A MANIFESTO FOR GREEN ARCHITECTURE

6 BROAD PRINCIPLES FOR A GREENER APPROACH TO ARCHITECTURE

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INTRODUCTION

In view of present global crises - population expansion, natural resource depletion and ecological disasters - there is an urgent need to align development and architecture with the concept of *sustainability*. In South Africa there is an unprecedented call for a leveling within society with the provision of housing and development infrastructure. With environmental understanding being particularly lacking within our local building industry, this paper sets out to unravel the concepts behind *Green Architecture* under the umbrella of the following six broad issues:

 SOCIO-ECONOMIC	Promoting social, economic & cultural upliftment.
 LAND	Respectful and in symbiosis with the local environment and its resources.
 WATER	The protection, conservation, efficiency and re-use of water.
 ENERGY	The conservation, efficiency, and renewable use of energy.
 HEALTH	Non-polluting environments and healthy materials.
 HOLISM	Holistic and intrinsically recyclable.

Green Architecture is not a style, trend or a vernacular and neither is it new. It is a climatically, geographically and culturally appropriate way of architecture and building, combining the best of both old and new technology. At its core is the principle of *respect and caring for the earth*. The issues of environmental responsiveness, resource efficiency, community and cultural sensitivity and healthy, non-polluting environments manifest in many different ways, and often reinforce each other. While safeguarding the future of generations to come, green design also results in:

- Reduced operating costs for both buildings and landscapes.
- Better health and productivity for building inhabitants.
- Increased occupancy rates.
- Higher property values.
- Low environmental impact.
- Sustainable development.

Indeed, sustainable construction is one of the major turnkeys for survival into the 21st century.

SOCIO-ECONOMIC - Promoting Social Economic and Cultural Upliftment

Development needs to take into consideration the effects and opportunities on local peoples and their communities before, during and after the construction phase. *Green Architecture* and planning is:

- **Consensual and consultative**. Being sensitive to local community needs and concerns. Involving affected peoples in the decision-making processes. Recognizing the importance of all the people involved and affected by a development.
- **Sensitive to local history and culture**. Respecting of local materials, skills and vernacular designs. Sensitivity to the existing built environment of the given location. Prioritize the conservation and preservation of old buildings as cultural beacons in the history of a place.
- **Respecting and promoting of a sense of place**. Imparting a sense of uniqueness and diversity that helps instill a sense of identity and community.
- **Providing for mixed-use, pedestrian-friendly neighbourhoods**. Promoting a safer, more integrated multi-functional use of land. Provide greater diversity of activity and employment opportunities.
- **Respecting the health of builders & occupants.** Using only healthy, non- polluting processes and materials. This also improves builders and occupants' rates of productivity as well as resulting in higher property values.
- **Supporting environmentally responsible suppliers and contractors**. Avoids putting money into the pockets of businesses that are polluting the environment.
- **Minimize high running costs & respect user's finances.** Design for efficiency of services. This avoids cutting initial costs to the bone at the expense of future tenants, who are often left to carry the on-going financial burdens imposed by inefficient services i.e. air conditioning, dependence on artificial lighting etc.
- **Duty of care**. Designers have an overriding responsibility to protect local and global planetary systems. Place community interests over and above any short-term, profit-motivated developer interests.
- **Providing for local job opportunities.** In the construction process as well as in the choice of products. This ensures that a significant amount of any funds invested in a building remains and circulates in local hands, to the benefit of local populace. For instance:
  - *Labour-based processes are to be preferred over machine processes. Costs cannot be taken at face value, as they need to be assessed according to labour vs. machine-based processes.*
  - *Enhance the transfer of skills thereby providing for local self-reliance and the development of local human resources.*
  - *Support locally manufactured products over imported products.*

LAND - Respectful and in Symbiosis with the Local Environment and it's Resources

Maintain and restore the Earth's diversity and ecological vitality i.e.

- **Avoid disturbance to ecologically sensitive areas** such as wetlands, floodplains, estuaries, natural forests etc. Preserve as much virgin land as possible.
- **Protect existing natural vegetation.** This is vitally important for protecting bio-diversity. Natural vegetation plays a critical role in our environment by providing habitat for wildlife, assisting in regulating the climate, retaining moisture and preventing drought and desertification.
- **Ensuring no overall loss to vegetation cover.** Plants generate oxygen, cleaning the air and absorbing excess $C0_2$, thus helping to offset the effects of pollution and *global warming*. As development clears vegetation for roads, parking areas, buildings etc. development needs to off-set the loss with the planting of trees and climbing creepers as well as building planters, roof gardens, living roofs etc.
- **Restoring degraded land.** Natural features, roadway designs and run-off are manipulated for erosion control and on-site storm water catchments for the watering of vegetation.
- **Protecting soils.** Soils need protection to avoid erosion. As such all site work needs to take measures to avoid soil erosion and be as sensitive in ones disturbance as possible. Valuable agricultural land is not taken out of production. However where this is in part unavoidable, the topsoil should be saved for use elsewhere.
- **Protecting natural watercourses.** Prevent disturbance and pollution to all sources of water.

Maximize the beneficial use of locally available resources i.e.

- **Sun** – is an abundant free source of energy and is used for lighting, heating and cooling purposes. It can be harnessed both actively and passively i.e. with passive solar design and solar water heating systems photo-voltaic cells,.
- **Wind** – it can be harnessed for cooling and natural ventilation as well as providing a source of renewable energy.
- **Vegetation** – gives protection from the elements and is an excellent climate moderator, purifying and humidifying the air, providing wind shelter, shade, etc. It also provides sustainable resources such as thatch, timber, firewood and food.
- **Landforms** – both natural and artificial can channel or divert winds, provide shade, reflect heat etc. Their features can be capitalized on for storm water management, erosion control, and roadway design as well as in passive solar systems.
- **Water** – can be sourced, as well as re-used locally. By tapping the Earth's free sources of water - rainfall and dew, and reusing wastewater with grey water recycling systems - our reliance on large dams and expensive infrastructures are reduced.
- **Locally available building materials** – stone, clay, straw, thatch, reeds and timbers, scrap, etc should be utilized in preference to imported, manufactured products.
- **Existing buildings and infrastructure** – are respected and should be restored and adapted for reuse, or elements recycled and material reconstituted to provide useful 'new' materials.

WATER - The Protection, Conservation, Efficiency and Re-use of Water

Our water sources are under threat due to increasing populations and present development practices of wasteful consumption and pollution. It is therefore vital that buildings do their utmost to make use of alternative water sources, and that they reduce consumption through conservation measures, greater efficiency of use and through the safe re-use of 'waste' water. It is estimated that with only the most basic water saving strategies it is possible to reduce water demand by up to 50% (Ref. 1). Unless we rethink our current approach to our water and sewage systems, we face the continued building of large, expensive dams and increasingly stringent water restrictions. With present increases in populations, and increasing levels of pollution there is an urgent need to safeguard future water supplies. The building industry must adopt a more sustainable approach to water use. A 4-point water wise strategy would include:

> **Protecting all water sources**, i.e. eliminating all polluting activities;
> **Conserving the use of water sources**, i.e. reducing the need to use water;
> **Water Efficiency**, i.e. using less water through greater efficiency, as with the use of water saving devices and appliances;
> **Recycling**, i.e. promoting recycling of 'waste' water, while being mindful of its potential to pollute local ecological systems if not properly managed.

• Protecting Water Sources

The effluents from sewage works, detergents from households, toxic wastes from industries, run-offs from pesticides and fertilizers, acid rain, etc, are all adding to the concentrations of contaminants finding their way into water supplies. These contaminants are becoming an increasing threat to present and future human and environmental health, as they slowly accumulate within our water sources. While drinking & shower water can be filtered with *water filters*, this can only be seen as a short-term measure. The only long-term solution is to prevent water pollution in the first place. Furthermore, developers must realize that by altering the physical form of the environment, development can positively or negatively affect the accumulation of pollutants and the self-cleansing ability of the water cycle.

– **Common Contaminants:**
  > Acids and acid rain
  > Arsenic
  > Chlorine & chlorinated substances
  > Bacteria & organic sources
  > Fluoride
  > Heavy Metals
  > Hazardous household wastes
  > Herbicides & pesticides
  > Oil and petroleum products
  > Nitrates (i.e. fertilizers)
  > Phosphates (i.e. detergents)
  > Radon
  > Sewage and septic tank effluent
  > Solvents
  > Synthetic organic chemicals

– **Altering the Environment:**

Inappropriate developments adversely affect water quality & pollution levels:
  > The building of large dams
  > The canalizing of natural watercourses
  > Interfering with flood plains

> Destruction of wetlands
> Erosion and topsoil run-off
> Increased run-off
> Excess evaporation
> Over-use of borehole water
> Careless planning around boreholes

- **Sources of Water Pollution in the Building Industry:**
  Potential contaminants of water sources are best avoided. However if their use is unavoidable, then a precautionary framework for the proper and 'safe' handling and possible disposal of pollutant sources must be firmly in place. (See *Appendix A: Construction Framework for the Protection of Water Sources).*
  - **Building Rubble** – A list of building materials potentially hazardous to water sources:
    > Adhesives and glues
    > Asbestos
    > Fluorescent light tubes
    > Paints
    > Paint strippers
    > Transformers (old types)
    > Wood preservatives
  - **Building Materials** – A list of materials with the potential for polluting drinking water:
    > Pipes and guttering – especially asbestos & PVC plastic.
    > Pipe sealants containing V.O.C's (Volatile Organic Compounds).
    > Tanks and water storage – especially asbestos & PVC plastic tanks.

- **Conserving the use of water sources**
  By reducing the need to use water in the first place, it is possible to make significant water savings. Some of the strategies for achieving a greater conservation of water are outlined below:
  - **Site Strategies:**
    - **Rainwater harvesting** – Collect rainwater off roofs, roads and other run-off surfaces for storage or use in:
      > Rainwater tanks
      > Ponds
      > Swimming pools
      > Underground cisterns
      > Mulch pits
      > Swales
      > Diversion ditches
      > Keyhole dams

    - **Dew catching** – Catch and make use of water carried in air by:
      > Utilizing dew catching devices
      > Retaining existing vegetation
      > Planting vegetation
      > Channeling and compressing air currents
      > Cooling air by creating shade or providing cold surfaces

- **Reducing evaporation and landscape water demand** – Help to reduce evaporation from the soil and reduce transpiration from plants by:
  - > Mulching the soil
  - > Not exposing the soil
  - > Providing for shade
  - > Planting windbreaks
  - > Building windbreaks
  - > Interplanting/companion planting
  - > Planting indigenous plants
  - > Planting less thirsty plants
  - > Xeroscaping the landscape (grouping of plants according to water needs)

- **Maximizing infiltration of water into the ground** – Try to hold water on the land for as long as possible, allowing for good ground water recharge by:
  - > Building swales
  - > Mulching the soil
  - > Building mulch pits
  - > Building good soils

– **Composting toilets:**
Composting toilets offer a more ecological way of dealing with human waste. They recycle sewage into a harmless resource, i.e. garden compost.

- There are a number of *waterless composting toilets* locally available. Having relatively inexpensive installation costs, minimal maintenance and none of the usual expensive sewage treatment work overheads, these systems are highly cost effective. However some kind of soak away, greywater recycling system or regular sewage connection will still be necessary for regular shower, basin, bath, laundry, kitchen sink and other 'waste' waters etc. It is also possible to build your own using a *twin vault system.*
- *Reed bed systems* combine both black and grey water. Sewage is treated by creating a mini eco system, which completely cleanses all water for further re-use. Building or installing such systems would depend on local expertise.

– **Saving Energy:**
Saving energy saves water. For every 1 K.Whr of electricity used, we use 1,32 litres of water *(Ref: 2).* This is because Eskom's process of generating power consumes large quantities of water.

• Water efficiency

Using less water through greater efficiency, as with the use of water saving devices and appliances.

– **Efficient Irrigation** – Inefficient irrigation systems and practices are to be avoided. Together with water saving site strategies, consider the use of more efficient irrigation systems, such as:
  - > Drip irrigation
  - > Dew catchers
  - > Greywater systems
  - > Soak aways

– **Swimming Pools** – Much water can be lost from swimming pools due to evaporation. Consider the use of:
  - > Pool blankets/covers
  - > Rainwater collectors

- **Water Saving Measures** – Greater water efficiency is achieved through careful design and specification. Ensure proper maintenance procedures are in place and efficient plumbing with:
  > Minimal lengths of "dead legs" in hot water piping through good layout design
  > Balancing hot and cold water pressure
  > Reducing excessively high water pressures with pressure reducing valves
  > Repairing of leaks (taps, toilet cisterns, hot water systems, pipe works, etc)

- **Toilets** – It is possible to make great water savings with more efficient flush toilets, and is normally a priority with any water saving strategy. In an average house, toilets are normally the largest single users of water and will consume up to one third of all the water used. *(Ref: 3 & 4)* Consider the use of:
  > Low litre flush toilets
  > Manual / multi flush toilet
  > Dual flush toilets
  > Toilet dams, bags etc. (retrofitting device only)
  > Composting toilets (combined with greywater recycling).

- **Taps & Showers** – It is possible to achieve a much greater efficiency with water saving fittings. However there is no point in using any of them if the hot and cold-water pressures are not balanced, and if the water pressure is too high. Generally showers are far more economical than baths, with an average 5-minute shower consuming 75 litres, compared to a bath, which uses up to 180 litres (Ref: 4).
  > Install flow-restrictors
  > Install tap aerators.
  > Install water efficient showerheads i.e. flow rates of 9-12 litres per min.

N.B. *The National Water Conservation Campaign (NWCC) – A Department of Water Affairs and Forestry project – has established the "A-Z of Water Saving Devices." Available in booklet form together with other water saving pamphlets, for more information:*

e-mail: *Conserve@cis.co.za* ***Tel:*** *(021) 462 1460* ***Fax:*** *(021) 462 1719*

• Recycling greywater

Promote recycling of 'waste' water, while being mindful of its potential to pollute local ecological systems if not properly managed i.e.

- Consider the design possibilities for recycling and redirecting 'waste' water that is normally channeled down storm water drains from:
  > Garden taps
  > Overflow pipes
  > Hard surfaces
- Both greywater (used bath, shower, hand basin and laundry water), as well as black water (used kitchen sink and toilet water) are recyclable. Consider the possibilities of recycling domestic 'waste' water for irrigation with:
  - Wet composting systems
  - These cleanse and recycle both black and grey 'waste' waters. Such systems usually consist of a series of ponds and reed beds, which can be incorporated within gardens or parklands as recreational features.
  - Biological grey-water systems
  - Such systems allow for the reuse of grey but not black water. They are designed to suit specific local conditions. They usually consist of a series of simple settling tanks, straw and sand filters followed by reed beds, which are planted along a swale.

- Mechanical grey-water systems
- Involve the use of a surge tank, and small pump, piped to an irrigation system or to a holding tank for toilet flushing. While these systems allow for recycling of bathing, basin and washing machine water, they exclude the use of kitchen and toilet waters. Unless a filtering system is also included, they should only be used for sub-surface irrigation.

N.B. *With all these systems, it is especially critical that the users are educated to only use environmentally acceptable, biodegradable washing and cleaning agents so as to prevent the potential risks of contamination to local ecosystems. Furthermore sodium salts found in most soap and detergent may damage soil structure by creating an alkaline condition. This can be corrected by adding gypsum to the soil. The SABS is in the process of finalizing recommendations for the re-use of grey water.*

ENERGY - The Conservation, Efficiency and Renewable Use of Energy

Scientists have warned that *global warming* is one of the most urgent environmental problems that we are presently faced with. The 'developed' world's dependence on *fossil fuels* to run economies is currently perpetuating a rise in the planets' temperatures resulting from the powering of buildings, industries and transport systems together with various polluting activities. Scientists and environmentalists all over the world are calling for a major rethink on our present use of energy. Existing energies need to be *conserved,* used more *efficiently* and ultimately switched over to cleaner, more *renewable* sources of energy.

- **Global Warming & CO_2 Emissions**

  The 'developed' world is presently responsible for approximately 50% of the planet's greenhouse gases. The construction industries, and those involved in designing building services, have a major part to play in averting the catastrophes of global warming (Ref 5).

  – Certain gases in the atmosphere, known as *greenhouse gases*, act like the glass of a greenhouse. They allow incoming short-wave radiation to enter and warm the surface of the Earth while preventing longer-wave radiation from escaping back into space. Their increase is causing the present rise in the earth's temperatures. This is called the *"greenhouse effect."*

  – The principal greenhouse gas contributing to present global warming is *Carbon Dioxide ($C0_2$),* and is generated from our use of electricity as well as the burning of fossil fuels to power motor vehicles. (In addition, *CFC's, HCFC's* and *halons* are other major greenhouse gases, which are related to the building industry).

- **Energy Conservation**

  Strategies to promote a greater conservation of existing energy are as follows:

  – Urban and landscape design:

    - Cities need to *reduce their reliance on the motorcar,* maximizing the use and potential for public transport, with more compact mixed-use, planning, and the concentration of development within existing urban areas and along transport corridors. Create attractive and safe cycle and footpath systems.
    - *Minimize land-use separation, zoning* and *sub-division*, with the integration of buildings to facilitate a multi layering of uses while maximizing the potential for making beneficial interconnections.
    - *Enhance local urban microclimates* with the use of dense belts of planting to protect various urban edges from adverse weather conditions. Planting trees, creating parkland and localized storm water and 'waste' water recycling systems with the use of planting in, around and on buildings will improve urban microclimates. In addition, planting will help in countering the effects of air pollution and global warming by their ability to enhance air quality and absorb excess C0 2.

  – Building Design & Construction:

    - - Consider the possibilities for the *conservation* and *adaptive reuse* of existing buildings and materials, rather than continually building new structures and manufacturing new materials.Existing structures and materials represent considerable investments in energy. Use construction techniques, which allow for *recycling, dismantling and re-erection* of structures and materials.
      > Consider the *life cycle costing* of materials and products.

Note: For table on A*ssessing Environmental Impacts*, refer to *Appendix B.*

> Try to avoid, or use sparingly those materials known for their *high-embodied energy*.

Note: For more information on E*mbodied Energy*, refer to *Appendix C.*

> *Avoid high transport costs* by using locally sourced natural building materials. Source materials and products as close as possible to the site, while trying not to use imported products.
> *Avoid designing deep plan offices,* which are reliant on costly and highly energy inefficient operating systems, such as artificial lighting and air-conditioning.
> - *Maximize the use of natural light.* Use skylights; make use of fanlights; design light shelves to bounce light further into spaces while also doubling up as sun shields and design courtyards and atriums to bring light further into spaces.
> Create comfortable internal and external environments with *passive solar design*.

Note: For more information on *Passive Solar Design*, refer to *Appendix D.*

> - *Maximize the use of natural ventilation*, with windows and vents, operated by simple, user-friendly means.
> - *Use insulating materials* or layers to reduce the effects of heat transfer, while avoiding *thermal bridging* within the building fabric, where poor insulators provide a bridge for the easy loss, or gain of heat.
> Design for adequate *sun shading* to avoid the build up of excess heat in summer, while allowing for good sun penetration during winter.
> Use *double-glazing*, other insulating types of glass, or insulated shutters for large glazed openings, so as to prevent excess heat loss or gain.
> *Avoid the excess use of un-insulated glazing on the cold side of buildings.*
> Use *draft proofing* around windows and doors to avoid excess heat loss (while avoiding potential problems with indoor air pollution – refer to chapter on *healthy non-polluting environments*).
> For large buildings (typically offices), *avoid false ceilings*, as they inhibit proper energy conservation. By exposing the underside of a concrete floor slab, the heat rising during the day will be absorbed by the structure and can either be flushed out at night to cool the building down in time for the next day, or else retained during winter for heating.

- **Energy Efficiency**

As part of an overall strategy to curb our reliance on fossil fuels, there is also a need to find ways of using energy much more efficiently. While investments to achieve this end may initially be higher, the longer-term effect is reduced running costs, with considerable savings both financially as well as to the environment.

Some of the measures to improve on energy efficiency within the construction process are listed below:

– Use *geyser blankets* and *pipe lagging* with hot water systems. Hot water systems are usually the biggest consumers of energy in an average household and as such, fitting insulating devices provides an excellent option with retrofitting as well as when installing new geysers. In addition avoid foamed insulating materials that use *CFC's* in their production.

Note: *for more information see the paragraph on Ozone Depletion.*

- *Position the geyser* as close as possible to its point of use. This will save energy as well as water.
- *Geyser timing devices* can be set to respond to a routine so as to reduce overall consumption of electricity.
- Consider using *instantaneous heaters* for small uses, rather than piping water from a distance away. However, these should not be used for heating larger quantities of hot water, such as in a bathroom. This will require that they draw greater Kilowatts of power, loading the peak demands for power supply.
- Use *energy saving lights* such as halogen or compact fluorescent lights (taking care with the placement of their *transformers*.

Note: *For more information, see the chapter on Healthy & non-polluting environments.*

- Use *intelligent lighting systems* such as occupancy sensors and lumostats.
- Specify *energy efficient appliances* i.e. the most energy efficient ones on the market.
- Make use of *heat exchangers* to recycle 'waste' heat.
- Consider using *natural gas as a fuel* as opposed to electricity as it is more efficient in its conversion of energy. Furthermore, methane also produces less CO_2 when burnt than other types of fuel. It burns cleanly unlike coal, (from which most of South Africa's power is generated) which is heavily polluting and causes problems with smog and acid rain.
- For large typically office type buildings, where passive design measures are not possible, consider the use of *evaporative coolers* in preference to air conditioning systems.

• Renewable Energy

Maximize the use of non-polluting renewable energy sources:

- *Solar hot water heaters* are, at present, the simplest and most highly effective means of saving energy and promoting renewable energy sources.
- *Solar ovens* are a simple, non-polluting way of cooking food without the use any fuel source other than what is freely available from the sun. They can be purchased or easily and cheaply built by oneself.
- *Solar Ponds* extract heat from specially designed salt pools for heating or power generation.
- *Solar Pumps* are an effective, renewable means of drawing water from one place to another for storage or use and do not require polluting batteries for their operation.
- *Bio-gas Digesters* are localized systems for obtaining fuel with the collection of methane gas. Methane burns relatively cleanly and furthermore, while it is a powerful *greenhouse gas* (contributing to approx.18% of the global warming effect; Ref: 6.) by collecting it, these systems are preventing its escape into the atmosphere. Although fairly easy to construct, these systems do require on-going maintenance and control.
- *Wind pumps* are used for pumping water from lower to higher levels.
- *Water Turbines* used on a localized scale are most effective when one has a reliable source of water that is either fast flowing or has sufficient level change to power a turbine.
- *Wave Power* generators have been developed, but are difficult and expensive to operate on a localized scale.

Use with caution those renewable sources of energy, which can cause pollution:

- *Photovoltaic cells* – are panels mounted to face the sun, which are capable of generating electric power. While the technologies for these are improving all the time -with the development of more efficient panels and integrated roofing and cladding systems (not yet locally available) - they still rely on heavily polluting technologies, in particular the use of batteries creating an ongoing source of toxic wastes. However if Eskom were to allow solar power producers to sell their excess electricity back to the grid, then this would alleviate the use of batteries.
- Wind Turbines – are highly effective at generating power. However unless it is possible to sell power directly to the grid, potentially polluting batteries are required. Some countries like Denmark have large wind farms that power whole towns and cities.
- *Firewood* is a completely renewable and sustainable energy source. However where its use is not accompanied by *replanting*, it will result in deforestation and the accumulation of the greenhouse gas, carbon dioxide, into the atmosphere.

HEALTH - Non-polluting Environments and Healthy Materials

Green Architecture avoids the use of polluting materials and activities. This minimizes the global and localized risks to planetary systems such as air, land, and water as well as minimizing the potential health risks for the users of buildings, the construction workers and the people involved in the production of materials. Some of these issues are discussed below:

- **Global Warming**

  With buildings presently responsible for approximately 50% of the planet's greenhouse gases and as discussed with the chapter on *Energy*, those involved in the building trade have a major part to play in averting the catastrophes of global warming. Building construction and design can significantly reduce the emissions of principal greenhouse gases like *Carbon dioxide ($C0_2$), CFC's,* and *HCFC's.*

  Furthermore, by *protecting and increasing the sinks for greenhouse gases* the building trade has a further responsibility to the health of planetary systems. This is achieved by:

  – *Using alternatives to non-renewable tropical hardwoods* so as to prevent the destruction of rain forests. Trees and forests act as great carbon sinks and are the lungs and rainmakers of our planetary systems.
  – *Protecting and increasing the overall coverage of vegetation* on a given site, by giving space for planting in, around, against the sides of, and on top of buildings.

Note: For more information on increasing carbon sinks, refer to the section on *"To maintain and restore earth's diversity and ecological vitality"* as outlined in the chapter on *Land.*

- **Ozone Depletion & CFC's**

  The present destruction of the ozone layer is well documented. It is the cause of increasing levels of harmful U-V rays, threatening the health of both humans and the environment at large, with the potential for devastating results. At very least 50% of the use of ozone-depleting substances – *CFC's* (chlorofluorocarbons), *HCFC's* (hydrochlorofluorocarbons) and *halons* - are associated with the building industry. (Ref: 7)

  The main measures that one can take to help phase out their use in the building industry include:

  – Design buildings which avoid *air-conditioning systems.* Avoid the usual *deep plan office* so as to maximize natural light and ventilation.
  – Avoid specifying materials, which utilize *CFC* or *HCFC* in their production, commonly being *plastic foamed materials* such as insulation boards, jointing and filler products. These include:
    > Expanded extruded polystyrenes
    > Polyisocyanurates
    > Polurethanes
    > Phenolics
  – Avoid specifying *halon*-based *fire extinguishers.*
  – Upgrade existing *air-conditioning systems* that use CFC's. Avoid the release of old refrigerants into the atmosphere as well as the repeated use of CFC-related materials including HCFC's.
  – Certain chlorine-based *solvents* - being ozone-damaging substances - are also to be avoided.

– Take especial care when dealing with:

  - Refrigerants:

  Air conditioning systems and *refrigeration* systems once commonly used CFC's as their refrigerant and can still be found with most old systems. Do not be easily duped by sales persons claiming to sell supposedly cleaner CFC-free fridges or air-conditioning systems. Many have simply been replaced with HCFC's, which although less damaging to the ozone layer, is still an ozone-depleting substance. Furthermore, as is the case with many new fridges, while they may have replaced the CFC or HCFC refrigerant, one often finds that the products are lined with a high-density foamed insulation material that has been manufactured with the use of CFC's.

  - Plastic Foamed Products:

  Extremely careful scrutiny is necessary when considering specifying products which have involved the use of a blowing agent, like *plastic foamed products – insulation boards, pipe* and *geyser lagging, refrigeration plant insulation* etc. For example, when dealing with *Sagex* - a major producer of plastic foamed insulation products – the sales representative claimed that ozone destruction was no longer a problem, as their polystyrene products were no longer made with CFC's, and displayed the ozone friendly labels. However when one looked at their complete range of products it became apparent that their pipe and geyser-lagging - a closed cell, phenolic insulating foam *"Megaphen"* - which they advertise as "non-toxic", did not bear the ozone-friendly label. This was because they are still using CFC's as the blowing agent for this product.

- **Trace Organics**

Substances, which have become known as *trace organics,* cover a wide range of carbon based structures and are causing wide concern related to their rising pollution with indoor air, as well as our supplies of water and food. A large number of such substances are cumulative in the body; some are carcinogenic and others cause damage to the liver and kidneys. In our present context the building industry is contributing heavily to the accumulation of these substances in the environment. In particular, all materials that contain solvents and preservatives are of concern.

Organic Solvents (non-water based)
Being dangerous to humans and the environment at large, the use of organic solvents is best avoided. Their use presents potential health problems for factory and construction workers as well as the inhabitants of the buildings that the solvent-containing materials end up polluting. Being volatile substances, which are unstable at room temperatures, (otherwise known as *volatile organic compounds or VOC's)*, they will off-gas, and as such will present problems with indoor air pollution. This is especially so with newly formed materials, where the levels of off-gassing is higher. These solvents are found in a wide range of common building products:

> Paints, especially non water-based enamels but including the emulsion-based acrylics.
> Adhesives used by the carpeting and tiling trades.
> Adhesives & glues used by the joinery trades for the laminating of veneers, counter tops, etc.

> Certain laminated timber products, shutter boards, plywoods, blockboards and laminated timbers sometimes make use of an oil based benzene (organic solvent).

> Certain wood treatment processes require the use of a solvent carrier i.e.
PCP (Pentachlorophenol)
TBTO / Lindane (Mix of Tributyl Tin Oxide & Gamma Benzine Hexachloride)

Note: For more information on *the identification of solvents with common Building Materials,* refer to Appendix E.

- **Sick Building Syndrome**

Unhealthy, polluting or toxic building materials and building systems, are causing what has commonly become known as *sick building syndrome (SBS)*, which is now considered one of the major threats to public health. *Indoor air pollution* is a major cause of SBS and modern scientific research has indicated that in certain cases, the indoor environment may be as much as 10 times more polluted than the outdoor environment. (Ref: 8) Other causes of SBS include *eyestrain*, *noise pollution*, the excess build-ups of *static* charges, and adverse *geo-magnetic* and *electro-magnetic fields*. Common symptoms of SBS include: allergies, asthma, eye, nose and throat irritations, fatigue, headaches, nervous-system disorders, respiratory congestion, sinus congestion, yuppie flue and cancer. Both worker's health and their levels of productivity are directly related to the health of a building and it's materials.

- Indoor Air Pollution:

The US Environmental Protection Agency considers indoor air pollution to be one of the top five threats to public health. (Ref: 9.) With many people spending up to 90% of their time indoors, the long-term exposure to off-gassing chemical vapours has caused a dramatic increase in the numbers of cases of allergies, chest related illnesses chemical hypersensitivity and cancer. Furthermore, the occupational hazards for construction workers and factory workers dealing with such materials are a peril to their health and safety. While the health hazards of *asbestos* are now widely accepted, concerns over a much wider range of substances have become evident.

A pollutant such as *formaldehyde* is a toxic off-gassing volatile organic substance (VOC) and a known carcinogen. It is commonly found in regular building materials like:

> Paints.

> Synthetic carpets and carpet backings.

> Tiling and carpeting adhesives.

> Chipboards, shutterboards, plywoods, blockboards, superwood and other pressed wood products. By far the most hazardous of these being chipboard and superwood.

> Insulation foams.

> Foamed products such as those used in upholstery and foam mattresses

> Other potentially harmful toxins, which pollute indoor air sources, are commonly found in:

- Asbestos. Note that it is more dangerous to remove asbestos materials than to leave them place.
- Synthetic materials that release hundreds of volatile organic chemicals into the air.
- Paints.
- Electronic devices, which emit a variety organic compounds.
- Toxic Wood preservatives.

- Anything which uses a non-water based solvent; such as resins, epoxy's, polyurethane, adhesives and many types of timber treatments.

Note: For a further guide to sources of chemical emissions refer to *Appendix F.*

- **Safeguards to Indoor Air Pollution:**
  The main safeguards against materials leaching out chemical gases to pollute the indoor air are:
  - Avoid the use of potentially polluting materials altogether by constructing, finishing and furnishing with natural rather than man-made materials.
  - Use non-toxic or low-emission, building materials and furnishings. Ask suppliers for a *Safety Data Sheet* of intended products, and avoid products with organic solvents, formaldehyde's, and other VOC's and harmful chemicals.
  - Specify water-based, solvent free materials and advise that maintenance staff avoid using solvent-based cleaning agents.
  - Avoid the design of deep plan types of buildings that are heavily reliant on artificial systems of lighting and ventilation.
  - Beware of tightly sealed building as they can help trap gases from synthetic materials.
  - Provide for adequate ventilation or fresh air exchange, with good natural ventilation.
  - Designed to give occupants control over their interior environments.
  - Designed to avoid interior condensation.
  - Seal off pollutants found in timber preservatives, particle boards etc to prevent the leaching of pollutants into indoor air;
  - Isolate certain polluting sources, such as having separate rooms for photocopiers.
  - Apply a technique known as a *bake-out,* to accelerate and so rid most of the harmful off gassing of pollutants as materials usually off gas most of their pollutants while still new.
  - Design for plants and trees as the living processes of plants, cleanse air and absorb toxins.

Note: For information about the *bake-out* technique, refer to appendix G.

- **Eyestrain -** Eyestrain causes headaches, fatigue, stress and leads to the deterioration of eyesight. Common causes of eyestrain are:
  - Inadequate natural light.
  - Absence of access to external views.
  - Glare.
  - Poorly positioned and inappropriately lit computer VDU screens.
  - Flickering lights such as old types of fluorescent lights (without high frequency ballast's).
  - Single end spectrum lights.

- **Static -** Common sources, which attract harmful, *positively charged ions* causing the air to become drained of beneficial, *negatively charged ions*:
  - Synthetic fabrics and carpets, which have not been treated for anti-static.
  - Plastics and other synthetics.

- Electrical appliances.
- Steel structures and the concentrated presence of metals.
- To alleviate the problem of the build-up of *positive ions* better known as *static*:
- Avoid designing structures using excessive amounts of steel or other metals, as they are draining of beneficial *negatively charged ions*.
- Design for flowing water, using fountains and flow-forms, as these are high in negative ions and hence excellent neutralizers of excess static charges.
- Plants, especially succulent plants help balance excess static charges.
- Install a *negative ionizer*.

- **Electro Magnetic Fields (EMF'S)**

  EMF's are invisible lines of force that surround any electric device. More recently epidemiological studies have begun to make links between prolonged exposure to electro magnetic fields and certain types of cancer, primarily leukemia and brain cancer. While there has been no scientific consensus, other than that better information is needed (Ref: 10), the evidence is mounting that there is a need for design and construction to help reduce people's risk to prolonged and accumulative exposure to EMF's. Exposure to EMF does appear to have an accumulative effect and people's tolerance to them varies. However once a certain threshold has been exceeded, illness will manifest, with symptoms often ascribed to "yuppie flue"

  While studies on EMF's are still emerging there are things with design and construction, which should be noted:

  - The earth exerts its own magnetic fields, also known as *Geomagnetic Fields* mainly in the form of DC's or static fields. This has long been noted, by the ancient practices of *dowsing* and *Feng Shui*.
  - Power lines, electrical wiring and appliances all produce electric and magnetic fields. With a lamp plugged in but turned off, the voltage produces an electric field. Once the lamp is turned on and current flows, a magnetic field is also produced. For greater safety circuit breakers can be installed for bedrooms.
  - Both electric and magnetic fields weaken with increasing distance from the source.
  - While electric fields are easily weakened and shielded by conducting objects, magnetic fields are not.
  - Buildings located in near proximity to high voltage power transmission lines poses particular danger to children, increasing risks of leukemia.
  - Steel structures generate their own EMF's due to stresses set up at a molecular level and varying levels of external corrosion. Furthermore steel structures will conduct electric fields induced from any electric circuitry passing near to the structure.
  - Electrical transformers emit high EMF's and need to be positioned with care.
  - Prolonged and close exposure to computer VDU (monitors) is ill advised. While low radiation monitors are available, they do not contain the fields and very careful planning of computer workspaces is required so as to reduce exposure, especially around the sides and back of screens where levels of EMF's are higher.
  - It is difficult to escape EMF's emitted by fluorescent lights.

- **Water Pollution**

  As discussed in the in the Water chapter: "*protecting water sources"*.

HOLISM – Holistic and Intrinsically Recyclable

The principle of holism looks at things in the context of the whole, seeking to understand the interconnections between the various parts that make up the whole. It is an over-reaching principle and embodies an attempt to embrace all the principles together in a mutually beneficial way. Some of the tools that aid a holistic approach to design are outlined below:

- Holism, like nature, is *cyclical* and not linear. Look at how to encourage the *repair*, *reuse* and *recycling* of elements at every level. This includes not simply the recycling of waste but how to recycle energy, water and all the other materials and resources that a building will consume within its life span.
- Holism tries to understand things over a period of time. Thus it looks at the overall long-term benefits and effects, rather than only the superficial short-term gains. This can be called a *life cycle approach* to design.
- *Everything is relative and needs to be understood in relation to its own specific context.* While one needs to try and follow the various guides to sustainability, it is also important to realize that most rules or recommendations need to be assessed in relation to all the components of the design and that these will vary in every circumstance. Designers thus need to approach every design solution with freshness and open mindedness, flexibility and an ability to continue learning.
- While *diversity* is important to a holistic approach to design, it is less concerned with the quantity of diverse elements, but rather with the number of beneficial connections made between these components.

CONCLUSION

The present state of architecture and development continues to perpetuate the inward spiral of high levels of resource consumption, pollution and wastefulness that have characterized the 20th century. At this present moment in history, humankind has the ability to affect the environment on an unprecedented level. The urgency exists for all to realize that, if we are not part of the solution, then we are part of the problem.

One of the biggest stumbling blocks with Green Design is our present state of 'disconnectedness' from the environment. We are now able to carry out a multitude of tasks from switching on a light bulb to flushing a toilet without ever directly seeing their environmental consequences. Furthermore our present capitalist system encourages the over consumption of resources in its haste to turn short-term profits. Our present attitudes to the use and ownership of land are such that the "owner" feels he or she has all the rights. Thus the land is often torn apart and bled to waste in the short-term interests of private profit.

It is primarily this blindness, coupled with self-interest that is intricately connected to our present state of wastefulness, diminishing resources, and accumulating levels of pollution. Attitudes and laws need to change, so as to foster an attitude of *stewardship* over and above the ownership of land. We need to see ourselves as partners with the land rather than it's dictators. In order to do this; development must begin by reflecting on the totality of its effects throughout it's various *life cycles*. Furthermore, government statutory structures need to think beyond the ability to generate profit and establish mechanisms to better help tie capital to promoting sustainable development. This is possible with such things as tax incentives, disincentives and interest free loans. While this may be beyond many of us, one of the keys for architects and designers to bear in mind is to favour labour-based processes over the industrial ones, which rely on high levels of mechanization and pollution.

Some may say that it is only possible to achieve a truly holistic approach to design and construction once the whole of society has moved in that direction. However, it is vitally important to realize that *Green Architecture* can show a vision, and become an inspiration for what such a society may entail. In trying to move construction to work with the forces of nature, a far greater equity will be possible within society. This will lead to fairer access to resources, better health, improved productivity levels, and decreased running costs, and increased property values, while ensuring that resources and planetary systems are protected for future generations to come.

APPENDICES

APPENDIX A
Construction Framework for the Protection of Water Sources:

- *The Contractor shall not in any way modify or damage streams, rivers or natural water bodies*. This includes:
    - Any physical altering of water bodies, i.e. bulldozing, canalizing etc
    - The dumping of any wastes.
    - Domestic pollution i.e. washing of clothes, vehicles etc
    - Construction activities like mixing cement, washing of equipment, etc.

- *The Contractor will take adequate measures to protect water sources by:*
    - Eliminating, where safe alternatives exist, the use of all polluting materials.
    - Minimizing further use of all hazardous materials.
    - The provision of on-site recycling, and proper sorting of any potential hazardous wastes. Recycling bins and hazardous wastes must be stored in appropriate containers, which must be clearly marked.
    - The proper 'safe' disposal of all hazardous construction wastes by approved waste disposal experts.
    - The demarcation of a buffer zone between construction activities and any natural water bodies, rivers or streams as in accordance with an agreed layout plan.
    - The contractor is to insure that there is adequate provision of on-site ablution facilities and that they are properly maintained.

- *The contractor is to ensure proper storm water management and erosion control by:*
    - Diverting natural runoff around site workings so as to prevent its pollution. This should be done so as not to increase the effects of erosion.
    - The provision of appropriate litter and silt traps.
    - Where storm water has accumulated in workings and needs to be pumped out, it should be disposed of in a manner that is approved by an Environmental Consultant. This means that the Contractor will be responsible for having the water tested in accordance with an Environmental Consultant's requirements to establish whether it is contaminated or not. In the event of the storm water being polluted, it will need specialized handling and disposal.
    - By undertaking to disturb the topsoil and existing natural vegetation as little as possible.
    - Adopting measures to prevent erosion of all bare soil, excavated areas and soil stockpiles shall be implemented in accordance with the specifications of the design team.
    - In the event of any spills of fuels, chemicals or any hazardous substances that occur on the site or that occur during the transport of materials to and from the site, the contractor shall notify the Principle Agent. Clean-up costs shall be for the account of the Contractor.

APPENDIX B

Cradle to Cradle Assessment: Table for Assessing Environmental Impacts

Environmental Issue	**Product Life Cycle**					
	Supply	Production	Distribution	Use	Disposal	Reuse
Waste Soil Contamination Water Contamination Air Contamination Energy Contamination Noise Local Habitat						

(After Ref: 11)

APPENDIX C

Embodied Energy

This is understood by first attempting to measure the *energy investment* of a material by accounting all the fossil fuel energy expended in the processes involved, from the extraction of raw materials to the transport and processing necessary to get a material into its finished state. The table below attempts to explain this:

1 tonne of Aluminium	=	Approx. 126 times 1 tonne of timber.
1 tonne of Steel	=	Approx. 24 times 1 tonne of timber.
1 tonne of Glass	=	Approx. 14 times 1 tonne of timber.
1 tonne of Plastic	=	Approx. 6 times 1 tonne of timber.
1 tonne of Cement	=	Approx. 5 times 1 tonne of timber.
1 tonne of fired Bricks	=	Approx. 4 times 1 tonne of timber.
1 tonne of adobe/raw cob	=	Approx. 0,05 times 1 tonne of timber.

(Ref: 12)

Once the initial energy investment is understood, other factors need to be taken into account such as the materials *relative density*, as this will affect the overall energy component. The total embodied energy can be modified by the *transport* involved (often reflected in the capital cost of a material) as well as the *on-site processes* with materials that are reliant on machines and powered tools.

APPENDIX D
Passive Solar Design

Passive solar design entails the careful placement of a building towards the elements of sun, wind, and earth and clever use of materials, in such a way as to make beneficial connections between the various components creating comfortable internal environments. Such buildings do not generally need external energies for heating or cooling.

Passive solar design employs principles such as:

- Use of 'free" sources of heat i.e. the *sun,* as well as the exhaust heats given off by the occupants, lights, computer systems etc.
- *Local winds* to induce beneficial air currents and promote good natural ventilation.
- Principles of *Thermal Dynamics* such as:
    - The *stack effect* i.e. hot air tends to rise while cold air tends to sink.
    - Air moves from areas of *high pressure* to areas of *low pressure* - cold air will cause a high pressure and hot air will cause a low pressure.
- *Glazing to trap the heat* of the sun.
- Materials of *high thermal mass* (stone, earth, brick, concrete etc) to absorb and store heat.
- Light or dark colours to either reflect or absorb heat and light.
- *Insulating materials* (air, straw, wood, etc) to retain or repel heat.
- *Plants and water,* to moderate any harsh external and internal elements.

Passive solar design may include elements such as:

- Windbreaks.
- Deciduous trees and plants
- Trellises and pergolas
- Sun-shading devices
- Wind scoops
- Solar chimneys
- Unglazed pots for evaporative cooling
- Trombe Walls
- Greenhouses
- Skylights
- Controllable vents

APPENDIX E
Identifying Organic Solvents

Green policy eliminates the use of organic solvents (oil based solvents) altogether. Architects and clients may need to contact the manufacturers of the various products they intend to use. To assist with the identification of various organic solvents, the main groups have been listed below:

Aromatics

- These are sweet smelling and include *toluene, xylene* and *benzene*. Exposure can cause the breakdown of genes and unconsciousness. Benzene is also known to accumulate and damage bone marrow.

Chlorinated hydrocarbons

- These smell sickly and include *chloroform, trichloroethylene, carbon tetrachloride, tetrachloroethane, methylene, chloride, perchloroethylene, trichloroethane* (Genklene and Clorothene) and *trichlorotrifluoroethane*. (Arklone). The first three are commonly associated with various types of liver damage.

Ethers

- These include *diethy ether, cellusove, THF* and *butyl ether.* A familiar smell in hospitals. These affect the liver and kidneys. Also causes wheezing dry coughs and congestion.

Alcohols

- These include *ethanol, methanol, ethylene glycol, IPS and Oxitol*. They affect kidneys and liver. Methanol is extremely dangerous and can lead to blindness and tremors.

Ketones

- These include *Isophorene, MEK, MIBK*, and *Furfural*, which all cause problems with liver and kidney damage, even causing paralysis with the breakdown of nerve ends. A high level of exposure to MEK damages the lungs, followed by coma and death.

(Ref. 12.)

APPENDIX F
Some Potential Sources of Indoor Air Pollution:

- Adhesives (tiles, carpets, wood composites etc)	Formaldehyde, Xylene/toluene, Benzine
- Print machines	Ammonia
- Carpeting	Alcohol's
- Caulking or mastic compounds	Formaldehyde, Xylene/toluene, Benzine & Alcohol's
- Ceiling tiles	Formaldehyde, Xylene/toluene, Benzine & Alcohol's
- Chipboard	Formaldehyde, Xylene/toluene, Benzine & Alcohol's
- Chlorinated tap water	Chloroform
- Cleaning products	Ammonia
- Computer VDU screens	Xylene/toluene
- Fabrics & Draperies	Formaldehyde.
- Floor coverings	Formaldehyde, Xylene/toluene, Benzine & Alcohol's.
- Paints	Formaldehyde, Xylene/toluene, Benzine & Alcohol's.
- Photocopiers	Xylene/toluene, Benzine, Trichloroethylene & Radon.
- Plywood	Formaldehyde.
- Stains and varnishes	Formaldehyde, Xylene/toluene, Benzine & Alcohol's.
- Treated Timber i.e.	Insecticides, fungicides, biocides, VOC's, solvents etc.
- Creosote – 200-300 petroleum compounds	Includes various polyphenols.
- PCP – Pentachlorophenol (banned in UK) solvent	Includes Chlorinated substances, phenols, biocides & carrier (White Spirits).
- TBTO / Lindane – Mix of Tributyl Tin Oxide & Gamma Benzine Hexachloride	Benzene, solvent carrier and biocides.
- CCA – Copper chrome arsenate.	Stable at room temperatures but highly toxic fumes are emitted if burnt.
- Upholstery	Formaldehyde.
- Wall coverings	Xylene/toluene, Benzine & Alcohol's.

(Ref: 12)

APPENDIX G
Bake Out

This is done when it is known that a newly finished building has used materials containing harmful indoor air pollutants. It involves the sealing off of the building and then strongly raising the temperatures for 48 hours. After which the rooms are given a thorough airing. By doing this, the pollutant chemicals are rapidly emitted, reducing their subsequent emissions.

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