CLIMATE NEUTRAL WATER SAVING SCHEMES

How to reuse water without increasing greenhouse gas emissions

*This discussion paper provides guidance for neutralising greenhouse gas emissions from **medium to large** water saving schemes.*

*A compendium is also provided to guide **smaller domestic** water saving schemes in the neutralising of greenhouse gas emissions*

CONTENTS

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Special thanks to the invaluable technical advice of Peter Holt from Ecological Engineering.

Glossary

Aerobic treatment – Biological process by which microbes decompose complex organic compounds in the presence of oxygen and use the liberated energy for reproduction and growth.

Afforestation – To convert (open land) into a forest by planting trees or their seeds.

Anaerobic treatment – Reduction of the net energy level and change in chemical composition of organic matter caused by micro-organisms in an oxygen-free environment.

Blackwater – Household wastewater from the kitchen, toilet and bidet.

E.Coli – Faecal bacteria found in the digestive tract of animals, which are used to indicate presence of wastewater contamination within an environment.

Embodied Energy – The energy consumed in by all the processes associated with the production of a product from the acquisition of natural resources to product delivery.

Greywater – Household wastewater that has not come into contact with toilet waste. It includes wastewater from the shower, bath, bathroom basin, laundry and kitchen.

'Light' Greywater – Household wastewater from the shower, bath and bathroom.

Potable water – Reticulated (piped) water distribution.

Process Energy Requirement – The energy directly related to the manufacture of a material.

Rainwater – Roof runoff, generally stored in rainwater tank.

Recycled water – Treated stormwater, greywater or blackwater suitable for a range of uses.

Reforestation - To replant (an area) with forest cover.

Stormwater – Catchment runoff from impervious areas like roads and pavements.

Suspended Solids – Particles in water that can be removed by sedimentation or filtration.

Acronyms

a.c. – alternating current

AGO – Australian Greenhouse Office

AWEA – Australian Wind Energy Association

BAU – Business as Usual

BOD – Biological Oxygen Demand

CO_2 – Carbon Dioxide

d.c. – direct current

GHG – Greenhouse Gas

PER – Process Energy Requirement

PMSEWIC – Prime Minister's Science, Engineering and Innovation Council

SS – Suspended Solids

UNFCCC – United Nations Framework Convention on Climate Change

UV – Ultra Violet

1. The City of Melbourne's Commitment to Climate Neutral Water Saving Schemes

The City of Melbourne is committed to integrating sustainability principles in water and energy management. Guiding principles for energy and water underline City of Melbourne's practical approach to climate neutral water saving schemes.

Water

The City of Melbourne is committed to developing a sustainable city - now and for future generations. Council is committed to taking an active lead in saving water, reducing wastewater and improving water quality as set out in *Total Watermark* (2004).

The guiding principles of sustainable water management are presented in our WSUD Guidelines.[1] They are "*centred on achieving integrated water cycle management solutions aimed at addressing the three urban water streams by:*

- *reducing potable mains water demand (e.g. through water efficient appliances, using alternative sources of water based on matching water quality to uses on a "fit-for-purpose")*
- *minimising wastewater disposal (e.g. through a combination of water efficient appliances and wastewater reuse)*
- *treating urban stormwater to meet water quality objectives for reuse and/or discharge to surface waters.*
- *reducing the impacts of urban development on catchment hydrology, particularly for protection of aquatic habitats (e.g. prevention of urban waterway erosion, maintenance of natural form of watercourses, etc.)."*[2]

To encourage the implementation of sustainable water management, the
City of Melbourne has defined targets which are:

- reduction of potable water (drinking water) consumption by 40%;
- implementation of best practice stormwater quality treatment:
  - 80% reduction in total suspended solids;
  - 45% reduction of nitrogen and phosphorous;
  - 70% reduction in litter entering stormwater from the site; and
- reduction of wastewater generation by 20%.

Figure 1: *Total Watermark* and *Zero Net Emissions by 2020* City of Melbourne environment strategies

Climate Change and Greenhouse Gas

The City of Melbourne is also committed to ending its contribution to global warming through the *Zero Net Emissions by 2020* strategy. The strategy outlines three key directions in which this will happen:

- energy efficiency through good design and operation
- greening the energy supply through use of renewable energy technologies and green energy products
- offsetting the remaining emissions through initiatives such as purchasing carbon credits and investing in tree-planting projects

The implementation of climate neutrality, is supported by the following targets:

- to reduce Council's own emissions by 50% below 1996 levels by 2010, and to achieve zero net emissions for the organisation by 2020; and
- to reduce the municipality's emissions by 20% below 1996 levels by 2010, and to reach zero net emissions for the municipality by 2020.

[1] City of Melbourne, 2006
[2] WSUD guidelines, City of Melbourne, 2005

Water and Greenhouse Together

Water conservation is extremely important in Australian cities such as Melbourne, as we need to use our existing supplies wisely to avoid drawing further supplies from our waterways, or causing ecological damage through the construction of dams and other infrastructure.

Reusing or harvesting water is a great way to reduce our reliance on potable water, but it can have environmental consequences in the form of extra greenhouse gas emissions.

This raises the question of whether we should save water by using alternative water sources if it means we are emitting extra greenhouse gas emissions which contribute to global warming that then leads to less rainfall.

2. Delivering Climate Neutral Water Saving Schemes

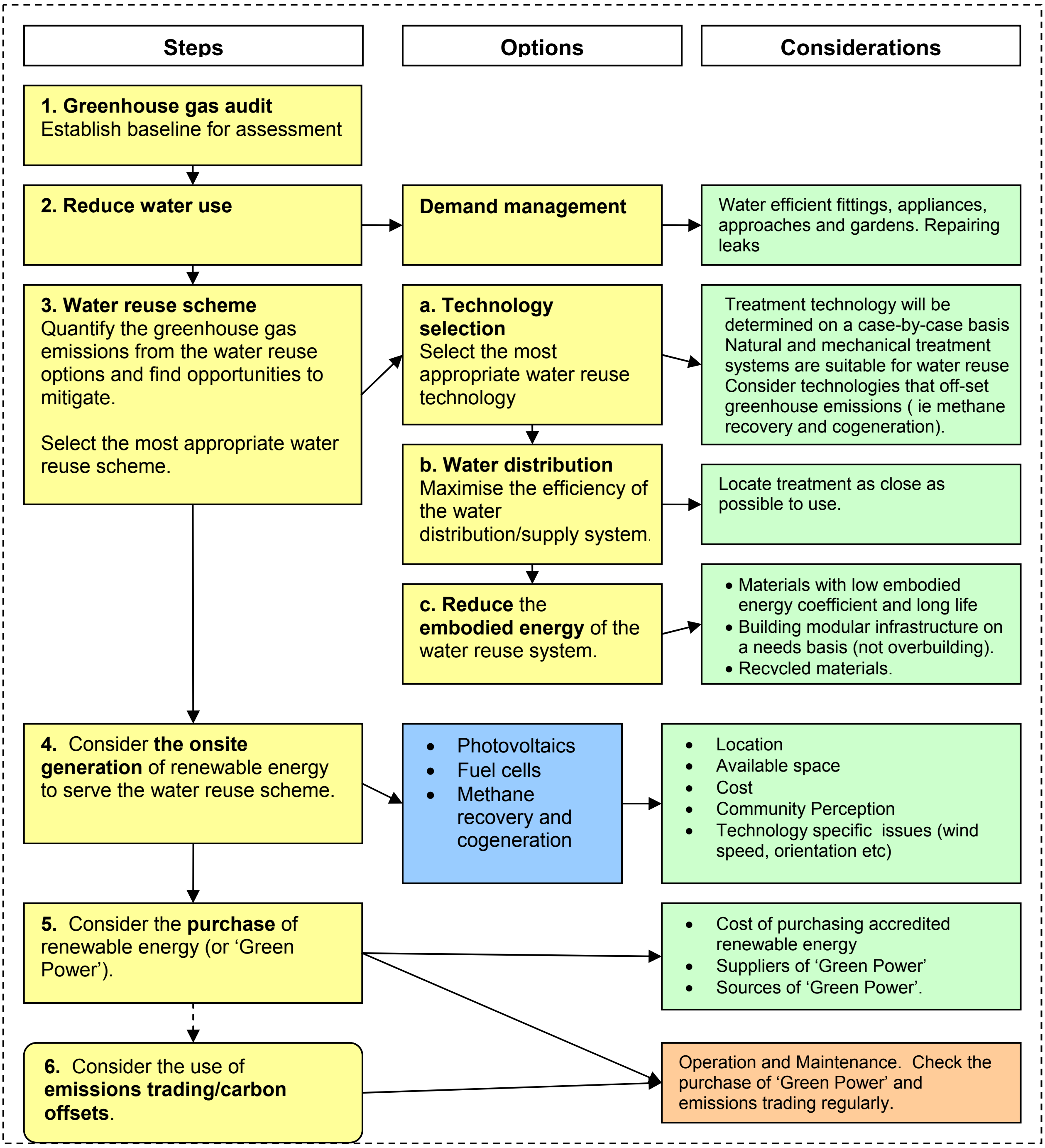
Greenhouse gas emissions are one element to consider for alternative water sources. The following is a simple process for considering greenhouse gas emissions arising from potential water saving projects:

- **firstly,** when planning, consider all opportunities for water conservation (because saving water will also reduce greenhouse gas emissions);
- **secondly,** consider opportunities for alternative sources of water, namely rainwater harvesting, stormwater and wastewater recycling. If an alternative source is to be used, then;
- **thirdly,** undertake assessment of greenhouse gases emitting from proposed alternative source.

The City of Melbourne has developed the following process to help deliver climate neutral water reuse (rainwater, stormwater, greywater and blackwater) projects.

If you have a household scale water saving scheme, including rainwater tanks or greywater systems for toilet flushing or outdoor use, there is a simpler process for you to follow as outlined in the Compendium.

Figure 2: Process for Implementing Climate Neutral Water Recycling



Each of the steps in the above greenhouse neutral water reuse schematic is discussed below.

Step 1 - Audit greenhouse gas emissions of current practices

There is a need to work out the amount of greenhouse gas emissions that will arise from continuing current practices. This will give us a baseline figure to compare our efforts against.

A full greenhouse gas analysis of the collection, treatment and transport of Melbourne's mains potable water is required to compare the level of greenhouse gas emissions to that of recycled water. This baseline assessment provides a benchmark for new alternatives to be assessed. This applies to projects at a range of scales from the household rainwater tank to the large scale water reuse projects for example the CH_2 building.

The first step is to establish a baseline assessment of current practices. The baseline assessment of greenhouse gases can be calculated from:

- the embodied energy of the water consumed and wastewater generated;

  Embodied energy is the energy consumed by all the processes associated with the production of a product, from the acquisition of natural resources to product delivery. The embodied energy accounts for the energy required in water transportation, treatment and disposal. The embodied energy is then related to the energy generation profile, predominately from non-renewable coal fired power stations in Victoria. Water is then used (typically only once) and wastewater is generated. The wastewater is then transported long distances (using more energy) for treatment prior to discharge.

- the biological degradation of wastewater.

  Greenhouse gas emissions are produced by the biological treatment of wastewater. The organic loading is predominately derived from faecal matter. Other organic matter is derived from kitchen wastes and laundry wastes. In Melbourne, greenhouse gas emissions are minimised by the capture and reuse of biogas.

Prior to the greenhouse gas audit, a water balance will have been prepared for the project which identifies and quantifies the total water use and wastewater generation of the site. The baseline water consumption enables the embodied energy to be calculated.

The greenhouse gas emissions for water and wastewater (per ML of water) are detailed in Table 1 for Melbourne. These figures are an aggregate of greenhouse gas emission for Melbourne. They enable a baseline for comparison to be readily calculated.

Table 1. Greenhouse gas emissions for water and wastewater in Melbourne[3]

Water	Equivalent CO_2 generated (CO_2t/ML)
Potable Water	0.173
Wastewater	0.875

Use the above figures to calculate the baseline greenhouse gas emissions that will arise from accessing and disposing of mains water.

Using the following formula will deduce the tonnes of CO_2 generated for a conventional approach.

GHG emissions (t CO_2-e) = PW x 0.173 + WW x 0.875

Where PW is the potable water (ML/y), and
WW is the wastewater (ML/y).

ACTION: Undertake a water balance for the site. Calculate baseline greenhouse gas emissions.

[3] These figures were supplied by Melbourne Water for the 2004/2005 year. The figures are an average for the entire distribution system for water supply and wastewater disposal including the GHG abatement strategies. They exclude GHG emissions from offices and company vehicles. The figures also include the GHG emissions from the water retailers (City West Water). Note the contribution from the water retailers is minor (0.4% for water supply and 4% for wastewater disposal).

What about the greenhouse gas emissions arising from mains water?

When considering the level of greenhouse gases emitted from the treatment/supply of recycled water to industry, commerce and residents it is important to note that potable mains water that is used for the majority of water applications in Melbourne also undergoes some treatment.

90% of Melbourne's potable mains water undergoes a treatment process involving disinfection, fluoridation and pH correction.[4] The addition of chemical is continuously monitored and controlled and this process inevitably will also involve some level of energy consumption and hence greenhouse gas emissions.

The remaining 10% of Melbourne's potable mains water undergoes full treatment. This includes coagulation and clarification to allow colour and turbidity particles to settle out, filtration, disinfection, pH correction, sludge processing and fluoridation.[5]

In addition 20 pumping stations are used to pump potable water through the distribution mains. All of these pumping stations require energy to operate.[6]

A full greenhouse gas analysis of the collection, treatment and transport of Melbourne's mains potable water is required to truly compare the level of greenhouse gas emissions to that of recycled water. [7]

It should also be noted that greenhouse gas emissions from the treatment and supply of potable mains water is significantly influenced by a number of external factors including drought (more energy required to pump water due to higher demands).[8]

Traditional centralised water supply systems rely on extension distribution mains to supply water to the end user. Likewise the wastewater disposal requires a separate network to collect and transport the water to centralised treatment facilities. Pumping water through these reticulation networks are the core energy requirement in the water service provision.

When considering the level of greenhouse gases emitted from the treatment/supply of recycled water it is important to note that potable mains water used for the majority of water applications in Melbourne also requires pumping and centralised treatment.

For treatment systems within the City of Melbourne, water pumping energy requirements can be minimised through:

- demand management measures;
- locating the water recycling/storage facility as close as possible to the end user; and
- relying on gravity where possible to supply water to the end user:
  - this includes the use of an elevated rainwater tank at the household level;
  - installation of a smaller header tank that is feed by a small, low energy trickle pump.

Alternative Water Sources – Many Factors to Consider

When deciding to replace potable water with alternative water sources, greenhouse gas emissions are only one of a number of issues that need to be taken into consideration. Other issues that require consideration include:

- water end use and demand profile;
- water quality and quantity;
- available space for treatment;
- infrastructure near the site e.g. trunk sewers;
- interaction with the environment;
- consumer reaction and social considerations;
- health implications;
- economic considerations e.g. life cycle costs;
- operation and maintenance; and
- ongoing ownership.[9]

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[4] Melbourne Water- Water Quality and Treatment, 2005
[5] Melbourne Water – Water Quality and Treatment, 2005
[6] Melbourne Water – Water Quality and Treatment, 2005
[7] An analysis of City West Water's Eco Footprint 2004 attributes 1,310 t CO2/GL to the total embedded greenhouse emissions of water delivery and services in Melbourne's west. This includes all MW service aspects and CWW contractor related impacts.
[8] Melbourne Water - Meeting the Greenhouse Challenge, 2005
[9] Landcom (2006) Wastewater reuse in the urban environment: selection of technologies

Step 2 – Reduce Water Use (demand management)

Greenhouse gas emissions associated with water treatment can be minimised by:

- reducing water consumption and wastewater generation;
- using alternative water supplies;
- reducing organic material in wastewater (this can be achieved by educating commerce and industry about waste minimisation and cleaner production);
- diverting organic waste from uncontrolled anaerobic conditions.

One of the most effective ways to reduce greenhouse gas emissions is through the reduction of water consumption and wastewater generation. This reduces the energy required to transport water large distances either form storages for use or wastewater treatment plants for treatment and disposal. Demand management measures include water efficient fittings (5A taps, 6/3L dual flush toilets), water efficient appliances (5A washing machines), water efficient gardens (xeriscaping, hydrozoning, smart irrigation techniques) and pressure reduction valves. Demand management measures reduce water consumption and wastewater generation. Consequently less energy required to heat (for hot water), treat and transport water to and from the City of Melbourne.

Avoid disposal of organic material for example food scraps, vegetable peelings into the wastewater system as greenhouse gases are produced by the biological decomposition of the organic matter (mostly human waste, but also kitchen waste such as food scraps, oils, vegetable peelings also contribute to the overall loading which require subsequent treatment.

In industrial applications, organic loadings can be reduced by reviewing operations and auditing processes. The wide range of activities and operations suggest that individual strategies are appropriate.

ACTION: Reduce water demand and organic loading of wastewater

Step 3 – Select an alternative water scheme and assess its greenhouse gas emissions

Step 3a - Reduce the greenhouse gas emissions associated with the treatment process

Treatment will be required to upgrade water quality for the appropriate end use. Typically water used within the City of Melbourne will be treated to a high standard reflecting the water reuse applications. A range of water sources are available for integrated water resource management as shown in Table 2.

Table 2. Water source and level and treatment

Water	Treatment
Rainwater	Minimal treatment required. The hotwater system (e.g. gas boosted system) can be integrated to provide thermal disinfection; alternatively UV disinfection may be installed.
Stormwater	Best practice treatment required. Typically this is through the use of natural treatment systems such as bioretention systems or constructed wetlands. Mechanical systems, for example filtration systems, can also be used for stormwater treatment, particularly for large scale systems where limited space is available for treatment.
Greywater	Diversion devices can be fitted to subsurface irrigation systems with no treatment required. Greywater reuse treatment systems can be situated on a household scale for reuse. Moderate treatment is required to ensure pathogens are removed from greywater for non-potable water reuse.
Blackwater	High level of treatment is required to remove pathogens and biological components to ensure water is safe for reuse. Mechanical treatment systems are typically used in cities due to the limited space available.

Greenhouse gas emissions will be dependent on the water source, water end-use and the treatment technology selected. The greenhouse gases in water treatment emissions are generated by:

- energy consumption; and
- biological degradation of organic matter that produces greenhouse gas emissions.

ENERGY CONSUMPTION

For all mechanical systems the greenhouse gas emissions can be calculated from the energy consumption. The energy consumption is the sum of all energy requirements of the system including pumping, disinfection and treatment components. This information is readily available from technology suppliers.

To calculate the greenhouse gas emissions arising from energy consumption use the following equation:

GHG emissions (t CO_2-e) = Q x EF / 1000

Where: Q (Activity) is the electricity used expressed in kWh and

EF is the relevant emissions factor expressed in kg CO2-e/kWh. For electricity consumption in Victoria, an emission factor (EF) of 1.467 kg CO2-e/kWh is recommended (AGO, 2005).

ACTION: Quantify greenhouse gas emissions for the energy consumption using the above equation.

BIOLOGICAL DEGRADATION

The type of treatment technology will determine the biological degradation (if any) occurring. Biological degradation under anaerobic conditions (no oxygen present), methane and other greenhouse gases such as nitrous oxide are generated. Where biological degradation occurs under aerobic conditions (oxygen present) energy is often required to mix and aerate.

For example, aerated membrane bioreactors typically contain an aerated vessel for water treatment. The biological content is converted to biomass prior to filtration. Whereas physical separation systems, such as the membrane filtration and reverse osmosis system installed in the City of Melbourne's CH_2 Building, will minimise organic reduction. For this water (sewer) mining application any biomass and sludge are returned to the sewer system and processed by centralised treatment facilities.

In the City of Melbourne, onsite biological degradation is expected to be minimal. The majority of greenhouse gas emissions for package treatment plants are typically derived from energy consumption. For alternative water systems that incorporate biological decomposition, the greenhouse gas emissions must also included. Appendix B contains a description of typical treatment technologies and their key greenhouse gas emissions are discussed.

To quantify the greenhouse gas emissions from the biological degradation of the wastewater, refer to the Australian Greenhouse Office's Handbook (2005). Section 3.3 (page 22) details the recommended approach and is repeated here.

$$\text{GHG emissions}(\text{t CO}_2\text{ -e}) = \{[(\text{P}\times\text{DC}_\text{W})\times(1-F_{sl})\times EF_W] + [P\times DC_W\times F_{sl}\times EF_{sl}] - R\}\times 21$$

The parameters are defined in Table 3.

Table 3. Municipal waste variables and default values (reproduced Table 16 from AGO, 2005)

Variable	Default Values
P	The population served and measured in 1000 persons and sourced from waste treatment records
DC_w	The quantity in kilograms of Biochemical Oxygen Demand (BOD) per capita per year of wastewater. In the event that no waste analysis data is available, a default value of 22.5kg per person per year can be used
BOD_w	Biochemical Oxygen Demand (BOD) in kilograms of BOD per year which is the product of DC_w and population
F_{sl}	Default fraction of BOD removed as sludge. Should be readily available from internal records of wastewater treatment plants (default value of 0.29)
EF_w	Default methane emission factor for wastewater with value of 0.65 kg CH_4/kg BOD
EF_{sl}	Default methane emission factor for sludge with value of 0.11 kg CH_4/kg BOD (sludge)
CH_4 - GWP	21 - the Global Warming Potential of CH_4 used to convert the CH_4 emitted from wastewater to $C0_2$ -e
Energy potential CH_4 / m3	33,810 kJ
Energy potential CH_4 / kg	50,312.5 kJ (0.672 kg CH_4 per m3)
R	Recovered methane from wastewater in an inventory year, measured/expressed in tonnes
21	Global warming potential used to convert the quantity of methane emitted for the wastewater produced to CO_2-e

ACTION: Quantify greenhouse gas emissions for the different water saving schemes that could be implemented

ADDITIONAL WATER SUPPLIED AND WASTEWATER GENERATED
The proposed alternative water scheme may only supply a set portion of the total water demand. Any additional water supplied by the potable water system will also contribute to greenhouse gas emissions.

Additional potable water demands and wastewater generated will also contribute to greenhouse gas emissions. These greenhouse gas emissions can be calculated using the approach outlined in Step 1 and Table 1. The approach is repeated here.

GHG emissions (t CO_2-e) = PW x 0.173 + WW x 0.875

Where PW is the potable water (ML/y), and
WW is the wastewater (ML/y).

ACTION: Quantify any additional potable water demands that are needed for the project.

ACTION: With the knowledge of the greenhouse gas emissions each water saving scheme emits, choose your preferred scheme by taking this into account alongside the full range of considerations including space availability, consumer reaction etc.

Step 3b - Maximise the efficiency of the distribution/supply system

The distribution and supply system is an important element to maximise the efficiency of the water reuse systems. The City of Melbourne's *Water Sensitive Urban Design Guidelines* identifies smaller, localised, modular treatment technologies over centralised treatments for water reuse. Here the water end use is located close to the treatment system. In contrast, centralised treatment means wastewater has to be transported to a treatment plant and then transported back to the consumer for reuse. The high level of transport is expensive and energy intensive due to the piping and pumping required.

Minimising energy requirements through the distribution and supply system can be achieved by:

- considering the location of the treatment. Locating the treatment as close as possible to the end user and relying on gravity where possible, minimises resource consumption (piping) and energy requirements (less need for pumping);
- using header tanks for water supply. These can be fed by low flow trickle pumps; and
- selection of energy efficient pumps and motors.

The greenhouse gas audit must also include the greenhouse energy requirements derived from the additional reticulation networks.

ACTION: Minimise the greenhouse impacts arising from the supply and distribution system.

Step 3c - Reduce the embodied energy of the water reuse system.

In order to achieve true 'carbon neutral' water recycling, the embodied energy of a water recycling scheme needs to be considered. Embodied energy is the energy consumed by all the processes associated with the production of a product, from the acquisition of natural resources to product delivery.[10] The embodied energy from Melbourne's centralised system has been previously described (refer to Step 1). This section focuses on the material selection in water reuse schemes.

Materials selection – embodied energy

The embodied energy contained in a structure is determined by a life cycle analysis. In general, the embodied energy of a product can be reduced through:

- the selection of appropriate materials with a low embodied energy coefficient and longer life expectancy;
- building modular infrastructure on a needs basis (not overbuilding); and
- considering the use of recycled material. The embodied energy in recycled materials is generally less than new materials.

The embodied energy of some common materials is shown below in Table 4. The figures quoted for embodied energy are based on the process energy requirement (PER), the energy directly related to the manufacture of the material. Limited information on the transportation and associated process is available to inform the LCA. The CO_2 emissions are highly correlated with the energy consumed in manufacturing building materials[11]. Embodied energy estimates can vary by up to a factor of 10[12], therefore figures should be applied as a relative guide in the selection of materials.

Table 4: PER Embodied Energy of Common Materials[13]

Material	PER Embodied Energy (MJ/KG)
Hardwood	2.0
Cement	5.6
PVC	80.0
Glass	12.7
Aluminium	170
Copper	100
Galvanised steel	38

For water reuse systems, the selection of materials for pipes is important. CSIRO Manufacturing and Infrastructure Technology conducted an embodied energy analysis of piping systems[14]. The study concluded that the basic factors that influence the embodied energy impact of a piping system include:

- pipe size – the bigger the pipe the more embodied energy;
- amount of materials used – more materials, higher embodied energy;
- pipes produced with significant recycled material – these materials usually have a lower overall embodied energy;
- materials with a low embodied energy coefficient – the lower the coefficient the lower the embodied energy; and
- piping systems that are more durable and have a longer life expectancy – less repair and replacement leads to lower embodied energy over the life cycle of the system.

These findings serve as a useful guide for reducing the embodied energy of the water reuse system by preferential materials selection.

ACTION: Select materials with low embodied energy

Question: Do you agree that embodied energy is an important environmental consideration? Is additional information needed to help work out embodied energy?

[10] AGO, 2004.
[11] CSIRO, undated.
[12] AGO, 2004.
[13] AGO, 2004 (Note also - Lawson, B (1996) Building materials, energy and the environment: Towards ecologically sustainable development RAIA, Canberra)
[14] CSIRO, 2002.

Step 3d - Calculate the overall greenhouse gas emissions

Calculate the overall greenhouse gas emissions from the proposed water reuse scheme. The greenhouse gas emissions are the sum of:

- the emissions from the energy consumption (treatment and pumping)
- emission from biological degradation
- embodied energy for materials selection

ACTION: Calculate the total greenhouse gas emissions for the water reuse scheme

Step 4 - Consider on-site generation of renewable energy to service the water saving scheme

After the completion of the greenhouse gas audit and considerations to maximise system efficiency, greenhouse gases may still be produced. These emissions can be negated or offset by on-site generation of renewable energy. Renewable energy uses natural resources that can be replaced or 'renewed' and does not contribute to the greenhouse effect and global warming. Renewable energies include but are not limited to:

Photovoltaics
Photovoltaic (PV) cells convert light energy from the sun directly into direct current electricity (d.c). An inverter then converts this into alternating current (a.c) electricity for use.[15] Currently photovoltaics are expensive except in specialist applications[16] such as in a large park where connecting to the electricity grid will be expensive. However as efficiencies increase and costs lower, the use of photovoltaics will become a more attractive economic alternative.

Solar powered water pumps are commercially available and can be considered as an option for small to medium pumping applications.

Wind
A wind turbine generator consists of a foundation, tower, nacelle and a rotor (blades on a central hub). The rotor turns a generator converting some of the wind's energy to electricity. As wind speed increases more energy is delivered to the rotor.

The use of wind power to fuel water recycling within the city of Melbourne is currently not a feasible option due to the following factors:

- wind farms are generally located where there is a good wind resource, local community support and plenty of open land available.[17] Land is limited within the City of Melbourne;
- an average annual wind speed of 5m/s for Melbourne has been modelled using the WindScape wind resource mapping tool[18]. According to the Australian Wind Energy Association this is below the optimal wind speed for generating electricity; and
- wind generators are more suited to non urban areas as the turbines need to be mounted on a tower and make some noise in operation according to the Australian Greenhouse Office (AGO),

Fuel Cells
Fuel cells convert energy from chemical reactions directly into electrical energy. They are cleaner and more efficient than any carbon fuelled engine, however as yet they are not greenhouse neutral. An analysis that compared molten carbonate fuel cells to three conventional approaches for recovered methane use (heat recovery, energy generator and natural gas production) found that the use of the fuel cell could be cost competitive with engine driven and turbine power plants.[19]

Today fuel cells typically require hydrogen as a fuel source and the creation of hydrogen usually requires the use of energy, which can have greenhouse implications. However there is some trialling of fuel cells running on natural gas provided by the existing mains network. This will create up to 90% of the building's hot water needs with close to zero greenhouse gas emissions.[20]

Methane Recovery & Cogeneration
Greenhouse gases (predominately methane) can be generated from the water treatment process when biological systems are used[21]. In these situations biogas (predominately methane) can be collected and used to operate co-generation plants that provide energy to the treatment plant and excess energy can be supplied to the electricity grid.

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[15] SEAV, 2004.
[16] City of Melbourne, 2003.
[17] AWEA, 2004.
[18] developed by the Wind Energy Research Unit of CSIRO Land and Water
[19] CH2M Hill (1997)
[20] www.ourgreenoffice.com
[21] Radcliffe, 2004

Methane is collected and utilised as an energy source at a number of wastewater treatment plants including those run by Melbourne Water. The capture and reuse of methane as a fuel source prevents methane from being discharged into the atmosphere and reduces reliance on traditional energy sources including electricity and gas. Biogas recovery systems improves efficiency of current practices, however it must be realised that there will still be a residual greenhouse impact associated with burning the methane to generate power. Carbon dioxide is released by the combustion of biogas (predominately methane) and this will need to be offset. . The EPA has defined a methodology for the calculation of methane recovery and is presented in Appendix G.

The onsite generation of renewable energy enables greenhouse gases to be offset.

ACTION: Investigate the onsite generation of renewable energy and quantify the greenhouse gas emissions that this can negate or offset.

Step 5 - Consider the purchase of accredited renewable energy

In achieving the aim of climate neutral water saving schemes, it is necessary to:

- minimise the energy requirements of the water saving system (discussed in Step 1); and
- consider the generation of renewable energy to service the system.

If there are greenhouse gas emissions from the water saving process after these steps have been taken, the purchase of Green Power™ from an accredited electricity supplier must be considered.

A project cannot be deemed carbon neutral unless there is 100% renewable energy servicing the project. It is necessary to ask the energy retailer for proof that their product is currently an accredited Green Power™ product, or to check that their product displays the Green Power Accreditation. Electricity customers can purchase a nominated amount of renewable energy from electricity suppliers. The equivalent amount of energy nominated is produced from renewable sources such as wind, solar and hydro-power.

The electricity suppliers in Victoria that provide accredited Green Power™ are listed below. See Appendix C for further details.

Table 5: Green Power™ Suppliers in Victoria (as of May 2006), as displayed on www.greenpower.com.au [22]

'Green Power' Suppliers	Sources of 'Green Power'	Sectors
AGL – AGL Green Energy	Biomass 65%, Low Impact Hydro 35%	Residential and Commercial
ActewAGL GreenChoice	Biomass 54.8%, Low Impact Hydro 39.6%, Wind 5.6%	Residential and Commercial
Auspower - Verdant	Biomass 100%	Commercial
Country Energy - countrygreen™ energy	Biomass 49.9%, Wind 49.8%, Solar 0.3%	Residential and Commercial
Origin Energy - GreenEarth	Wind 74%, Low Impact Hydro 20%, Biomass 6%	Residential and Commercial
TXU – Green Energy	Biomass 100%	Residential and Commercial

A project cannot be deemed carbon neutral unless there is 100% renewable energy servicing the project.

ACTION: Purchase Green Power™ to offset greenhouse gas emissions

[22] Source: Greenpower (undated)

Step 6 - Consider offsetting emissions by purchasing carbon credits

Offsetting the greenhouse impact of a project means purchasing 'credits' from greenhouse abatement projects undertaken by other organisations. These abatement projects may be energy efficiency, renewable energy generation, or sequestering carbon from the atmosphere through the establishment of carbon sinks (forests).

Under the Kyoto Protocol, developed countries including Australia are required to limit their greenhouse gas emissions. The 'actual emissions must be less than or equal to the assigned amount +/- carbon sinks and Kyoto emissions.' This means that Australia can emit more than its assigned amount if it can simultaneously sequester the equivalent amount in sinks.

Under the United Nations Framework Convention on Climate Change (UNFCCC), countries could use a trading system to help meet their emission targets. In principle, a country may allocate permits to individual companies for the emission of a set quantity of greenhouse gases. If the company is incapable of meeting the targets they could buy permits from companies that are under their targets. The trading system would allow for the issuing of 'carbon credits' for afforestation and reforestation activities[23].

Although there is no 'mature' market for the buying and selling of credits (such as what an emissions trading scheme would provide), the regulation, standards and monitoring frameworks are slowly emerging across the Country, using the Kyoto Protocol's credit and trading guidelines as a starting point. This has led to the following programs:

- The Federal Government's *Greenhouse Friendly* Program[24]
- The NSW NGACS scheme[25]
- The Federal Government MRET Scheme[26]
- Carbon sink investments by the Victorian Government[27]
- Kyoto Clean Development Mechanism 'Gold Standard' credits[28]

A number of 'carbon brokers' are now providing companies with credits, some of which are derived from the schemes mentioned above. If the credits are not derived from these schemes, it is important to check that the credits meet Kyoto and domestic standards. It is also important to ensure that the investment in credits is creating 'additionality'. That is, the payment you provide is creating an abatement that would otherwise not have occurred. In many cases companies may be seeking to raise revenue for abatement they are required to undertake due to regulation, and would occur regardless of the finding a purchase for the credits. A carbon broker should be able to determine if this is the case.

The City of Melbourne has a draft policy statement outlining its best practice principles for offset purchases. See Appendix H.

ACTION: Purchase carbon credits to offset greenhouse gas emissions

[23] Australian Academy of Science, 2005
[24] http://www.greenhouse.gov.au/greenhousefriendly/index.html
[25] http://www.greenhousegas.nsw.gov.au/default.asp
[26] http://www.greenhouse.gov.au/markets/mret/
[27] http://www.greenhouse.vic.gov.au/greenhousesinks.htm
[28] http://www.cdmgoldstandard.org/

3 Example of a Water Reuse Scheme

To demonstrate the application of climate neutral water recycling schemes, the waste water reuse system for CH_2, the City of Melbourne's latest commercial building situated on Little Collins St has been investigated. A household scenario is also provided in the Compendium.

Case Study *CH_2 Building – Water Mining*

The City of Melbourne's latest building, Council House 2 (CH_2), incorporates the best practice design for a green commercial building. It achieves a six star rating by the Green Building Council's rating system. The calculation is based on 600 employees for a net lettable area of 9,373 m^2.

Step 1. Baseline establishment

The CH_2 building is compared to a conventional commercial building for water consumption and derived greenhouse gas emissions. The net lettable area is the best indicator of water consumption within commercial buildings. CH_2's net lettable area is 9,373m². As a baseline assessment, a conventional building typically consumes 1.4 kL m^{-2} y^{-1} of water based on the net lettable area. This equates to 13 ML y^{-1} for the CH_2 building. This water consumption correlates to a total greenhouse gas emission of 11.8 t CO_2-e/y as shown in Table.

Table 6. Equivalent tonnes of CO_2 emitted from a conventional office building

Water	Equivalent $C0_2$ generated (tCO2-e/ML)	Conventional building (tCO2-e/y)
Potable Water	0.173	2.25
Wastewater	0.875	9.59
	Sub-total	11.8

Step 2. Demand Management measures

The City of Melbourne has implemented best practice water management in the design of the CH_2 building. Water efficient fittings (AAA taps, fittings, dual flush toilets), pressure reduction valves and appliances are installed to reduce water demand.

The total demand is calculated as 10.6 ML/y with a break down provided in Tables 7 and 8. This is comprised of a 2.0 ML/y potable water demand for drinking, hand basins and showers. An additional water demand of 8.6 ML/y is estimated for the provision of non-potable water to toilets, irrigation, cooling towers and tankers (for irrigation) and street sweepers. Best practice water management in office buildings is 0.5 kL m^{-2} y^{-1} to 0.75 kL m^{-2} y^{-1} which corresponds to 4.7 – 7.0 ML y^{-1} and correlates well with City of Melbourne's water balance of 6.4 ML/y (excluding the demand for tankers and street sweepers – outside the building). The water balance figures are used to determine the greenhouse gas emissions for CH2 building.[29]

Table 7. Potable water demand for CH_2 building (City of Melbourne, 2006)

Water use	kL/d
Drinking	5.8
Showers and sinks	1.9
Total	7.7 kL/d
Total	2.0 ML/y

Table 8. Non-potable water demand for CH_2 building (City of Melbourne, 2006)

Water use	kL/d
Toilet flushing	11
Irrigation	2
Cooling towers	4
Tankers and street sweepers	16
Total	33 kL/d
Total	8.6 ML/y

The greenhouse gas emission from the potable water supply is 0.35 t CO_2-e/y as shown in Table. Note as wastewater is imported into the building for additional demands there is a reduction in wastewater (on a volumetric basis). All sludge and organic matter is returned to the sewer system for centralised processing. This highlighted by the negative value for wastewater imported.

[29] To convert from kL/d to ML/y -all the calculations are based on a 5 days per week over 52 weeks of the year = 260 days.

Table 9. Greenhouse gas emissions from CH_2 building

Water	Equivalent $C0_2$ generated (tCO_2-e/ML)	Water (ML/y)	Water efficient building (tCO_2-e/y)
Potable Water	0.173	2.0	0.345
Wastewater imported	0.875	3.5	-3.06
		Sub-total	1.75

The non-potable water supply is technology and systems dependent with the greenhouse gas emissions calculated in Step 3.

Step 3. Alternative water reuse scheme

Step 3a. Technology selection

A blackwater reuse system is installed in the basement of the CH_2 building. Wastewater from the building and additional water from the sewer is treated to a high water quality. Solids are removed by an initial screening process, with finer pollutants removed by the subsequent ultra-filtration and reverse osmosis. Pathogens are effectively removed by the physical separation process. This physical separation process can adjust to meet demand.

Stormwater is harvested from the roof and collected for reuse within the building. This provides an additional water source to contribute to the non-potable water supply.

The reused water (consisting of treated blackwater and harvested stormwater) is fed to a 20 kL header tank before distribution throughout the building. The water is used for toilet flushing, irrigation, cooling towers, external irrigation (i.e. supplied to tankers) and street sweepers.

The energy requirements are accounted for by the treatment train components and include:

- Pumping from sump and sewer
- Ultra-filtration unit
- Reverse osmosis unit
- Hot water system for cleaning and disinfection

The design estimates for energy consumption are 2.5 – 3.0 kW/kL treated water[30].

The plant operates for 8 hours a day over a typical work week (5 days). The greenhouse gas produced is 248 – 297 t CO_2-e per year as shown in Table .

Table 10. Equivalent Greenhouse gas emission from the operation of the water mining system

Energy consumption	Energy consumption (kWh per kL of treated water)	Equivalent CO_2 produced (t CO_2-e per y)
Minimum (kWh/kL)	2.5	248
Maximum (kWh/kL)	3.0	297

As the system is a physical separation system (i.e. filtration), no degradation of the organic waste occurs onsite. The organic material is directed to the sewer systems and treated at centralised facilities. Biological decomposition occurs at centralised facilities, and in this case at the Western Treatment Plant at Werribee. For this analysis, this component is negligible as Melbourne Water's Werribee treatment plant captures and reuses biogas, reducing the emission of greenhouse gases.

Figure 3: CH2 sewer mining plant

[30] Data supplied by NuSource (technology supplier) and these figures can be validated and refined once the system is commissioned and fully operating.

Step 3b – Distribution system

The distribution system consists of a header tank situated on the roof, dual supply reticulation and a pumping system. Reused water is pumped from the basement to a header tank. The water is pressurised by a second pump before delivery to the building.

The ongoing energy requirements are from the pumping system.
- Distribution pump (situated in basement) – 5.5 kW
- Pressurised pump (situated at roof) – 4.0 kW

The pumps are assumed to operate for 8 hours per day for a typical working work (5 days). After commissioning, real data can be utilised to refine this conservative estimate.

Table 11. Greenhouse gas emissions from pumping network

Energy consumption	Energy consumption (kWh)	Equivalent CO_2 produced (t CO_2-e per y)
Distribution pump	5.5	17
Pressurised pump	4.0	12

The embodied energy requirements are due to the additional materials for the headers tanks, dual supply reticulation and associated equipment. These components are summarised in Table 12. These components are assumed to be suitable for the life of the building (50 years) to enable inclusion with ongoing greenhouse gas emissions demands.

Table 12. Embodied energy for rainwater tanks and harvesting system

Item	Quantity	Mass (kg)	Embodied energy (MJ/kg)	Embodied energy (MJ)	Green-house gas emissions (t CO_2-e)	Green-house gas emissions (t CO_2-e/y)
Header tank	20 kL	1000	38	38000	15.2	0.30
Holding tank	30 kL	1500	38	57000	22.9	0.46
Rainwater holding tank	10 kL	500	38	19000	7.6	0.15
Dual supply reticulation network	Throughout building an additional 1300m of copper plumbing and fittings	1650	100	165000	66.2	1.32
					Sub-total	2.24

A summary of the greenhouse gas emission is provided in the Table . There is a net increase of greenhouse gas emissions from the water mining treatment system. The majority of the emissions are derived from the treatment and distribution energy requirements. A net increase of 314 t-CO_2e/y will have to be generated or offset to ensure there is no net increase in water recycling.

Table 13. Summary of greenhouse gas emissions

Baseline assessment - Conventional building	
	t-CO_2e/y
Water	2.25
Wastewater	9.59
Sub-total	11.8
CH2 water efficient building	
Water (mains supply)	0.345
Wastewater imported	-3.06
Treatment	297
Distribution	30.8
Sub-total	325
Net increase	**314**

Step 4 – Onsite renewable energy

In all, CH2 will use approximately 549,257 kWh of electricity per year for all its operational needs. If this were sourced only by conventional energy this would generate 764 tonnes of greenhouse gases.

However, CH_2 building has onsite renewable energy systems including[31]:

- **Electricity from co-generation** - A gas-fired co-generation plant on the roof will be used to generate electricity and heat, reducing reliance on the public electricity grid.

  The co-generation plant will have much lower CO_2 emissions than coal-fired electrical generation and will provide 164, 777 kWh per year of electricity, meeting about 30 per cent of CH_2's electricity needs. This will save 229 tonnes of greenhouse gases.

- **Solar photovoltaic cells** - CH_2 will use about 26 square metres of photovoltaic cells on the roof to generate about 12, 775 kWh per year of electricity from the sun's energy. This energy will power the movement of the louvres used to shade the west façade. This will provide 2% of the buildings energy needs and save 17 tonnes of greenhouse gas emissions.

This results in on-site generation of 32% of CH_2's electricity needs.

In addition the following technologies provide efficiencies that will result in greenhouse gas savings:

- **Heat from co-generation** - Heat from the co-generation plant (about 100Kw) will be used to help CH_2's air conditioning plant. This heat can be used directly for heating or, via an absorption chiller, for cooling. It is estimated the co-generation plant will satisfy 80% of the building's fresh air heating/cooling requirements just by using waste heat;
- **Heat recovery** - Heat is recovered from the air that gets exhausted out of the offices. CH_2's fresh air system uses no re-circulated air so fresh air from outside needs to be constantly heated or cooled to be supplied at 18°C. Through a simple heat exchange process, the temperature of the air exhausted from the space is used to help heat or cool the fresh supply air;
- **Solar hot water heat recovery** - About 60 per cent of the hot water supply will be provided by 48 square metres of solar hot water panels on the roof. On days with little solar heat gain, a gas boiler will heat water instead; and
- **Wind turbines** - Six wind turbines will extract air from the offices spaces through ducts on the north façade. The turbines, especially designed for CH_2, are 3.5m high and replace electric fans that would normally carry out the same function.

Step 5 – Purchase accredited green energy

In Step 4, it could be seen that 32% of CH_2's energy needs will be supplied by renewable sources. This leaves 68% of power for CH_2 still needing to be sourced by mains electricity. Management of CH_2 has decided to fully fund the mains electricity requirement with accredited Green Power$_{TM.}$

For the purposes of the requirements for this climate neutral water recycling policy, it is considered that 68% of the power needed for the recycling plant should be funded by Green Power$_{TM.}$

Step 6 – Carbon trading

The owners of CH2 have agreed to supply Green Power$_{TM}$ for all their 'mains' energy needs. Because of this, there is no remaining 'mains' energy that needs to be offset by exploring carbon off-set programs.

[31] www.melbourne.vic.gov.au

4 Implementation of Climate Neutral Water Saving Schemes

In order to achieve climate neutral water saving schemes, the policy commitment must be addressed at project assessment and management stages.

A number of key issues have been identified for follow up, to ensure the implementation of climate neutral water recycling for reuse schemes within the City of Melbourne.

1. Consider all responses to this discussion paper and develop a policy response for Council to adopt;
2. If in accordance with community feedback, make it a requirement for all new water saving schemes to detail:
    - expected greenhouse gas emissions; and
    - how greenhouse gas emissions are proposed to be reduced/offset.

   This can be wrapped into the capital works program approvals process.

3. Undertake calculations to account for any trucking of water that takes place either in the baseline audit (Step 1) or as part of a water saving solution (Step 3).
4. Develop of a number of data/information sheets detailing:
    - greenhouse gas emission from different water treatment methods and pumping requirement to assisting with the quantification of emissions;
    - the impact purchasing ‘green power’ (in its various quantities) will have on the cost of recycled water; and
    - key legislation impacting on the production and use of recycled water from a compliance/risk management perspective.

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6 Appendices

Appendix A - EPA Water Quality Objectives

The EPA has water quality objectives for water reuse. They are outlined in the EPA publication: *Guidelines for Environmental Management: Use of Reclaimed Water* publication.

Table 14: EPA water quality objectives for reclaimed water treatment[32]

Water quality objectives for reclaimed water treatment (Victoria EPA, publication 464.2, Table 1)

Class	Water quality objectives	Range of uses, including lower class uses
A	<10 E.coli org/100ml <10 mg/L BOD <5 mg/L SS Turbidity < 2 NTU Disinfection	Urban - uncontrolled public access. Used in toilet flushing, irrigation. Industrial - used in open systems. There is potential for worker exposure.
B	<100 E.coli org/100ml <20 mg/L BOD <30 mg/L SS	Industrial - used as wash down water, for example.
C	<1000 E.coli org/100ml <20 mg/L BOD <30 mg/L SS	Urban - controlled public access. Used in subsurface irrigation or irrigation of areas where there is no public access.

The Environment Protection and Heritage Council and the National Resource Management Ministerial Council have initiated the development of national guidelines for water recycling. The guidelines comprise a risk management framework and guidance on managing health and environmental risks associated with the use of recycled water.[33]

Below are the water quality objectives for water reuse as set out in the national draft guidelines.

[32] Source: Victoria EPA (2003) Guidelines for Environmental Management: Use of Reclaimed Water Publication 464.2.
[33] Environment Protection and Heritage Council, 2005

Table 15: National Water Quality Objectives – Suitable uses of reclaimed water after treatment and/or on-site controls

Suitable Uses	Treatment	On-site Controls	Water Quality Requirements
Dual reticulation (toilet flushing, car washing, garden watering etc) Municipal irrigation (open space, sports grounds, golf courses, dust suppression, landscape irrigation) Firefighting Industrial uses	Secondary treatment Coagulation, filtration, disinfection		Turbidity ≤ 2 NTU Chlorine residual to achieve minimum *Ct* (could vary depending on use eg ≥60mg.min/L for dual reticulation but lower for industrial uses) UV light to provide minimum dose (eg 100mJ/cm^2 for dual reticulation but lower for other uses) *E.coli* < 1 per 100mL for dual reticulation *E.coli* < 10 per 100mL for other uses BOD < 20mg/L (as a measure of effectiveness of secondary treatment)
Municipal irrigation (open space, sports grounds, golf courses, dust suppression)	Secondary treatment with disinfection	Combinations of: • No public access during irrigation • Exclusion periods (eg no use until 1-4 hrs after irrigation) • 25-30m buffer zones to nearest point of public access. • Spray drift control: - low throw sprinklers - microsprinklers - part circle sprinklers (180° inward throw) - tree/shrub screens - anemometer switching	Chlorine residual to achieve minimum *Ct* (eg ≥ 15 mg.min/L)[a] *E.coli* < 100 per 100mL BOD < 20mg/L, SS<30mg/L (as a measure of effectiveness of secondary treatment)
Municipal irrigation (open space, sports grounds, golf courses, dust suppression)	Primary or secondary treatment with extended lagoon detention eg > 30 for secondary effluent > 60 days for primary effluent)	As above	*E.coli* < 1000 per 100mL Soluble BOD < 20mg/L, SS<30 mg/L (as a measure of effectiveness of secondary treatment)
Landscape irrigation (trees shrubs, garden beds, ornamental ponds etc)		Combinations of: • Microspray • Drip irrigation • No public access during irrigation	*E.coli* <1000 per 100mL BOD < 20 mg/L, SS<mg/L (as a measure of effectiveness of secondary treatment)

BOD = biochemical oxygen demand; Ct = concentration of disinfectant (mg/L) x time (min); SS = suspended solids
[a] Other forms of disinfection may be used. In these cases alternative methods of measuring effectiveness will need to be identified eg. minimum UV dose.

Appendix B – Typical treatment systems

Aerobic Treatment
Aerobic treatment (with oxygen) generally requires energy to mix or aerate wastewater. Aerobic treatment technologies include:

- activated sludge treatment;
- aerated ponds;
- aerobic ponds;
- trickling filter systems; and
- aerobic package treatment plants.

Non mechanical aerobic systems are a preferred option as they do not create methane under anaerobic conditions and energy is not required to mix and aerate.

Anaerobic Treatment
Gases generated from anaerobic digestion (with no oxygen present) of wastewater or associated sludge is known as biogas. This gas is predominately methane though also contains carbon dioxide. Unmitigated biogas emissions have a significant impact, due to the high concentration of methane which has 21 times the warming potential of carbon dioxide.

The high content of methane enables the use of biogas as a fuel. In sufficient quantities this gas can be captured and used (i.e. combusted) to produce energy. The conversion of biogas (a potent greenhouse gas) to carbon dioxide enables energy to be harvested onsite and the reduction of methane emission to the atmosphere. Thus the total greenhouse emissions can be reduced through the recovery of methane for energy generation.

For small scale systems, sufficient biogas must be generated to ensure the viability of the system. Biogas can be supplemented by natural gas in a methane recovery and cogeneration facility.

Water Mining
For water (sewer) mining projects, the net change in greenhouse gas emission from the biological degradation is minimal. That is the biological decomposition will either occur on site or at centralised treatment facilities. The only exception is the anaerobic digestion of biological matter.

To quantify the greenhouse gas emissions for this scenario, a calculation method developed by the EPA is presented in Appendix G.

Appendix C - Green Power™ (accredited renewable energy)

Electricity customers can purchase a nominated amount of Green Power™ from electricity suppliers. The retailer then has to source an equivalent amount of energy from wholesale renewable energy generators such as wind, solar and hydro-power, instead of sourcing it from coal fired generators.

The National Green Power Program "aims to drive investment in renewable energy in Australia with a view to increase the sustainability of Australia's electricity supply. This will be achieved by raising awareness of, and ensuring consumer confidence in, accredited renewable energy products and increasing their uptake."[34]

The Accreditation Program sets out technical criteria, marketing criteria and eligibility requirements for energy products to be included in the scheme. The energy product's retailer is required to provide information through a quarterly and annual process, to ensure the criteria and requirements are being met.

The Green Power Scheme, including it's accreditation process, is overseen by a national steering committee with representatives from the lead State Government agency working in renewable energy issues in each state. Currently, this is the only scheme in Australia that has a clear framework to ensure consumer confidence, a robust and transparent accounting process, and a mechanism which links consumer demand to stimulating growth of renewable energy infrastructure in Australia.

See www.greenpower.com.au for more information.

[34] From www.greenpower.com.au

Appendix D - Acts and Regulations relevant to water recycling

Acts

Environment Protection Act 1970
Building Act 1993
Health Act 1958
Trade Practices Act 1974
Safe Drinking Water Act 2003
Food Act 1984
Livestock Disease Control Act 1994
Occupational Health and Safety Act 1985
Water Act 1989

Regulations
Environment Protection (Scheduled Premises And Exemptions) Regulations 1996, No. 66/1996

State environment protection policies
State Environment Protection Policy (Groundwaters Of Victoria) Publication S160
State Environment Protection Policy (Waters Of Victoria) Publication S13
State Environment Protection Policy (Prevention And Management Of Contaminated Land) 2002

Codes, standards and guidelines
EPA Victoria (1991) Publication 168: *Guidelines for wastewater irrigation*
EPA Victoria (1993) Publication 384: *Enforcement policy*
EPA Victoria (1999) Publication 441: *A guide to the sampling and analysis of water, wastewaters, soils and wastes*
EPA Victoria (2003) Publication 464.2: *Guidelines for environmental management: Use of reclaimed water*
EPA Victoria (1997) Publication 500: *Code of practice for small wastewater treatment plants*
EPA Victoria (2002) Publication 730: *Guidelines for environmental management: Disinfection of treated wastewater*
EPA Victoria (2001) Publication 812: *Domestic wastewater management series: Reuse options for household wastewater*
EPA Victoria (2005) Publication 865.2: *Environmental auditor guidelines for appointment and conduct*
EPA Victoria (June 2004) Publication 952: *Environmental auditor guidelines for the preparation of environmental audit reports on risk to the environment*
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AS/NZS 4360:2004 *Risk Management*
AS/NZS 3500:2003 *National Plumbing And Drainage Code*
AS 1345 *Identification Of The Contents Of Piping, Conduits And Ducts*
AS 1319 *Safety Signs for the Occupational Environment*
AS 2845.1 *Water Supply – Backflow Prevention Devices*
AS 2845.3 *Water Supply – Backflow Prevention Devices – Field Testing And Maintenance*
AS 203*1 Sample Collection And Preservation Techniques*
AS 2419-1 *Fire Hydrant Installations*
Plumbing Industry Commission & Water Authorities (2005) *Recycled Water Plumbing Guide*
NHRMC *Australian Drinking Water Guidelines 2004*
Department of Sustainability and Environment Circular No. 287 *Blue-green algae coordination arrangements for 2004/2005 and related matters*, as updated.
Natural Resource Management Ministerial Council and Environment Protection and Heritage Council (2005) National Guidelines for Water Recycling Managing Health and Environmental Risks – Draft for Public Consultation

Adapted from EPA Victoria (2005).

Appendix E – Checklist for Climate Neutral Water Saving Schemes

This checklist applies to all new water saving schemes and to major renovations of water saving schemes.

- please tick all measures included or indicate 'NA' where not applicable.
- please cross the box if one of the listed measures cannot be considered and indicate at the end of the section why the measure cannot be considered.

Checklist to be included with capital works applications and cc'd to City Sustainability

Project:	
Project Manager:	
Checklist Completed By:	

Step 1. Audit greenhouse gas emissions of current practices

Ref	Measure	Check
1.1	Undertake a water balance for the site which quantifies water use and water discharge.	
1.2	Establish baseline greenhouse assessment of current practices from • embodied energy of water consumption and wastewater • biological degradation of wastewater	

Step 2. Reduce water use

Ref	Measure	Check
2.1	Reduce water consumption through a full range of initiatives including water efficient fittings, appliances, smart irrigation systems and pressure reduction valves	
2.2	Avoid disposal of organic material (for example food scraps, vegetable peelings) into the wastewater system	

Step 3. Select alternative water scheme and assess its greenhouse gas emissions

Ref	Measure	Check
3.1	Consider where the water will come from: • rainwater; • stormwater; • 'light' greywater; • greywater; • blackwater. Recognise that different water sources have different treatment requirements. For example, rainwater will need less treatment than greywater (therefore requiring less energy and emitting less greenhouse gases)	
3.2	Consider where the water will be used: • drinking water; • hot water system; • clothes washing; • toilet flushing; • garden irrigation; • municipal irrigation; • industrial; • firefighting. Recognise that different water uses have different treatment requirements.	
3.3	Compare water sources to reuse applications (refer to Table 14)	
3.4	Consider 'fit for use' philosophy and the water quality hierarchy to match water sources with appropriate uses.	
3.5	Alongside greenhouse emissions, be sure to consider these additional factors before choosing your water saving technology:	

	• cost; • operation and maintenance requirements; • available space; • health implications; • on-going ownership and management.	

4. Maximise the efficiency of the treatment/distribution supply system

Ref	Measure	Check
4.1	Has the scale of the treatment been considered? Smaller localised modular treatment technologies are favoured over centralised treatments as they are generally more efficient.	
4.2	Is the treatment located as close as possible to the end user to minimise resource consumption and energy requirements?	
4.3	Does the scheme use header tanks that can be trickle-fed?	
4.4	Does the scheme use energy efficient pumps and motors?	

5. Reduce the embodied energy of the water reuse system

Ref	Measures	Check
5.1	Does the scheme have materials with a low embodied energy coefficient and long life expectancy?	
5.2	Does the scheme use modular infrastructure on a needs basis (not overbuilding)?	
5.3	Does the scheme use recycled materials?	
5.4	Does the scheme use durable materials?	

6. Consider on-site generation of renewable energy to service the water reuse scheme

Ref	Measures	Check
6.1	Consider solar energy to supply electricity or power water pumps.	
6.2	Consider latest fuel cell technology to power water saving scheme.	
6.2	Consider the capture and of methane to operate cogeneration to provide energy to the treatment plant.	

7. Consider the purchase of accredited renewable energy ('Green Power')

Ref	Measures	Check
7.1	Consider and cost the purchase of accredited renewable energy to meet water reuse energy requirements.	

8. Consider the use of emissions trading/carbon offsets

Ref	Measures	Check
	Note: For future consideration. Not applicable at present.	
8.1	Consider the purchase of 'carbon credits' for afforestation and reforestation activities to offset the energy required for water treatment/reuse.	

Measures not considered – Please complete details:

Ref	Reasons for no consideration

Table 16: Water Sources and Suitable Reuse Applications

Water	Reuse Applications (Based on Water Quality)	Treatment Required for Reuse Applications
Potable Mains Water	All uses[1]	None[2]
Rainwater (roof runoff)	Hot water system, clothes washing, irrigation, toilet flushing	Low. Sedimentation can occur inside rainwater tank.
Rainwater (stormwater runoff)	Clothes washing, garden irrigation, toilet flushing.	Reasonable treatment needed to reduce litter and reduce sediment and nutrient loading.
'Light' Greywater	Clothes washing, garden irrigation, toilet flushing.	Moderate treatment required to reduce pathogens and organic content.
Greywater	Garden irrigation and toilet flushing.	High level of treatment. High organic loading and high variable quality.
Blackwater	Garden irrigation, toilet	Advanced treatment and disinfection required.

(Adapted from City of Melbourne, 2005)
[1]Whist it is not preferable to use potable water for all applications it is possible based on the high level of water quality

Fit-for-Purpose Water Use

Fit-for-Purpose Water Use

This involves matching available water sources with appropriate uses. For example using potable water for irrigation and toilet flushing is a waste of a high quality resource. The use of alternative water sources (such as rainwater) would be more suitable. (City of Melbourne, 2005).

Table 17: Hierarchy of Water Reuse

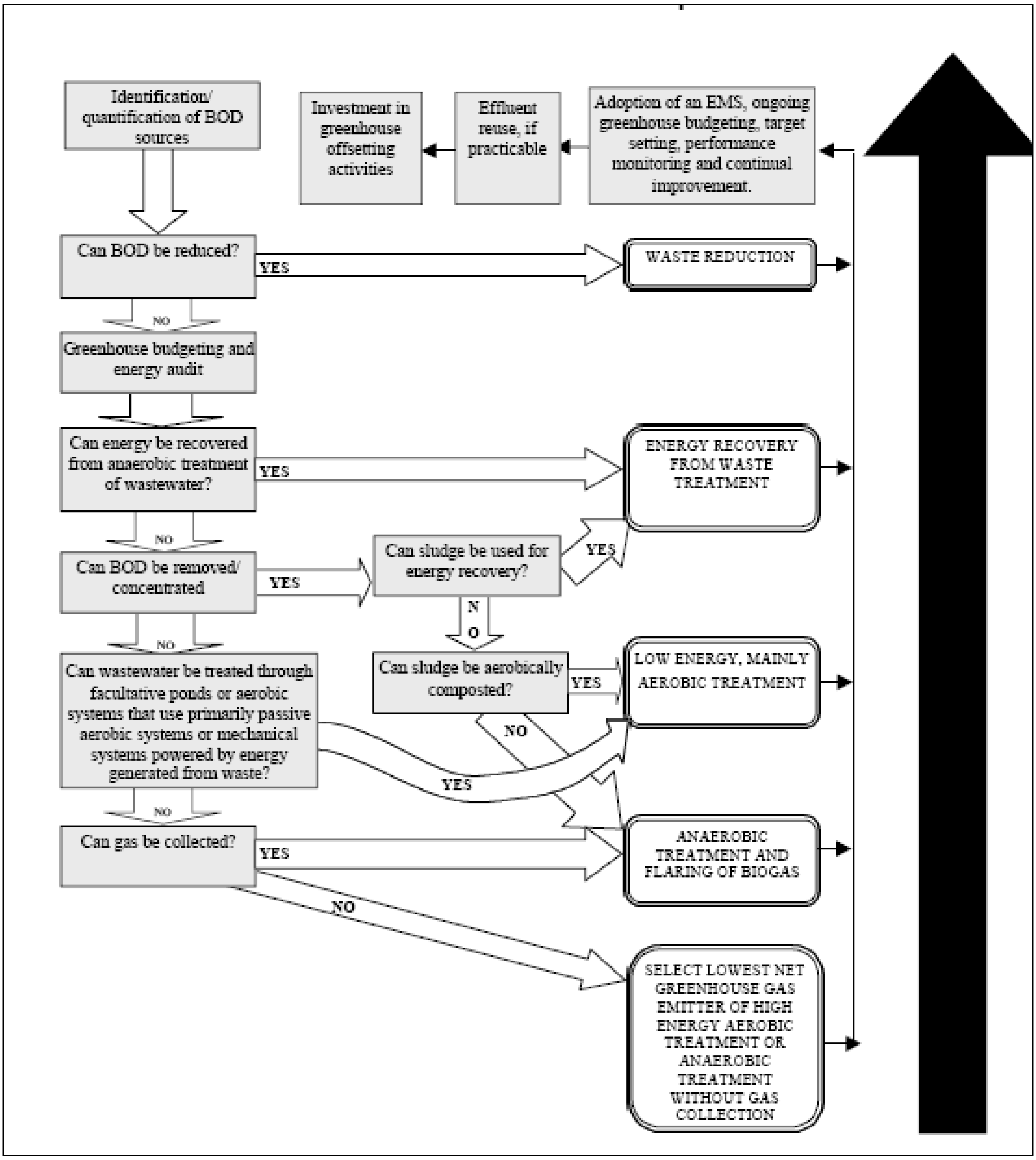
Preference	Water for Reuse
1	Rainwater (roof run-off)
2	Stormwater
3	Light Greywater
4	Greywater
5	Blackwater

The hierarchy of water reuse follows the hierarchy of water quality. Reuse the best quality of water available first. For example on a site where rainwater and blackwater can be harvested but both are not required, the rainwater should be utilised first as there are less associated risks, treatment is less resourceful and less greenhouse gas intensive.

Appendix F – EPA Decision Making Flowchart

Framework for managing greenhouse gas emissions
The Victorian EPA has created a decision making flowchart for managing greenhouse gas emissions from wastewater treatment operations. This framework, shown in Figure 4, was developed to assist regulatory authorities to manage greenhouse gas emissions.

Figure 4: Decision making flowchart for managing greenhouse gas emissions from wastewater treatment operation



Source: EPA Victoria (2000) Publication 722

Appendix G – How to Calculate Greenhouse Gas Emissions from methane recovery devices

According to EPA Victoria (2000), methane emissions from the wastewater treatment can be estimated from the BOD of the wastewater flow and an estimate of the degree to which degradation is anaerobic.

For a preliminary assessment, the methane potential can be estimated by multiplying the total BOD load in kilogram by 0.25. The greenhouse gas equivalent can be estimated by multiplying this figure by 21.

Table 18: Methane from Wastewater Assessment Table

Methane from Wastewater				
Volume of wastewater treated anaerobically (L/yr)		-from records	=	E
Average BOD of wastewater (mg/L)		-from records	=	F
Total BOD (tonne/yr)	=	E X F /1,000,000,000	=	G
Methane (tonne/yr)	=	G X 0.25 tonnes/tonne	=	H
GHG potential (tonnes CO2e/yr)	=	H X 21	=	I
Gas capture				
% methane captured		*(eg. 40%)*	=	K
% of captured methane combusted		*(eg. 95%)*	=	L
Total methane combusted	=	J X K X L	=	M
Fugitive emissions	=	J - M	=	N
GHG emissions (CO2e/yr)	=	N X 21	=	O
Energy Recovery				
Energy potential of methane (GJ/year)	=	M X 50.0 to 55.5 GJ/tonne	=	P
Methane Converted to electricity				
Electrical energy coversion efficiency		*(e.g. 20-26%)*	=	Q
Electrical energy generated (MJ/yr)	=	P X Q X 1000	=	R
Electrical energy generated (kWh/yr)	=	R / 3.6 MJ/kWh	=	S
Avoided GHG from energy recovery (tonnes CO2e/yr)	=	S X0.00138 tonnes CO2 e/kWh	=	T
Methane used for gas heating				
Gas energy conversion efficiency (%)		*(e.g. 80%)*	=	U
Gas energy generated	=	P X S	=	V
Avoided GHG from energy recovery (tonnes CO2e/yr)	=	V X 0.0663 tonnes/MJ	=	W
TOTAL GHG IMPACT (tonnes CO_2 e/year)	=	O - T - W	=	X

Source: EPA Victoria (2000) Publication 722.

Appendix H –
City of Melbourne Draft Best Practice Greenhouse Offsets Statement

This Statement acts as Council's internal guidelines for 'best practice' offset purchases. Offsets can be used to negate 'residual' greenhouse emissions, where energy efficiency, onsite generation and Green Power options have been exhausted. Some examples of this application include:

- offsetting residual emissions of a Council building or facility, to make it 'carbon neutral';
- offsetting a Council facility such as the Town Hall, where energy efficiency opportunities are limited due to heritage issues; and
- offsetting the greenhouse impact of Council's travel activities, such as car use and air travel.

The Statement reflects what is considered 'best practice' by stakeholders with experience in the field, and incorporates Council's triple bottom line approach. It is anticipated that as Council trials more offset projects, and the market matures, this Statement will form the basis of an **Offsets Policy**.

Policy context

- *Zero Net Emissions by 2020* strategy
- *Greenhouse Action Plan 2006-2010*

Broad Principles for Best Practice Greenhouse Offsets

- Greenhouse reduction through efficiency, on-site generation and Green Power will be explored before considering an offset purchase;
- Offset credits purchased should be created from projects located in Australia;
- The offset credit should be created from projects that demonstrate additionality. That is, the offset project was not set up to meet a company's core legal or regulatory requirements;
- The offset must have no negative environmental or social outcomes;
- The offset project demonstrates a high level of greenhouse accounting standards;
- Council will buy credits created from reductions that have already occurred, as opposed to future reductions;
- A purchase, investment or contract will have a one-year timeframe; and
- Council will not 'on-sell' credits.

Purchasing offsets created from carbon sinks (bio-sequestration)

- The plantings must be located in Victoria (governed by Victorian law);
- The project must meet Australian standards for accounting and monitoring (Interim Australian Standard AS4978.1 (Int) 2002- *Carbon Accounting for Greenhouse Sinks Part 1: Afforestation and Reforestation*);
- Carbon property rights must be registered on title of the land (Victorian Forestry Rights Act 2001);
- The sink must be able to demonstrate other positive environmental benefits, such as high level of biodiversity improvement, land restoration, and habitat renewal;
- The offset provider must demonstrate good land management practices for risk mitigation (eg fire and pest management);
- 3rd party verification of risk management is required for accounting, monitoring, compliance with standards, and record keeping; and
- The plantation must be permanent.

Compendium –
Greenhouse Neutral Water Saving Schemes for Households

The following is a simple process for considering greenhouse gas emissions arising from potential household water saving projects:

- firstly, in the planning stage, consider all opportunities for water conservation (because saving water will also reduce greenhouse gas emissions);
- secondly, consider opportunities for alternative sources of water, namely rainwater harvesting, stormwater and wastewater recycling. If an alternative source is to be used, then;
- thirdly, undertake assessment of greenhouse gases emitting from proposed alternative source.

The City of Melbourne has developed the following simplified process to help households deliver climate neutral water reuse (rainwater tanks and treated/untreated greywater systems for toilet flushing or outdoor use) projects.

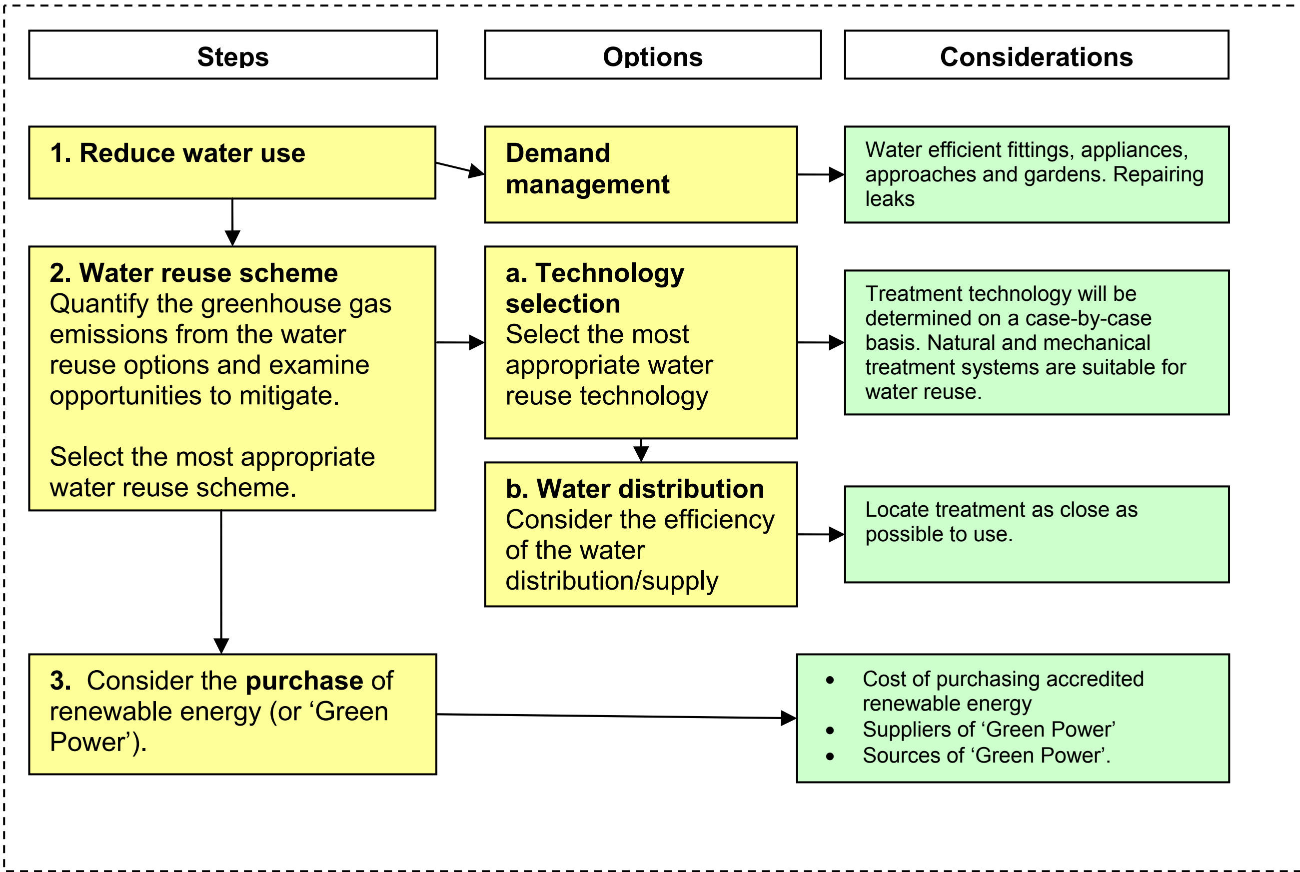


Figure 5: Process for Implementing Climate Neutral Water Recycling in the household

Step 1: Reduce Water Use

Greenhouse gas emissions associated with water treatment can be minimised by:

- reducing water consumption and wastewater generation;
- using alternative water supplies;
- reducing organic material in wastewater (this can be achieved by educating commerce and industry about waste minimisation and cleaner production);
- diverting organic waste from uncontrolled anaerobic conditions.

One of the most effective ways to reduce greenhouse gas emissions is through the reduction of water consumption and wastewater generation.

Demand management measures include water efficient fittings (5A taps, 6/3L dual flush toilets), water efficient appliances (5A washing machines), water efficient gardens (xeriscaping, hydrozoning, smart irrigation techniques) and pressure reduction valves. Demand management measures reduce water consumption and wastewater generation. Consequently less energy required to heat (for hot water), treat and transport water to and from the City of Melbourne.

Avoid disposal of organic material for example food scraps, vegetable peelings into the wastewater system.

Step 2 – Select an alternative water scheme and assess its greenhouse gas emissions

Step 2a - Reduce the greenhouse gas emissions associated with the treatment process

Quantify greenhouse gas emissions generated from the energy consumption required for the water treatment process.

Treatment will be required to upgrade water quality for the appropriate end use. Typically water used within the City of Melbourne will be treated to a high standard reflecting the water reuse applications.

Table 19. Water source and level and treatment

Water	Treatment
Rainwater	Minimal treatment required. The hotwater system (e.g. gas boosted system) can be integrated to provide thermal disinfection; alternatively UV disinfection may be installed.
Stormwater	Best practice treatment required. Typically this is through the use of natural treatment systems such as bioretention systems or constructed wetlands. Mechanical systems, for example filtration systems, can also be used for stormwater treatment, particularly for large scale systems where limited space is available for treatment.
Greywater	Diversion devices can be fitted to subsurface irrigation systems with no treatment required. Greywater reuse treatment systems can be situated on a household scale for reuse. Moderate treatment is required to ensure pathogens are removed from greywater for non-potable water reuse.
Blackwater	High level of treatment is required to remove pathogens and biological components to ensure water is safe for reuse. Mechanical treatment systems are typically used in cities due to the limited space available.

Greenhouse gas emissions will be dependent on the water source, water end-use and the treatment technology selected.

ENERGY CONSUMPTION
For all mechanical systems the greenhouse gas emissions can be calculated from the energy consumption. The energy consumption is the sum of all energy requirements of the system including pumping, disinfection and treatment components. This information is readily available from technology suppliers.

Step 2b - Maximise the efficiency of the distribution/supply system

The distribution and supply system is an important element to maximise the efficiency of the water reuse systems. The City of Melbourne's *Water Sensitive Urban Design Guidelines* identifies smaller, localised, modular treatment technologies over centralised treatments for water reuse.

Here the water end use is located close to the treatment system. In contrast, centralised treatment means wastewater has to be transported to a treatment plant and then transported back to the consumer for reuse. The high level of transport is expensive and energy intensive due to the piping and pumping required.

Minimising energy requirements through the distribution and supply system can be achieved by:

- considering the location of the treatment. Locating the treatment as close as possible to the end user and relying on gravity where possible, minimises resource consumption (piping) and energy requirements (less need for pumping);
- using header tanks for water supply. These can be fed by low flow trickle pumps; and
- selection of energy efficient pumps and motors.

The greenhouse gas audit must also include the greenhouse energy requirements derived from the additional reticulation networks.

Step 3 - Consider the purchase of accredited renewable energy

In achieving the aim of climate neutral water saving, it is necessary to minimise the energy requirements of the water saving system as discussed in Step 1.

If there are greenhouse gas emissions arising from the water saving process after these steps have been taken, the purchase of Green Power™ from an accredited electricity supplier must be considered.

A project cannot be deemed carbon neutral unless there is 100% renewable energy servicing the project. It is necessary to ask the energy retailer for proof that their product is currently an accredited Green Power™ product, or to check that their product displays the Green Power Accreditation. Electricity customers can purchase a nominated amount of renewable energy from electricity suppliers. The equivalent amount of energy nominated is produced from renewable sources such as wind, solar and hydro-power.

The electricity suppliers in Victoria that provide accredited 'green power' are listed below. See Appendix C for further details.

Table 20: Green Power™ Product Green Power' Suppliers in Victoria (as of May 2006), as displayed on www.greenpower.com.au [35]

'Green Power' Suppliers	Sources of 'Green Power'	Sectors
AGL – AGL Green Energy	Biomass 65%, Low Impact Hydro 35%	Residential and Commercial
ActewAGL GreenChoice	Biomass 54.8%, Low Impact Hydro 39.6%, Wind 5.6%	Residential and Commercial
Auspower - Verdant	Biomass 100%	Commercial
Country Energy - countrygreen™ energy	Biomass 49.9%, Wind 49.8%, Solar 0.3%	Residential and Commercial
Origin Energy - GreenEarth	Wind 74%, Low Impact Hydro 20%, Biomass 6%	Residential and Commercial
TXU – Green Energy	Biomass 100%	Residential and Commercial

A project cannot be deemed carbon neutral unless there is 100% renewable energy servicing the project.

[35] Source: Greenpower (undated)

Case Study: *Single allotment – rainwater harvesting*

This example is based on the Terraces – T1 developed in the City of Melbourne's *WSUD Guidelines* (2005).

A single household allotment is investigated for the harvesting of rainwater and reuse within the block. This scenario is based on a small inner city redevelopment. The terrace house is bordered by properties on either side. Limited garden is available within the block with the harvested water used for toilet flushing.

The roof area of 45 m^2 is collected in a 1.5 kL tank (refer to *WSUD Guidelines* for the sizing of tank). The tank is situated within the roof and the water gravity feeding to the toilets. This removes the requirements for any pumps. *[Note in situations where tanks cannot be installed in the roof, a pump will be required for distribution.]*

The harvested rainwater will be used for toilet flushing (demand of 50L/d).

Step 1. Demand management

Reducing water demand by the installation of dual flush toilet (6/3L) also reduced greenhouse gas emissions. A water efficient toilet consumes 50 L/d (18.3 kL/y) for toilet flushing. Reducing water consumption reduces the transportation of both water and wastewater through the centralised networks. It also reduces the volume of water to be treated at centralised facilities.

Step 2. Alternative water scheme

The 1.5 kL tank provides stormwater for 87% of the demand, that is, 15.9 kL/y with the remainder supplied by potable water (2.4 kL/y). This reduces the overall greenhouse gas emissions to 16.4 kg CO_2-e/y as shown in Table 23 in Appendix. Wastewater is still disposed via centralised treatment facilities being transported to Werribee for treatment and release back into the environment. The energy requirements and consequent greenhouse gas emissions are calculated for the transportation and treatment.

The embodied energy is calculated for materials for the rainwater tank and additional plumbing. Additional plumbing is required for collection of rainwater and supply to the toilets. No treatment is required for this scheme beyond the settling achieved in the rainwater tank. As there are no mechanical systems or electrical motors attached to this system, no ongoing energy is required. The total embodied energy is 6890 MJ. The analysis estimates a life span of 50 years and thus the average greenhouse gas emissions are 55 kg CO_2-e/y (refer to Table in the Appendix).

As an example a summary of the greenhouse gas emissions from both the conventional and water efficient household is provided in Table 21. There will be a net increase of 18 kg CO_2-e/y in the greenhouse gas emissions, predominately from the additional materials required to construct the rainwater tank and additional plumbing required. This can be offset by the purchase of green energy (refer to Step 3).

Table 21. Summary of greenhouse gas emissions from rainwater tank for toilet flushing

Baseline assessment - Conventional	
	kg-CO_2e/y
Water	5.54
Wastewater	28.1
Sub-total	33.6
Water efficient terrace	
Water (mains supply)	0.41
Wastewater	16.0
Rainwater tank	24.8
Distribution	10.2
Sub-total	51
	kg-CO2e/y
Net increase	**18**

Step 3 – purchase green energy

It is recommended to purchase green energy to off set the net increase in green house energy. This water reuse scheme will have a net increased of 18 kg CO2e/y and this can be offset by the purchase of green power.

Appendix for Compendium - Detailed calculations for single household

Baseline establishment
A conventional household consume 88 L/d (based on 2.5 occupants) and generates 34 kg of CO_2-e/y for water use and wastewater generation from the toilet as shown in Table 22 below. This provides a baseline for our assessment.

Table 22.
Baseline assessment for water use and wastewater generation for household toilet

Water	Equivalent CO_2 generated (tCO_2-e/ML)	Conventional building (kg CO_2-e/y)
Potable Water	0.173	5.5
Wastewater	0.875	28.1
	Sub-total	33.6

Table 23. Greenhouse gas emissions generated from a water efficient toilet

Water	Equivalent CO_2 generated (tCO_2-e/ML)	Water (ML/y)	Water efficient building (kg CO_2-e/y)
Potable Water	0.173	0.0024	0.411
Wastewater	0.875	0.0183	16.0
		Sub-total	16.4

Table 24. Embodied energy for rainwater tanks and harvesting system

Item	Quantity	Mass (kg)	Embodied energy (MJ/kg)	Embodied energy (MJ)	Greenhouse gas emissions (kg CO_2-e)	Greenhouse gas emissions (kg CO_2-e/y)
Rainwater tank (polyethylene)	1500 L	30	103	3090	1239	24.8
Dual supply reticulation network	45 m of 15 mm diameter pipe	38	100	3800	1524	30.5
					Sub-total	55.3