Climate change mitigation in the water sector

or How to reduce the carbon footprint of water

by Taryn Pereira

EMG
Environmental Monitoring Group

Table of contents

Acknowledgements Thanks to all who contributed ideas and information to this paper – particularly Jessica Wilson and other colleagues at EMG, Victor Munnik, Shafick Hoossein and others. Thanks also to all who kindly agreed to be interviewed. This research was partially funded by Masibambane, and the printing of this paper was funded by HBS. EMG gratefully acknowledges the support of the Heinrich Böll Foundation and Masibambane for funding this research'.

Executive Summary

CLIMATE CHANGE IS HAPPENING NOW. The way we respond to climate change now and in the near future will have huge implications - ecologically, socially and politically. One of the most immediate ways in which we are going to experience climate change in South Africa is in the pressure it places on our already scarce water resources, and on our already weak water services. There is therefore a lot that needs to be done in terms of preparing to adapt to climate change. But that is not where the water sector's response to climate change should end. The processes of changing water from a raw natural resource into a treated, piped and widely distributed consumable, involves the use of a lot of energy, which means the emission of a lot of greenhouse gases. The reduction of greenhouse gas emissions across all sectors, including the water sector, is crucial. This poses a huge challenge for a sector that is already facing many constraints, pressures and commitments, and it also poses a challenge for civil society, who are committed to the goals of accessible water and sanitation for all. An important question is thus raised: What needs to be done to ensure that there is sufficient water for everyone, in a manner that is acceptable and accessible to the poor, and which is sensitive to both water scarcity and reducing greenhouse gas emissions? This paper attempts to address this question, by looking at the specific greenhouse gas contributions (measured in CO_2) of the different stages in water provision and treatment, considering the impacts of alternative technologies and approaches, and identifying good practices which require further support and action.

Introduction

'A strong connection exists between water provision and energy consumption.. As readily available water sources are depleted, future supply options will likely have higher energy requirements'
(Stokes and Horvath, 2006)

The relationship between climate change and water is complex and intimate. For a start, the close interconnectedness between the climate and the hydrological cycle means that water resources will be intensely impacted by climate change. As average global temperatures increase, water cycles will change all over the world. The IPCC 4th Assessment Report projects a 10 – 30% decrease in runoff in southern Africa, and the Long Term Mitigation Scenarios (LTMS) projects a 5 - 30% decrease in winter rainfall in the Western Cape. What this means in practical terms is that it is very likely that we will face water shortages as a result of climate change, particularly in the Western Cape.

Another aspect of the relationship between climate change and water is the fact that the water we use in our homes, farms and factories has a 'carbon footprint'. This carbon footprint is mainly a result of the large quantities of energy used in the impoundment, treatment and distribution of water. The consumption of energy in the form of electricity requires coal to be burned, which leads to emissions of the greenhouse gas carbon dioxide (CO_2), which contributes to global warming and in turn drives climate change. Methane is another gas that is produced in the process of delivering water, mainly through damming rivers. For every litre of tap water that you drink or wash your dishes with or flush down the toilet, a few grams of CO_2 (carbon dioxide equivalents) are emitted into the atmosphere! Carbon dioxide equivalents are a way of measuring the contribution of all greenhouse gases on the same scale by equating their warming potential to that of CO_2.

To complicate matters further, the carbon footprint of water is likely to grow as a result of climate change – as available water sources become less reliable, we may need to consider more remote or alternative sources, which will often carry much higher energy and carbon costs (Griffiths-Sattenspiel and Wilson 2009).

This is already a very complex picture – potable water consumes energy, which in turn contributes to climate change, which influences the hydrological cycle so that there is less available water, and as water becomes more scarce, new water sources require higher consumption of energy, which drives climate change... etc. (Figure 1).

Given the nature of these positive feedbacks between water and climate change, it clearly makes sense to reduce both water and energy consumption, in the interests of climate change mitigation and conservation of water resources.

But, a crucial part of the picture is still missing – where do **people** fit in? What about the vast numbers of people in South Africa who *still* do not have access to safe and sufficient drinking water and sanitation?

Access to water (or a lack thereof) is an extremely sensitive issue in South Africa. It is a politically charged issue, linked to class struggles and social status. It is an issue which is used by politicians as a benchmark of their successes or of their opponent's failures. Underlying all of this are the contradictions between a Constitution which enshrines the right to water, and grossly inequitable and inadequate infrastructure and service delivery.

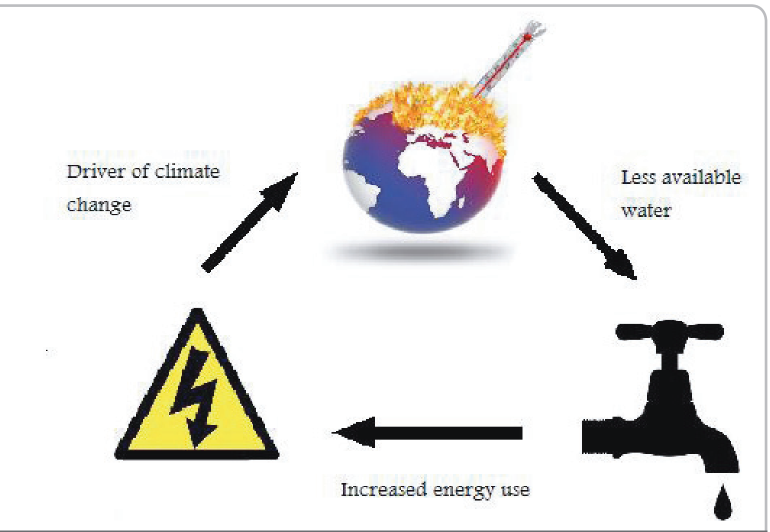

Figure 1: The relationship between potable water, energy consumption and climate change

As civil society, we are committed to certain developmental goals – clean water and safe sanitation for all. Our government is committed to ensuring 'water security in terms of quantity and quality to support South Africa's requirements for economic growth and social development' (DWAF 2009). At the same time, there is an urgent need to take climate change action. According to the IPCC, global greenhouse gas emissions must peak by 2015 and then decline, if we are to keep temperature increase between 2.0 and 2.4° C. The LTMS (Long Term Mitigation Scenarios) 'required by science' scenario calculates that South Africa needs to limit its emissions to 30 – 40% of 2003 levels by 2050 (Scenario Building Team 2007). The government has committed in principle to emissions peaking between 2020 and 2025. If we are to achieve this, there must be drastic emission reductions in **all** sectors of society, including the water sector.

So: how can we ensure that everyone gets enough water, within the constraints of threatened water resources, weak water services, and a carbon saturated atmosphere?

In order to address this question, this paper

- Describes the relationship between water and climate change mitigation in a South African context;
- Considers the climate change impact of each stage in water provision and treatment in general, and in specific South African examples;
- Explores some alternative approaches, in terms of their potential for *reduced impacts on climate change, improved water and sanitation for the poor,* and *conservation of water resources;*
- Identifies obstacles to good alternatives, and ways for civil society to engage with those obstacles.

Scope and Methodology:

This paper presents each of the stages in a generic South African urban water cycle, with specific examples from different municipalities for each stage. These specific examples are mostly from Cape Town, Johannesburg and Durban. While there are of course large differences between different regions of the country in terms of water sources, water quality, topography and climate, this will hopefully provide an overview, and a framework for understanding the carbon footprint of water in any South African municipality.

The intended audience for this paper is the growing cadre of people and organisations working on water and climate change – civil society, labour, academia and government. It is hoped that this paper will serve as a starting point for more in depth discussions about addressing climate change mitigation in the water sector, and also to identify specific opportunities for immediate lobbying and action.

The research which has gone into this paper involved an extensive literature review, interviews with others in civil society, in municipalities, in the then-named Department of Water Affairs (DWAF) and Department of Environmental Affairs and Toursim (DEAT), and with academics and scientists. At the national climate change summit in March 2009, a seminar was held, entitled 'Water's Carbon Footprint?', and two other researchers – Victor Munnik and Shafick Hoossein – made presentations and shared their research. Many of the ideas presented in this paper were debated, discussed and developed at this meeting.

Water and climate change mitigation

Understandably, the South African water sector's response to climate change has largely been from the perspective of the projected impacts of climate change on water, the added pressure on resources, and strategies for *coping with* or *adapting to* climate change. But the water sector also contributes to climate change. The process of getting water from a 'raw' or natural state to users, and treating it so that it is drinkable and so that the final effluent is safe to release into the environment, involves using a lot of carbon-burning electricity, as well as the emission of other greenhouse gases. While water's carbon footprint may not seem very big compared to other sectors, like mining or transport, this footprint is going to continue to grow, and we must address it if we are to uphold our commitments to mitigation across all sectors.

South African mitigation commitments of relevance to the water sector

1. The South African government is committed to energy efficiency and conservation across all sectors: "The Start Now strategic option as outlined in the LTMS will be further implemented. This is based, amongst others, on accelerated energy efficiency and conservation across all sectors" (DEAT 2009).
2. In the National Climate Change Response Policy Document, DEAT also talks specifically about mitigation in the water sector: "All key affected national departments must initiate and facilitate the development of the sector-specific components of the National Climate Change Response Policy that fall within their mandate, jurisdiction or sphere of influence, including: DWAF - the mitigation of greenhouse gas emissions from the water and forestry sectors, including through demand-side management and efficiency, and the adaptation of water and forestry to manage and/or minimise the impacts of climate change, while ensuring the ecological reserve is maintained" (DEAT 2009).
3. The Minister of DWAF explicitly committed to addressing mitigation: "At this stage we are collating our input into the development of the national climate change response policy. We will also use this policy to guide our own future actions, especially related to mitigation"... (we will)... Develop measures to assess carbon footprints from our infrastructure and propose ways of reducing these" (Hendricks 2009).
4. This commitment is re-iterated in the Water for Growth and Development Framework: "The Department's potential impact on mitigation of climate change is relatively small, and probably lies most in leveraging other government departments that have a greater impact on carbon emissions. However, in terms of mitigation, the department should ensure that carbon accounting forms part of the planning process for all major projects" (DWAF 2009).
5. In the context of the City of Cape Town, the City is aiming for a 12% increase in energy efficiency in all municipal buildings by 2015; at present, the City has a total electricity consumption of 796 GWh per year, with water supply and treatment contributing 11% to this total. (City of Cape Town 2006).

Despite these arguments and commitments, climate change mitigation in the water sector can be a tough sell. The water sector is under immense pressure as it is; water resource scarcity, wastewater treatment plants in dis-repair, service backlogs, huge challenges with water financing, a lack of capacity – all of these things make the job of trying to get enough water to everyone, everywhere, an extremely difficult one. Given the seemingly small contribution that water makes to global warming, why worry about mitigation?

In fact, mitigation in the water sector is essentially about sustainable development. It is about closing loops and minimising waste. Furthermore, mitigation in the water sector overlaps strongly with climate change adaptation. Consider the adaptation options highlighted by the City of Cape Town's Long Term Water Conservation and Water Demand Management (WC and WDM) Strategy (April 2007).

'The type of adaptations that will be needed are as follows:

1. Enhance our water use efficiency – to make the same amount of water go further.
2. Reduce our pollution impacts – to keep the same water cleaner for further use.
3. Make significant infrastructure and technical changes in order to ensure that we increase our ability to store water, and our ability to hold back floodwaters'.

Most of these work as mitigation options too. To mitigate, we need to improve water use efficiency (because water efficiency = energy efficiency); we need to have cleaner water (because it takes energy and chemicals to clean water); we need to think about alternative ways of storing water and building water infrastructure. And we need to think about doing all of these things in ALL communities.

However, some of the alternatives that we might consider in terms of climate change mitigation are problematic in other ways – in ways that make things more difficult for the poor, or that entrench existing inequalities, or that, while seeming more 'climate friendly' at first consideration, actually have hidden costs, for the environment and for people. These hidden aspects of any alternative must be illuminated and explored.

The water-energy nexus

Water UK estimates that the pumping and treating of water currently produces about 1% of the country's greenhouse gas emissions (Water UK 2009). The most recent estimates for the United States are higher – there, it is estimated that water-related energy use amounts to 13% of national energy consumption, contributing 5% of the country's greenhouse gas emissions, equating to 291 million tonnes of CO_2 (Griffiths-Sattenspiel and Wilson 2009).

In South Africa, a lot of emphasis has been placed on ensuring the sustainability of water provision (as reflected in many laws, e.g. the National Water Act 36 of 1998). Most sustainability efforts have focussed on the Ecological Reserve, sustainable abstraction rates from the environment, and the effects of discharge to rivers; but very little work has looked at the sustainability of the actual processes of producing potable water and treating wastewater (Friedrich *et al*. 2007). Life cycle analysis (LCA) studies are a useful tool for considering the environmental burdens of those processes, and since one of the most important impact categories in the LCA literature is 'Global Warming Potential', LCA studies are an obvious starting point for understanding the contribution of the water sector to climate change.

In the LCA studies that have been carried out for South Africa's water systems, it has been found that most of the environmental burden can be attributed to the coal-based electricity which is needed in every stage of water provision and treatment – this has led scientists to suggest an electricity index should be used as a measure of environmental performance for South African urban water systems (Friedrich *et al.* 2007). A study conducted in Durban estimated that, for every kl of water 'produced' (i.e. stored, distributed and treated), 0.67 kg of CO_2 are emitted (Friedrich *et al.* 2009, Figure 2).

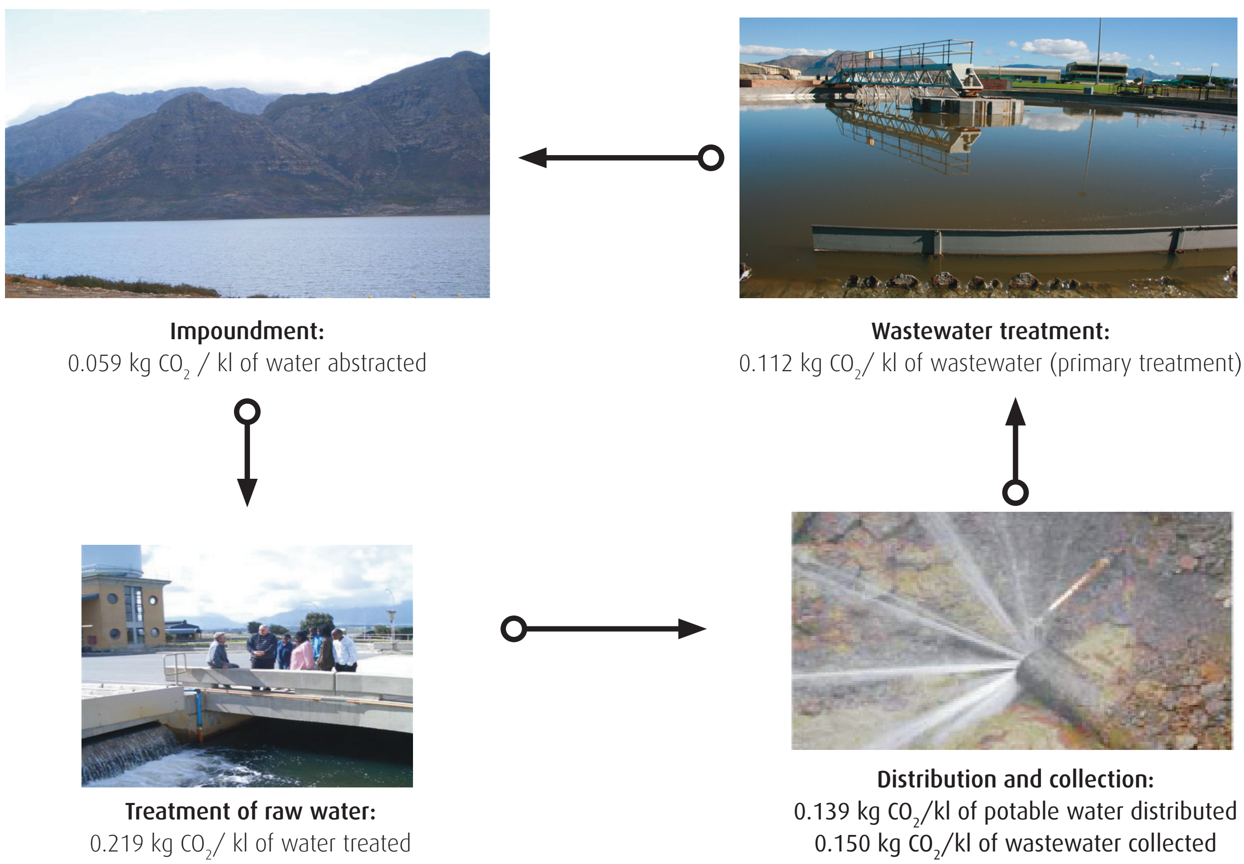

Figure 2: Carbon emissions from an urban water cycle – the case of eThekwini municipality. Calculations for supplying 200 000 households, with disposal of wastewater to sea (Data source: Friedrich et al. 2009)

To put this into perspective, 1.08 kg of CO_2 is emitted per 1 kWh of electricity, and 0.3 kg of CO_2 is emitted per kilometre in a car (Smart Living Handbook 2008). However, the energy cost of water varies greatly depending on water quality, topography and distance from source to consumer. For other cities, this figure could be much higher. For example, Johannesburg's water is pumped up from the Vaal River, at a head of 180 - 300m, whereas in both Durban and Cape Town, water flows down into these cities under gravity.

Lobbying opportunity: energy efficient pumps and motors

1. Given the close relationship between water and electricity, one of the key actions for reducing the carbon footprint of water is to improve the energy efficiency of the motors and pumps used in every stage of water provision and treatment.
2. Find out when old pumps or motors that supply your water need to be replaced, and lobby for them to be replaced with energy efficient upgrades
3. ESKOM is offering subsidies on energy efficient motors - these subsidies are still quite low, but opportunities like this do exist, and we need to support and access these kinds of offers.
4. Energy efficient (ee) alternatives are still more expensive per unit than conventional motors, and therefore there may be some reluctance from water managers to invest in them. Economic analyses of ee motors for water distribution and treatment, showing the rate of return on investment, are essential for proving that they are a viable option. This kind of research needs to be undertaken in each municipality.
5. Alternatively, lobby for a by-law to make ee alternatives mandatory.

But our water's climate change footprint is not only due to electricity consumption. Stopping a river is hard work. It takes a lot of concrete to build a dam. Concrete is not only energy intensive to make, it releases additional carbon dioxide through the chemical process of converting limestone ($CaCO_3$) to cement. In terms of non-carbon greenhouse gas emissions, water provision and treatment systems also contribute to the release of climate potent gases like methane and nitrous oxide from sewers and wastewater treatment plants, and the release of methane from decaying organic matter in dams.

What can we do about it? There are three main things:

1. Improve the energy efficiency of water provision and treatment
2. Change the methods used in water provision and treatment
3. Reduce the amount of water we consume

With these three modes of action in mind, let us consider each stage in the process of water provision and treatment.

Bulk water supply

The status quo

Dams

In South Africa, 77% of our available water is surface water (i.e. from rivers, streams, wetlands, and man-made impoundments of these sources - dams). The rest of our available water comes from return flows (14%) – water that has already been used and treated upstream - and groundwater (9%). While additional sources of water are being considered, due to the increasing risks of water shortages, surface water will remain the predominant source of water in the long term (DWAF 2009).

So, how do dams contribute to climate change? Quite significantly, it turns out. Recent research has estimated that the world's large dams may be responsible for more than 4% of total warming due to anthropogenic activities, making them one of the single most important contributors to global warming (Lima *et al.* 2007). This impact is due to the methane emissions produced by decomposing organic material submerged beneath the dams' waters; the study calculated that the world's 52,000 large dams are the largest source of human-caused methane emissions. The notion that hydro-power is 'clean energy' is strongly disputed in Lima *et al*'s paper, which states that "the massive amounts of methane produced by hydropower reservoirs in the tropics mean that these dams can have a much higher warming impact than even the dirtiest fossil fuel plants generating similar quantities of electricity" (www.internationalrivers.org). Methane is a much more potent greenhouse gas than carbon dioxide, with a global warming potential 21 times higher on a mass basis than CO_2, although it persists in the atmosphere for a much shorter time than CO_2 (12 years compared to 120 years for CO_2). It has been identified as an 'excellent candidate for mitigation' (Energy Research Centre, 2007).

In addition to high methane emissions, the processes and materials that go into constructing a dam also contribute to climate change. Consider the example of Inanda Dam in eThekwini municipality, which has a maximum daily abstraction capacity of 300 ML, and a projected lifespan of 70 to 100 years. The construction phase of the dam involved the use of cement, sand, and stone for poured concrete, as well as the processes of excavation and filling (Friedrich *et al.* 2009). The carbon emissions from the construction phase were calculated to be 0.008 kg CO_2 equivalents (e)/ kL of water extracted. The emissions for the operation phase of the dam relate to the amount of organic carbon entering the dam which ends up as methane and carbon dioxide, and was calculated for Inanda Dam to be 0.051 kg CO_2 e/ kL, so that the final emissions score for the dam is 0.059 kg CO_2 e/ kL of water abstracted (*ibid).*

However, dams can also contribute to electricity savings; for example, there is a pump storage plant at the Steenbras Dam (Western Cape) – water is pumped from the lower pump storage dam to the upper dam during off peak periods, and electricity is generated by running the water back down again in peak periods. This has saved the City of Cape Town approximately R2.5 million per month. This system, along with the city's other electricity generation plants (two gas turbines at Roggebaai and Athlone) are used for load management and emergencies (City of Cape Town 2006).

The location of a dam relative to the users it is supplying is very important in terms of energy efficiency. In the City of Cape Town, for example, the major supply dams are higher than the metro, mostly in the mountains to the east of the city. This means that very little pumping is required, as the water is leveraged by gravity. It also means that the water is very clean, as there are no upstream human settlements or other sources of pollutants (Arne Singels *pers. comm.)* Johannesburg, on the other hand, is built on a ridge, and potable water has to be pumped over 50km from the Vaal River at a head of 180 – 360m (Rand Water 2009).

The managers and engineers involved in bulk water are 'nowhere near being able to think about our carbon footprint' (Arne Singels *pers. comm.),* due to capacity constraints, and due to the perception that it is a lesser concern, compared to the other issues they face.

Alternatives in bulk water supply – opportunities and constraints

Improving the energy efficiency of pumps used to transport bulk water to treatment plants is a crucial step towards reducing the climate footprint of bulk water (see Text Box 2). There is also the potential for capturing methane from dams and using it as a source of power (Lima *et al.* 2008). This has not yet been explored in South Africa, and requires more research.

However, any way you look at it, dams do carry large environmental burdens:
'…it seems, from an environmental viewpoint, that big hydraulic projects should be considered the last option because they are rigid and long-term infrastructures (several decades and even centuries of operation) that provoke important environmental loads with only a small margin for reducing them' (Raluy *et al.* 2005). Aside from their contribution to climate change, large dams can have devastating social and ecological impacts. Therefore, it is essential to consider alternatives to big dams.

DWAF has prioritized 'diversifying the water mix', by relying less on surface water sources and increasing the use of groundwater, treated effluent, and desalination (DWAF 2009). In Cape Town, future supply options have been identified and are being researched and piloted – in particular, the Table Mountain Group Aquifer, wastewater re-use and a desalination plant (City of Cape Town 2008). What are the benefits and barriers to these alternatives?

Treated effluent

'Recycling of water will reduce the need for extraction, treatment, distribution and collection. It will save a scarce resource and reduce the environmental burdens associated with the treatment and distribution of water' (Friedrich et al. 2009).

In Cape Town, over 500 ML of wastewater is treated per day; at present, 10% of this is re-used, mostly for irrigation and industrial use – for example the Potsdam oil refinery uses treated wastewater in its plant, and Century City, most golf courses, and the University of the Western Cape use it for irrigation. To date, wider use of effluent has been limited by the widespread aversion that people have towards having contact with wastewater, and the fear of health risks; however, more extensive re-use of effluent is apparently possible and safe, with good engineering and management (DWAF 2005). The following uses are under consideration:

- Urban irrigation of sports fields and public open spaces;
- Use in certain industrial processes;
- Agricultural irrigation;
- Dual reticulation systems for garden watering and toilet flushing;
- Aquifer recharge; and
- Potable re-use (DWAF 2005.)

The use of effluent for non-agricultural irrigation and industrial processes is very water and energy efficient, because the effluent does not need to go undergo additional treatment. According to Kevin Samson (Manager: Wastewater, City of Cape Town), the effluent that is sold for irrigation is actually too clean; it has been stripped of nutrients like phosphorus and nitrates, to prevent eutrophication in downstream eco-systems, and users of the effluent often actually add these same nutrients in the form of fertilizer. However, addressing this waste of energy and nutrients would be difficult, because of the regulations covering the quality of water leaving the treatment plant.

For agricultural irrigation, only treated domestic effluent can be used (because of the persistent toxins in industrial wastewater). The option of dual-reticulation would involve the use of treated effluent by individual households for use in gardens and toilet flushing. Since the watering of gardens accounts for 35% of domestic water consumption and toilet flushing for 30%, the use of lower quality water for these activities would significantly reduce the demand for potable water (DWAF 2005). This option could be implemented in all new housing developments, but retrofitting existing properties would be more difficult.

The use of treated wastewater as potable water is also being considered. This requires the further treatment of domestic wastewater (beyond the normal treatment processes), the pumping of that water to existing dams, where it would mix with freshwater, before being treated and distributed for consumption.

From a climate change mitigation perspective, the re-use of water makes a lot of sense; it reduces waste, it conserves energy, and it means that less water needs to be abstracted and treated from the environment. This is particularly true for the use of effluent in non-agricultural irrigation and industry, where the users are close to the wastewater treatment plants, and no additional treatment is required: 'supplying industries situated close to wastewater treatment plants with recycled water should be encouraged and promoted... [it] will obviously reduce the need for extraction, treatment, distribution and collection' (Friedrich *et al*. 2009). However, the further away and the more sensitive the end user, the higher the climate costs involved, particularly in terms of pumping and additional treatment. Wastewater treatment plants are often located in low-lying areas, so that sewerage can flow down to them under gravity. Therefore the energy required to pump the treated effluent to end users will be significant, especially if it is to be used for agricultural irrigation, or secondary re-use as potable water (in which case it needs to be pumped all the way back 'uphill' to storage dams). The additional treatment that wastewater requires to get it to a potable standard is also very energy intensive. Improved energy efficiency, alternative energy sources and treatment processes would need to be explored.

The main barriers to the implementation of treated effluent use is public aversion to contact with wastewater, and concern about health risks. Some of the specific causes for concern are: the risk of toxins building up in the soil if industrial effluent is used for irrigation; the health risk if there is an accidental cross connection of wastewater pipes with potable water pipes; the reduced marketability of agricultural produce which has been irrigated with wastewater; the lack of legal guidelines or established tariff structures, and the increased institutional capacity required for effective monitoring and regulating of water quality (DWAF 2005).

Another issue to flag here is the concern that a dual reticulation system, allowing for re-use of treated water, could lead to a lowering of the priority of providing safe drinking water to all. Imagine a scenario where wealthy households use treated 'grey water' for toilet flushing, laundry, garden irrigation etc. – and can afford to buy bottled water for drinking and washing. This could reduce the pressure and mandate for municipalities to provide safe water, as well as reducing municipal income from potable water, and could leave poor households without safe drinking water.

Desalination:

'Desalination is no quick fix solution to water scarcity'
(Arne Singels, Head of Bulk Water, City of Cape Town).

"Water, water everywhere, nor any drop to drink". This ancient mariner's lament reflects the age-old frustration of living on a planet which is 70% water, but only 0.007% of that water being drinkable. As with most age-old problems, there now promises to be a technological solution: desalination. By removing the salt from seawater, the limitless bounty of the ocean's water becomes available to be used by humans. At a cost, of course. Desalination is extremely energy intensive – most of the world's desalination plants are to be found in the Middle East, where fossil fuels are cheap and readily available - and the dumping of the extremely saline brine by-products back into the ocean is harmful to marine eco-systems.

Stokes and Horvath (2006), conducting LCA studies for water utilities in California, compared three different water supply augmentation options – importation of water, recycling of water, and desalination – and found that desalination had a 2 – 5 times higher energy demand than importation and recycling, and 2 – 18 times more associated emissions.

In Cape Town, where a pilot desalination plant is set to be built in the near future, the bulk water manager, Arne Singels, believes that a full scale 300 ML/day desalination plant is still a long way off. In his opinion, desalination is not a quick fix. Building and operating a desalination plant is very expensive. It is likely that consumers in Cape Town, used to such high standards of drinking water, will object to the brackish flavour of desalinated water- it will therefore need to go through the desalination process twice to get it to an acceptable flavour. In Cape Town, there is a further complication: the greatest need for supply augmentation is on the West coast, but it takes a lot more energy, and is more difficult, to desalinate colder, more nutrient-rich water, such as that found on the West coast. Nevertheless, this is where the pilot plant will most likely be built, either at Melkbos or at Koeberg.

From a climate change mitigation perspective, desalination is not a good option. LCA studies have shown that desalination has a much higher carbon footprint than other bulk water supply options, such as dams. In Australia, this drawback of desalination has been responded to, and desalination plants in Perth, Sydney and Queensland are powered partially or completely by renewable energy (Sydney Water 2008). The use of renewable energy adds to the operating costs of the plants, but studies and experience there have shown that consumers are willing to accept higher water prices in order that their water supply be augmented without damaging the atmosphere (Dolnicar and Schafer 2008). The use of renewable energy to power South Africa's proposed desalination plants needs to be lobbied for and promoted, but the raising of water prices to the detriment of poor communities and households must be avoided.

Groundwater and Aquifers

It is only very recently that the groundwater resources of South Africa have been quantified on a national scale (Woodford *et al.* 2006). This study found that South Africa has 19 000ML/year in available extractable groundwater. At present, only approximately 6% of this is being abstracted annually. There is therefore the potential to significantly augment our bulk water supply with groundwater, and this potential is currently being explored.

In Cape Town, there are three important aquifers - the Atlantis aquifer, the Cape Flats aquifer and the Table Mountain Group Aquifer. The Atlantis aquifer is used, and supplies the Atlantis area with much of its water. The Cape Flats aquifer is also used, with households being encouraged to use available shallow aquifer water for domestic use (Nel and Bishop 2006); however, this aquifer is at risk of being polluted by leakage and overflow from the Cape Flats wastewater treatment works (Kevin Samson, *pers. comm.).*

The Table Mountain Aquifer Group (TMG) is currently the subject of studies investigating the quantity and quality of water in the aquifer, to assess its viability as an alternative source of bulk water. Groundwater is sometimes of poor drinking quality, due to the presence of dissolved chemicals. There are some concerns about the effect of over-abstraction on the surface flows of rivers in the area; at this stage, the ecological impacts of large scale abstraction from this source are unknown, but this is something to keep an eye on.

The benefits of groundwater as an alternative supply are great from a climate change perspective. Groundwater abstraction requires no new bulk storage infrastructure being built – storage happens underground, and is evaporation free! In the case of the TMG, it is anticipated that pumping will not be required to get the water to the surface – it is under pressure, a few kilometres beneath the surface, and will gush to the surface when boreholes are drilled. If the water is of a high quality, and does not require special additional treatment, the carbon footprint is likely to be lower than other options. The other potential ecological impacts must, however, be researched and considered.

Treatment of 'raw' water

The status quo

The process of getting water into a potable, drinkable state differs according to the quality of the 'raw' water. Usually, the water needs to have colour removed, organic material and bacteria removed, and the acidity adjusted to a neutral pH, so that the water does not corrode the pipes.

Cape Town's bulk water is treated with coagulants (lime) and flocculants (ferric chloride) to remove the tannins and other organic material which gives the raw water a brown colour. It is then treated with CO_2 to reduce the pH, and with chlorine to disinfect the water.

In Johannesburg, Rand Water treats it's water through a similar process of coagulation, flocculation, pH stabilisation and primary disinfection with chlorine (Rand Water 2009). Because of the polluted state of the Vaal River, the raw water must undergo a secondary disinfection, with chloramine, a mixture of chlorine and ammonia, which stays active as a disinfectant for longer than chlorine

Umgeni water (KZN) uses ozonation to treat raw water. The ozonation process involves using a high intensity UV light, which converts oxygen into ozone under high pressure. The ozone then passes into a diffuser, which forms ozone-saturated bubbles, which is mixed with water and then fed into the water purification tank, where the ozone oxidises organic matter in the water. Ozonation uses a lot of electricity; in the eThekwini LCA, the ozonation process at Wiggins Water Works was shown to use 4300 kWh/ day, at 0.1 kWh/ kl of water treated. This amounts to a carbon footprint of 0.219 kg CO_2 e / kL of water treated The ozonation unit at this water works is made up of an ozone generator, and a thermal destruction unit, which destroys excess ozone by heating the gas to 300°C (Friedrich *et al.* 2009). The thermal destruction unit used 72% of the electricity used for the whole ozonation process.

Alternatives in the treatment of 'raw' water – opportunities and constraints

The use of chlorine and chloramine in raw water treatment has been linked to cancer and other health risks (Moriss *et al.* 1992), and the manufacture and transport of chemicals such as chlorine also leaves an ecological footprint. Some environmentalists have promoted ozonation as an environmentally friendly alternative. However, from a climate change perspective, ozonation also carries a high cost, because of the large amounts of electricity consumed in the process.

It is possible for ozonation to be more energy efficient. Researchers at Wiggins Waterworks found a few simple ways of decreasing the amount of electricity required. They found that decreasing the air flow into the thermal destruction unit, thus increasing the concentration of ozone and decreasing the total volumetric flow, resulted in a 70% reduction in electricity use (Friedrich *et al.* 2009). This is specific to a particular ozonation unit; however, it shows that by applying some thought to improving energy efficiency, it was relatively easy to achieve. The challenge, then, is to support engineers and technicians in water treatment works to be pro-active and innovative about improving energy efficiency.

Water conveyance

The climate change impact associated with the collection and distribution of water has to do with the amount of electricity-powered pumping that is required, as well as the materials the pipes are made of.

In Ethekwini municipality, the electricity consumption in the distribution and collection of water/ wastewater due to the pumping requirements of the system amounts to 5200 kWh/d for distribution and 5 600 kWh/d for collection. This translates to 0.139 kg CO_2 e/ kL of water distributed and 0.150 kg CO_2 e/ kL of water collected. In Cape Town, the distribution of water has a very low electricity use, because the majority of the city's reservoirs are at an altitude of 100 metres, and so the water travels to consumers under gravity. Some pumping is required for collecting wastewater and getting it to the wastewater treatment plants. As with all other pumps in the urban water cycle, replacing old pumps with energy efficient pumps must be promoted and supported (Text box 2).

The choice of piping material dramatically affects the environmental footprint of the whole reticulation system. Studies by Jeschar et al. (1995) found that plastics have the highest energy costs and associated emissions, and concrete the lowest. But this study did not take the full lifetime of the pipe into account; over time, depending how long they last, environmental performance may be different.

Water conservation and Water demand management

Water conservation (WC) and water demand management (WDM) strategies require changes in behaviour, at a municipal, household and personal level. In terms of climate change, appropriate WC/WDM should be a fundamental part of both mitigation and adaptation. This is especially true in the Western Cape, where projected water shortages mean that far-sighted water conservation is going to be essential. The role of WC/WDM in 'postponing the need for expensive capital infrastructure projects... and minimizing water wastage' (City of Cape Town 2007) has significant implications in terms of avoiding major new sources of greenhouse gas emissions.

According to the Western Cape Reconciliation Strategy (2005) WDM is currently pursued via the following methods:

1. Leakage detection and repair
2. Leakage repair beyond the meter
3. Pressure management (e.g. Khayalitsha Pressure Reduction Scheme)
4. Use of water efficient fittings
5. Elimination of automatic flush urinals
6. Adjustment of water tariffs, metering and credit control
7. User education

The following decentralised water supply augmentations have also been considered as part of WDM:

- Grey water usage
- Use of rainwater tanks
- Use of private well points and boreholes

The next section focuses on a few of these methods, and discusses some problems with many water demand management strategies as they are conceived and carried out at present.

Rainwater tanks

The collection of rainwater to supplement a household's water needs, for non-potable uses like gardening, toilet flushing, dish-washing etc., is an extremely 'climate friendly' water supply option. Rainwater tanks are widely used in Australia, where they have been found to be far more energy efficient than dams or desalination (Clarke 2007), and there are also many rainwater tank projects taking place in South Africa at present.

The usefulness and appropriateness of rainwater tanks is extremely dependent on the rainfall and climate, as well as the density of settlement in a particular area. In summer rainfall areas, household rainwater tanks are a good idea; but in winter rainfall areas, like the Western Cape, the amount of storage

space that would be required to hold winter's rains to last the thirsty summer months, make them a less useful option.

There is a lot of potential for looking beyond the scale of the individual household for rainwater tanks – for example, schools, or neighbourhoods, could share larger rainwater tanks, with greater storage capacity over the dry months.

There are some legal/ institutional barriers to the installation of rainwater tanks: in Cape Town, there is a by-law prohibiting the use of un-sterilised rainwater from rainwater tanks for domestic purposes (DWAF 2005). If rainwater is used for flushing toilets, there is a possibility of that water being sucked into the mains and mixing with the treated water, and this could pose a health risk (Arne Singels *pers. comm.*), which is why rainwater tanks have to be kept completely 'off the grid'. At present, the cost of rainwater tanks is still prohibitive, and, in the Western Cape at least, they are not yet a cost effective option. But, the idea of using rainwater tanks as a 'back-up' or additional supply, especially in middle class/ affluent areas, should be pursued in all areas, as well as the potential for larger rainwater tanks, shared by neighbours or a small community.

Leak fixing and tariffs

Huge amounts of potable water – i.e., water which has been treated to a drinkable level – are lost through leaks in the water reticulation system. Worldwide, it is estimated that 10 – 60% of treated water is lost through leaks (EMG Water Handbook 2008). In the City of Cape Town, 'pre-consumption' losses are estimated to be as high as 35 % of total water demand, or 279 Ml/day (City of Cape Town 2007). This amounts to a steady trickling away and loss of precious water, energy and money. At present, eThekwini Municipality is aiming to reduce their losses through leaks from 30% to 20 % by 2012 (Scruton 2007, cited in Friedrich *et al.* 2009). If they can achieve this, it will amount to a saving of 19 600 kg CO_2 e per day. If they achieve their 'best practice' target of 10% losses, this would save 29 400 kg CO_2 e being emitted per day. In comparison, another consumer demand management strategy, the use of a rising block tariff, was calculated to have the *potential* to reduce consumption in eThekwini by 3.3 %. The principle of rising block tariffs is that they should make water affordable for poor users, with the first block often being free, while high end consumers users pay a premium in order to cross subsidise the low income groups. In theory, all users should consume less – low income users are expected to consume less to stay below the 'free basic water' block, and high income users are expected to consume less to avoid being heavily penalised (Bailey 2003). In reality, however, rising block tariffs are not always used properly by municipalities, and because of the conflict of interests of municipalities needing to both manage the resource and earn income from tariffs, the three functions of an ideal tariff – affordable water for the poor, overall reductions in consumption, and cost recovery – are hardly ever achieved.

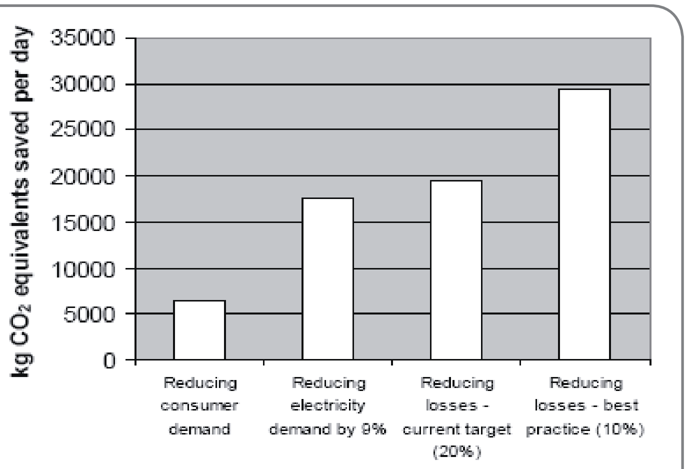

Figure 3: Potential savings due to reducing consumer and supplier demand in eThekwini (Friedrich et al. 2009).

Figure 3 shows the comparative savings from *projections of savings* from these different methods of demand management. This graph shows the relatively high savings that could be made through the fixing of leaks.

Too often, strategies carried out in the name of WC/WDM end up being harmful and manipulative, particularly towards the poor. Certain approaches to the specific issue of improving the energy efficiency of municipal water, has resulted in some of the most controversial (and, many would say, illegal) strategies for water demand management in South Africa's recent past – the prepayment water meters in Soweto and the water management devices in the City of Cape Town. Proponents of environmental justice reject these approaches - because they are really about cost recovery, more than anything else; they discriminate on the basis of class, and require that the poor bear the largest burden in terms of water and therefore energy and cost savings.

But water demand management is not an inherently bad principle. It is the way in which it is implemented – often with a complete lack of participation, sensitivity and transparency – that is so problematic. In order for water demand management strategies to be successful, and to be acceptable to the citizens who are asked to adhere to these strategies, there is a need for real participation in these processes. New approaches to water demand management, as part of a larger process of participatory budgeting, need to be pursued (see EMG water and climate change seminar 4 proceedings).

One example of such an approach is the Water Leaks Project, a project of the Western Cape Water Caucus, which was an attempt to mobilise and train community members to detect and fix leaks in their areas. This project has encountered several obstacles and has not yet been realised, but the idea remains alive and vital, and it is something to support wholeheartedly as part of our local response to climate change.

Wastewater treatment

The status quo

The treatment of wastewater carries the largest 'climate change' burden in the entire anthropogenic water cycle. LCA studies of different conventional wastewater treatment works show that electricity use makes the largest impact in terms of their total environmental burdens (Friedrich *et al.* 2007; Zhang and Wilson 2000; Emmerson *et al.* 1995). There are also a lot of chemicals used in conventional processes, as well as methane emissions from wastewater. Globally, wastewater treatment is responsible for 38% of the greenhouse gas emissions from waste, and nitrous oxide from human sewage is responsible for 6% (Figure 3). At the same time there are many other pressing problems facing wastewater treatment plants in South Africa – most are running at over-capacity and are struggling to treat wastewater levels to the necessary levels to prevent environmental hazards and outbreaks of disease. In this context, understandably enough, responding to climate change is not very high up on the list of priorities (Kevin Samson, *pers. comm.)*.

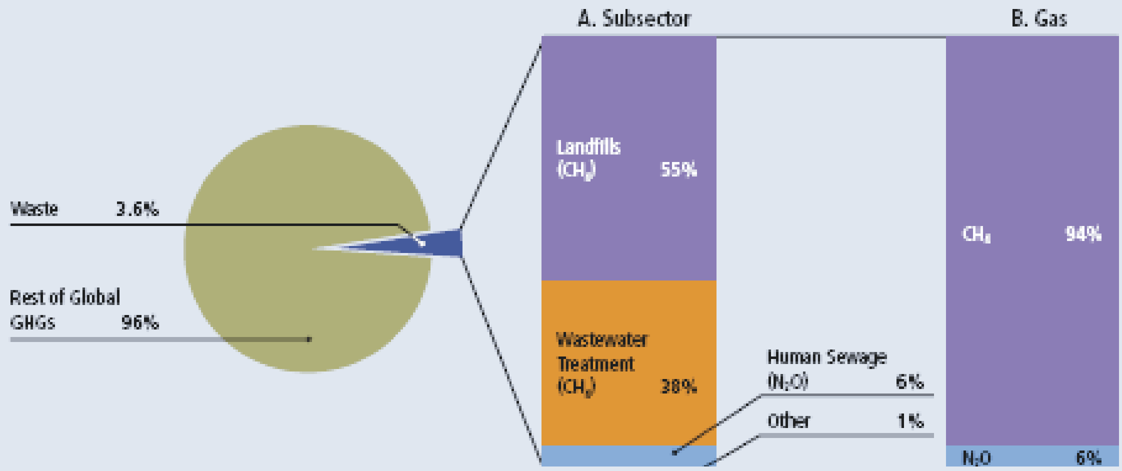

Figure 4: Greenhouse gases from waste (from Navigating the Numbers, 2005, World Resources Institute, www.wri.org

Conventional wastewater treatment– activated sludge

The dominant methods for treating wastewater in South Africa are very electricity intensive: "There are three main conventional processes for treating sewage. The physical processes include stirring (aeration), holding the sewage and letting it settle out. Most physical processes are electricity-intensive, and thus vulnerable to electricity interruptions... Conventional works use large amounts of electrical energy, mechanical equipment, cement structures and chemicals, and require specific skills to run. When they go wrong, problems include odours, flies, spills and overflows into receiving streams" (Munnik 2008). And things do go wrong. Most sewage treatment plants in South Africa are not cleaning water to the required standards, and are releasing poor quality effluent into the environment (Snyman *et al.* 2006).

One of the things causing the most damage at wastewater treatment plants is storm water ingress into sewage pipes. This storm water then washes through the treatment plants, and taking many of the biological organisms used in water treatment out with it. This reduces the ability of the plant to treat water to the necessary quality, and damages infrastructure. Highly impermeable paved surfaces increase storm water run-off, and some people illegally divert storm water into the sewers (Kevin Samson, *pers. comm.*).

It is the activated sludge treatment process that consumes the most electricity. This process involves large air blowers moving the sludge around. At the Southern Wastewater Treatment Works in Durban, 9700 kWh/ day are used in activated sludge treatment (Friedrich *et al.* 2009).

Alternatives to conventional wastewater treatment – opportunities and constraints

There are ways in which to improve the energy efficiency and negative environmental impact of conventional wastewater treatment. For a start, the electricity-guzzling air blowers used in the activated sludge process could be modified to run off renewable energy. At wastewater treatment plants, there is always a ready supply of latent energy waiting to be transformed and put to work – the option of using bio-digestors to produce methane, and then turning that methane into electricity, needs to be explored and researched.

Lobbying Opportunity:

Biodigesters at the Cape Flats Wastewater Treatment Works

Anaerobic digestion is used in wastewater treatment as a sludge treatment process – it reduces the volume and COD (chemical oxygen demand) of sludge. A by-product of the process is bio-gas, which consists mostly of methane, and which can be used as an alternative energy source. It is possible to use bio-gas to power gas engines to produce electrical energy, which can contribute significantly to the energy needs of the treatment works, and the waste heat can be used to heat the digester to the necessary temperatures, so that the sludge is sterilised. Another by-product is sludge pellets, which have a very high calorific value and can be used either as fertiliser or as a flammable fuel source. There are multiple benefits to the climate of using biodigesters to their full potential in wastewater treatment: the generation of energy from a non fossil-fuel source; reduction of uncontrolled methane discharge (methane is a very potent greenhouse gas); and the replacement of industrially-produced fertilisers (which are very energy intensive to produce, and which are made from petroleum-based raw materials).

The Cape Flats Wastewater Treatment Plant (WTP) currently has 2 functional anaerobic digesters. It is the only treatment works in Cape Town using digesters (Athlone WTP is currently decommissioning their digesters because of a lack of maintenance and the high cost of fixing them, and they are converting to a centrifugal process for de-watering and stabilising the sludge – a very electricity intensive process!). At present, the Cape Flats WTP digesters are operating at about 35% efficiency. They are intended to produce enough biogas to fire the boiler used for digester pre-heating *and* to run a sludge-pellet drying plant, but currently they are only producing enough to heat the digesters, which has meant that the pellet drying plant has been running on diesel – this diesel is very expensive, both financially and in terms of the plant's carbon footprint. At the same time, the Cape Flats WTP uses a huge amount of electricity in their water treatment processes – it is estimated that they use in the region of 2.45gWh per month, with monthly electricity bills of close to R800 000 (Burton *et al.* 2009; Toll *pers. comm.* 2009).

The digesters are currently being upgraded, and a third one refurbished. With the upgrade to the digesters, it is anticipated that there will be a total of 2000m^3/hr of biogas produced. However, the systems and technology are not in place to use all of the biogas produced; in fact, there will be an estimated excess of 40%, which amounts to 800m^3/hr, which will have to be flared off.

So, lets do some hypothetical number crunching:
Approximately 6 kWh's can be generated per m^3 of biogas (Burton *et al.* 2009).
If 800m^3 of excess biogas is flared off per hour, that amounts to a lost potential of 4800kWh per hour, and if the plants run for 24 hours a day, that comes to 115 200 kWh per day, and 3 456 000 kWh per month. If we assume a 20% efficiency loss (due to 'down-time' when sludge loads are low, or technical inefficiencies in the digesters), that comes to a lost potential of 2 764 800 kWh, or 2.76 gWh, which would be sufficient to cover **all** energy requirements for the plant!

Clearly the biodigesters at the Cape Flats WTP are not currently being used to their full potential. Even once the current efficiency upgrades are complete, the infrastructure required to convert excess methane into electrical energy will not be available. This means that large amounts of methane will be flared off, and that there will be no reduction in the use of fossil-fuel based electricity at this plant.

What are the constraints to using energy from biogas at our wastewater treatment plants? Biogas generators are still very expensive to buy and maintain, particularly since there are no local technicians; this expense is a barrier to local investment, especially since there are not enough incentives for the generation of clean energy through, for example, feed-in tariffs. The conversion to a new and different system is often perceived by decision makers as being risky, especially when there is not a lot of local capacity or experience to manage the new way of doing things. These barriers, in the market and in people's perceptions, need to be addressed and challenged, so that this massive potential for reducing the carbon footprint of wastewater treatment can be realised.

Many wastewater treatment plants have bio-digester facilities that are no longer in operation (e.g. Athlone, Mitchells Plain) – these need to be refurbished and revived**.** However, a major stumbling block, as raised by Kevin Samson (Manager: Wastewater treatment, City of Cape Town) is the fact that people involved in the wastewater treatment sector have so many urgent, immediate crises to handle and contain, that improving energy efficiency, while it is acknowledged as being important, is not a high priority. In this regard, there is a real need for civil society to support over-stretched government departments, by doing some of the legwork, finding out the most affordable and viable route to improving energy efficiency, and then lobbying for these measures to be put in place.

There are some steps we can take as individuals. The dirtier the water going into a treatment plant, the more energy needed to treat it – how can we ensure that our sewage water is cleaner? It helps to use 'environmentally friendly' detergents, soaps etc.; and to reduce the amount of paved areas around our houses – diesel and petrol runs off these surfaces into the sewers, and is very difficult to clean. We can also be water watchdogs in our own communities, and try to prevent illegal discharging of storm water into sewage system.

For smaller municipalities, there are completely alternative ways to treat wastewater; for example, the integrated algal ponding system (IAPS), or simply algal ponds.

Algal ponds

Biological ponding systems have been used for sewage treatment for many years, particularly in Asia (Munnik, 2008). The main principle of pond systems is that microorganisms play a central role in the wastewater treatment, chemicals are not used, and very little energy input is required. In algal ponds, as the name suggests, it is algae catalysing the purification of the water – through the algae's process of photosynthesis, oxygen is released, which is taken up by bacteria, enabling them to oxidise organic compounds in the dirty water. In turn, the bacterial process of metabolism releases carbon dioxide, which is taken up by the algae in photosynthesis – the algae and bacteria are in a mutualistic relationship, and a 'side event' of their processes of metabolism is the cleansing of wastewater! (Prof. Duncan Mara, cited in Munnik 2008).

Integrated algal ponding systems compare very favourably to activated sludge treatment, in terms of climate change mitigation and more generally in terms of sustainable development principles. Algal ponds use 5% of the electricity that activated sludge uses . As an added bonus, the algae even act as a carbon sink! There is not much skilled labour associated with IAPS directly, but there is a lot of opportunity for downstream employment, through the use of algal by-products as fertilizers (Munnik 2008).

While IAPS is best suited to a small scale, they can also work at a large scale, and are sometimes used in conjunction with anaerobic treatment for treating larger quantities of wastewater. IAPS even has the potential for industrial application. South African Breweries (SAB) is presently using IAPS for treating effluent at their Port Elizabeth brewery, and for creating downstream employment through aquaculture and vegetable gardens. This flagship project will be able to serve as an example and a challenge to other industries.

The major obstacle to the implementation of this sustainable wastewater treatment technology is that decision makers perceive it as being too risky. It is very difficult to convince municipal managers to take 'the road less traveled' (Munnik, *pers. comm.* 2009). It is also difficult to find engineers who are willing to sign off on technology they are not familiar with. Beyond an aversion to the unknown, decision makers and constituencies in small municipalities also often have a perception that low energy, low-tech alternatives are inferior and second rate, and are reluctant to settle for such an option. These kinds of reactions and perceptions are true for many supposedly 'green' alternatives – including, for example, dry sanitation.

Dry sanitation (i.e. less wastewater to be treated)

In the context of massive sanitation backlogs in areas without access to piped water, dry sanitation – i.e. variations on the bucket system and the pit latrine - is often used as a 'temporary' measure. However, given the realities of water resource scarcity and the huge pressure on wastewater treatment plants, dry sanitation technologies are considered by many to be viable, sustainable solutions. One such technology is the Urine Diversion (UD) toilet. The idea behind these toilets is that urine and faeces are kept in separate 'vaults', that ash is thrown on the faeces to keep it dry and odourless, and when the vaults are full, they can be emptied, and the contents used as compost. There are some who are strong advocates for the UD toilet, saying it is easy to use, environmentally friendly, and good for the garden. However, many of the communities into which it has been introduced in South Africa have rejected it outright (Hoossein 2009; Matsebe and Duncker, 2007). Some have suggested that the reason these communities rejected the toilets was that they were not properly involved in the decision making process, and were not properly taught how to use them. The reasons that community members themselves gave for their dissatisfaction include bad smells, the embarrassment and inconvenience of having to empty the vaults and handle human faeces, the fact that it was just another bucket system... and the fact that they were still waiting for their long promised flush toilets.

There are other dry sanitation options, such as VIP toilets, and *Afrisan* 'eco-toilets'. Even if these are implemented in more considerate and participatory ways, dry sanitation is very unlikely to be accepted on a large scale. Despite the strong case that can be made for dry sanitation, in terms of water scarcity, cost effectiveness and growing pressure on sewerage treatment infrastructure, these alternatives are widely viewed as inferior. In the South African political context, waterborne sewage is aspired to, and considered the 'top of the sanitation ladder' (Munnik 2008).

The only areas where these water-less toilets are being promoted is in poor communities – which perpetuates the notion that 'low-tech', sustainable technologies are only suitable for the poor, and reveals a very narrow and shallow commitment to sustainability. Unless these kinds of technologies are taken up on a massive scale, by the middle and upper classes, and are rolled out in high cost housing developments as much as in low income housing, their acceptance by the poor can not be expected.

Conclusions and recommendations

This paper has unpacked the 'carbon footprint' of all of the stages in a generic urban water cycle, with descriptions of specific cases for each stage.

This paper has also identified alternative technologies and approaches for each stage, discussing their appropriateness in terms of climate change mitigation, water resource protection, and their potential for either benefiting or harming people. For those alternatives which seem like they have positive implications all round, obstacles to their implementation were pointed out. In conclusion, these obstacles are summarised, some ways around these obstacles imagined, and some steps for immediate and ongoing action proposed.

At present, the largest constraint to 'climate-proofing' water and wastewater processes is that the engineers and managers and decision-makers in charge of our water are not even beginning to think about climate change mitigation. This is understandable. The people responsible for this fundamentally crucial role in our society are faced with so many pressing needs: trying to prevent outbreaks of disease, dealing with long overdue service backlogs, expanding to serve the needs of the ever-poorer population, the ever-expanding cities, and the ever-thirstier consumer. And on top of all this, to have to make contingency plans for coping with the uncertainties of water in a climate changed world. Dealing with something like climate change mitigation, particularly when, compared to other sectors, water seems so innocent, is therefore a very big ask. The changes to infrastructure and processes to incorporate energy efficient and greener practices are perceived as being risky, extravagant and unnecessary. In places where new infrastructure is going up, there is a resistance to 'environmentally-friendly' technologies in the water sector, because they are either viewed as inferior, inconvenient or health hazards.

Nevertheless, as has been highlighted in this paper, the water sector *does* contribute to climate change. Also, many of the climate-friendly options for the water sector would have significant benefits beyond the context of climate change mitigation. Energy efficiency means cost efficiency – this is important to everyone, especially in the cash-strapped world of water financing. We need convincing and accessible analyses of the rates of return on different energy efficient technologies, and we need to put pressure on water managers to replace old infrastructure with clean and efficient alternatives. Reducing the amount of water we consume has benefits for the environment and for the water sector on the whole.

We also need to be alert to the fact that official responses to climate change and to water resource scarcity can often make things more difficult for poor people. When water demand management is confused with debt collection, and is carried out in ways that many people experience as 'punishment for being poor', the mistrust and anger that people feel towards the government deepens, and spaces for real collaboration and sharing of responsibilities close down.

There are some ways in which we can intervene, promote alternatives, and support managers, decision makers and communities:

- Support and promote the replacement of old and damaged infrastructure with more energy efficient pumps, motors and piping, through further research, information sharing and persistent raising of the issue;

- Make managers and decision makers aware of situations where climate friendly alternatives have *worked* – challenging the idea that these alternatives are risky, inferior or expensive;

- Challenge the notion that different technologies or 'sustainability standards' are appropriate for different class groups;

- Work to shift perceptions about sustainable alternatives being inferior by actively promoting their implementation in wealthy areas;

- Challenge and reject water demand management strategies, carried out in the name of climate change response or water conservation, which discriminate on the basis of class, and which threaten the right of all to safe water and sanitation;

- Make our voices heard with regards to new bulk water options (for e.g. pointing out the problems with desalination). According to Arne Singels, head of bulk water for Cape Town: 'there is space for citizen participation in these kinds of decisions';

- Call for guidance, leadership and regulation when it comes to climate change mitigation – challenging DWEA and the rest of government to honour its written commitments to mitigation;

- Think about what kinds of financial incentives water services could be given to improve their 'carbon footprint' or improve energy efficiency;

- Identify the key decision making points where we should make interventions. As civil society and interested citizens, we should participate in IDP processes, and other spaces where legislation and policies about our water infrastructure are open to input.

In the City of Cape Town, there are three immediate lobbying issues:

- Replacing old pumps and motors with energy efficient alternatives
- Refurbishing existing bio-digestors at wastewater treatment plants in Cape Town, and making biogas generators more affordable
- Making it clear that we do not accept water demand management strategies which restrict access to water for the poor – for example, water management devices.

Finally, the questions we should take forward with us are the same questions posed at the very beginning of this paper: how do we, as civil society committed to moving people up the 'water ladder', even within a context of threatened water resources, do this in a sustainable, low carbon manner? How do we build the principles of 'closing loops', water and energy efficiency, and participatory budgeting and decision making, into the growth of water services? These questions should guide us as we confront the many water and climate change related challenges ahead.

References

Bailey, R. 2003. 'Designing a Welfare Maximising Water Tariff for Durban with Ramsey Pricing Principles'. MBA Dissertation, School of Business, University of Natal, Pietermaritzburg, South Africa.

Burton S., Cohen B., Harrison S (Prof)., Pather-Elias S., Stafford W., van Hille R. and Von Blottnitz H. 2009. Energy from wastewater - A feasibility study technical report. WRC Report No. 1732/1/09.

Clarke, S. 2007. 'Rainwater tanks better than dams, desalination: report'. ABC News Online. Monday April 16, 2007.

City of Cape Town 2006. 'Energy and Climate Change Strategy'. Available at http://www.capetown.gov.za/en/EnvironmentalResourceManagement/EnergyEfficiency/Pages/PolicyandStrategyDocuments.aspx.

City of Cape Town 2007. 'Long Term Water Conservation and Water Demand Management Strategy'. Summary Document, April 2007.

City of Cape Town 2008. 'Water Services Development Plan: Executive Summary'. Draft 2, 18 April 2008.

DEAT 2009. 'The National Climate Change Response Policy', South Africa: DEAT. Available on http://www.ccsummit2009.co.za/Downloads/2009-03-01_CLIMATE_CHANGE_POLICY_FRAMEWORK%20_Rev%207_.pdf

DWAF 2005. 'Water Re-Use', Western Cape Reconciliation Strategy Screening of Options Workshop, August 2005.

DWAF 2009. 'Water for Growth and Development Version 7', South Africa: DWAF.

Dolnicar, S. and Schafer, A. I. 2008. 'Desalinated versus recycled water: Public perceptions and profiles of the accepters'. Journal of Environmental Management Volume 90, Issue 2.

EMG 2008. Water Handbook for South African Activists and Decision Makers in Urban Areas. Environmental Monitoring Group.

Emmerson, R.H C., Morse, G. K., Lester, J. N. and Edge, D. R. 1995. 'The life-cycle analysis of small scale sewage-treatment processes'. *J. CIWEM*. **9** 317-325.

Energy Research Centre, 2007. 'Non Energy Emissions - Agriculture, Forestry and Waste: an input into the Long Term Mitigation Scenarios'. University of Cape Town.

Friedrich, E., Pillay, S. and Buckley, C. A. 2007. 'The use of LCA in the water industry and the case for an environmental performance indicator'. *Water SA* Vol. 33 No. 4. Available on http://www.wrc.org.za.

Friedrich, E., Pillay, S. and Buckley, C. A. 2009. 'Carbon footprint analysis for increasing water supply and sanitation in South Africa: a case study'. *Journal of Cleaner Production*, Volume 17, Issue 1.

Griffiths-Sattenspiel, B. and Wilson, W. 2009. 'The Carbon Footprint of Water'. A River Network Report. Available at www.rivernetwork.org.

Hendricks, L. 2009. 'Government's Vision on Climate Change Adaptation'. Available at
http://www.ccsummit2009.co.za/Downloads/Media/Speech_Minister_Lindiwe_Hendricks.pdf

Hoossein, S. 2009. 'The development of sustainability criteria to facilitate decision making for sanitation systems within Buffalo City Municipality – a case study'. Presentation made at EMG side event at the Climate Change Summit in Midrand, March 2009.

Interview with Arne Singels, Head of the Bulk Water Directorate, Water Services, City of Cape Town, March 2009.

Interview with Kevin Samson, Manager of Wastewater Directorate, City of Cape Town, March 2009.

Interview with Michael Toll, Manager of Cape Flats Wastewater Treatment Plant, June 2009.

Jeschar, R. Specht, E. and Steinbrueck, A. (1995) 'Energieverbrauch und CO_2-Emission bei der Herstellung und Entsorgung von Abwasserrohren aus Verschiedenen Werkstoffen'. *Korrespondenz Abwasser* **42** (4). *In:* Friedrich, E., Pillay, S. and Buckley, C. A. 2007. 'The use of LCA in the water industry and the case for an environmental performance indicator'. *Water SA* Vol. 33 No. 4. Available on http://www.wrc.org.za.

Lima, I. et al. 2007. 'Methane Emissions from Large Dams as Renewable Energy Resources: A Developing Nation Perspective'. Mitigation and Adaptation Strategies for Global Change, published on-line March 2007. http://tinyurl.com/2bzawj

Matsebe, M. and Duncker, L. 2005. 'Urine Diversion in South Africa: Is this a solution?' Presentation made at EcoSan Conference, Durban, May 2005.

Morris, R.D., Audet, A.M., Angelillo, I.F., Chalmers, T.C., and Mosteller, F. 1992. 'Chlorination, chlorination by-products, and cancer: a meta-analysis'. *American Journal of Public Health*, **82**, 7: 955 – 963.
Munnik, V. 2008. 'Creating wealth in rural and peri-urban communities through small wastewater treatment plants'. Background Paper, 31 July 2008.

Navigating the Numbers 2005. World Resources Institute, Available at www.wri.org.

Nel, J. and Bishop, R. C. 2006. 'Strategic use of groundwater in Cape Town, South Africa'. Presentation to World Water Forum 4, Mexico, 16 – 22 March 2006.

Rand Water 2009 . 'Storage System Management' Available at http://www.randwater.co.za/WaterAndInfastructureManagement/Pages/StorageSystemManagement.aspx.

Raluy, R. G., Serra, L., Uche, J and Valero, A, 2005. 'Life Cycle Assessment of Water Production Technologies - Part 2: Reverse Osmosis Desalination versus the Ebro River Water Transfer'. *The International Journal of Life Cycle Assessment,* Vol. 10, No. 5.

Scenario Building Team 2007. 'Long Term Mitigation Scenarios: Strategic Options for South Africa'. Department of Environmental Affairs and Tourism.

Smart Living Handbook 2008. City of Cape Town, AMATHEMBA Management Consultants, Sustainable Energy Africa. Published by the City of Cape Town. Available at www.capetown.gov.za/environment.

Snyman, H. G., van Niekerk, A. M. and Rajasakran, N. 2006. 'Sustainable wastewater treatment – What has gone wrong and how do we get back on track?'. Available at:
http://www.waterinformation.co.za/literature/files/327%20Snyman.pdf.

Stokes, J. and Horvath, A. 2006. 'Life cycle energy assessment of alternative water supply'. *International Journal of LCA* **11** (5).

Sydney Water 2008. 'Sydney's Desalination Plant: Renewable Energy'. Available at http://www.sydneywater.com.au/MajorProjects/Desalination/documents/RenewableEnergy.pdf#Page=1.

Water UK 2009. 'How the water industry is managing its contribution to climate change'. Climate change mitigation Water UK briefing, May 2009. Available at http://www.water.org.uk/home/policy/climate-change.

Woodford, A., Rosewarne, P. and Girman, J. 2006. 'How much groundwater does South Africa have?' Available on http://www.srk.cl/pdf/html/groundwater/PDFs/1_A_Woodford.pdf.

Zhang, Z. and Wilson, F. 2000. Life Cycle Assessment of a Sewage Treatment Plant in South-East Asia. *J. CIWEM.* **14**