INTRODUCTION TO THE GREENY FLAT EXPERIMENT

I believe that we can learn to live in harmony with our environment. Indigenous people all around the world knew how to do this before "civilisation" came along. It was only when we started to burn fossil fuels on a large scale that we lost our connection to that which sustains us. Our addiction to fossil fuels has led to everything that is unsustainable about our current global predicament. This includes the ridiculous assumption that we can sustain infinite growth (in global economies, global population, and "quality of life") in spite of the Earth's finite ecosystem. So, for me, learning to live in harmony with the planet means learning to live without fossil fuels. Before I'm accused of gross hypocrisy, let me be the first to admit that my way of life is highly unsustainable. I drive a car, I eat food grown in faraway places, I use fossil fuels. I certainly don't have all the answers, I'm simply attempting to take the first steps towards a fossil-fuel-free future and that is what the Greeny Flat Experiment is all about.

The Greeny Flat is a full-scale living experiment currently underway on a quiet street in Mittagong in the Southern Highlands of NSW to see if it's possible to build a small, comfortable, healthy, energy positive, low-maintenance, fire-resistant, water-efficient, elderly-friendly infill house at an affordable price. Our two primary aims were to try to make it energy positive and affordable.

For twenty years I designed and built "sustainable" houses in the Rocky Mountains of Montana near the Canadian border where the winters get down to -40˚C and the summers up to +40˚C. In that climate, attempting to come even close to Net-Zero-Energy buildings was a huge challenge. When I returned home to the Southern Highlands a couple of years ago it quickly dawned on me that building an energy positive home here should be relatively easy and inexpensive. I have since learned that the cost of most things in Australia is much higher than in the States so making the Greeny Flat affordable has proved to be our biggest challenge. Meanwhile Cintia and I have lived in the house for nearly six months now, closely monitoring its energy performance, water usage, water quality, indoor air quality, and comfort levels to see whether it actually meets the initial goals.

- [Sidebar: AN ALL ELECTRIC HOUSE
  The Greeny Flat is all electric, i.e. it has no gas, petrol or wood burning appliances. Even our lawn mower and weedeater are electric. This decision was partly due to our desire to be able to clearly compare how much energy we use with how much we produce, a comparison that is much easier when everything is electric. More importantly, given the broader goal of learning to live without fossil fuels, we can produce electricity with renewable energy systems. In our case this is a 3kW grid-tied solar power system. Hopefully there will soon be cost-effective energy storage systems available that will reduce our dependence on the fossil-fuel-powered grid for the times when the sun isn't shining. Meanwhile we try to use electricity when the sun is shining as much as possible. For example, we often use a slow-cooker (that uses about 400W) throughout the day to cook our evening meal and we mow our grass when the sun is shining.

The design of the Greeny flat is based on a Triple-Bottom-Line philosophy which aims to improve the Environmental, Financial and Social outcomes of the choices we make. For this article I'd like to focus on three of the key things that make this possible: 1) finding the perfect site; 2) keeping it small and simple; and 3) employing passive solar design principles throughout the project.

THE PERFECT SITE

The Greeny Flat is designed to meet the possible future needs of my ageing parents who, in their infinite wisdom, had found and purchased the perfect site over twenty years ago. There is an existing fibro cottage on the east half of the lot which they rent out and which left the west half available for us to build the Greeny Flat.

It is the perfect site for a passive solar home with a gentle slope to the northeast, nice views to the north, and existing buildings and trees to the west and south providing protection from cold winter and hot summer winds. The excellent solar access is also protected by the street to the north of the lot which means that no neighbour can build or plant anything that might block our sun in the future.

Just as importantly, this is an infill site in an already developed area which helps to reduce sprawl; preserve open space, agricultural land, and natural habitats; maximize use of existing infrastructure; and reduce driving. All the things we use on a regular basis (including shops, schools, medical centres, the town library, parks, playgrounds, hardware stores, and trains to Sydney, Canberra and Melbourne) are within easy walking distance of the Greeny Flat so we could easily live here without a car.

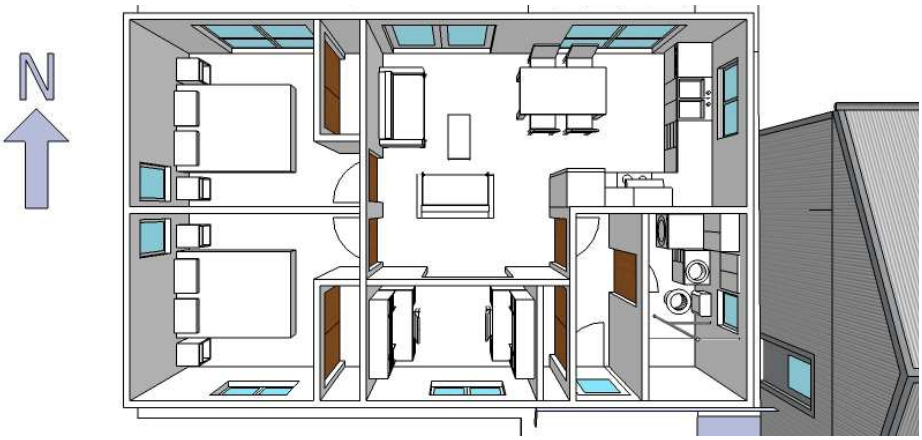
To give an indication of how important this is, according to our most recent power bill, the Greeny Flat uses an average of 3.62kWh per day and the average Australian home with 2 people uses 16kWh/day. So our home's energy consumption is less than a quarter of the Australian average. Meanwhile a commuter might use 40kWh worth of energy to drive 50km per day. In other words, it takes about ten times as much energy to drive 50km as it does for us to run our entire house for a day.

As you can see, living close to the things we need, and walking or riding our bikes whenever possible can have a HUGE impact on our overall energy consumption. Thus the location of our home is critical to reducing our fossil fuel use and overall environmental impact.

Another aspect of infill housing that greatly reduces the overall cost of any granny flat is the fact that the land is already paid for. In this area (the Southern Highlands of NSW), land is expensive and if we had had to buy the land to build this house it could have easily doubled the cost of construction. And, since there are very few vacant lots within the established town areas, we would most likely have had to build out on the edge of town in a new subdivision that used to be bushland or farmland. We'd be contributing to urban sprawl. We'd be paying a LOT more. And we wouldn't be able to live so conveniently close to everything. Thus infill housing is a good example of a Triple Bottom Line benefit.

K.I.S.S.

The first rule for building more sustainably is to Keep It Small and Simple. The Greeny Flat has two bedrooms and one bathroom on a 57m2 footprint. It is a simple, rectangular plan with a gable roof and a concrete-slab floor. The kitchen and bathroom are next to each other in order to simplify the plumbing system, and the living spaces face north to make the best use of natural light and sun. The small size means less energy and materials were required for construction and less energy is required for operation. The simple design and systems made it quicker and more affordable to build and easier to maintain.



PASSIVE SOLAR DESIGN

There are two parts to the energy positive equation. The first, and most important, is Energy Conservation. By minimising our energy useage we make it much easier and more affordable to produce more energy than we use via renewable energy systems. The primary way that we reduce energy consumption in the Greeny Flat is by using passive solar design principles. To summarise these principles very briefly: the northerly aspect, window placement, eave overhang, room layout, insulation, air-sealing, double-glazed windows, thermal-mass floor, summer shading, ventilation, reflective exterior, and landscaping are all specifically designed to work together to keep the interior cool in summer and warm in winter without the need for any additional heating or cooling. In addition to the passive solar design, the solar hot water system, low-flow plumbing fixtures and short plumbing runs greatly reduce the amount of energy required to heat water. And the natural lighting, solar clothes drying and energy-efficient electrical fixtures further reduce the overall energy consumption to the point where we can easily meet our requirements with renewable energy.

Because of the experimental nature of the project we didn't know when we started what size solar power system would be required for us to be energy positive. So we chose to install a 3kW system which, as it turns out, is over twice as big as we really need.

RESULTS

At the time of writing this article, Cintia and I have lived in the Greeny Flat for over five months. The table below summarises the results we have recorded so far. In that time: we have exported about 2.5 times as much electricity as we have imported; we have used more tank water than town water; and the interior has stayed pretty comfortable with very little in the way of additional heating or cooling (we did occasionally run a small radiator to keep the bedroom warm in the winter). Admittedly there were a couple of times when the interior got down below 13˚C when the outside temperature was around -4˚C which many people would find uncomfortable (we didn't mind it and simply put on a jumper and some slippers). But we also made plenty of extra energy so that, if we wanted to, we could run some sort of heating system and still be comfortably energy positive.

	ENERGY		WATER		COMFORT			
MONTH	ENERGY EXPORTED (kWh)	ENERGY IMPORTED (kWh)	TOWN WATER (litres)	TANK WATER (litres)	OUTDOOR MIN (Deg C)	OUTDOOR MAX (Deg C)	INDOOR MIN (Deg C)	INDOOR MAX (Deg C)
MAY 2014	268	137	1441	4563	2.2	27.6	14.6	26.5
JUN 2014	237	101	1109	3201	0.5	26.2	14.2	25.4
JUL 2014	297	68	3244	1278	-4.0	21.2	12.4	23.7
AUG 2014	288	130	6899	1169	-4.6	25.7	12.7	23.3
SEP 2014	326	146	0	7209	0.8	23.4	14.0	23.9
OCT 2014								
NOV 2014								
DEC 2014								
JAN 2015								
FEB 2015								
MAR 2015								
APR 2015								
TOTAL SO FAR	1416	582	12693	17420	-4.0	27.6	12.4	26.5

CONSTRUCTION COST

During the design and construction of the Greeny Flat we carefully weighed the up-front costs against the long-term benefits in terms of reduced operating costs, reduced environmental impact, and improved quality of life and community.

In total the Greeny Flat cost $128,000 to build and that has to be considered as cost price, i.e. all the materials, subcontractors, and our own labour has been included with no markup for overhead or profit. In other words, if a builder had built this for us they would have had to charge more. The table below is the cost breakdown for the project.

STAGE	SUBTOTALS
Planning, permitting, insurance, and survey	**7,160**
Earthworks, services and concrete	**14,240**
Solar panels, SHW and rainwater systems	**14,130**
House shell, windows, cladding and insulation	**37,830**
Interior fitout	**24,740**
Electrical	**10,440**
Plumbing	**8,230**
Exterior porches, patio, paving and raised beds	**10,840**
TOTAL	**127,610**
Cost/m2 (Size = 57m2)	2,239

The cost per square metre number at the end of the table is of particular interest. To put it into perspective, typical building costs in Australia range from about $1,200/m2 for the cheapest code minimum housing, up to $3,000/m2 and more for the highest quality, custom homes. So we're somewhere near the middle. Realistically, if a builder were to build this house and make a profit they would have to charge at least $150,000 which would be $2,630/m2.

We were hoping we could build the Greeny Flat for around $1,750/m2 (i.e. total cost under $100,000) so we clearly have a lot of work to do to reach that goal. On the other hand we've looked at a number of other options (like kit homes of a similar size) and by the time we add double-glazing, extra insulation, solar power, solar hot water, rainwater harvesting, etc, etc, the price always comes out to at least $150,000.

When discussing costs it is important to remember that housing affordability relates to much more than the up-front construction cost. Over the life of a typical home there will be at least as much spent on running costs like electricity, gas, water, and maintenance. So, in the long-term the Greeny Flat will save a lot of money by reducing these ongoing expenses.

OPERATING COSTS

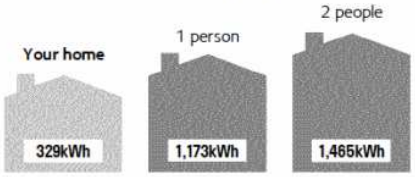
We recently received our electricity bill for June, July and August. The total came to $89.51 which works out to $0.98c/day and that was for the coldest three months of the year. Of that total bill, $64.76 was for what they call "Supply Charges" (this is the daily fee that we pay (currently $0.7162/day) just to be connected to the grid) and $14.12 was GST. So we actually only paid $10.63 for the electricity that we used over the three months.

If you look at our bill below, on the left hand side you will see that our home used 329kWh for the 91 day period. Next to that it shows that the average usage for a home with two people is 1465kWh. So we are using less than a quarter of the average amount of electricity for similar homes in our area. And that doesn't even factor in what we produced from our solar panels. On the second page it shows that we exported a total of 823kWh from our PV system. That works out to an average of 9kWh per day. Our average daily usage was just 3.62kWh. So we exported 2.5 times as much electricity as we imported. Since we don't have any gas or wood burning appliances this accounts for our total energy equation in the home for the three month period.

How much energy are you using?

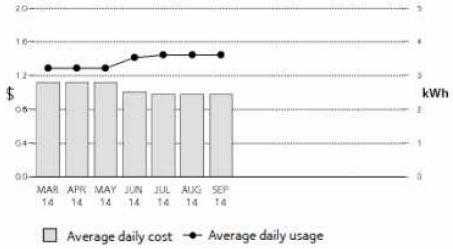
Bill period: 7 Jun 2014 to 5 Sep 2014 (91 days)

Compare with other homes in your area.



Average usage data supplied by Australian Energy Regulator.
Visit energymadeeasy.gov.au for more information.

Average daily cost and usage.



Snapshot.

Average daily cost:
$0.98

Average daily usage:
3.62kWh

Tax Invoice Issued: 9 Sep 2014
AGL Sales Pty Limited ABN 88 090 538 337

Your bill overview.

Balance brought forward	**$0.00**
+	
New charges	**$89.51**
=	
Total due	**$89.51**

Due date	**29 Sep 2014**

To avoid a late payment fee of $12.73, please pay by the due date.

Thank you.

Meter no.	Read date	Read type	Rate description	Start read	End read	kWh
2514720	5 Sep 14	Actual	Peak	222	551	329
2514721	5 Sep 14	Actual	Solar	447	1,270	823

Your next meter read is due between **2 Dec 14 and 8 Dec 14**. Please ensure easy access to your meter on these days.

How we've worked out your bill.

Previous balance and payments.

		Total
Previous balance	$76.35	
30 Jun 14 payment	$76.35cr	
Balance brought forward		**$0.00**

New charges and credits.

Usage and supply charges	Units	Price	Amount		
Peak	86kWh	$0.2466	$21.21		
Supply charge	24 days	$0.6988	$16.77		
Price change - 1 Jul 14 to 5 Sep 14 (67 days)					
Peak	243kWh	$0.2274	$55.26		
Supply charge	67 days	$0.7162	$47.99		
Total charges				+	*$141.23*
Credits					
AGL Solar Buyback*	217kWh	$0.08	$17.36cr		
AGL Solar Buyback*	606kWh	$0.08	$48.48cr		
Total credits				-	*$65.84cr*
Total new charges and credits				=	*$75.39*
Total GST				+	*$14.12*
Total due (includes GST)				=	**$89.51**

*Item is not subject to GST. All other items are subject to GST.

LESSONS LEARNED SO FAR

Our testing and monitoring of the Greeny Flat experiment will continue for at least one full year so we have a long way to go and lots more to learn. Nevertheless there are a few lessons that we have learned already and will probably do differently in the next project.

One major thing is that we will probably choose not to install a solar power system in the next one. We have an evacuated tube solar hot water system on the Greeny Flat which does a decent job of heating

our water. However it cost over $6000. Meanwhile our 3kW PV system (which cost less than $5000) is producing way more power than we are using. So for large parts of the day we are exporting our excess power and getting paid $0.08c/kWh for it. We would be better off to have an electric heat-pump hot water system or even just an electric tank water heater with a standard element. This would allow us to use our excess power during the day to heat water for use at night, reduce the amount of power that we are putting into the grid, and save a significant amount on the initial cost of the system. Heat pumps are much more efficient than a standard tank water heater but they are also more expensive, make a significant amount of noise, and are much more complicated with motors and moving parts that could wear out over time.

Another thing we would do differently is to insulate the edge of the concrete slab. The reason we didn't do this on the Greeny Flat is because we needed to expose the edge of the slab for termite protection. However we have since learned of a termite barrier that would allow us to insulate the slab edge. This would significantly reduce the amount of heat loss in the winter and make the Greeny Flat even more energy efficient. Also, while we love the dark colour of our polished concrete floor, we are finding that it shows every speck of dirt so we may well choose to use a lighter colour for our next floor.

- [Sidebar: GREENY FLAT SPECS
- Energy Conservation: Passive Solar Design. Maximum use of north aspect for solar access. Eaves sized for maximum winter sun and minimum summer sun. Double-glazed windows placed for maximum sun in winter and cross-ventilation in summer. Concrete slab for interior thermal mass. Day-use spaces on north side for natural light. Air-sealed and extra-insulated thermal boundary. Landscaping for maximum sun in winter, shade in summer. Energy efficient appliances. Solar hot water. Two clothes lines (one under cover).
- Concrete slab: dark coloured to absorb heat and sealed with non-outgassing clear sealer ("Polyclear" from Ecocolour). Concrete slab as termite barriers with edge exposed and collars installed around plumbing penetrations.
- Wall frames: H2 treated pine using advanced framing techniques to minimise wood use and maximise insulation.
- Roof: "Versiclad Corrolink" colourbond sandwich panel. 'Shale Grey' to reflect heat and insulated with Polystyrene to R3.7.
- External cladding: galvanised iron (reflects some heat and is low maintenance, durable, and fire-resistant).
- Windows and exterior doors: "Stegbar" doubled-glazed aluminium frames; metal fly screens for bushfire spark protection.
- Wall iInsulation: "Tontine" recycled polyester R2.0 batts plus reflective thermal break R0.3.
- Internal lining: low outgassing, sustainably harvested "Ecoply" sealed with Zero-VOC "Polyclear" from Ecocolour.
- Plumbing: PEX pipe fed from Clark Tanks 5000l "Slimline" Polyethylene rainwater tank with mains backup and "Bianco Rainsaver" automatic switching device. All plumbing accessible along eastern wall.
- Solar hot water system: "Apricus" evacuated tube collector on roof with 160ltr storage tank in attic above bathroom/laundry.
- Drain lines: PVC pipe underneath exterior pavers. Double sewer lines installed for possible future greywater system.
- Solar Power: 3kW grid-tied photovoltaic (12 x Trina 250W panels); SMA inverter.
- Surface-mounted electrical system: accessible in picture rail and exposed conduit to switches, lights and powerpoints.
- Kitchen: exhaust fan to outside; low outgassing cabinets; space for dishwasher, electric stove and cooktop; super-energy-efficient "Samsung Digital Inverter" fridge.

- Bathroom/laundry: low water use shower head, taps and toilet cistern; energy and water efficient washing machine, no clothes dryer.
- Ventilation: adjustable flow continuous exhaust fan in bathroom. Fixed flow exhaust fan in bathroom switched with lights. Kitchen rangehood. An air inlet pipe laid beneath the slab to bring fresh, cool air in underneath the refrigerator.
- Lighting: LED lights and bulbs throughout.
- Elderly friendly: ramped under-cover access to both front and back doors, minimum steps, wide doors to allow for walkers or wheelchairs, lever handles and taps, bathroom rails, raised garden beds.
- Outside landscape: low maintenance, low water requirement, front patio sized to fit demountable shade gazebo and surrounded by raised garden beds. Private sheltered rear courtyard.
- Other:
- Single lock-up steel-frame garage with well lit workshop/storage space, Colourbond roof, galvanised cladding, on concrete slab.
- Low maintenance throughout and no paint.
- Low power and water bills.
- Easy clean.
- Reclaimed retaining wall blocks, pavers and interior doors.
- Entire structure can be dismantled and materials recycled.