Environmental issues:

Energy:

Energy efficiency must be an important consideration in the design of a building. During the design process, careful consideration must be given to the selection of building and system components with regard to energy efficiency. Renewable resources are available indefinitely but at a finite rate of replenishment. Solar energy, as a renewable resource, supplies the earth with energy at a relatively steady rate, and will continue to do so for the future. The fact is that the worldwide supply of non-renewable resources is dwindling, and energy costs will rise over the long term. Two things are certain: there is a fixed limit to non-renewable fuel resources, and we are using them up at a rapid rate. The result is that a building which is designed today with a 50-year functional life and a 100-year structural life may very well outlast the supply of fossil fuels.

Designers are faced with the following challenges:

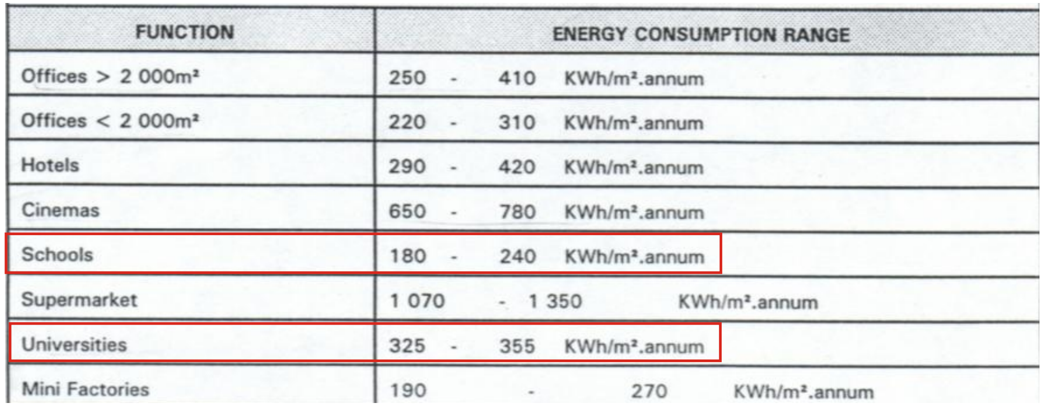
- The minimum use of energy that can be justified within a current economic condition.
- Design buildings so that they can be eventually weaned away from dependence upon non-renewable resources.

The concept of the building envelope is evolving into that of an "energy mediator": sensitively attuned to the indigenous natural resources of the sun, wind and water. These are viewed as resources to be manipulated to balance the energy flows across this envelope, rather than as environmental intruders. By displacing mechanical and electrical systems with passive environmental control systems in the envelope itself, energy consumption can be minimized. Up to 20% of energy use can be saved by establishing a building culture of cooler clothes, cross ventilation, stack ventilation and direct heat gain (Gibbert, 2002).

There are five main design factors that influence the energy consumption in a building:

- Function of building.
- Climate.
- Occupancy.
- Building design.
- Building services.

The energy requirements for the centre are approximately the same as the requirements for a school or a university facility. The energy consumption due to energy losses and gains through the facade can be reduced dramatically by selecting a proper shape for the building. There is an increase in energy consumption when the number of storeys increases:



FUNCTION	ENERGY CONSUMPTION RANGE
Offices > 2 000m²	250 - 410 KWh/m².annum
Offices < 2 000m²	220 - 310 KWh/m².annum
Hotels	290 - 420 KWh/m².annum
Cinemas	650 - 780 KWh/m².annum
Schools	180 - 240 KWh/m².annum
Supermarket	1 070 - 1 350 KWh/m².annum
Universities	325 - 355 KWh/m².annum
Mini Factories	190 - 270 KWh/m².annum

Fig 247. Function and energy consumption of a building.

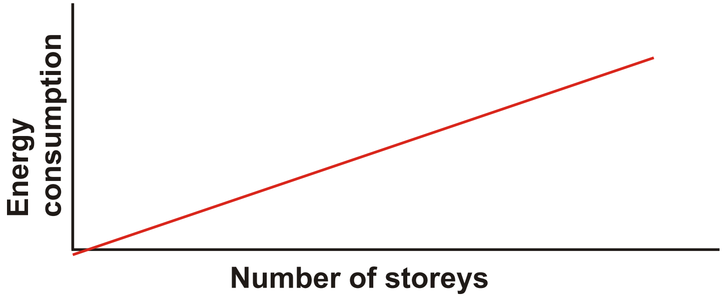


Fig 248. Relationship between energy consumption and number of storeys.

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By energy efficient design the architect has the capability to reduce the current loads imposed on the services by 50%

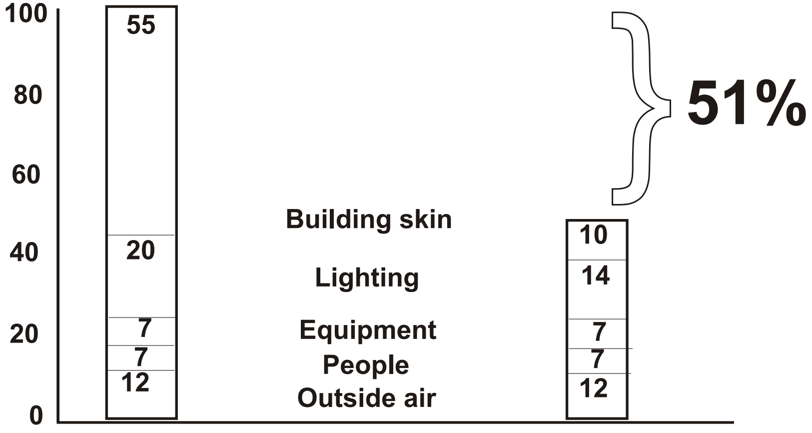

Fig 249. Design lowers the energy costs.

Energy contracting is quite new in South Africa. The owner of the building appoints a specialist company to manage the energy and share the savings with the company. The Public Works Department has initiated this type of contract in South Africa and made substantial energy cost savings this way without taking a risk.

An energy code is long overdue in South Africa. The majority of buildings constructed are thermally inefficient which results in substantial high quality energy wastage. The long term cost effect of wasted energy due to these inefficiencies is currently borne by tenants and in the long time by future generations. Making energy conservation part of the design process can only benefit all.

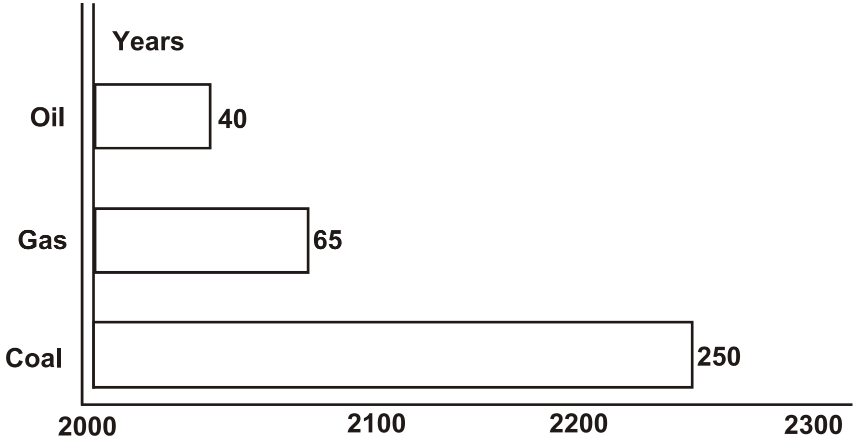

Fig 250. We are running out of energy resources.

What is not realised by designers is that we are in for an energy shock in the future. The world is slowly running out of energy resources on which we depend. At the moment energy cost is small compared to rental cost which results in complacency in our industry.

Fig 251. We all have a responsibility to save energy.

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Heating and cooling systems:

Passive systems work with nature, instead of against it. Generally they are low technology, are lower in cost, and should be designed to be aesthetically appropriate. A building may be thought of as a "footprint" on the land. The ratio of length to width is called the aspect ratio. The height is usually expressed in terms of the number of stories for a given floor area requirement. The optimum shape for a skin-load-dominated building in any climate is a rectangular form elongated some degree in the east-west direction. The longer northern façade of the structure provides a maximum of solar gain during winter, when the bulk of the sunshine is low in the northern sky at an angle of 40 with the horizontal line. The smaller eastern and western exposures minimize heat gain from the longer, low easterly and westerly sweeps of the sun in summer.

Heat transfer between the interior and the exterior is dependant on the surface area of the materials separating the inside from the outside. An elongated form exposes more surface area than a compact form. A thinner, more linear plan takes advantage of natural airflow.

The various modes of operation of a building envelope are:

- admit heat gain
- exclude heat gain
- contain internal heat
- dissipate excess internal heat

The effect of insulation is to reduce heat gain and heat loss. The more insulation in a building's exterior envelope, the less heat transferred into or out of the building. A good insulation material has a low overall conductance to reduce the energy flow across to another material. The insulation retards the flow of heat and therefore has a high resistance. The R-value of a material represents the degree of resistance to heat flow or insulating ability. The U-value is the thermal conductance. The U-value of a roof should be low (well insulated). Thermal conductance, U, is the inverse of thermal resistance, R.

$$U = 1/R$$

One must consider the environmental effects of an insulation material. Foam plastics are petroleum-based, and some utilize CFC's or HCFC's in the manufacturing process. Manufacturers are making considerable progress in producing greener products by substitution of less environmentally damaging CFC's in place of those traditionally used. Some CFC-free materials are available but are not appropriate for all applications. Man-made mineral fibres are generally considered to be "green" material in use, although problems can be created during installation with inhalation of airborne fibres. Foamed glass offers interesting possibilities as a green insulant. Cork can be specified wherever appropriate. Air-gaps and gas-filled voids can also be considered where appropriate.

Insulation products are not easily recyclable but are normally specified for long life. It is generally accepted that the advantage of good insulation (lower energy usage) outweighs the detrimental effects that some materials produce. It is nevertheless important to minimize those effects as far as possible, principally by selecting CFC-free materials where possible. Using waste for insulation materials is already taking place: cellulose-based products, shredded paper and recycled paper and wood, treated to make it fire-resistant, are available. Shredded telephone directories produce a product 25% cheaper than traditional materials (J T Designers, 1993:38).

Sol-Thermo Loft International is a new company based in Auckland Park, Johannesburg, that provides insulation products which are friendly to the environment. The product is made from spun polyester fibre which is recyclable. A life expectancy of 20 years or more are guaranteed. Labour

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intensity, technology intensity and energy intensity during the manufacturing process are low. No waste products are produced during assembly. The product is easy to install and no special tools are required. The cost is from R5.00 to R14.00 per square metre. The South African Bureau of Standard estimated a 40 mm thick panel with reflective foil layer on both sides to have a thermal resistance of 0.73. Two layers of 77 mm thicknesses with an air gap has a R-value of 1.76. Sol-thermo provide poly-fibre insulation thicknesses of 40 mm in 10 m by 1.250 m roll sizes.

The “Greenhouse Project” is a project developed to encourage the development, awareness and use of environmentally responsible products. The project collected data related to this product and rated it as extremely environmentally responsible in terms of environmental impact and manufacturing process.

Resistive or bulk insulation is the best insulators. These materials trap small pockets of air within themselves, because air has a very high resistance to conduction. Insulators include poly-fibre, mineral wool, expanded polystyrene and polyurethane foam. The best way of insulating masonry or concrete walls is to affix rigid sheets of insulation to the wall surfaces, and cover them with a protective material.

Heat flow across a building envelope depend on the following factors:

- U-values of elements
- Mass insulation provided by elements
- Heat bridges (where insulation is by-passed)

Heat bridges need to be avoided. The avoidance of heat bridges allows the overall U-value of the structure to be lower. The U-value of every element needs to be considered. If an element's U-value is high, then it is a potential heat bridge that should be avoided. The insulation in a wall becomes less effective if thermal bridges connect panels. Brandering in a ceiling not covered by insulation acts as a thermal bridge and heats up linear patches on the ceiling directly below.

A high mass wall can absorb several times more energy than a lightweight construction. In direct sunlight, the high mass structure will need time to heat all the way through. The time needed to transmit heat from one surface to the other is lag time (in hours). The lag time is a benefit in thermal control when it is a hot afternoon outside, the inside surface of a high mass wall is cool due to early morning outside temperatures. When it is a cold night outside, the inside surface temperature is warm due to the hot afternoon several hours earlier. If the mass received solar radiation, the effect is much more marked. Lag time is dependent on the heat capacity of the structure. The lag time for a concrete roof slab or a 220 brick wall is around 6 hours and for a 330 brick wall up to 11 hours. High mass structures are best suited for locations where the average summer temperature falls in the comfort zone: for Johannesburg it is 23 24 C.

Mass insulation is also known as the direct heat gain passive system. Direct penetration through windows into spaces are necessary. Short wave solar radiation falls on surfaces within the space that absorb the energy and begin to heat up. As the surfaces heat up, some of the absorbed energy is re-radiated into the space as long wave infrared radiation later when the space cools down. In Johannesburg, a 20% (of floor area) solar window combined with thermal mass and insulation of low-mass elements will result in winter thermal comfort.

Ventilation system:

During summer cooling will take place by means of natural cross ventilation and stack ventilation.

Location:

The building is located within 50 m of a bus stop and one city block from the mini-taxi bus terminus, Metro Mall. People make use of public transport that saves energy and puts less strain on the environment.

Appliances and fittings:

Energy efficient fittings and devices are specified. 80% of light fittings are fluorescent or have low energy consumption (Explained in 2.1.4).

Appliance	Conventional (kw/h)	Possible (kw/h)
Fridge	1900	900
Washing machine	960	540
Freezer	1800	765

Water has a high specific heat and takes a lot of energy to heat up. Hot taps needs to be close to the geysers as possible. If there are separate sets of plumbing spaced some distance apart, separate smaller geysers save more energy, even if the installation costs higher. Pipes need to be properly insulated, as do geysers. Hot water systems are often only 60% efficient (Napier, 2000:10.3). 25% of the electricity consumed by a household heating system can leak out of the geyser due to standing losses. 15% are lost in hot water pipes. An extra insulation blanket is an investment. The instant water heater is a popular solution where high heat wastage applies. Cold water pipes need to be out of radiant sun. The pipes need to be kept in shaded routes by means of a recess or insulation.

Recycling and reuse:

Raw materials and new components used in buildings consume resources and energy in their manufacture and processes. Buildings accommodate activities that consume large amounts of resources and products and produce large amounts of waste. Reducing the use of new materials and components in buildings and in the activities accommodated and reducing waste by recycling and reuse supports sustainability by reducing the energy consumption and resource consumption.

Inorganic and organic waste:

Integrated waste management systems must be considered in South African cities. Waste is a people's problem and people have to take responsibility for their own waste. In order to be sustainable, waste management must consider the waste stream in a holistic "cradle-to-grave" manner in order to optimize the use of natural resources and reduce environmental impacts. An integrated approach, which combines several techniques such as reuse and recycling, must be considered. Local authorities have to develop Integrated Waste Management Plans for general waste. Emphasis must be placed on a phased approach to the implementation of more sustainable processes.

Cleansing (litter removal and street sweeping), as well as waste collection is the most costly components of city waste management systems. Commuters must be encouraged to take responsibility for their waste and be consulted in preparing a strategy for their area. Citizens must be made aware of and reminded of the aims and objectives of the waste strategy being implemented. When considering the collection of waste from urban areas and the transport of waste the strategy must include action plans to firstly ensure that all wastes enter the waste stream. Illegal dumping must be stopped. Enough waste bins need to be provided outside and inside the building. Sustainable landfills must be defined as waste disposal systems where air space, processes, use of products and residues are at an optimum and where minimal negative effects on the environment are detected.

Fig 252. Waste management.

Proper planning must be carried out prior to recycling programmes. The elements that need to be considered include source separation, curbside collection, material recovery facilities and mixed waste processing. Drop off points form a major part of recycling initiatives. Institutions provide necessary service and earn an income in the process. Bottle and paper banks situated in convenient spots in an urban area can work if the site is not neglected and integrated into municipal programmes with signage and litter bins available. The litter problem results in blockage of storm water inlets. The area is served by the Robinson Deep Landfill and Springfield Incinerator and recycling plant. There is a garden refuse site at Robinson Deep. The newly created agency, PIKITUP, is now responsible for waste management in the city.

Organic waste must be separated from inorganic waste by means of separate containers. Organic waste can be used to produce compost used for fertilizer. Inorganic waste must be sorted by means of a separated shaft into containers from where the waste will be removed to a recycling plant.

Sewerage:

The main interest is water conservation. The benefits of the re-use of grey water to flush toilets reduce the demand for water, an increasingly valuable source, and to reduce the energy and capacity requirements on any downstream treatment process. Grey water can be stored in a reservoir, pumped up to the roof and used for flushing. The quality of water needs to be fitted to the use. On-site treatment requires monitoring, maintenance and supervision. This is a less attractive option than local sewerage disposal, but is more sustainable.

Construction waste:

Building work results in large quantities of waste, much of which could be salvaged for reuse. Construction waste needs to be minimized. Better site management could cut over-ordering, reduce general mishandling, and improve the poor storage that renders materials useless. Although the volume of demolition waste is huge, much of it is inert, allowing it to be crushed, processed, and reused as an aggregate in road building. The concrete structure and concrete panels can be recycled to a certain extend. Pre-cast concrete with a high degree of standardization minimizes construction waste. 90 by 90 by 190, 190 by 190 by190 and 190 by 190 by 290 modular concrete blocks and modular 90 by 90 by 190 clay bricks has great value as recyclable materials. Bricks that are damaged can be crushed and recycled and returned to the manufacturing process, or used as ground cover in crushed form. Waste wood can make chipboard.

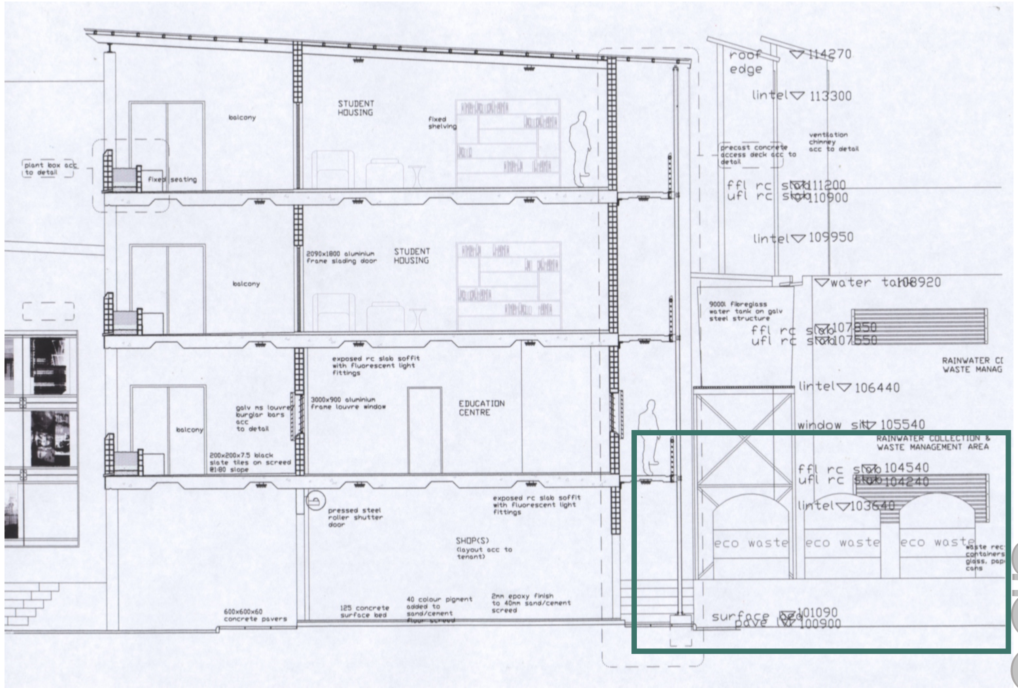

Fig 253. Waste management.

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Site:

Any building has a footprint that takes up space otherwise occupied by natural ecosystems that contributes to sustainability and by maintaining an environment that supports life. The new development should be an improvement on the site by introducing its own sustainable systems.

Brownfield site:

A brownfield site is a site with little ecological value: an open piece of land where there is no real natural ecosystem. It is wasted land. The site is fenced in and does not serve any purpose currently. By placing a sustainable development, which works with nature, can only be an improvement on the current state. The new development is seen as an opportunity to repair existing ecosystems or to develop new ecosystems.

Neighbouring buildings:

The new building will not have a harmful effect on neighboring buildings in term of over shading or any other aspect. The new development can only improve the use of the adjacent Turbine Hall building, recently renovated as Johannesburg's newest music venue. The public environment links the two buildings and facilities are shared by its users.

Vegetation:

There are six million trees in Johannesburg. On satellite pictures, the city looks like a rain forest, albeit man-made. There are 1.2 million trees within the parks and on the pavements, and 4.8 million in private gardens throughout the suburbs. Pre-1994 records were kept of which trees in the city had been planted and pruned, and up to 30% of the city's trees had been monitored and counted. This programme has now been taken up again (Davie, 2002). Extensive use of vegetation will be implemented. There has to be made provision for much needed open spaces in the CBD, whether it is in the form of green soft spaces or well-functioning public spaces like the Turbine Square. Social gathering places within the urban fabric are needed. Boulevard treatment is proposed along main routes like Jeppe and West Streets. When heat rises from the tar, trees act as a natural coolant. Carbon dioxide emitted from cars is taken in by trees and converted into oxygen. Trees also reduce noise levels. The pavements have to be a little over two metres wide to plant trees. Tree-lined paths will be used on the square to define public spaces and to create a comfortable outdoor

Fig 254. The site does not serve any purpose at the moment.

Materials and components:

Buildings are major consumers of raw materials and energy resources that relate directly to environmental impacts on a global, regional and local scale. Global warming and carbon dioxide emissions due to energy usage are considered to be the most important environmental concern.

Embodied energy:

Embodied energy is defined as the energy consumed by all the processes associated with the production of a building, from the acquisition of natural resources to product delivery, including mining, manufacturing of materials and equipment, transport and administrative functions. Representative embodied energy values for different materials are produced for each country so designers can choose environmentally preferred materials.

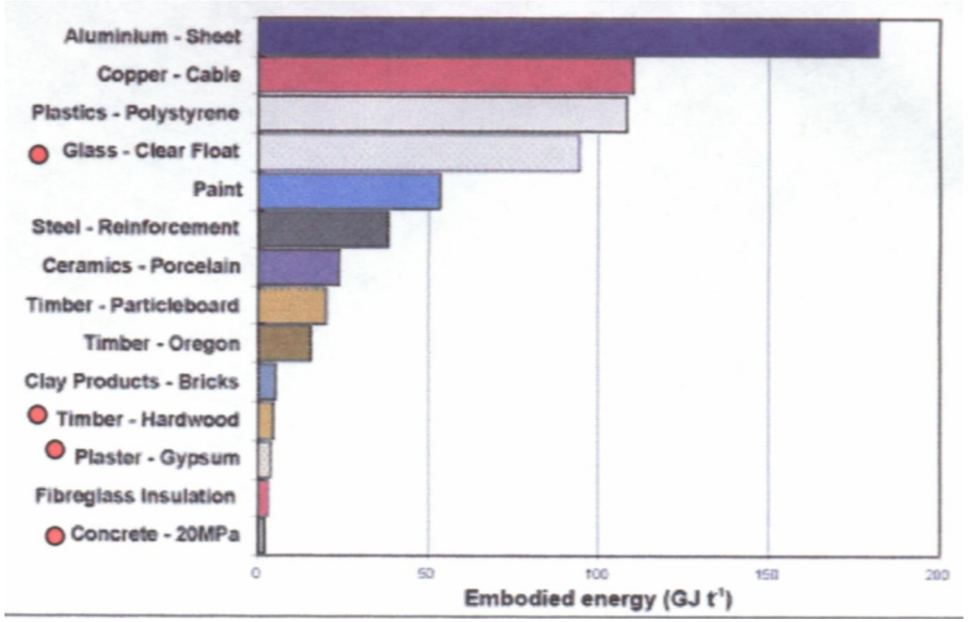

Fig 255. Embodied energy of materials.

Embodied energy graphs overlook two important issues:

- the role of design in reducing quantities of material;
- potential resource and energy benefits of material recovery and recycling.

These factors may facilitate large reductions in embodied energy without the use of unfamiliar or unsuitable materials. 80% of the building materials and components have to be made from materials with low embodied energy. Such materials include locally made and sourced timber, concrete, concrete blocks and timber window and door frames.

Manufacturing processes:

The manufacturing of materials and components must not be harmful to the environment and people. No green house gasses must be released: the least impact on the environment (pollution), the better. No toxic paints, asbestos for

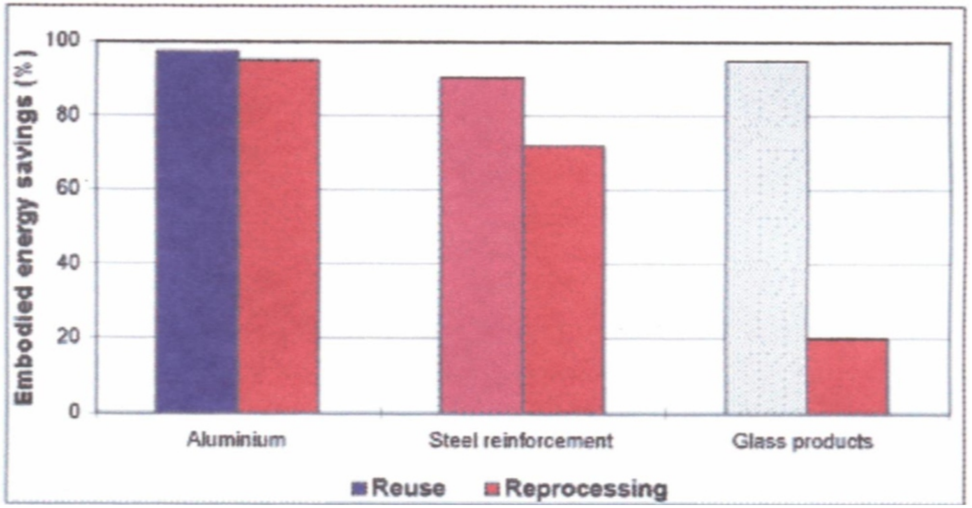

Fig 256. Embodied energy and recycling.

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for insulation or blown insulation must be used. Latex paints are free from flammable and toxic solvents, and paints based entirely on plant extracts and natural oils are becoming more widely available.

The water consumed during the manufacturing process must be taken into consideration:

Material	Water consumed (l)
1 tonne of bricks	2200 l
1 tonne steel	165 000 l
1 tonne plastic	1.32 million l
Typical 42 - 45 kg Cement bag	23 l)

Recycled and reused materials and components:

Materials and components must be made from renewable resources if possible. 10% of the building's materials and components must be reused or be from recycled sources. The reuse of building materials commonly saves about 95% of embodied energy, which would otherwise be wasted. Some materials such as bricks and tiles, suffer damage losses up to 30% in reuse. If materials were recycled at the end of their useful life in a specific application, the energy that would have been required to process the same product from raw material would be saved. The savings by recycling materials for reprocessing varies considerably with savings up to 95% for aluminium but only 20% for glass. Long transport distances to recycling plants use more energy. The use of recycled steel reinforcing, concrete from an energy-efficient plant and optimal slab design may reduce the embodied energy for the concrete slab. Standardized materials, easily separated parts and information from suppliers ensure recycling. Avoid redundant structure. Do not skimp on insulation and double-glazing: these materials have low embodied energy compared with operational energy savings.

Water:

Water is required for many activities. A reliable water supply is essential to any development. The large-scale provision of conventional water supply has many environmental implications. Water needs to be stored (sometimes taking up large areas of valuable land and disturbing natural drainage patterns with associated problems from erosion), it also needs to be pumped (using energy) through a large network of pipes (that need to be maintained and repaired). Having delivered the water, a parallel effort is then required to dispose of this after it is used (sewerage systems). Reducing water consumption supports sustainability by reducing the environmental impact required to deliver water, and dispose of this after use in a conventional system. The quality of the water must always be matched with the usage.

Rainwater:

Rainwater is a source to be utilized in a building. The sizing of gutters is based on the area to be drained and the maximum recorded rate of rainfall at the particular location. The highest recorded 24 hour rainfall (mm/hour) in Johannesburg is 188mm/24 hours.

R = rate of rainfall = 0.31 inch/hour

Gallons/minute (gpm) = A (sqr ft)/96 * R (inc/hr)

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R = rate of rainfall = 0.31 inch/hour

Gallons/minute (gpm) = A (sqr ft)/96 * R

= 14902 / 96 * 0.31
= 48.12 gpm

1 gpm * 0.0631 l/s

48.12 gpm = 3.03l/s

If it rains for 1 hour at a rate of 188mm/24 hours, a total of

(0.03 * 3600s)
= 10 908 litres can be collected from roof surface.

15 l /person / day is needed in high quality, low cost housing. This same amount will be used by the 20 students per day. Each shop will also use 15 l/ day.

20 students = 20(15) = 300 litres (Gibbert, 2002)
5 shops = 5(15) = 75 litres

375 litres can be provided by the rain collected from roof surface A1. This water will not be fit for drinking after filtration, only for washing purposes.

A water efficient dual flush toilet will not use more than 6 l per flush.

If approximately 375 litres of grey water is produced, each toilet will have 62.5 l of grey water to flush it. This equals 10 flushes.

Storm water can be ultimately be discharged into municipal storm sewers. If a storm sewer is not available, water may be allowed to soak into the ground. This is only possible if the soil is permeable enough to absorb water at a sufficient rate. Planting over a site can increase the natural soakage into the ground. Rainwater must rather be collected for general building use. Storm water collected from roof surfaces may be filtered and stored in an urban reservoir (cistern) for later use. If the reservoir is elevated above the end use, water may be supplied simply by the flow of gravity. Otherwise, a pump is needed.

The volume of water able to be captured by a reservoir (V) can be calculated:

$$V\ (\text{cubic m}) = \frac{R\ (\text{cm/hr})\ \ A\ (\text{m})\ \ t\ (\text{hr})}{100\text{cm/m}} \qquad V = \frac{0.78 * 1384.95 * 1}{100}$$

V = 10.8 cubic metre 1 cubic metre = 1000 litres

The reservoir must hold 10 802 litres of rain water.

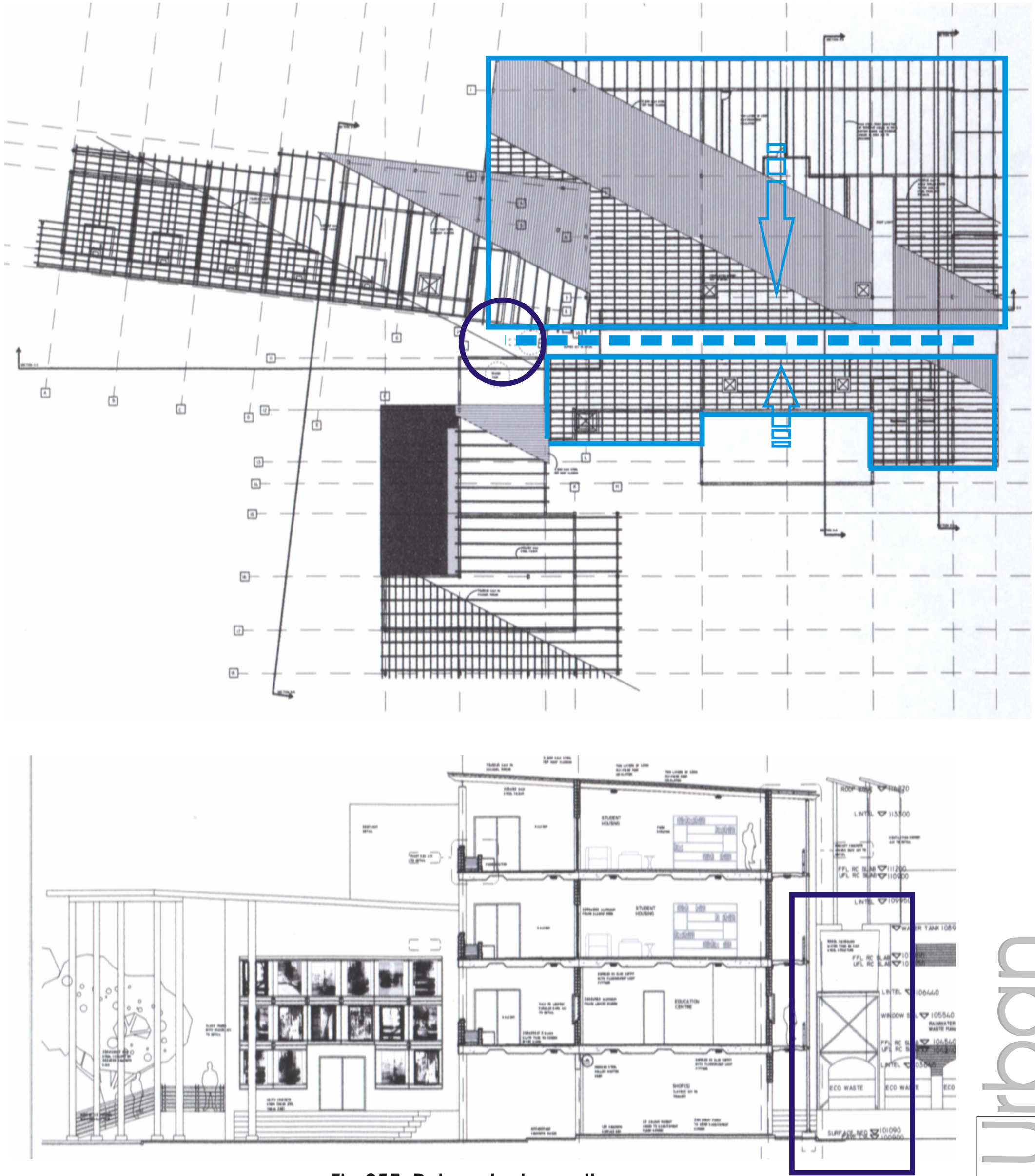

Fig 257. Rain water harvesting.