Alteration – temperate

Inner city sydney

'Sydney's Sustainable House' is one of Australia's best-known examples of sustainable urban living. It was the result of renovations in 1996 to an inner city terrace, with the goal of making the home self-sufficient in water and energy.

BUILDING TYPE: Renovation of an existing home.	
CLIMATE: Temperate - New South Wales	
Topics Covered	Success Level
Passive heating & cooling	Good
Renewable energy use	Excellent
Rainwater harvesting	Excellent
Water treatment/re-use	Very good
Greenhouse gas reductions	Excellent
Sustainable materials use	Very good
Waste minimisation/recycling	Excellent
Indoor air quality	Good

Note: A NatHERS rating has not been conducted

The main components of the renovation were:

> A renewable energy system

> A rainwater collection system

> A wastewater treatment system

As a result of the renovations, the house's sewage is now treated on-site and no longer pollutes the ocean. The rainwater and sunlight which fall naturally onto the site are utilised as a precious resource.

The original project was well documented in the owners' book, "The Sustainable House". This case study reviews the performance of the house five and a half years on, focusing on its successes and the lessons learnt.

The significance of the project

Several factors made 'Sydney's Sustainable House' unique when it was completed in 1996. It showed that it was possible to create an almost entirely autonomous house on a compact, inner city site and within a relatively modest budget.

The greatest contribution of the project is that it has made the concept of sustainable home design more accessible, largely due to excellent publicity and the detail with which the renovation process was documented.

'Sydney's Sustainable House' is the subject of a book and an ABC online feature, and features in the Ecologic Exhibition at the Powerhouse Museum in Sydney. In addition, over 15,000 people have visited the house on the tours run weekly.

BACKGROUND

Design goals

When the kitchen and bathroom of an existing terrace house were renovated in 1996, the owners, Heather Armstrong and Michael Mobbs, set the following design goals to make the house self sufficient for water and energy.

In addition, the owners wanted their house to feel like any other house to live in, and to be suitable for sale on the mainstream housing market.

The existing home

The two storey inner city terrace was built in the 1890s. It sits on a 150 square metre site (5 metres wide and 30 metres deep), located 2 kilometres from Sydney's central business district and 10 minutes walk from Darling Harbour. The precinct is a heritage conservation area under the local council planning controls, so all renovations must fit in with the existing character of the streetscape. [See: Streets & Communities]

The renovation

The scope of the renovations limited the opportunity to consider issues like passive design and materials use. Even so, this simple renovation was able to make a significant difference.

THE SOLAR ENERGY SYSTEM

Renewable electricity generation

Clean, renewable electricity is generated from the sun's energy using a photovoltaic system. Photovoltaic systems have no moving parts, require little maintenance, and are suitable for use in urban areas as they take up little space and make no noise.

The grid-interactive photovoltaic system uses 18 x 120 watt photovoltaic panels located on the north-facing roof area. These generate up to 2555 kilowatt- hours per year and provide around 70% of the electricity used in the house. [See: Renewable Electricity Overview, Photovoltaic Systems]

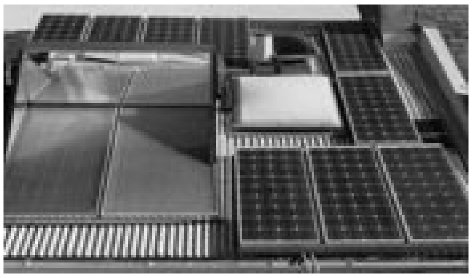
An inverter converts this electricity to 240V so it can be used within the house or diverted to the main grid. The main grid acts as 'storage' for the electricity produced, replacing the need for bulky battery storage. [See: Batteries & Inverters]

Surplus solar electricity is exported to the main grid during the day, putting the household bills into credit with the local power company. At night, electricity is imported from the main grid.

This system supports all the home's electricity requirements, including refrigerator, fax, photocopier, video, television, computer, stereo, clothes dryer, front-loading washing machine, and dishwasher.

The house was to be a net exporter of clean electricity to the main grid. The inefficient refrigerator, which uses around a third of the household electricity, has prevented this from happening so far. The owners plan to replace it with a more efficient model. [See: White Goods]

Solar hot water service



Reflector devices were added to the existing solar hot water service, increasing its efficiency during winter by around 17 percent. These reflectors are positioned at the sides and top of the existing solar hot water panels, to capture low angle winter sun and reflect it onto the solar hot water panels.

A gas booster was installed to replace the existing electric booster on the solar hot water service. In most cases, natural gas produces only about a third of the greenhouse gas emissions of conventional electricity. The booster can be set to operate only at nominated times. It can be turned off when there is sufficient sun to keep the water hot without boosting. [See: Solar Hot Water]

Reducing household energy demand

Before the renovation the house used 24 kwh of electricity a day on average. Now, after the use of energy efficient appliances and lighting, and the switch to gas for cooking, hot water boosting and space heating, it uses about 10 kwh. Of that, the refrigerator is using over 3 kwh. [See: Energy Use Introduction]

Energy and water efficiency were the main criteria for appliance selection.

A gas cooktop and oven/grill were used, along with a water-efficient dishwasher and washing machine.

The washing machine is a front loading model. The cold water tap is connected to recycled water, and the hot water tap is connected to the rainwater.

The refrigerator is an older model which belonged to the owners before the renovation. It consumes around a third of the household electricity and prevents the home from being a net exporter of electricity.

Ventilating the space behind the fridge will also be considered in the future as a way of improving its energy efficiency. Good air flow behind the fridge allows the heat pump to dissipate energy more quickly, reducing its running time. [See: White Goods]

An energy rating label must be displayed on all appliances for sale, and gives an indication of the appliance's energy efficiency. The higher the number of stars, the higher the energy efficiency.

Energy efficient lighting is also used in the renovated areas to reduce energy demand. Five individually switched compact fluorescent ceiling lights, which together use less energy than one conventional incandescent light bulb, were placed to shine directly onto bench work surfaces in the kitchen. [See: Lighting]

Reducing water demand

To reduce water demand, water-efficient appliances and fixtures are used. These include:

> Toilet 3/6 litre dual flush

> Showerhead AAA-rated

as well as the water-efficient dishwasher and washing machine previously described. [See: Reducing Water Demand]

Rainwater collection

The house is almost self sufficient in water. Rainwater is collected and used for drinking, cooking, showers, baths and hot water.

Roof materials and finishes need to be carefully chosen when collecting rainwater. Avoid lead-based and tar-based paints. Suitable materials include galvanized steel, Colorbond, Zincalume, slate and tiles.

Specially designed gutters, which are covered to exclude sediment, leaves and pollutants, collect the rainwater which falls on the galvanized steel roof.

A rainhead attached to the downpipe excludes any leaves and other debris that may have somehow entered the covered gutters. Whilst not essential, these reduce maintenance and the likelihood of blocking of the first flush diverters.

A diverter ensures that the first 8-10 litres of first flowing, dirty rainwater are automatically diverted to the garden. This is particularly important in cities like Sydney where air quality can be poor, leaving the roof covered in pollutants between rain periods.

Clean rainwater is diverted to a 10,000 litre concrete storage tank located in the back garden, beneath the deck. A sump between the first flush diverter and the rainwater tank contains a fine stainless steel mesh grate to ensure no further sediment enters the tank.

A small pump delivers the stored rainwater to the house when a tap is turned on. This pump is required to achieve the necessary water pressure, and is housed in an acoustic hood at the back of the garden. [See: Rainwater]

The stored rainwater is pumped on demand when a tap is turned on. Overflow is contained in a small wetland which transpires some of the excess into the atmosphere, reducing the load on the stormwater system. [See: Stormwater]

Recent sophisticated water quality tests (2002) show that, despite the inner city location, with planes flying overhead and traffic congestion, the rainwater contains no hydrocarbons and none of the by-products of chlorine decay present in town water.

Wastewater treatment

To stop sewage leaving the site, wastewater is treated and recycled using a wet compost system. This process treats all types of wastewater, whether it be from a toilet or kitchen sink, by filtering it through compost beds. There is also a carbon filter and UV disinfection.

The wastewater treatment system treats washing, kitchen and household waste to tertiary quality levels for treatment and re-use.

Treated water is used to flush the toilet, wash clothes and water the garden. The system uses a natural, self-adjusting biological process. Yet the house appears the same as any other, having a conventional dual flush toilet, and typical water efficient appliances.

System design

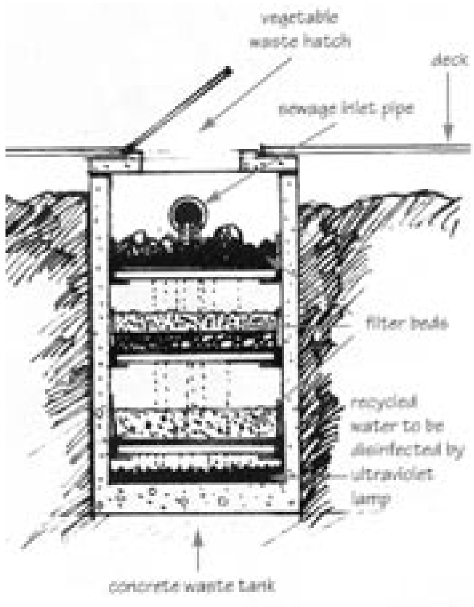
Wastewater is piped from the house to a concrete tank beneath the garden deck which houses a series of filter beds, collectively known as a ‘biolytic filter’

A hatch located near the inlet to the tank allows vegetable scraps, waste paper and other biodegradable household waste to go into the wastewater treatment system.

In the tank a series of filter beds consisting of sand and peat, worms, insects and microorganisms break down the waste present in the water. A carbon filter removes any remaining odour and colour from the filtered wastewater.

An ultra violet (UV) lamp provides a final stage of treatment, disinfecting the filtered wastewater as it is pumped to the house for reuse. This is the only system component that needs regular replacing (approximately once every 12-18 months). [See: Wastewater Reuse]

Excess filtered wastewater is discharged into a wetland at the side of the garden, where it is absorbed by the plants and released to the atmosphere through evapotranspiration. This wetland also provides habitat for frogs and native birds.



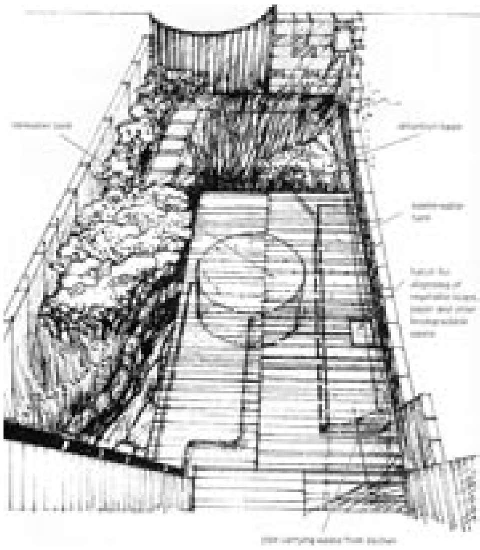
LIMITATIONS OF THE ORIGINAL DESIGN

The wastewater system was experimental, with the tank designed to a particular size and proportion (0.5 metres wide by 8 metres long) in order to fit the available space in the back yard, next to the previously installed rainwater tank. Five and a half years on, it has become clear that this design was not adequate.

The distribution system, responsible for distributing wastewater within the tank, was not designed to suit the narrow tank proportions. It was a system more suited to the conventional round-shaped wastewater tank. As a result, wastewater was not evenly dispersed for treatment.

In hindsight, it would have been much easier to use a conventional round-shaped wastewater tank and design the rainwater tank to fit the remaining space, instead of the other way around.

The wastewater system was intended to be aerobic, but poor distribution meant that its capacity was severely decreased, and that it became anaerobic. Anaerobic wastewater treatment (the kind that occurs in a septic tank) produces less sludge than aerobic but is very smelly when it's working well. Aerobic treatment produces few odours.



The owner has made some modifications to the system as the manufacturer has gone out of business. Since this system was installed there has been significant research and development in the area of on-site wastewater systems. Many reliable systems are now available.

Materials and indoor air quality

Only plantation or re-growth timbers were used in the renovation. Re-growth timber comes from forests that have re-grown after logging many years ago. As the original ecology never completely returns to a logged forest, this type of native forest has lower conservation and biodiversity value than an old growth forest, whilst still yielding some of the durability characteristics of old growth native timbers. [See: Biodiversity Off-site]

Polished timber floors were used in the renovated kitchen and living area, as carpet can be a source of irritants for those allergic to dust mites.

A tung-oil based floor sealer was specified for the timber floor, but the contractor used an oil-modified urethane product. While this is not as harmful as polyurethane, it still contains volatile organic compounds (VOCs) and is moderately toxic.

Plantation hoop pine was used for the kitchen joinery. The kitchen joinery incorporates a specially designed waste sorter under the sink, a pull-out bin system which allows easy separation of waste for recycling.

Good ventilation in the kitchen and living area was achieved by use of louvre windows and external glazed doors opening to the garden. If too little fresh air enters a home, pollutants can accumulate to levels that can pose health and comfort levels. [See: Indoor air quality]

Radially-sawn plantation hardwood timber was used for the outdoor deck. This technique reduces the amount of waste generated by traditional saw-milling, provided that the rhomboid shaped sections it produces can be used efficiently. Decking is an ideal use.

Avoiding the use of PVC was difficult at the time, as information could not easily be found on viable alternatives. The first flush diverter, the electrical wiring, the dishwasher and the paint to the interior all had PVC content. Greenpeace have since compiled a guide of alternative materials which can be found on their website.

Water-based paints were specified as they are generally environmentally preferable to oil-based paints. However, it was later discovered that the paints used contained some PVC content.

Plant or mineral based 'bio-paints' are environmentally preferred, with 'low VOC' conventional (synthetic) water-based paints being the next best option. [See: Indoor air quality]

WAS IT EXPENSIVE?

Up-front costs

The costs (in 1996) were:

> water system $11,000

> waste system $11,000

> energy system $26,000

These costs could be reduced by about 30 to 50 percent on a bigger site, a sloping site or a new site.

If they were to do the same renovation in 2002, the owners, who have done considerable research, estimate that the costs would be:

> water system $3,000

> waste system $6,000-8,000

> energy system $15,000

This is due to improved technology and increased availability of products. In the case of the energy system, this also takes into account increased installation efficiency and the government rebates available.

The Commonwealth Government currently provides rebates for photovoltaic systems. It is expected that all the systems will last at least 30 years, although there are no 30 year old photovoltaic systems of this kind to use as a benchmark.

Running costs

Before the renovation, household bills were $1600 a year and rising.

Now, the owners feel they should be able to live in the house and get all the energy and water they need for about $200 a year (about $60 every 12-18 months to replace the UV lamp, and about $100 a year to maintain the pumps).

LIFESYTLE AND MAINTENANCE

Is it a spartan lifestyle?

"The house has improved our lifestyle and made it easier to live here in the bigger, snazzier kitchen and bathroom. We no longer bump into each other when cooking and washing.

When a friend stayed here last year, and we went away for two weeks having left her with no special instructions, I asked her when we returned, "How was the house?" and she replied, "Fine. Why?" So we expect we can sell it if we need to, to anyone in the inner city housing market.

During the water alert in Sydney in 1998 we alone of our 4 million neighbours did not have to boil our water; it's cleaner than the town water. We are getting zero faecal coliform counts for the waste water". - Michael Mobbs

Is it a 'high maintenance' home?

The renewable energy system and the solar hot water system have not required any maintenance since their installation five and a half years ago.

The rainwater system requires minimal maintenance. The four first-flush devices are rinsed every 3-6 months, a simple procedure. The pump is expected to last 10-15 years.

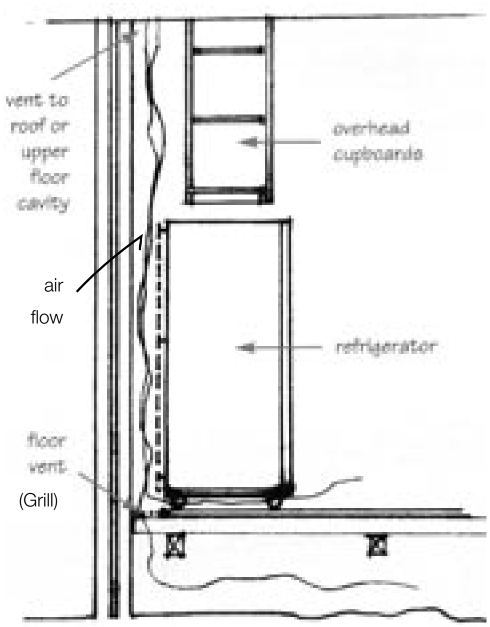
The wastewater system should be pumped out every 5 years to remove sludge. The carbon filter needs replacing roughly every 6 months, and the UV lamp every 12-18 months.
The pump is expected to last 10-15 years.

If they could do it all over again...

Following is a summary of the most important things the owners learnt through the process of renovating and living in their sustainable house, and what they would do differently if they had the chance again.

Link payment to the delivery of design goals in the contracts for building and other services, so that design professionals, builders and tradespeople understand that these goals are not negotiable and are encouraged to seek creative solutions.

Ensure that all consultants work as a team right from the beginning of the project, as good communication is essential for achieving optimum, workable solutions. Without this integration of skills and knowledge, many opportunities can be missed. If the owners could go through the process again, they would ensure that the architect, engineer, builder and tradespeople collaborated right from the beginning of the process.



A key opportunity to improve energy efficiency was lost due to a lack of communication between consultants. A grate in the floor under the fridge could have drawn cool underfloor air past the back of the fridge and exhausted it through a small grate at the back of the cupboard above the fridge. This would have improved the energy efficiency of the fridge by up to 25 percent, as well as helping to dry teatowels in the cupboard overhead. If the energy consultant, architect, engineer and builder had met to discuss opportunities earlier in the design stage this could have been addressed.

The wastewater system should have been designed using a round tank - an optimum shape for the system. It was not possible to fit this alongside the previously installed rainwater tank. In hindsight, a correctly proportioned wastewater tank should have been located first, and the rainwater tank designed to fit the remaining space, as its shape and proportions have no bearing on performance.

One of the owner's tips for designers and purchasers of wastewater systems is that they should be as modular as possible to allow easy maintenance and replacement of parts. Also, ask to see performance data before purchasing a system. [See: Wastewater Reuse]

Ensure that solar panels are not overshadowed (by chimney stacks, roof ventilators, adjacent buildings, etc), as this will reduce their efficiency. The owners discovered that the overshadowing of one panel was reducing the efficiency of all the panels in the array. [See: Photovoltaic Systems]

Pay careful attention to glazing location and type. The west-facing wall in the kitchen and living area was extensively glazed to let in plenty of natural light. Unfortunately, this makes the space too hot in summer and too cold in winter. Although it is often advisable to minimise the area of west facing glass, this is not always feasible on compact urban sites. In this case, west facing windows were the only way of getting natural light to the kitchen. Use of a removable shadecloth outside the windows would improve summer performance. Use of double glazing would be one way to improve winter performance. [See: Orientation, Glazing Overview, Shading]

The use of toxic materials such as PVC and polyurethane came about largely due to the lack of easily available information on alternatives. Since that time, many resources have been developed on materials use and indoor air quality. [See: Indoor Air Quality, Materials Use Introduction]

ADDITIONAL KEY REFERENCES
Mobbs, Michael (1998) Sustainable House: Living for our future CHOICE Books ISBN 0-947277-48X Available by calling Choicebooks at the Australian Consumers Association on 1800 069 552, or at www.choice.com.au
www.sustainablehouse.com.au
BDP *Environment Design Guide*
Illustrations from "Sustainable House" by Michael Mobbs, published by CHOICEBooks and available at www.Choice.com.au.