Rain Water Tanks - Life Cycle Analysis

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1. Introduction

A typical Australian household uses about 280,000 litres of water annually. Approximately half of this amount is used to water the garden and flush toilets. Installing a rain water tank has the potential to reduce residential fresh water requirements by 50% and contribute to more effective use of precious water resources. In addition, rain water tanks contribute to a reduction in peak stormwater flows and sediment transport. At present, there are three generic types of rain water tanks: reinforced concrete, plastic and galvanised steel tanks.

An independent study, conducted by the Centre for Sustainable Technology at the University of Newcastle, presents a comparison based on Life Cycle Analysis (LCA) of the three types of rain water tanks. The LCA includes all stages in the life of the tank: extraction and processing of raw materials, transport to tank manufacturing site, tank fabrication, transport to customer's site, installation, operation and disposal at the end of the useful life.

2. The Life Cycle Approach and Analysis

Information was gathered on the manufacturing operations involved in producing the concrete, plastic and steel water tanks. The LCA study involved the following steps:

- Goal definition and scope
- Definition of system boundaries and functional unit
- Inventory of material, energy inputs and outputs
- Quantifying emissions
- Analysis of impacts

The functional unit was simplified by choosing tanks with the same storage capacity of 5,000 litres. The life cycle stages for each type of water tank were grouped in the following categories:

- Extraction and processing of raw materials, transportation to production site, eg. steelworks, cement producers etc, and production of materials, eg. cement, steel and plastic
- Transport of materials to tank fabricators and fabrication (the energy associated with the fabrication of the tank is negligible and has not been included in this analysis)
- Transportation of water tank to customer's site
- Tank installation (assumes concrete pad is used as base)
- Disposal at the end of its operational life, assuming full utilisation of tank materials

The tanks were assumed to be at ground level and would normally require the use of a water pump[1]. Because the operation of the pump is independent of the tank material, this part of the life cycle was excluded from the analysis. Environmental burdens in terms of resource consumption and emissions were obtained from Australian National Greenhouse Gas Inventory and BHP Billiton Minerals Technology database.

The total embodied energy and emissions were used to assess the environmental burden of each water tank. This allowed for comparisons of the environmental performance of the different rain water tanks to be made based on embodied energy, water, GGE, SOx and NOx emissions.

([1]The annual environmental burden of a 300W water pump, powered by electricity from a coal fired power station, pumping 140,000 litres of water per year (half of household's annual requirements), equates to around 0.4 GJ of energy, 0.5 t of water, 0.1 t of GGE, 0.61 kg of SOx and 0.27 kg of NOx. Compared to the other life cycle stages in this analysis the annual operation of a rain water tank (pumping of water) produces the largest environmental burden.)

What is Life Cycle Analysis?

Life cycle analysis is an important tool for both analysing processes to find ways to improve them, and assessing materials and products.

LCA consists of two components: inventory analysis and impact analysis.

Inventory analysis involves summarising the material and energy flows for a defined system. The 'system' is the combination of processes and activities that manufacture a product or achieve an outcome. This typically includes all of the processes associated with the extraction of resources, supply of energy, manufacture of the product, use of the product and disposal and recycling. The resultant inventory is a list of the resources consumed and the emissions associated with the system.

Impact assessment involves interpreting the significance of the resource consumption and emissions determined in the inventory stage. It should be noted that in life cycle assessment, these are restricted to environmental impacts.

The model used for this study examines the material use and emissions in a product, from raw materials through to end of its life. It also assesses the impact of products and processes on the environment - from the extraction of the raw materials, through the manufacturing processes, to disposal by processes such as recycling at the end of a product's useful life.

It does this by examining such things as:

- wastes generated during production
- energy consumed during production and the use of the product; and
- the amount of recycling the product is capable of.

Today steel products are being designed to be more environmentally sustainable, enabling easier and faster construction, more efficient utilisation, and ease of recycling of components at the end of their product life.

2.1 Plastic Tank

The material used in the fabrication of plastic tanks is High Density Polyethylene (HDPE), derived from fossil fuels. Transportation stages involve delivery of materials and road transport of manufactured tanks to customers. For the purpose of this study it was assumed that the tank fabrication is in Orange, NSW. The total mass of the 5,000 litres HDPE tank is 100kg.The fabricated tank (eight tanks in a medium size truck) is transported to the customer's site at the Central Coast, Gosford, NSW.

The useful operational life of the HDPE water tank was taken as 25 years, the same as the manufacturer's warranty. It is assumed that at the end of the tank's useful life the feedstock energy is recovered by combustion. Currently, 100% "virgin" plastic is used in manufacture due to concerns over ultra violet light exposure of used HDPE. The life cycle stages and the environmental burden of the HDPE tank are presented in Figure 1.

The largest embodied energy is associated with the production of the HDPE, part of which is recovered by combustion at the end of its useful life, displacing an equivalent amount of fuel oil. However, there is a significant net gain of CO_2 emission associated with the combustion of HDPE.

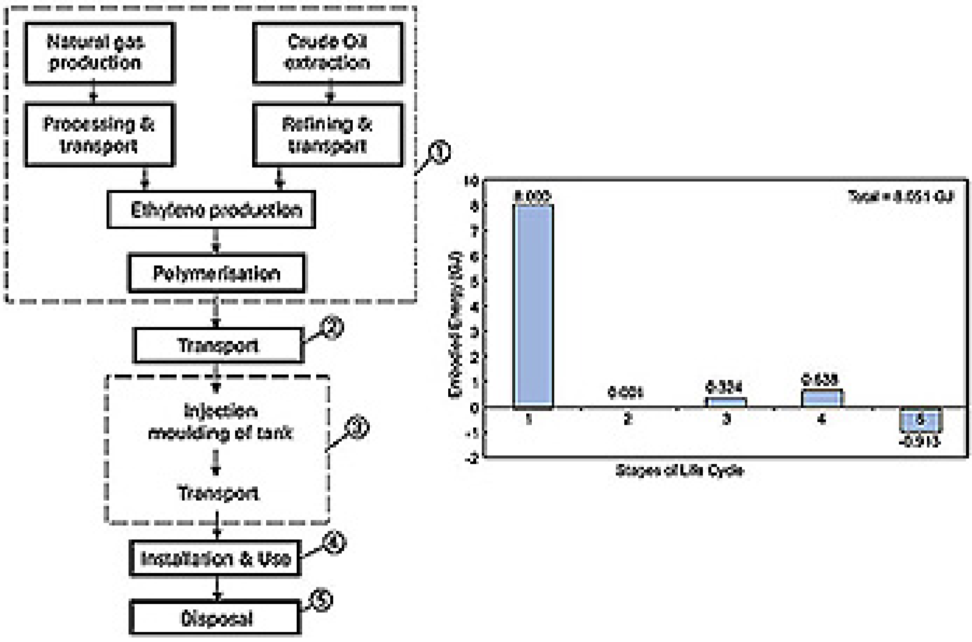


Figure 1: Life cycle tree and environmental burden of 5,000 litres HDPE water tank over its operational life

2.2 Steel Tanks

The steel tank in this study is a water tank made from AQUAPLATE® steel. These tanks feature corrugated low carbon galvanised steel, lined with hot bonded food-grade polymer. Transportation stages involve delivery of materials and road transport of manufactured tanks to customers. For the purpose of this study it was assumed that steel is supplied from Port Kembla Steelworks and the tank fabrication is at Parramatta, NSW. The total mass of the tank is 104kg, predominantly steel. The fabricated tank (five tanks in a medium size truck) is transported to the customer's site at the Central Coast, Gosford, NSW.

The useful operational life of the water tank made from AQUAPLATE® steel was taken as 20 years, the same as the manufacturer's warranty. It is assumed that at the end of the tank's useful life the steel is recovered as scrap. The life cycle stages and environmental burden of a water tank made from AQUAPLATE® steel are presented in figure 2. The largest embodied energy is associated with the production of steel. A large proportion of the embodied energy and savings in water and emissions are achieved by recycling the tank at the end of its useful life.

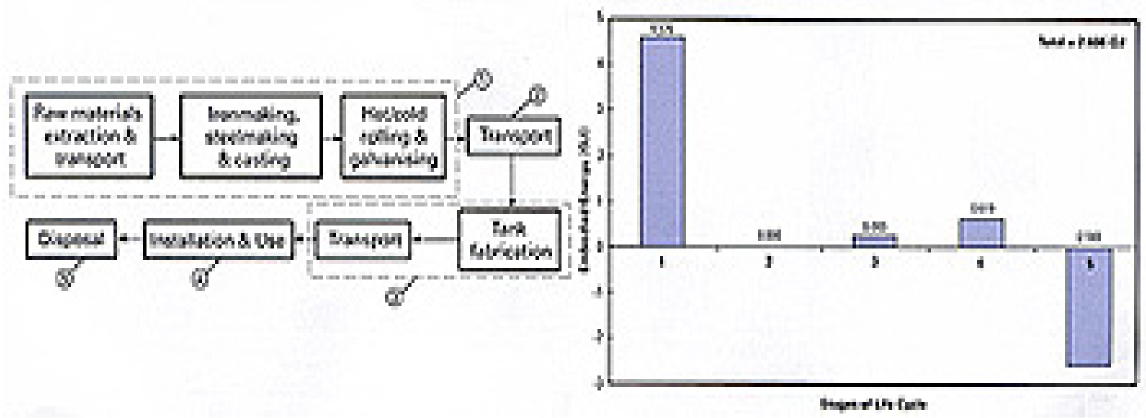


Figure 2: Life cycle tree and environmental burden of 5,000 litres AQUAPLATE® steel water tank over its operational life

2.3 Concrete Tanks

The raw materials used to manufacture a concrete tank include steel reinforcement, gravel, sand, cement and water. Transportation stages involve delivery of materials associated with the fabrication of the tanks and road transport of manufactured tanks to customers. For the purpose of this study it was assumed that the tank fabrication is at Rutherford, NSW, with concrete supplied locally. The total mass of the 5,000 litre concrete tank is 2,600kg, including 156kg of steel reinforcement. The fabricated tank (four tanks in a medium size truck) is transported to the customer's site at the Central Coast, Gosford, NSW.

The useful operational life of the concrete water tank was taken as 15 years, the same as the manufacturer's warranty. It is assumed that at the end of its service life the tank is disposed of by crushing, using the concrete as an aggregate and recycling the steel reinforcement as scrap. The life cycle stages and the environmental burden of a concrete tank are presented in Figure 3.

The largest embodied energy, water, GGE, SOx and NOx emissions are associated with the production of raw materials. Close to 70% of the embodied energy is attributed to the steel reinforcement. A significant amount of energy (and consequent savings in water and emissions) is recovered by recycling the steel material used for reinforcement at the end of the useful life of the tank.

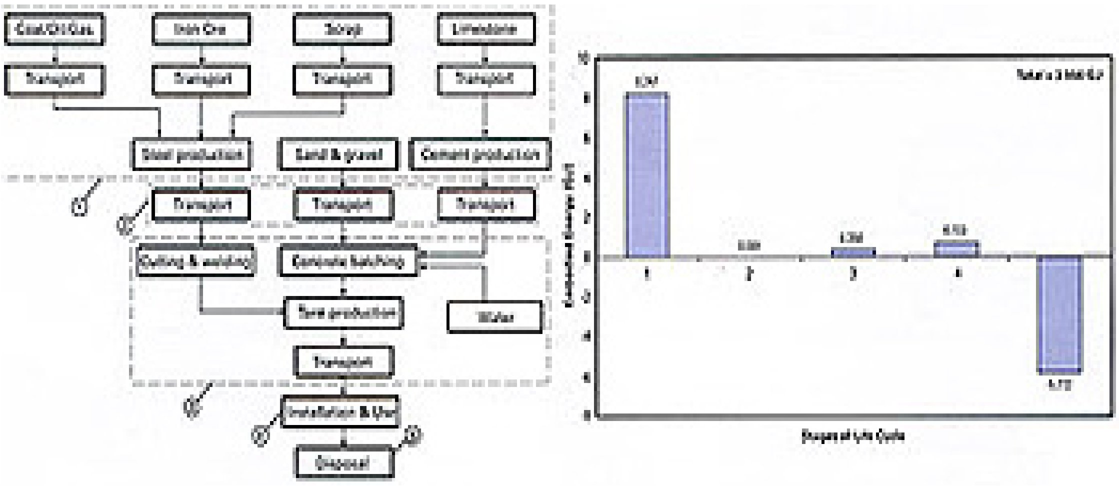
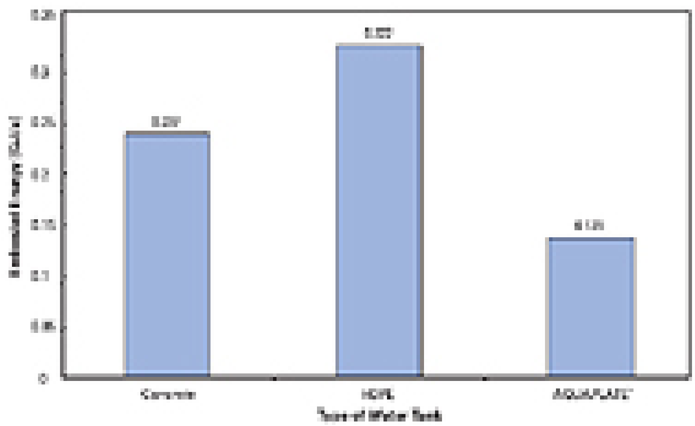
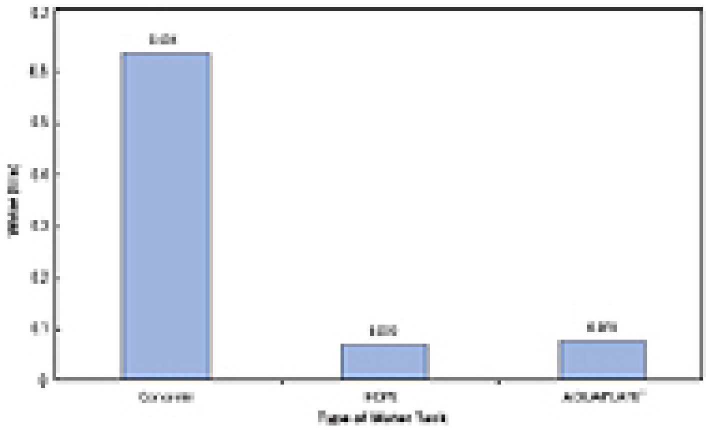


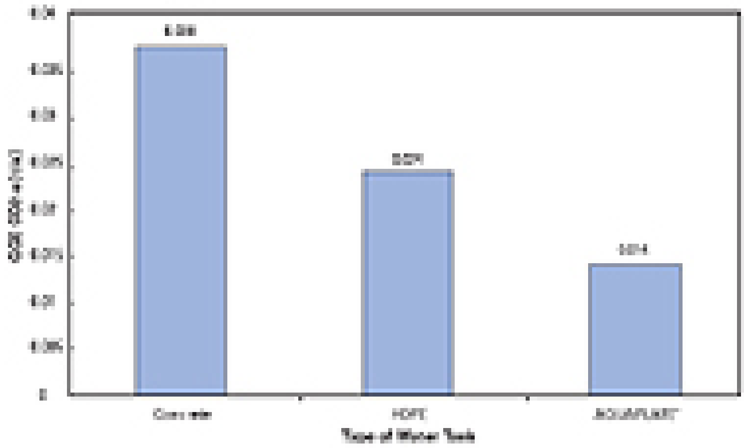
Figure 3: Life cycle stages and environmental burden of 5,000 litres concrete water tank over its operational life

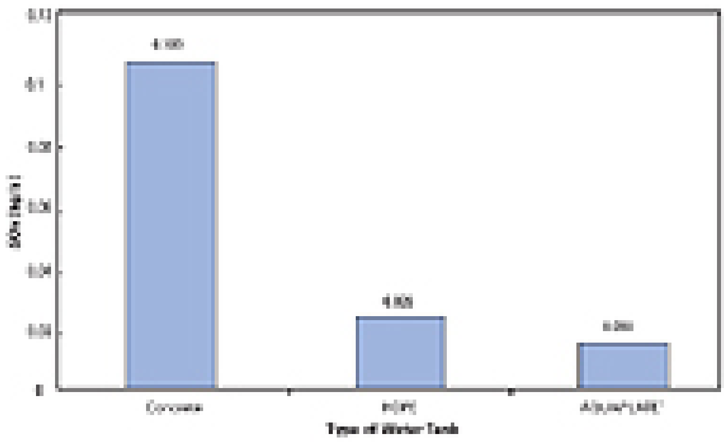
3. Conclusions

In order to provide a quantitative measure of the environmental performance, the environmental burdens of the concrete, plastic and steel tanks were normalised on an annual basis, according to their respective useful operational life. A comparative environmental performance is presented in Figure 4.









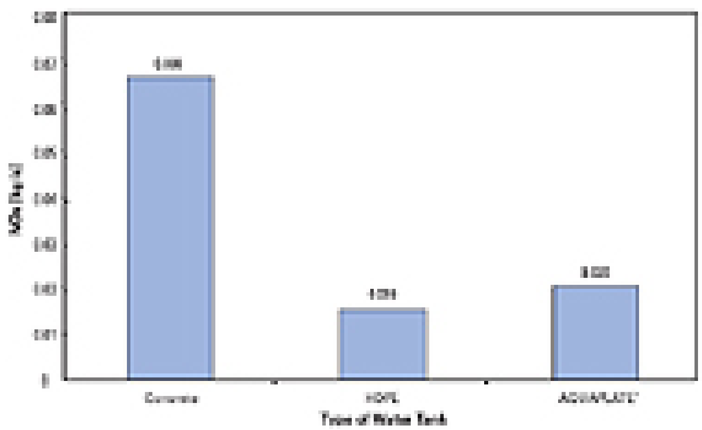


Figure 4: Comparative environmental performance of concrete, HPDE and AQUAPLATE® steel rain water tanks

Based on this LCA study the following conclusions could be made:

- Rain water tanks made from AQUAPLATE® steel have the lowest overall environmental impact.
- Compared to concrete and HDPE rain water tanks, AQUAPLATE® steel has the lowest embodied energy, GGE and SOx emissons.
- Water tanks made from both AQUAPLATE® steel and HDPE performed similarly in terms of water and NOx environmental burdens, outperforming concrete tanks.
- Compared to a tank made from AQUAPLATE® steel, there is 50% more steel in a concrete tank as part of the structural reinforcement.
- The annual environmental burden of a water tank made from AQUAPLATE® steel is equivalent to one 100W light bulb switched on for approximately one week.