribution. A roof the size of that on 73-77 Trongate should yield sufficient water for toilet flushing to cater for approximately six staff, so more water will be required to flush the toilets. The water should only require simple filtration although we would recommend a UV filter in case the water becomes infected with bird droppings. However, provided rainwater is kept away from sunlight and organic matter (such as leaves and dead animals) it can be safely stored and remains fresh. It should not be drunk as it can contain small quantities of pollutants from vehicle emissions as well as animal pathogens.

The options of use presented for the building at 73-77 Trongate all have relatively low water demand, particularly the office and retail spaces. An approximate estimate of the likely water consumption has been made which suggests that the rainwater system would save approximately 80,000 litres/annum of water. In terms of cost this equates to approximately £50/annum assuming the building water supply is metered.

The following table shows some simple approaches to saving water

Solution	Description	Products Available
Spray Taps or fix spray nozzles to existing taps	Reduces volume coming out of tap.	Ecospray Sirrus Solo Mixer
Tapmagic	Allows a spray or full flow	Tapmagic

Supply Restricting Valves	Keeps water flow constant despite pressure fluctuations. May prevent and detect leaks.	Marishhower Restrictor-flow Waterfuse
Urinal Controls	Cistern only flushes after use. Urinals flush control by time clock set to match the hours of use.	Smart Flush Magnetic Door switch Infra-red door switch Flush-controller
Waterless urinals	Use no water other than for daily cleaning	Armitage Shanks Eko Logic(UK) EMPS Limited Basic solution
Tap Controls	Switches taps off after certain time.	Tap-off system Aqua Sense Pushtap Press-Air Cormorant
Water saving device (Cistern Dams) in standard toilets	Reduces the volume of water used during flush.	Hippo Thames Water Hog Restricta-flush Cistern Dam Eco-Dam
Low flush toilets	Reduces the volume of water used during flush.	Evac Sanivac
Dual-flush toilets **Collect and recycle rainwater**	Potential for water saving Use for WC flushing, watering garden.	Ifo cera Water Butt WISY Kiskic System

Greywater	Greywater from handbasin after basic disinfectant or microbiological treatment can be used for flushing the toilet	Well butt greywater re-use system

We would recommend the use of low flush toilets, preferably by adopting the valve system in preference to the siphonic system. Such systems can achieve an efficient flush with only 4 litres of water or 2 litres for a half flush. We are not convinced at the cost effectiveness of incorporating greywater recycling for toilet flushing. However it may be considered for demonstration purposes. Because soap and dirt will mix with the shower and basin water, the resulting greywater will biodegrade and would likely cause odour or hygiene problems which would require chemical blocks to be added to the cisterns, possibly negating any environmental advantage. If such water is stored for more than 24 hours, any pathogenic organisms can multiply rapidly. If stored, the tank must be well sealed and cisterns sterilised. To avoid smells the water should be used within 24 hours.

The use of dual flow WCs and low water flow taps would reduce the overall water consumption of the building without incurring additional capital expenditure.

The use of High Density cross linked polyethylene (HDPE) pipework should be considered as it has a lower embodied energy than copper or steel.

4.3.7.2 Solar Thermal Water Heating

The use of solar thermal panels to heat the domestic water supply could be applied effectively to the building scenario where there is a café area on the attic floor. The panels could also be applied to the office and retail options although the low water use associated with these options would likely mean that the full benefit of the panels would not be realised.

A solar panel to serve the building would probably cost £3,500 and would have an annual energy saving varying from approximately £35/annum for the office development and £80/annum for the retail and café option.

The system would incorporate a roof mounted solar panel with pipework connections to a hot water cylinder. The distribution of water from the panel to the cylinder would be by a variable speed pump powered by a small photovoltaic panel.

4.3.7.3 Natural Ventilation

Natural Ventilation Delivery of a low energy solution in an office development demands an understanding of the concepts, particularly the limitations in close control aspirations of occupants conditioned to expect static internal temperatures from modern office space. It is generally accepted that the commitment required to recognise the benefits of such a solution are more likely in an owner/occupier situation although there are examples of successful use of the techniques in speculative developments.

Low energy buildings necessarily depend on natural ventilation techniques, albeit this mode of operation can be supplemented by mechanical means to deliver higher cooling capacities on demand. This operating mechanism delivers a dynamic environment where the temperature and air movement vary with the effects of the external situation.

Natural ventilation via openable windows demands that external air quality in the vicinity of the building is acceptable in terms of pollutants, particularly vehicle exhaust gases and discharges from surrounding buildings. The action of opening windows also potentially reduces the acoustic performance of the building envelope and the ability to achieve an acceptable internal acoustic environment.

The building's main frontage faces Argyle Street, where both noise and pollution could potentially be an issue, as could security. A decision to adopt a natural ventilation strategy employing openings on to Argyle Street would have to give careful consideration to these issues.

Amongst the options considered for the building is a combination of office and retail space. A natural ventilation strategy to best service these areas would employ a mixture of cross and stack ventilation. The cross ventilation strategy could use a mixture of manually or automatically opening windows/louvres while stack ventilation could be provided by a mini central atria with natural exhaust at roof level.

To deliver a successful naturally ventilated solution, it is essential that the building envelope and structure are utilised effectively to act as climate moderators and heat gain mitigators. The envelope must be optimised to minimise the proportion of solar gains that enter the internal space. The site affords little opportunity to influence the performance of the envelope using the orientation of the building, but a combination of applied shading and the solar control glazing should limit the level of solar exposure.

Most office developments deliver a net cooling demand throughout their occupied periods due to equipment and personnel gains, and a highly insulated façade works against a low energy solution in this respect and the internal gains will tend to be held within the space. A dynamic thermal assessment of the building would further advise the final design appraisals (Refer to section 4.3.7.9).

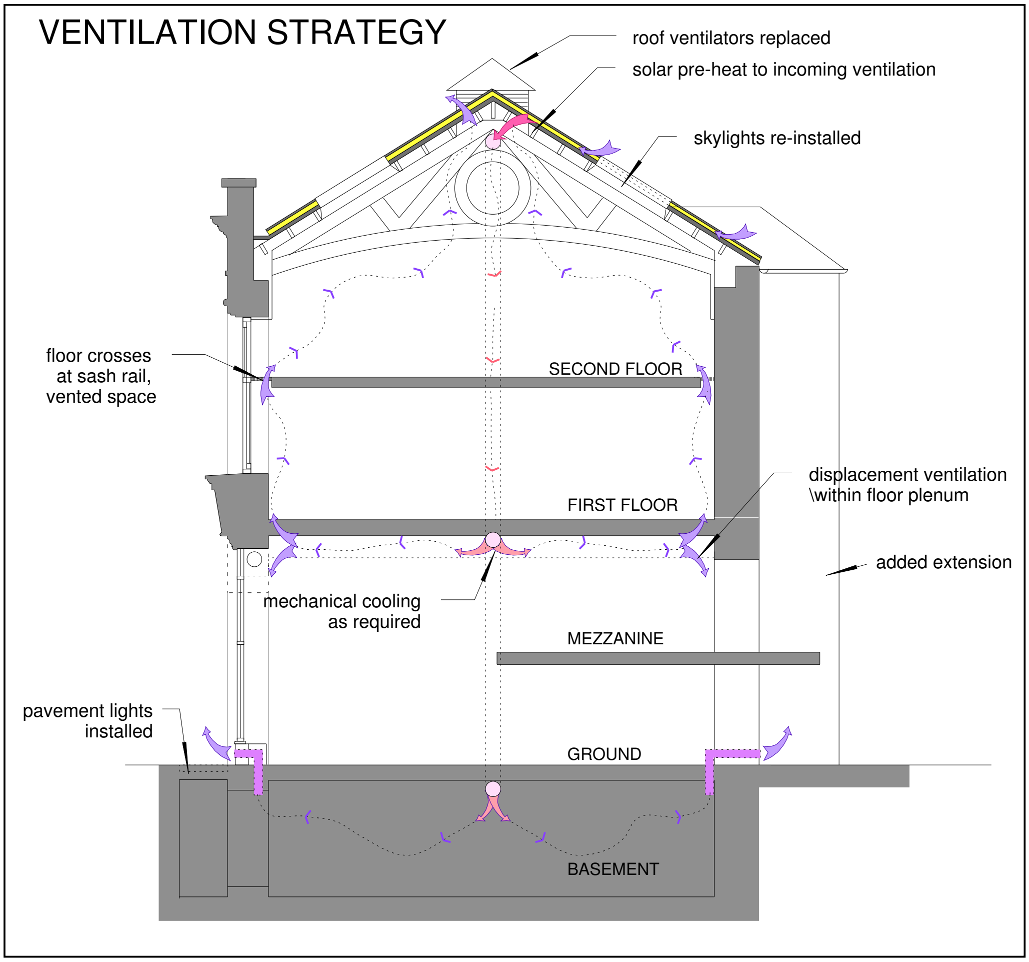
Exposing the structural mass of the development to the occupied space would enable the building to absorb heat gains during the occupied period effectively attenuating the peak temperatures. This benefit can be enhanced by using controlled night purge cooling to sub cool the structure; this is generally achieved by automatically actuated high level windows/vents.

4.3.7.4 Mechanical Ventilation

An alternative to a natural ventilation solution is to deploy a mixed mode solution using a displacement floor ventilation system combined with either ceiling level mechanical or natural extract.

The displacement system would typically consist of either a floor plenum with floor diffusers or a series of floor mounted displacement terminals. The terminals would be supplied with fresh air at a temperature typically 18^{o}C. The high supply air temperature enables the system to maximise the benefits of free cooling i.e. when the external temperature is below 18^{o}C the system is providing free cooling. The fresh air would be supplied by an air handling unit that would incorporate LTHW heating coils and possibly a refrigerant coil for cooling purposes. The use of mechanical cooling with this system could be considered an optional extra as it would only be required when the external air temperature was above 18^{o}C. For the vast majority of the year this temperature will not be exceeded and the cooling unit could be retrofitted very easily at a later date should the peak summertime temperatures prove problematic. (Again the use of thermal simulation – refer to section 4.3.7.9 – would inform the final proposals as to the likely requirement for mechanical cooling of this nature).

The displacement strategy will provide greater comfort control than the natural ventilation solution while also ensuring that issues of noise and pollution are not a factor.



The supply air for the displacement ventilation system could incorporate the use of a ‘solar ventilation’ system to preheat the incoming fresh air. This system would require ductwork connections through the sarking boards at roof level to draw air from behind the roof slates. This strategy has been developed at Napier University, Edinburgh and provides a cost effective means of pre-heating fresh air.

The extract ventilation could either be by mechanical or natural means. Should a mechanical extract be provided, the use of heat recovery between the supply and exhaust air streams should be incorporated. This would typically consist of a plate heat exchanger connecting the supply and extract units together.

As in the case of the natural ventilation solution, a natural extract could be provided via a mini central atria.

4.3.7.5 Low Temperature Water Heating: Boiler Plant, Heat Emitters and Pipework

The heating installation within the building would be best served by a high efficiency gas fired condensing boiler and variable speed circulating pumps. The pipework distribution throughout the building could be installed using High Density Cross Linked Polyethylene (HDPE) pipework which has a lower embodied energy than copper or steel.

The boiler plant would serve the requirements of the domestic hot water (if solar thermal panels are used refer to section 4.9.2), space heating and fresh air supply, should a mechanical ventilation system be used.

Both the office and retail spaces could be heated by means of radiators, trench heaters and radiant panels to suit the overall layout and space requirements.

The use of condensing boilers will increase the overall system efficiency by approximately 10% when compared to a standard boiler installation. The latest technology variable speed pumps will reduce pump energy consumption by up to 50%. The heating installation should be provided with automatic controls and good local zone control.

4.3.7.6 Lighting

It is not always realised that lighting is responsible for a large percentage of the total electricity load in any building; accounting for up to 50% of the electricity used in office buildings. As modern society makes profligate use of electric light, to reduce energy costs, lighting must therefore be one of the most important aspects of energy use to address. Lighting is responsible for such high percentages of total electrical energy loads, it must therefore be good economic and environmental practice to ensure that lighting installations are designed to be energy and environmentally efficient.

Natural Lighting

The first step towards saving energy is to improve natural lighting. It is important to maximise the levels of natural daylight transmitted to the internal spaces of a building, as well as to select light fittings and components that will be energy efficient. Glare factors should be minimised within the office environment, especially where visual display equipment could be prominent.

At 73-77 Trongate, the frontage of the building which faces Argyle Street has large areas of glazing which will provide a good source of natural daylight for the main areas. The front elevation faces primarily north, therefore minimising direct solar exposure and glare.

The rear of the building will require careful consideration to ensure that daylight penetration can be achieved. It may not be possible to have large glazed areas to the rear elevation due to the requirements set out in the Building Standards, and in this case the use of a central atria could be beneficial.

Artificial Lighting Requirements

The energy consumption of an artificial lighting installation will depend on the way in which it is used, which will be strongly influenced by the lighting controls and the amount of daylight available.

At 73-77 Trongate, natural lighting levels will be higher along the front facade, which has a large area of glazing, than along the rear wall. Lights should therefore be zoned so that they are switched in rows parallel to the front elevation and not across the room. They can then be switched on progressively when natural light levels are insufficient. The lighting should be controlled to ensure that the use of daylighting is maximised by using daylight control fittings and should feature low energy light fittings and good local control and zone switching.

It is desirable to have light fittings that complement the daylighting system and provide maximum energy savings. Increasing the efficiency of the lighting will be one of the fastest ways in which to decrease the energy costs.

Adjustability is also a key issue in office lighting, as it gives individuals the ability to control their light to meet their visual needs. The control of lighting must suit the needs of the building as well as those using the space. The installation of a combined presence detection and light level control can also increase the energy efficiency of a lighting system.

A room's shape, size and colour can affect how much light requires to be provided. Spaces with dark surfaces and high ceilings are much harder to light efficiently than spaces with lower ceilings and light coloured surfaces, when the light source is at ceiling height. These issues must therefore be considered at an early design stage.

While minimising energy consumption and the cost of the lighting system operation and maintenance, good lighting will also produce a more comfortable working environment.

Lamp choice

The choice of lamp to be used in light fittings is an important consideration in terms of energy efficiency. Incandescent light bulbs use a wire coil filament to produce visible light but as a by-product of heat. More than 90% of the energy consumed by incandescent light bulbs is given off as heat rather than visible light, so they are not energy efficient. Heat generated by lighting can also increase the need for cooling within buildings, therefore increasing energy consumption further.

Compact fluorescent lamps (CFLs) use between 40% and 60% less energy than incandescent lamps with the same light output. They have about eight times the lifespan, therefore also requiring less maintenance. A 22 Watt CFL has about the same light output as a 100 Watt incandescent bulb but uses much less energy. CFLs use little power in use but can be energy intensive at start up. However, electronic starters and high frequency ballasts will enhance the output and useful life of the lamps, with the added benefit of flicker free start up.

In office situations, light fittings using fluorescent type bulbs, such as 32 or 42 Watt TCT fluorescents, will be the most energy efficient, and are most commonly used in recessed downlighters.

If modular or suspended type fittings are to be used, then it is more energy efficient to use a T5 fluorescent type tube than a standard T8 tube. This type of tube is suitable for use in small width louvre luminaires and produces an increased light yield for the same output.

The lighting requirements of the retail and retail/café scenarios have not been investigated at this stage. Lighting levels will be dependent on the nature of the retailer and the specific requirements for display. An obvious issue for consideration will be the amount of heat generated by high levels of lighting, and whether this creates problems for the users of the building, or the products on display.

4.3.7.7 Lift Installation

Alternative types of lift

The are three main types of lift :

- Hydraulic
- Traction
- Machine roomless lift with gearless drive

All three types of lift have similar speeds, so the comparisons must therefore be made in terms of motor size, oil content, weight, noise level and machine room size, in determining overall efficiency.

The **hydraulic lift** has the largest motor, the highest oil content, and the greatest weight of the three lift types. It generally has a noise level similar to that of a traction type lift but has the highest energy consumption and is therefore the least energy efficient of the three lift types.

The engine used in a **traction lift** is approximately half the size of that of a hydraulic lift but has a similar noise level. The oil content is very low but there is some oil required. The traction lift uses less energy than the hydraulic lift but more than the gearless type lift. It is therefore slightly more energy efficient than the hydraulic lift. It is, however, less space saving, as the machine room required for this type of lift is the largest of all three types.

Lifts with a **gearless motor**, manufactured by elevator companies under various trade names, have the smallest motor, no oil content, the lowest weight and also the lowest noise level. It has the lowest energy consumption, so is therefore the most energy efficient of the three lift types. It does not require a machine room, so is also the most space saving.

The above comparisons outline the pros and cons of each lift type but also raise the elements important to consider in terms of sustainability and energy efficiency.

Energy Consumption:
One of the most important considerations in the selection of a lift, is in terms of the energy required to power the lift and therefore the energy efficiency of the lift.

Motor Size:
The size of the motor used to power a lift will be directly related to its energy consumption, so it important to select a lift that does not have a very large motor.

Weight:
The weight of the lift will have an effect on the structure of the liftwell as well as the building structure itself. If the lift is very heavy, then the structure of an existing building will require to be strengthened to accommodate this additional weight. Less heavy installations will therefore result in lower construction costs.

Oil Content:
If a lift requires to use oil, then there is the risk of future soil contamination. If the lift has no oil content, then this risk is removed and the problem of oil disposal eliminated. The risk of fire that can accompany hydraulic installations is also then eliminated.

Machine Room Requirements:
The compactness of equipment required for gearless motor type lift installations enables the lift to be designed without a machine room, therefore making more efficient use of space.

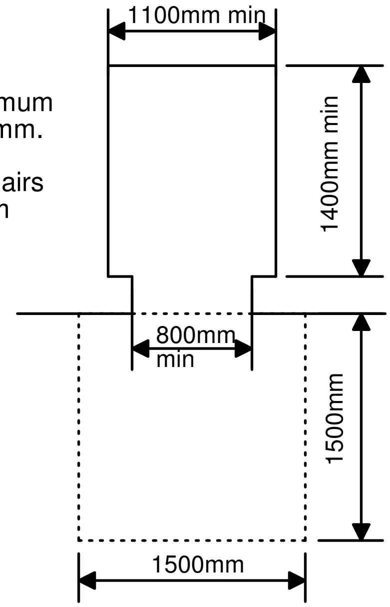
In terms of energy efficiency, as well as efficient use of space and structure, the gearless motor type lift would therefore be the most appropriate choice.

Requirements for Disabled Access:

In selecting a suitable, energy efficient lift, the requirements for disabled access must also be taken into consideration.

Lift installation

The lift car should have a minimum dimension of 1400mm x 1100mm. The landings need to be of a sufficient size to allow wheelchairs to turn, i.e. 1500mm x 1500mm



The following should be used as a guideline for the installation of a lift, whether within retail or office accommodation, so that the lift is accessible to all:

- Lifts should be served by landings at each level large enough for wheelchair users to turn to reverse into or out of the lift;
- The call panel should be easily distinguishable from its background;
- Lift buttons should be clearly distinguishable;
- Lift doors should remain open for five seconds, providing an adequate time for entry. Door re-activating devices which rely on infrared or photo eye systems are necessary to ensure no-one can be trapped in the doors;
- Control panels should be located on a side wall, and preferably on both side walls of the lift car; raised and well contrasted numbers on buttons help people with sight impairments;
- Audible announcements and visual displays are recommended internally and externally to indicate floor reached or inform that the doors are open;
- Emergency telephones in the lift car should contain inductive couplers so that hearing aid users can make use of them;
- Alarm buttons in the lift car should be fitted with a visual acknowledgement that the alarm bell has sounded.

4.3.7.8 Alternative Energy Solutions

The size and nature of the development limits the type of systems that can be applied effectively. The following systems have been discussed and considered but with the exception of photovoltaic panels are not presented as suitable options for this development.

- Photovoltaic panels
- Combined Heat & Power (CHP)
- Fuel Cells
- Ground Source Heat Pumps

The use of photovoltaic (PV) facades and roofs for generating electricity are a proven technology and can deliver a substantial contribution to the building's overall electrical energy requirements. The capital cost of these systems is extremely prohibitive although there have been recent advances within the industry that have reduced the cost of the laminates used within the PV panels. For a typical 5kW installation the capital cost would be of the order of £7,000 and would require a south facing roof area of approximately 35m^2. This would result in approximate annual savings of £300. At 73-77 Trongate it would be most suitable to have a small grid connected system that does not incorporate any battery storage. Battery storage is not "green" and for an installation of the nature proposed, the building power requirements would be able to more than match the level of the electrical PV generation, i.e. when the PV system is producing electricity, the building loads will be absorbing it.

Combined heat and power systems are currently widely available for large scale applications. The industry is beginning to develop engines suitable for use in small commercial and single residential applications but these are as yet not well developed or widely used. Combined Heat and Power requires near continuous operation to ensure optimum efficiency and cost benefit (typically a minimum of 17 hours per day is required for economic payback). The use of this technology is not readily applicable to the office sector as the continuous demand profile cannot be achieved.

Fuel Cells are currently becoming available for stationary applications but as yet are not widely available. Fuel cells are used to generate both heat and electricity and the comments noted above regarding traditional CHP are applicable to fuel cells also.

Ground source heat pumps are an effective system for providing heating and cooling with high system coefficients of performance (COP). A closed loop ground source system would require a substantial area of ground to accommodate the necessary pipe loops and the building would not be able to accommodate the requirements.

4.3.7.9 Simulation Analysis

The finalised proposals would benefit from a dynamic thermal assessment using computer based simulation tools to determine the most effective fabric upgrades to minimise energy use and maximise occupant comfort. This is particularly relevant for retail and office accommodation where internal heat gains can be significant and the use of high levels of insulation can sometimes result in increased internal temperatures and additional cooling energy requirements (if provided), over the life of the building. The simulation tools could also be used to inform the natural ventilation design.

Any proposals for maximising natural light would also benefit from an assessment using a simulation tool to inform the final decisions.

4.3.8 Daily Operations

The following is intended as a manual for Sustainable Office Management. It is directed towards Forward Scotland as the client and potential end user of the building, but is directly relevant to all users of office spaces.

4.3.8.1 Sustainable Office Management

Sustainability issues will touch upon many aspects of Forward Scotland's office management as an agency promoting 'best practice' development and the long-term interests of natural and human resources in Scotland.

4.3.8.2 Existing Premises and Office Procedures

An analysis of present working practices should be undertaken to establish where improvements can be made in terms of energy use, waste and the overall environmental impact resulting from the day to day running of the office.

The analytical process should extend to cover all aspects of the building and those who work in it, including operational systems, issues of location and transport requirements, possibilities for 'tele-working', and how the building might need to adapt in the future.

4.3.8.3 New Office Premises

The opportunity should be grasped by Forward Scotland, whether in an enabling role or as end user to embody the principles of sustainability in the refurbishment of 73-77 Trongate. This would seem appropriate for an organisation which promotes innovation, investment and development in Scotland. The fact that this will be a refurbishment project should also be used to promote the re-use of buildings as part of the regeneration of the urban environment.