Sustainable Urban Living – a Perth perspective

William Grace
GHD Pty Ltd – Western Australia.

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ABSTRACT

The greater Perth area is one of the fastest growing urban regions in Australia. The existing residential sector is straining waste supply and energy infrastructure, and giving rise to increasing stress on the environment. The huge predicted urban growth demands new approaches to housing, the water supply infrastructure and waste management practices if Perth is to progress towards sustainability. The measures discussed for housing include reducing the size of new housing; the adoption of passive solar design as a principle for all new housing and housing retro-fits; reducing the embodied energy per unit floor area; and adopting solar hot water as a standard. The potential for dramatic reductions in scheme water use arising from water efficient fixtures, rainwater tanks and recycling are identified as appropriate responses to the critical water supply issues facing Perth. Opportunities for additional domestic waste recovery in the areas of mixed solid waste and construction and demolition waste are discussed.

1. INTRODUCTION

Looking forward to 2031 the projected total population of Perth and environs will be some 2.22 million, or a 52 per cent increase over 2001. Most of these residents in 2031 will be new to the area – about 260,000 have yet to be born and roughly 500 000 will migrate from other parts of the state, Australia and overseas. On the basis of these population projections there may be a need for an additional 375,000 new homes in the Perth and Peel metropolitan area (Western Australian Planning Commission 2004). An increasingly affluent and resource-hungry urban lifestyle, combined with this rapid population growth is leading to unsustainable stresses on the environment, and challenging business-as-usual approaches to urban development and re-development.

With rainfall down 20% and streamflows down 65% from 1911-1975 averages, water is the most publicised aspect of Perth's sustainability challenge. In order to meet the growing demand from population growth, the Water Corporation has relied increasingly on the use of groundwater, which now supplies nearly 65% of Perth's scheme water. This has brought its own problems. Perth's waterways as well as the groundwater-dependent ecosystems are suffering ecological decline resulting partly from this extraction – much of it inappropriately used for non-potable purposes such as domestic and market gardens and municipal parks. In the process of using such large quantities of water, Perth also generates large amounts of wastewater from households. About 280 million litres of wastewater per day (more than 100 billion litres per year) is generated in Perth, the bulk of which is treated to secondary standards and disposed of to the ocean.

In addition to the ecological impacts of reduced water availability, Perth's waterways are suffering from excessive nutrient inputs from leaching of fertilisers applied to the city's 500,000 residential gardens and municipal parks. Such leaching occurs because of Perth's extremely poor sandy soils that have very low organic matter and hence minimal capacity to bind nutrients and retain water.

In Perth, as elsewhere in Australia, houses are increasing in size (from an average of 130 sq m in 1971 to 212 in 1999) (Burbidge 2000) while the number of occupants is falling. This fact, coupled with the increasing use of air-conditioning, means the energy embodied in the construction and consumed in operation is steadily growing.

This population pressure, and increasingly wasteful habits are also causing serious waste problems. About 2.5 million tonnes of municipal solid waste is deposited as landfill in Perth per year. Most of this waste is currently hauled to a landfill site about 50 km away.

The wasteful and inefficient exploitation of finite natural resources facing Perth, is typical of cities and urban settlements worldwide. Our current ‘once through’ approach to exploiting natural resources, and treating and disposing of resultant household wastes to the environment is widely recognised as being unsustainable, and from the community’s perspective, no longer acceptable. As a result, Governments and communities are looking creatively at ways of improving resource efficiency. The Western Australian Government has recently turned its attention to changing society’s paradigm of development, which is based on overexploitation and wasting of finite natural resources at a growing cost to the environment and society. Government has embraced the goal of sustainable urban development and set tangible, challenging requirements:

- The State Water Strategy (released in 2002) contains targets for reduction of use of schemewater, and 20% reuse of treated wastewater be achieved by 2012;
- The Strategic Vision for Waste Management in Western Australia (released in 2004) is aimed at achieving zero waste;
- The State Sustainability Strategy for Western Australia (2003) targets more innovative and efficient management of resources and wastes in the urban context, and the need to maximise the recovery and recycling of resources from waste;
- The recently released State Greenhouse Strategy includes action areas including reducing greenhouse emissions from households (currently 15 tonnes per annum or 10% of the State’s emissions) and progressing a strategy for renewable energy sources.

This paper describes the author’s views on the various measures necessary to operationalise these strategies for improving the sustainability of Perth, focusing on the following, and the inter-relationships between them:

- The design of new housing and retrofit of existing housing
- Developing integrated water cycle strategies for greenfield and brownfield urban areas.
- The opportunities for resource recovery and reuse of municipal solid wastes

2. HOUSING

The residential sector is responsible for producing 63 million tonnes CO_2–e of greenhouse gases per annum - around 20% of Australia’s total emissions (Wilkenfeld, 2003). The sector shows a 23% increase over the period 1990-95, the largest absolute increase in sectoral emissions over that period. These emissions represent some 9 tonnes CO_2–e per dwelling per annum. In addition to these emissions that arise from every day energy use, the energy embodied in the 120,000 new houses added to the stock each year add another 6 million tonnes CO_2–e.

Addressing these emissions should be an urgent priority for governments around the country, particularly given the generally poor efficiencies of the existing housing stock. The key opportunities for improvements in the Perth region are:

- Reducing the size of new housing to suit the demographic profile of modern Australia;
- The adoption of passive solar design as a principle for all new housing and housing retro-fits;
- Reducing the material intensity, and hence embodied energy per unit floor area;

- Adopting solar hot water as a standard;

2.1 House Sizes

The average number of occupants in Australian households has been dropping steadily for many years. From 1990 to 2001 the number dropped from 2.8 to 2.6 people across Australia and the figures are similar for Perth. In the same period, the size of housing increased by some 30 m^2 to an average of around 210m^2 (Burbidge 2003). This represents an increase in housing size of some 25% per person over the decade to 2001.

A cursory glance at the weekend papers in Perth indicates that houses with 4 to 5 bedrooms plus separate lounge, family rooms and theatres are increasingly common. The author's own private anecdotal survey reveals that a significant percentage of the rooms in such houses are unoccupied for most of the time. Notwithstanding the implications for energy efficiency and greenhouse emissions, there must be serious questions about the quality of investment in such houses over the long term given that 30% of households in Perth now house only couples or individuals (up from 25% in 1991).

Reducing the size of new housing to suit the real needs of families and individuals, now and in the future would have many benefits including housing affordability, maintenance of housing values and energy efficiency (embodied and operational).

2.2 Passive Solar Design

Perth has an almost perfect climate for passive solar housing. Our winters are mild, and cold nights are typically followed by clear warm days with excellent solar heating potential. When the weather is cloudy and wet, the night-time temperatures are higher, offsetting the reduction in solar gains the following day. In the summer-time, the prevailing cooling breezes come from the south-west which facilitates cross-ventilation in houses of 1 to 2 rooms depth. It is only on the relatively rare occasions that a heat wave of several days occurs that purely passive measures fail to maintain adequate levels of thermal comfort. The additional benefit of house design that facilitates solar access is that high levels of natural light improve the ambience of the spaces, and further reduce energy demand.

The author has designed dwellings of several types that perform very well without air-conditioning and with minimal space heating. Although design of such housing is straightforward, the conventional designs produced by mass–market project house builders generally perform poorly, and require air-conditioning to maintain adequate levels of thermal comfort. Although the housing industry has made a start in improving awareness and capability through the Housing Industry Association's Greensmart program[1], a much more rapid take up is necessary to ensure that energy efficient design is the basis of all new housing.

Much can also be done to improve the energy efficiency of existing housing. As Perth has a preponderance of cavity brick construction, there is generally sufficient internal thermal mass to form a basis for improving passive performance. Although solar orientation is problematical for many houses, certain measures can still be taken that will significantly improve passive performance, including:

- Insulation of wall cavities and roof spaces;
- Internal curtain / blind systems with insulating properties;
- External shading devices that promote solar access in winter but limit it in summer;
- Ventilation of roof spaces in the summer-time;
- Internal modifications to promote cross-ventilation, particularly in the north-south direction;

2.3 Material Intensity

Although designers are presently limited to selecting existing products and materials, a couple of immediate options could be pursued that would have significant impact.

As noted above, Perth has predominantly cavity brick construction for external walls. This adds considerable material intensity / embodied energy and achieves poor overall insulation properties (overall R-value of approximately 0.5-0.6). While there are thermal mass benefits in retaining the internal leaf as masonry construction, there is a strong case for moving away from masonry as the external leaf, the so-called “reverse brick veneer” solution. While the exact greenhouse profile will depend on the type of material, in most cases the use of lightweight external cladding systems will both reduce embodied energy and facilitate more effective insulation of the building envelope.

The other perennial of Perth housing construction is the concrete floor slab. Again there are benefits in terms of internal thermal mass, but dis-benefits from the material intensity / embodied energy in using concrete. The use of supplementary cementitious materials such as fly ash, blast furnace slag and silica fume in concrete is widespread in the infrastructure sector, where these materials are used to enhance the thermal and durability performance of concrete. The cement fraction of concrete contributes only about 15% of the mass but about 90% of the embodied energy. Accordingly the replacement of cement with such materials has a significant impact on the embodied energy of concrete.

2.4 Solar Hot Water Systems

Some 30% of the energy consumed in the average house is for heating water. With 7.8 daily average sunshine hours, the use of solar hot water is ideally suited to Perth. Gas boosted solar hot water systems are estimated to have only 25 % of the annual energy demand (and operating cost) of a similar capacity 5 star efficient gas storage system.

With the rebate systems in place, we should be moving rapidly to the adoption of solar hot water heating as a standard practice in new houses, and encouraging take-up in existing houses.

The available rebates are:
- Gas-boosted for any home: $600
- Electricity-boosted for new homes only: $300
- First homeowners receive an additional $200
- Systems installed in off-grid areas receive an additional $200
- One panel solar hot water systems receive $200 less

This rebate is in addition to the Federal Government's RECs scheme (up to $1,200).

2.5 Energy Efficient Appliances

Some 27% of household energy is consumed powering appliances, with more that half of this in refrigeration. The Energy Rating Scheme now has made significant impact in assisting consumers determine the greenhouse benefits in selecting energy efficient appliances. A broader take up would have a major impact on household emissions. For example a 6 star 360 litre fridge has around a third of the emissions of a 3 star fridge. Modern fluorescent bulbs use only about a quarter of the energy of incandescent bulbs.

2.6 Greenhouse Benefits

The adoption of the measures described above would have a dramatic impact on greenhouse emissions in the residential sector, as illustrated in Table 1.

In new housing, the cumulative impact would result in around 40% reductions in energy consumption of the household and over 50% in terms of greenhouse emissions (due to the mix of electricity and gas).

The benefits of retrofitting existing dwellings is likely to be much more variable and dependent on the opportunities offered by the site and the house. However it is reasonable to suggest on average that similar reductions are feasible.

Table 1 Operational Energy Reduction Opportunities

	Current Average	**New Houses**		**Existing Houses**	
		Optimum	Reduction	Optimum	Reduction
	(MJ)	(MJ)		(MJ)	
Heating & Cooling	12,515	5,313	58%	9,386	25%
Water Heating	14,922	5,773	61%	5,773	61%
Other Appliances	5,295	3,971	25%	3,971	25%
Lighting	1,925	817	58%	963	50%
Cooking	5,776	5,198	10%	5,198	10%
Refrigeration	7,701	2,696	65%	2,696	65%
	48,134	23,768	51%	27,987	42%
Area (m^2)	212	180		212	
Energy per m^2 (MJ/m^2)	227	132	42%	132	42%
Emissions (T CO2-e)	6.75	3.41	49%	3.78	44%

(Emissions calculated from average electricity / gas mix using AGO GHG coefficients)

Reducing the average size of houses and adopting the measures proposed in 2.3 above would also have a major beneficial impact on the embodied energy in our new housing stock. Table 2 sets out the potential embodied energy reductions opportunities (changes proposed in 2.3 highlighted). The reductions are based on the calculation of embodied energy in a conventional Perth project house (Taylor 2002) and Australian Greenhouse Office (AGO 1999) estimates of average embodied energy.

Table 2 Embodied Energy Reduction Opportunities

	Average Existing (GJ)	Reduced EE (GJ)	Reduced EE & Size (GJ)
Walls	233	150	127
Slab	111	62	53
Frames	120	120	102
Windows	39	39	33
Roof	96	96	82
Plasterboard	13	13	11
Glass	5	5	4
Tiles	1	1	1
Insulation	20	20	17
Paving	18	18	15
Replacement / Waste	27	27	23
	683	551	468
Floor Area (m^2)	212	212	180
Embodied Energy (GJ/m^2)	3.2	2.6	2.6
Emissions @ 70 kg/GJ (T CO_2-e)	47.8	38.6	32.7
Reduction in emissions		19%	31%

2.7 Water Efficiency Opportunities

Water efficiencies in the household are available through in-house measures and more water sensitive landscaping and irrigation.

The Water Corporation's Waterwise initiative involves both the promotion of water efficiency measures and the provision of rebates for approved products and systems. Waterwise rebates (of up to $500) are available for measures such as approved tap timers, in-tap flow regulators, soil wetting agents and water efficient washing machines with a 'A' rating of AAAA and over and showerheads rated AAA or above. Rebates are also available for approved garden bores, rainwater tanks, greywater reuse systems and aerobic treatment units.

The use of rainwater tanks has long been considered to have limited benefit in the Perth environment, where long dry summers limit opportunities for substituting scheme water for irrigation. However the author has demonstrated that a 3,000 litre rainwater tank, integrated into the scheme supply, and serving in-house uses such as toilets, laundry and hot water (one-third of in-house use) would save around 38% of all in-house water use.

Around 56% of all scheme water used in households goes on watering lawns and gardens (Loh and Coghlan 2003). Water efficiency opportunities being promoted by the Water Corporation involve a range of measures including:

- Minimise the extent of water consuming planting.
- Maximise the use of water conserving elements and techniques.
- Apply the basic principle of hydrozoning to planting design (grouping plants on the basis of having similar water requirements).
- Using soil conditioners / mulches to improve moisture and nutrient holding capacity

Table 3 describes the benefits of adopting water efficient fixtures / fitting inside the house and irrigation efficiencies (Reduced Usage), and rainwater tanks for partial in-house scheme water substitution (Reduced Usage + Water Tank).

Table 3 Water Efficiency Opportunities in the Home

	Existing Average Usage (kL/yr)	Reduced Usage (kL/yr)	Reduced Usage + Water Tank (kL/yr)
Inhouse			
Bath & Shower	62	59	59
Washing Machine	51	33	33
Toilet	41	27	27
Tap	30	25	25
Other	7	5	5
	191	149	149
less rainwater supply			57
Net In-house use	191	149	92
Reductions		22%	52%
Ex house			
Irrigation	251	190	190
Pools	7	7	7
Net Ex-house use	258	197	197
Reductions		24%	24%
Total Household Use	449	346	289
Reductions		23%	36%

Further improvements in household water use can be achieved by substituting potable water with non-potable sources for irrigation use. These opportunities are discussed in the following section.

3. INTEGRATING THE WATER CYCLE

Perth's total annual demand for scheme water is presently around 325 GL, of which about 70% is used in domestic dwellings. Perth, like most other cities, has traditionally had a "once through" approach to urban water. Scheme water was sourced from surface water run-off to dams in the hills area to the east of the city, and supplied for all use inside and outside the home. Over the last 20 years, as rainfall and run-off has diminished and population has grown, the scheme supply has become increasingly dependent on groundwater supplies. These now account for more than half of the scheme water supplied to the Integrated Water Supply System (IWSS).

Perth is served by three large metropolitan wastewater treatment plants at Beenyup, Subiaco and Woodman Point. These produce 117 GL of wastewater every year, of which around 100 GL is discharged to the ocean. Wastewater is potentially a major source of water and this is recognised by the State Water Strategy, which aims to recycle 20% of wastewater by 2012. The Water Corporation has a comprehensive strategy to increase the use of treated wastewater and has recently commissioned a sophisticated tertiary plant to supply high quality water to industry in the Kwinana area. However to date, there is no re-use in the urban domestic sector.

Even tertiary treated wastewater has residual levels of nutrients, pathogens and other pollutants (eg solids, oil and greases, detergents and heavy metals). Accordingly its re-use needs to be carefully researched to protect both human and eco-system health. Reuse models being researched by the author for the Water Corporation include both direct and indirect reuse of wastewater. Direct re-use involves the supply of treated wastewater via the so-called "third pipe" for non-potable uses in the household including garden irrigation and toilet cisterns. Indirect re-use via "managed aquifer recharge" (MAR) involves the infiltration or injection of treated wastewater into the superficial aquifer, and its recovery from bores down gradient of the infiltration site. This approach has the attraction of allowing the groundwater environment to further treat the wastewater, and of negating some, or all of, the third pipe network needed for distribution.

The major opportunity for replacing scheme water with wastewater is for irrigation, where the risks to health are minimised, and the residual nutrients will be beneficial. Irrigation flows in Perth are of course much higher in the summer than the winter, and peak flows are far in excess of wastewater flows. This means that under the third pipe scenario, wastewater would need to be complemented by groundwater or scheme-water to meet demand. In the winter-time, the opposite holds, when irrigation demand is negligible, the excess wastewater flows will need to be either infiltrated or discharged to ocean outfalls.

Very significant savings in scheme water would accrue from either of these wastewater reuse schemes in the domestic environment. If the household measures discussed in Section 2.6 are included, the savings are even greater, as shown in Table 4. The 36% saving can be essentially doubled when the scheme water benefits of recycling are added.

Table 4 Scheme Water Benefits from Wastewater Recycling

	Existing Demand			Reduced Demand	
	Conventional	3rd pipe	MAR	3rd pipe	MAR
Scheme	449	129	129	99	99
Rain		69	69	58	58
Wastewater		132	191	103	149
Groundwater		119	60	87	41
	449	449	449	347	347
Scheme reductions		71%	71%	78%	78%
Scheme + groundwater reductions		45%	58%	59%	69%

The feasibility of wastewater recycling will be dependent on a number of factors including the proximity of treatment plants to the houses to be supplied, the potential for safe discharge in the event of failure, and local groundwater and terrestrial environment constraints. The schemes described above are most suited to urban areas adjacent to wastewater treatment plants, and where the local soil and groundwater conditions are suitable for infiltration. In urban areas where the groundwater is near-surface, and wastewater treatment is remote, an alternative to recycling wastewater is the recycling of drainage water.

Conventional urban development results in a significant quantity of water being introduced to the local groundwater environment. This additional water arises from:

- The additional surface flows associated with drainage of rainwater from hard surfaces (much of which would otherwise be subject to evapo-transpiration);
- The recharge component of household irrigation.

This additional water will find its way to the superficial aquifer and / or any natural or manmade surface drainage feature. An approximate quantification of this additional water is around 250 kL / lot / year (noting that this calculation is sensitive to a number of assumptions). In low lying and poorly draining locations, this additional water creates a significant challenge to the design of a drainage system.

The objective of water cycle management is to integrate all sources of water in supplying households and public open space, while addressing the environmental implications of surface drainage and wastewater discharge. In circumstances of high water table and poorly draining soils the opportunity is to re-use a component of the rainwater and drainage water in order to both:

- Reduce the demand on scheme water, and
- Ameliorate the difficulties of managing drainage water

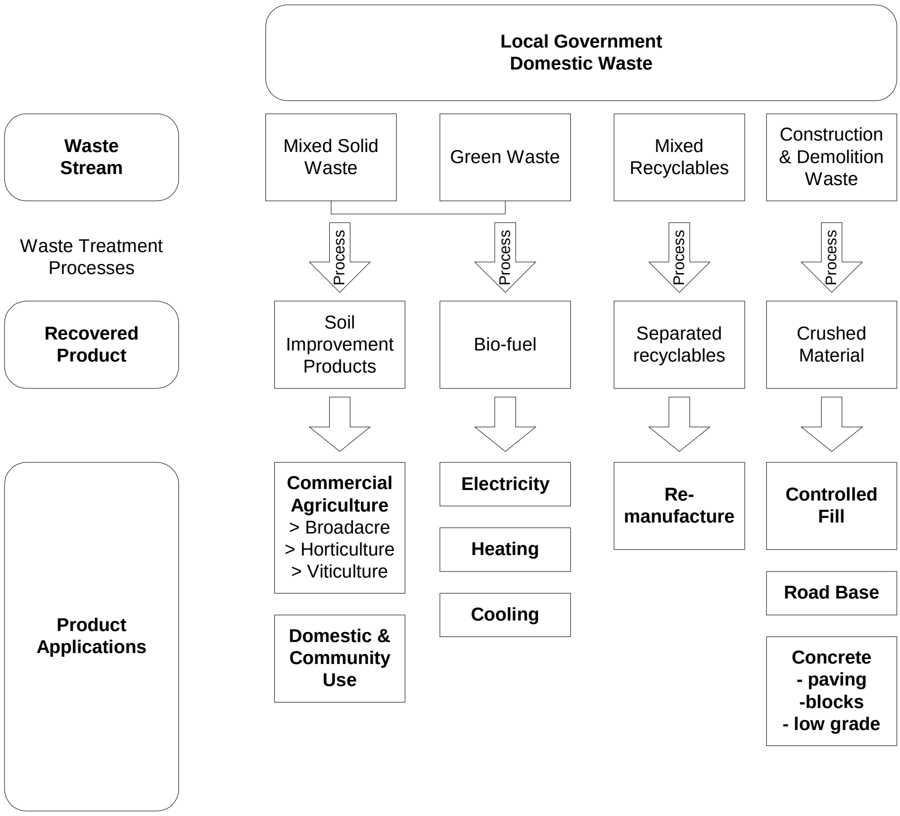
However the vast majority of the irrigation demand arises in summer and hence does not occur during the time that drainage water is available during winter. This means storage of water harvested in winter will be required for use in summer. Assuming urban development of (say) 10,000 lots the total annual stored volume would be in the order of 1-1.5 GL pa. Given the cost of surface storing such a large quantity of water it is probable that Aquifer Storage and Recovery (ASR) will be the most feasible storage solution. Storage in the superficial aquifer is not likely to be viable given that at the time that storage is needed, there will be very little capacity. Hence it is thought that injection into and recovery from the confined aquifer(s) below the superficial aquifer is the most likely solution. This would involve a network of injection / recovery points in the area. Assuming treatment prior to injection, the recovered water would require little or no further treatment prior to use for irrigation purposes. Such a scheme is under review by the author for a specific new urban development and offers an alternative to wastewater recycling that achieves the same overall benefits set out in Table 4.

The opportunity for the integrated water cycle management described above is greatest for new urban development. As infill development activity increases, these and other approaches will need to be developed for existing urban areas.

4. RESOURCE RECOVERY FROM DOMESTIC WASTE

The domestic waste streams that converge at Perth's local government waste transfer stations represent a major challenge to the State's sustainability. This challenge is to divert these streams from landfill and convert them to beneficial recovered products, and in the process create value where there is now only cost. Figure 1 depicts the possibilities from some of the main waste streams.

Figure 1 The Municipal Waste Challenge



Of those streams depicted, significant levels of recycling already occur in the mixed recyclables area (ie paper, cans etc) but major opportunities in recovering products from organic wastes and construction and demolition waste remain. These are also areas where opportunities readily exist.

4.1 Organic Wastes

Presently most of Perth's mixed solid waste goes to landfill, thereby impacting the environment at the landfill site, creating traffic and associated emissions, and wasting nutrients. Simultaneously Perth residents and the local councils that collect and dispose of the wastes use large quantities of soluble fertilisers on parks and gardens.

There is so far only one major resource recovery facility operated by the Southern Metropolitan Regional Council[2] (SMRC). This facility utilises the Bedminster composting technique to processes all collected household organic material and turns 98% of it into compost. Western Metropolitan Regional Council (WMRC) is planning a further resource recovery trial in the western suburbs.

A range of non-thermal technologies are available to process mixed solid waste, including:

- Enclosed / In-vessel composting (such as adopted by SMRC)
- Anaerobic Digestion
- Combined aerobic / anaerobic digestion (such as proposed by WMRC)
- Fermentation
- Vermiculture

All of these processes produce compost (directly or indirectly) and / or other soil improvement products. Anaerobic digestion and fermentation also produce bio-fuels (methane and ethanol respectively). Depending on the scale of the process plant, and adjacent energy use opportunities, exploitation of these fuel sources may be feasible.

The WMRC proposal involves a combined aerobic / anaerobic digestion plant (capacity 20,000t/yr) developed by Western Australia company Organic Resource Technologies. This process has been demonstrated via a pilot plant built and operated by ORT at Jandakot. The output of the process is biogas (50 – 60% methane) and compost. This technology appears to have some significant benefits including its small footprint and lower capital and operating costs.

The opportunity that arises from these technologies is to recycle the nutrients produced into compost and soil improvement products that can replace, or at least reduce the use of soluble fertilisers in the urban environment. Although the focus to date has been on their use in larger scale agricultural applications, the immediate opportunity is in the urban area, where both councils and residents currently use large quantities of fertilisers in areas adjacent to wetlands and waterways. The much slower release of nutrients from composts used in conjunction with mulch (also available via local councils' greenwaste programs), together with their moisture retention properties, make this approach very attractive for urban Perth.

This vision is one of the objectives of the Compost Supply Chain Roadmap Project[3]. It's aim is to develop a viable and sustainable organics recycling industry across Australia. This will involve new product and market identification and development of strategic plans that target both niche and wide-ranging markets for recycled organics.

4.2 Construction and Demolition Waste

Approximately half of all the material going to landfill in the Perth area is construction and demolition waste (1.1m tonnes in 2001). At least two-thirds of this material is potentially suitable for crushing and incorporation as "aggregate" in construction applications such as road base, blocks / bricks and low grade concrete. This material is effectively owned by local government, which is also a major procurer of construction materials – particularly in the local roads sector. Recycled aggregate is now widely used in Europe.

A significant opportunity exists to simultaneously:
- Massively reduce the material going to landfill
- Reduce the environmental impact of new construction
- Promote cleaner production in the construction industry
- Support emerging commercial recycling companies

The impediments to large scale adoption of such an approach are cited as:
- Shortages of recycled material available to product manufacturers

- Costs of processing / transporting materials
- Reluctance of purchasers to use products containing recycled material
- Contamination issues associated with certain materials

Given the potential market for the use of recycled aggregate by local and state government, a study is required to progress this opportunity. Such as study would investigate:

Technical	Identify materials suitable for re-use and applications for re-use
Economic	Identify threshold costs for economic use and propose supply chain arrangements
Regulatory	Identify State / Local Govt policy and regulation to promote supply of recycled aggregates

5. DISCUSSION AND CONCLUSIONS

The measures proposed above would have a major impact on resource efficiency in the Perth urban sector. As noted above, Perth will likely add some 375,000 new dwellings to the existing stock of (approximately) 610,000 over the next 25 years.

Assuming that the measures were introduced now for new housing, and retrofits completed over the next 20 years, the 25 year benefits in greenhouse emissions and in scheme / ground water would be approximately as shown in Figures 2 and 3.

Figure 2 Cumulative Domestic GHG Emissions 2005-2031

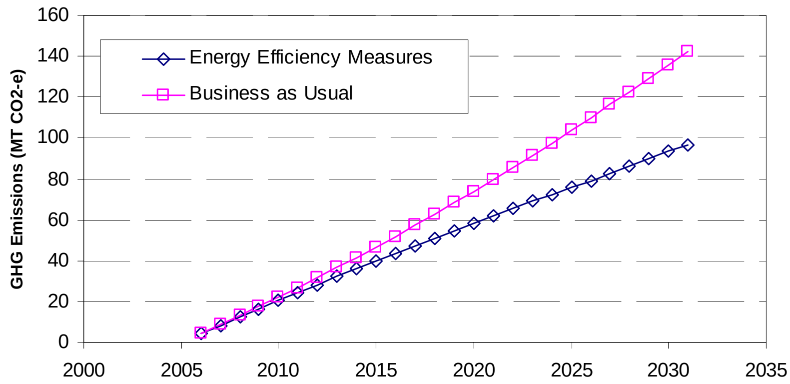
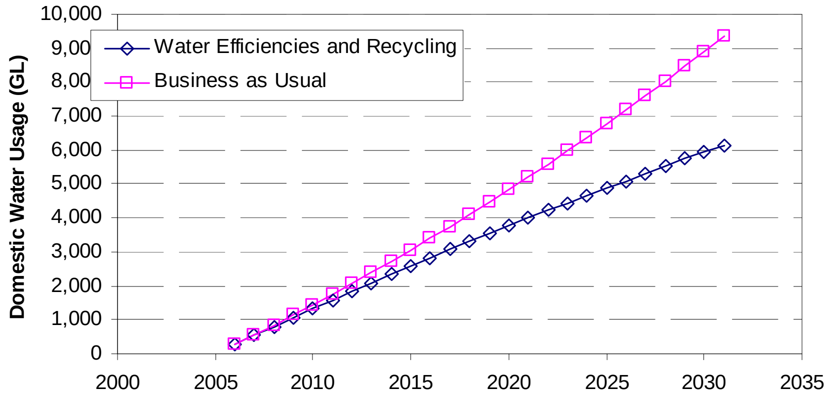


Figure 3 Cumulative Domestic Water Usage 2005-2031



Establishing waste management practices including resource recovery and recycling in this sector is also urgent if we are to reduce the overall environmental impacts of landfill, transport and eutrophication of waterways from fertiliser use.

While these measures will not in themselves, “solve” Perth’s greenhouse emission, water supply and waste management problems, they provide a basis for establishing new patterns of resource efficiency in the domestic sector.

The nature of future urban growth and redevelopment in Perth is in the hands of the two levels of government and private sector developers. They will rely heavily on engineering inputs to fashion the key decisions that will determine environmental impacts in the domestic sector over the coming years and decades. All the measures identified in this paper rely on existing technologies. It is imperative that the engineers involved move beyond existing practice, become familiar with these and other opportunities if they are to fulfil their obligation to contribute to a more sustainable urban form.

6. REFERENCES

Burbidge, A., 2000, Housing and Families: Towards an Alternative View, Australian Institute of Family Studies Seminar.

Loh, M. and Coghlan, P., 2003, Domestic Water Use Study In Perth, Western Australia 1998-2001.

Taylor, N., 2002, Energy Efficiency for Everyone: Analysis and Development of an Energy Efficient Project Home.

Western Australian Planning Commission, 2004, Network City: Community Planning Strategy for Perth and Peel.

Wilkenfeld, G. 2003, Australia's National Greenhouse Gas Inventory 1990, 1995 and 1999, End Use Allocation of Emissions, Report to the Australian Greenhouse Office, George Wilkenfeld & Associates Pty Ltd and Energy Strategies.

Website References

1. http://www.greensmart.com.au/
2. http://www.smrc.com.au/
3. http://www.wmaa.asn.au/roadmap/compost.html

Sustainability Specialist – Bill Grace

Bill Grace is Deputy Chairman of the WA Premier's Sustainability Roundtable, which is charged with providing the government with advice on implementation of the State Sustainability Strategy. He is a member of the Roundtable's Sustainable Building, Construction and Land Development group, and of the WA Planning Commission's Statutory Planning and Metropolitan Region Planning committees.

Mr Grace is a Fellow of the Institution of Engineers with 25 years experience in infrastructure and development projects. He is presently GHD's Manager of Sustainability Services, and coordinates GHD sustainability related work across the whole range of management and technical disciplines.