Sustainable cities need sustainable buildings

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SUSTAINABLE CITIES NEED SUSTAINABLE BUILDINGS

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ABSTRACT

Sustainable cities require sustainable solutions at all scales and in every sector. One major weak link in attaining sustainable cities is that we currently build unsustainable; some would say increasingly unsustainable, urban buildings. This paper seeks to define what is currently possible in creating sustainable urban buildings and explores the challenges that this would entail.

The paper demonstrates how by utilizing existing techniques and technologies it is possible to design and deliver buildings which have a drastically reduced energy, material and water resource requirements. It explores a range of strategies to enhance life cycle self-sufficiency in urban buildings. These include ways to minimize life-cycle energy load by using natural environmental systems with passive and active energy generation; water conservation strategies; design for durability and disassembly as well as a range of waste minimization strategies.

KEYWORDS

Resource conservation; Sustainable urban buildings; Self-sufficient design

INTRODUCTION

During the last 40 years more of the earth's resources have been expended than in the whole of human history put together and the rate of usage continues to rise (Corson). This rate of increase is fuelled by rising world population, increased demand for resources from developing countries seeking to emulate western society and ever increasing resource demands by developed societies. Resources are finite however and it is already known that supplies of many materials will run out early this century unless current trends are reversed (Corson). It is obvious that with a rapidly rising proportion of the world's population living and working within our cities that an ever increasing proportion of our resources are consumed in our cities. Indeed cities have always taken a disproportionately high percentage of available resources per capita due to the relative sophistication of their buildings and infrastructure, and their inability to provide their own food.

Calls for our cities to be more sustainable grow louder by the day. If we are to seriously address this issue however we must consider how to make our urban buildings sustainable, as these constitute the major part of the human intervention in the city. During the last 50 years, buildings in general and large urban buildings in particular, have become significantly less not more durable and much more resource consumptive (Storey 1999). Most have been designed on the presumption of a never-ending supply of new materials and inexhaustible sources of energy. Such assumptions are now seen to be untenable. There is a multiplicity of factors involved in creating truly sustainable buildings (Norton). In this paper the focus is on resource conservation issues and in particular on energy, materials and water conservation. By minimizing the use of resources in our urban buildings we can go a long way to making our city buildings and so our cities more sustainable.

ENERGY

A substantial effort has been made by many international organizations to make buildings more energy efficient. In most cases these ideas focus on reducing operating energy requirements. In the short term we should perhaps seek to balance operational energy requirements by energy inputs from a building's integral sustainable energy generating sources. While this is certainly a step in the right direction it is only a step. In the longer term we should perhaps be aiming to make our city buildings at least energy neutral over their whole lifespan and in the long term be considering our city buildings as net providers of energy. To achieve each level of energy sustainability a designer would need to focus on three strategies; minimize energy requirements; maximize passive energy generation and top up any shortfall using active energy generation systems. Obviously the more ambitious we get in terms of the desired level of sustainability we aim to achieve the greater the active element of generation is likely to become.

Minimizing Energy Requirements.

If we seek to balance the operating energy requirements with energy generation then it is important to minimize the operating energy requirements and the design features of the building become important. Features such as orientation, shape, glazing, shading, thermal insulation etc. can all be used to minimize operational energy needs and can also affect passive energy generation. If we wish to produce buildings which are energy neutral during their lifespan then the total energy debt, which consists of the total lifecycle embodied energy plus the total operating energy needs to be balanced by total passive and active energy generation in the building. Therefore material selection and lifespan of the building also become significant issues. The lower the lifecycle embodied energy and the longer the lifespan of the building the lower the annual 'repayment' rate and the easier it is to attain.

Deriving lifecycle embodied energy figures and including them at design stage is quite complex (Baird 1994) despite the good information on the topic available in New Zealand (Alcorn). A simple checklist would be required if embodied energy were to be incorporated at the initial design stage of a building. The establishment of target embodied energy intensities for different building types would be very useful and would encourage the wider use of embodied energy calculations. If all materials were required to carry a factory gate embodied energy figure this would also be helpful. Most manufacturers have these figures but do not choose to issue them. Their release would drastically improve the accuracy of embodied energy calculations.

Natural Systems of Climate Control

Whole volumes have been written about design for energy conservation and it is not the intention of this paper to reiterate that information. In the last ten years or so dramatic advances have been made in the use of natural climate control systems, which can drastically reduce the amount of imported energy required in buildings and we are now seeing built examples of such buildings all around the world.

Ventilation Systems

Wind and stack effects have been used since time immemorial to ventilate buildings in a wide range of climatic regions. The advent of mechanical systems during the course of the twentieth century halted the further development of such natural systems. However, there has been a resurgence of interest over the last decade or so, with a significant number of large buildings designed for natural ventilation.

Short Ford and Associate's well documented Queen's Building at de Montfort University, Leicester (Blennerhassett) was a pioneer in terms of the use of stack effect to ventilate classrooms and lecture theatres. More recent examples include Mitchell Giurgola Thorp Associates' Red Centre at the University of New South Wales in Sydney, and Abhikram's Torrent Research Centre in Ahmedabad. The former (Cantrill) uses a multiplicity of vertical ducts, each one connected to a teaching space and terminating in a wind driven long volume turbine well above roof level, to exhaust the air. For the latter case, in which Short Ford Associates were involved as consultants, centrally placed towers of relatively large cross-section act as air intakes, while smaller towers on the perimeter act as air outlets. The motive force (a downdraft in this case) is supplied by the cooling effect of a fine mist of water sprayed in at the top of the larger centrally placed towers.

While a number of buildings have combined wind and stack effects in various ways, depending on the local climatic conditions, building height, exposure and so on, a few have deliberately set out to maximise the potential of the wind. Arguably the most expressive of this intent is Hamzah and Yeang's Menara UMNO in Penang (Hamzah). There, sets of vertical wing walls are used to capture and direct the predominant winds into the various floors of the building via balcony openings. In the case of Meiji University's Liberty Tower in Tokyo, a Nikken Sekkei design (Ikaga), a wind floor on the 18th level serves as the exhaust point for the natural ventilation system, the intakes for which are on the perimeter of each floor.

Heating and Cooling Systems

In general terms, there has been a trend over the last few years towards mixed-mode systems of heating and cooling, as well as ventilation; typically, when the outside temperatures and wind speeds are within a suitable range, the mechanical ventilation system is switched off and the building, having been designed appropriately, operates in natural ventilation mode. The mechanical systems are brought on only under extreme design conditions, in mid-winter or mid-summer, say, natural systems being designed to cope with the more moderate conditions of spring or autumn. Appropriate building orientation, together with well thought out disposition of 'glass, mass, and insulation', the principles of which need no repetition here, serve to extend the period during which natural systems can operate satisfactorily.

Further gains in this direction can be made, for example, by the use of rock storage for cooling as in Pearce Partnership's Harare International School (Goodchild) or by ground tempering the fresh air intake as in Nikken Sekkei's Konami Training Center at Mount Nasu, north of Tokyo (Ray-Jones); though of course these types of systems tend to depend on some mechanical ventilation equipment for their successful operation. Another option is to utilise a double façade arrangement, as at Webler and Geissler's Gotz Headquarters in Wurzburg (Webler) where warm air from the sunny side of the building can be circulated to the cooler facades in winter.

Daylighting Systems

There must be few people remaining who are not aware of the high electricity consumption of artificial lighting systems and their attendant contribution to the cooling load of many city centre buildings. While there may be little that can be done as regards night-time use, other than ensuring the efficacy of the artificial lighting systems installed, there can be no excuse for building designs where the perimeter spaces require artificial lighting during the day-time.

The design of several recent buildings indicates the deliberate attempts that are being made to break out of what seemed to have become a dependence on artificial lighting, even during daylight hours. This is evident at Nikken Sekkei's Earth Port building in Yokohama (Ray-Jones) where the slope of the North facing atrium glazing is angled to prevent direct sun penetration, but allow daylight from more than half the sky hemisphere. The design also enables double sided natural lighting to the office spaces, via three-quarter height glazed screens on the atrium side and light-shelved/sun-shaded windows on the other (south) side. The 34-storey RWE Headquarters building in Essen (Briegleb) provides another example of an office tower with full height glazing and relatively shallow office spaces with more than adequate daylight, together with a comprehensive set of controls for the artificial lighting system, should it be required. This building also features a double façade, which is designed to enable natural ventilation under moderate temperature and wind conditions.

Current research (see, for example, Greenup and Edmonds, 2000) aims to develop shading technologies that can redirect sunlight deeper into perimeter spaces than more conventional light shelves, and pipe daylight from the façade into deep plan office buildings. Glass shading devices are becoming increasingly popular in this respect. These permit some daylight penetration while they only minimally obstruct views out of the building. They can incorporate prismatic or holographic devices to redirect sunlight into the interior of the building, as is the case with the Suva Building in Basle. Translucent insulations too have undergone radical development over the last few years. These usually consist of aligned glass, mirror coated plastic tubes or uncoloured fibreglass held between two sheets of glass or plastic. These insulations can give similar thermal resistance figures to opaque insulated walls while delivering up to 60% daylight (Compagno) without increasing energy loads.

Energy Efficient Equipment

The selection and use of energy efficient computers, printers, copiers and other office equipment can make substantial savings not only in direct energy requirements but also in reductions to cooling loads. New generations of cold-fusing and ion-dispersion imaging devices for printers, copiers and faxes, combined with improved power management systems and low power monitors for computers all promise major savings in energy demand for office equipment. The way that a building is operated in terms of maintaining optimum operating efficiencies of equipment, development and operation of energy management for both equipment and personnel and the use of building energy management systems can all make significant savings in energy demand. The human factor becomes particularly critical when all the other energy demand elements are minimised. Monitoring and targeting software programmes have proved to be particularly effective in identifying areas of energy waste that can often be remedied by low cost solutions (CAE). Energy saving incentive schemes seem generally to work better with building users than automatic control unless the systems are very effective and can go totally unnoticed by users (CAE).

Sustainable Energy Generation Systems

While active energy generation is usually considerably more resource intensive than passive systems the power sources, sun and wind driven systems are sustainable. Most modern generating equipment will produce many times the embodied energy required to make the equipment initially and operate it.

Solar-Thermal Systems

While by no means universally applied, even in countries with abundant solar energy, this technology is comparatively well developed, with a range of collector types and standard storage and distribution systems. While the predominant application appears to be in hot water service systems for domestic buildings, they are used in commercial buildings too, and for space heating applications in some circumstances. This is the case at Pearce Partnership's Eastgate Centre (Slessor), a large commercial development in Harare. The collectors must be oriented appropriately for the latitude of the building and the particular application, and this can have some design implications. However, it is difficult to believe that this is the major impediment to their more widespread application on city buildings. Clearly, many potential clients and designers remain unaware or unconvinced of the benefits of such systems

Photovoltaic Systems

These are nowhere nearly as well established as solar-thermal systems, and are still far from economical, particularly for city building applications. However, their inherent promise and potential has meant that the development of photovoltaic systems has been pursued vigorously over the last decade, leading to significant improvements in their performance – resulting in a doubling of efficiency and a halving of costs according to a recent report from Europe (European Commission).

While costs may not have reached a level where this would be the preferred energy generation option, there are an increasing number of major installations. Several of these are in Germany, ranging from the modest 210kW installation on the roof of Kiessler and Partner's Sciencepark building in Gelsenkirchen (Dawson) which supplies around 190MW, about 15 per cent of its energy requirement, to the grid; up to the 1000+ kW arrays on the roofs large buildings like the new Trade Fair building in Munich and the Further Education Complex at Herne-Sodingen. Paradoxically, given their relative durations of sunshine, it has taken rather longer for such developments to be pursued in Australia. However, a significant developer-driven project is now taking place in Brisbane (Wren). A 20-storey building is under construction that has its entire (overhanging) roof structure made of photovoltaic panels. With an installed capacity of 80kW it is expected to produce some 140MW per year, around six per cent of the building's energy requirements, at a cost of only around three times that of current grid prices.

With pioneering projects of these types being pursued on such a scale, it is difficult not to be swept along by the continued enthusiasm and anticipation that this form of energy generation will become economical sooner rather than later – certainly, they already appear to have more than enough capacity to power the currently available natural systems of internal environmental control.

Wind Turbine Systems

Some architects have been actively exploring the possibilities of incorporating wind turbines into their designs (eg, Burdett, 1995, Battle McCarthy, 1999), while others have been conducting research and development into the implications of the use of various kinds of turbine for the design of buildings to enhance their mutual performance (Taylor). One of the most clearly articulated and integrated project designs remains Richard Rogers, Turbine Tower for Tokyo designed in 1992. While there are no built examples of significance to report as yet, they should not be long in coming. Clearly, the overall form and orientation of the building are critical to the performance of the wind turbines associated with it. Power outputs of tens to hundreds of kilowatts are claimed to be achievable. Despite the variability of the wind, it is no less predictable than sunshine, and has the decided advantage that it is available at night. Sun and wind work well together as a combined system of power generation

WATER

Water is an increasingly precious and scarce resource. In rural areas in many countries buildings are used to collect and store rainwater for their occupants. Sewage disposal is also carried out on site, and with the rapid development of treatment systems in the last ten years on-site treatment is now a very real option. Michael Mobbs in his book *Sustainable House* (Mobbs) demonstrated how these systems could be readily applied in the urban situation. Many city buildings could be made virtually self sufficient in water and require very little by way of sewerage connections by using roof top rainwater collection and filtration systems, waterless toilets and urinals, low volume taps and the advanced sewerage treatment systems now available. Many Local Authorities however continue to resist any such moves because of their lingering concerns about health.

MATERIALS

Concurrent with the depletion of fossil fuels is the rapid depletion of other material resources. At least 3 billon tonnes of materials are used in buildings each year, which is equivalent to about 40% of total global material flows (Roodman). Building material waste is estimated to be about 2 billion tonnes per year (Roodman). All but a tiny fraction of the materials used in construction are from virgin sources. Requirements are rising as supplies become depleted. A conservative estimate is that we will require between three and four times the amount of building materials we currently use by the year 2020 (Corson). The question we need to ask is from where do we get all these extra materials? We certainly cannot simply assume that virgin sources will continue to be available. Take aluminium as an example. In 1990 it was estimated that there was 50-100 years supply of aluminium ore left in the world, at the then current production figures; but between 1950and 1987 production was not constant, it rose tenfold (Corson). Demand continues to rise but even extrapolating these figures, somewhere between 2010 and 2020 we are going to run out of aluminium ore.

It is clear that we must of necessity reduce the amount of resources we use to construct our buildings. The question is how? No single strategy will be enough, we must use all and every means to slow down if not reverse the depletion of material resources in the built environment.

Reduce

If we can design our buildings for a long useful life of centuries rather than decades, build well once rather than 5 or 10 times poorly then the resource savings are tremendous. We used to build that way so we know that it is possible. Everyone gains in the long term by adopting this strategy, building owners, users and the community, as well as the planet (Storey 1996). This is so even if some extra resources are incorporated into the building to ensure its longevity. Perdurable, low maintenance materials need to be employed for all those parts of the building which are expected to remain essentially unaltered, foundations, structure and probably façade, roof and floor. Some modest structural redundancy might also be incorporated to facilitate future extension. The building would of necessity be designed to be highly adaptable to changing circumstances and uses. Such buildings can also be designed to be disassembled at the end of their lives to reutilise precious resources. Long life buildings must be designed to be beautiful and desirable so that users would continue to find them appealing.

Short life buildings are today's commercial norm. Generally such buildings are conceived as consumer 'durables' and thought about in terms of short term financial returns to the to the building developer. They tend to have a designated life of about 50 years. While this does not necessarily mean that these buildings are built to regulatory minimas, too often this is the reality. Currently even within a commercial building's brief lifespan many buildings undergo major reconstruction. In effect many such buildings have been virtually rebuilt at least once even in their brief existence (Storey 1996).

While there are great resource benefits to be gained by returning to perdurable construction the most likely scenario seems to be an increase rather than a decrease in the percentage of short life city buildings at least for the immediate future. What then can we do to minimise resource usage in such a situation? We must design to maintain maximum adaptability and flexibility to ensure maximum usefulness of these buildings during their lifespan. Brand identifies six shearing planes of change, site, structure, skin, services, space plan, (interior division) and stuff (furniture and fittings) which need to be kept separate because they change at different rates. Keeping them separate facilitates change and minimises disruption to other layers of the building (Brand). The effect is to reduce resource use. All layers should be designed to facilitate reuse and recycling by designing for disassembly.

We should not permit the single use and abandonment of building sites. Land is too valuable a resource to be used and 'thrown away'. Regulations must be set in place to guard land from this form of mistreatment. Structures, including foundations generally have a much greater lifespan than other components of a building. Often a very significant proportion of the onsite time and cost is involved in work below ground; therefore money, time and resources can be saved by re-utilisation of the existing structure even if it has to be modified.

The materials used in building facades usually have a life far in excess of the 15 years minimum demanded in New Zealand, usually closer to 50 years or more. Failures tend to occur not in the materials themselves but in the fixings or joints. It is perfectly possible to design joints and fixings that will last for the anticipated life of the building but this does require more effort and care in their design and making. The general adoption of more durable, reliable, low maintenance jointing and fixing systems would save a great deal of resources at very little cost. Very few building owners want to contemplate the total recladding of their buildings after 15 years anyway. Therefore a realistic but also resource sensitive strategy might be to legislate to require exterior elements including, joints and fixings, to have the same life as the life of the building or 50 years, whichever is the shorter.

Services machinery will be minimised by using natural climate control systems. One interesting development in recent times has been that some manufacturers are now selling a service instead of equipment. A company might for instance contract to maintain the temperature within the building within certain agreed parameters for a fee. It then makes sense for the service provider to install highly durable, trouble free equipment, easy to repair, upgrade and even periodically remanufacture to retain customer satisfaction and maximise its profit. This scenario also however has the effect of minimising resource use and everyone comes out a winner. The same methodology can be applied to any equipment furniture and fittings. A number of carpet manufacturers for instance in the USA operate on the same basis, some even recycling worn out carpet as feedstock for the manufacture of new carpet.

The elements of interior division partitions, floors and ceilings are often subject to substantial and unpredictable change during the life of the building. There is a tendency today to go for cheap, temporary, inflexible interior fit outs because it is recognised that a great deal of money can be invested in unused flexibility. This however tends to mean in practice that considerable amounts of materials are thrown out at quite frequent intervals. If standard size components were used and put together using reversible fixings then much of the material could be recovered for reuse or sold on to defray costs and minimise resource wastage. In many instances the use of standard sheets and simple reversible fixing systems would enable incremental reconfiguration of the interior division elements without buying in new material at all. The other requirement for a resource efficient reconfiguration is a simple way to relocate services. Currently this can often be the most destructive part of a reconfiguration. By using natural environmental systems, and a simple modular access floor system to accommodate IT and power systems much of this waste also can be obviated.

Reuse

Fundamentally the greater the level of reuse attainable in a given situation the more material resources are saved. If we can reuse buildings, then this is almost always the most resource efficient solution to providing accommodation, even if they require considerable upgrading. If we cannot reuse the building then we should aim to reuse as much of the building fabric in as large pieces as possible i.e. whole walls or ceilings or facades rather than just doors or doorknobs. Quite often it is possible to weave old and new together to achieve both aesthetic and resource benefits.

When designing new buildings we should think not only of initial assembly but also of ultimate disassembly. Given the very high levels of prefabrication now employed in buildings this should neither be too difficult nor too onerous. Unfortunately there is no current incentive for anyone in the building industry to do this. To initiate this fundamental change in the way we approach this assembly/disassembly cycle would almost certainly require government intervention, as any financial benefits due to material recovery are too remote and uncertain for building commissioners to entertain. Possibly the way ahead is to require designers to demonstrate reversibility at building consent stage despite the howls of protest about compliance costs that would usher in such a requirement.

Recycling

Every building contains enormous amounts of potentially recyclable materials, yet most are thrown away, because recovery is not regarded as economically feasible in many situations. Often this is because materials are so locked together that taking them apart is simply impossible. Composite components for instance, which fuse together several materials can often be just as easily and often with considerable benefit be made using separated layers of material, making them far easier to recycle. We can learn a great deal from the car industry concerning recycling. Some car manufacturers have learnt how to recycle more than 90% of the materials in their cars but they have only done so because of government regulation. We need much more recycling in the building industry so why not regulate for this? Some building regulations constrain the use of reused and recycled materials and these regulations should be reviewed to ensure that any constraints imposed are still valid and based on fact rather than on ignorance or prejudice.

Part of the recycling problem is lack of markets for recycled materials and the public perception that they are inferior. To counter this we should actively seek to maximize the use of recycled materials or materials with high recycled content in our buildings. In the British Building Research Establishment's Advanced Office Building demonstration project the intention was to source a proportion of the material for the new building from the building it replaced (Collins). While this did not happen in practice it is still a very worthwhile and intriguing idea. It would be difficult to get it to work within the site boundaries in most city buildings where space is usually at a premium, but delivery of demolition materials to local production plants instead of virgin raw materials makes excellent resource sense, especially for high bulk materials such as concrete.

Recovery

Straw, rubber tyres, mining tailings, fly ash and many other so called waste materials are currently used as raw materials for building products. The use of waste products as sources of raw materials for the building industry could however be much more widely practiced as a method of resource conservation. The key here is to ensure a secure, abundant, cheap waste with predictable performance characteristics. There is a big future for the use of waste products in this way and currently we are only scratching the surface. We should at least be able to use the 2 billion tonnes of building materials we throw away each year in this way.

Waste minimization remains a significant issue it the building industry. No one sees it as their problem. Architects could make a major contribution to waste reduction by designing to use standard size materials for instance, but almost never do so. Builders and building sub-contractors can organize work areas to keep offcuts at hand to utilize as infill pieces but rarely do. Separation at source is generally recognized as a key factor in successful recycling yet on most building sites this is not carried out and mixed waste is not so easy to recycle and so seldom is. And so on. Perhaps someday the landfills will be mined for their bounty of materials but that time is not yet. Regulation of landfills to separate out various categories of materials would hasten the process. Perhaps even in the short term such separated materials could become the gathering point, the source for materials made from waste. High charges for unseparated waste would be one way of turning this problem around, but this would only be effective if all landfills were required to operate with the same pricing regime.

CONCLUSION

As we look forward into the new millennium the sustainability of many of the world's cities is the subject to increasing speculation and doubt. Their ecological footprints, the amount of land and resources required to support a cities, are coalescing. Already we know that, if all city populations used resources at the same rate as the average North American then we would need an additional planet the size of the Earth to supply their requirements (Wackernagel). This is an obviously impossible and patently unsustainable situation. We must therefore devise ways to reduce our resource use. We could make our cities significantly more sustainable by making our urban buildings more self-sufficient and by adopting comprehensive closed loop resource use practices. While almost all self-sufficient buildings so far constructed are domestic it is increasingly feasible to think in terms of self-sufficiency in larger and more complex building forms. Much of the technology is in place, as illustrated in the foregoing sections of this paper, and year by year self-sufficiency becomes more economically viable, as well as making resource sense.

In energy terms the obvious short terms energy objective should be to make new buildings energy self-sufficient in operation. This is quite ambitious by current day standards but by minimizing necessary energy input requirements, maximizing passive energy generation and making up the shortfall using active renewable power generation, using currently available technologies as described elsewhere in this paper a close approximation of energy self-sufficiency may be achieved. With the advent of new technologies such as metallic energy collecting dyes, which do the same job as PV cells but at much higher conversion rates, and phase change energy storage systems self-sufficiency becomes even more attainable. Governments could encourage such development by discriminating in favour of renewable energy generation in their subsidies and tax breaks in the same way as they have previously done for fossil fuels. This could be increasingly attractive to governments faced with having to 'make good' on their CO2 reduction promises.

A medium term goal might be to design buildings that are energy neutral over their lifetimes. These buildings would have to generate sufficient energy over and above their operational energy requirements to 'pay back' the lifecycle-embodied energy of the materials incorporated into the building. If such a requirement were to be incorporated into law it would accelerate energy self-sufficiency enormously. Even if the initial legal requirement were defined as a fraction of the total lifecycle energy load it would encourage development of more self-sufficient energy designs and technologies. It might also encourage the design of more perdurable buildings, and the greater reuse of buildings, as in both cases the annual energy payback would be comparatively low compared with more ephemeral buildings designs, and would result in substantial additional resource savings.

The ultimate goal would of course be to design urban buildings that generate enough surplus energy from renewable sources to supply energy to older buildings and even city transport systems as well as themselves, so that the whole city would be ultimately energy self-sustaining. This may take rather longer than the preceding two scenarios to achieve. Given the expected substantial increases in fossil fuel costs beyond 2010, the increasing pressure on governments to reduce CO2 emissions, advances in renewable power generation technology, the increased effectiveness of natural climate control and passive energy collection design, the short term and medium term objectives outlined appear increasingly attainable. This is particularly true in such benign climatic conditions as those found in many parts of New Zealand.

Considerable effort has been expended to improve energy conservation in many countries and while there is still a long way to go there are encouraging signs, at least in relation to improving the operational energy characteristics of buildings. The situation with regard to water and material conservation is much bleaker.

Water is an increasingly precious resource. Even in New Zealand there have been significant water shortages in several areas of the country, including Auckland. In both older and new cities centralized water and drainage services are very resource intensive to supply and maintain and are sometimes stretched to breaking point and beyond. Yet the technology is available to enable many urban buildings to be essentially self-sufficient in both water and water treatment services and this would be a desirable objective in terms of producing more sustainable cities.

There seems as yet little realization of the serious depletion of the planet's material resources that has occurred over the last fifty years or so. Government action seems largely to be focused in minimizing landfill waste. This certainly can have incidental benefits in terms of encouraging recycling but fails to address the much wider problem of resource depletion. Reusing rather than replacing buildings is generally the most resource effective strategy to provide accommodation, especially if such buildings are redeveloped to incorporate resource conservation strategies. In New Zealand the last ten years has seen a good deal of building reuse but little eco-renovation. There remains a very strong focus on low initial cost even in user commissioned buildings. This militates against a return to more perdurable practices where life cycle costs tend to be lower but initial costs are higher. Yet the adoption of perdurable design practices would result in considerable resource savings in the long term. If the short life buildings, which are commonly built today, were built for disassembly, then it would be much easier to reuse and recycle components and materials from such buildings when they were demolished, making them considerably more resource efficient than the current generation of such buildings.

The greatly increased utilization of recycled building products and materials, together with the comprehensive utilization of agricultural and manufacturing wastes as raw materials for the production of building materials, combined with a systematic effort to privilege the use of renewable materials and a determined effort to minimize the use of virgin, non-renewable materials would also have a very big impact on resource depletion.

If all these measures were adopted then the resource situation in the building industry could be totally transformed. The way ahead has to be on a whole series of fronts. Manufacturing companies and agricultural industries must be made more aware of the potential of their wastes as raw materials for other industries and encouraged to adopt the zero waste philosophies of such companies as 3M. Governments, public and professionals must all be made much more resource conscious. Recycling initiatives by public and private organizations must be encouraged and nurtured especially during their gestation period. Governments as the declared guardians of their nation's well being are the only organizations who have the power, resources and the long term vision to force a significant shift towards resource efficient building practices. A judicious application of 'sticks and carrots' by governments could utterly change the resource situation and make our cities much more sustainable. To take just one example, if all government building projects were required to incorporate the resource efficiency measures outlined in relation to energy, water and materials, then rapid progress would be made on all fronts. Such requirements might initially be fairly simple to comply with but be made more demanding over time to encourage industry lead research and development programmes.

There seems to be a curious reluctance by governments to take the notion of holistic resource conservation in the building industry seriously, yet this is one of the keys to making our urban buildings and consequently our cities more sustainable. Governments cannot sit back and depend on market forces to preserve the planet's resource base. Such a 'hands off' policy did not work with the depletion of the world's fisheries and it will not work with resource depletion either. We need action now, preferably at an international level but certainly at a national level. Legislation is required if the necessary rapid progress is to be made in this area. What we do now will have major effect on the sustainability of our cities for at least the century ahead. Resource depletion is a reality of the twenty first century, like climate change, and the longer we avoid it as an issue, the harder it will be to mitigate its effects. We are building the future now but we are not building for a sustainable future.

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