FINAL REPORT

Financial Analysis of Photo Voltaic Solar Technology at Newington Village Homebush

Prepared for

Demand Management and Planning Project
NSW Department of Planning

Level 2, Suite 201
52 Atchison St, St Leonards
NSW 2065

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43187168

dmpp Demand Management & Planning Project

Department of
Infrastructure, Planning and Natural Resources

EnergyAustralia™

TransGrid

URS

Project Manager: …………………………………..
Birribi Dillon
Senior Associate

Project Director: …………………………………..
Greg Loftus
Principal

URS Australia Pty Ltd
Level 3, 116 Miller Street
North Sydney, NSW 2060 Australia
Tel: 61 2 8925 5500
Fax: 61 2 8925 5555

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Executive Summary

The Demand Management and Planning Project (DMPP) have commissioned URS Finance and Economics to investigate Photo Voltaic (PV) solar systems as a contributor to reducing peak demand in NSW. This study is intended to investigate the effectiveness and efficiency of PV technology by considering previous studies and investigation of the financial viability of a typical PV installation decision. The analysis is primarily based on information gleaned from the case study of a large scale PV installation in Newington, Sydney.

The financial analysis has primarily incorporated information from two previous Newington technical reports. Supplementary information has been gathered from government and industry in compiling a financial model for a typical PV installation investment decision.

The analysis was completed from the point of view of a typical Sydney resident considering an installation of PV technology. Information on the performance and output of PV systems was based on the data available from the Newington Case study. Performance figures used in the base case analysis include such characteristics as:

- 1kWh PV system;
- 0.85 kW grid-interactive inverter;
- 0.61 Performance Ratio;
- PV output of 1,152 kWh per annum;
- developed on a large-scale along with a number of other homes; and
- life of system of 25 years.

Other information relating to the potential price of electricity, costs of installation and maintenance and potential grants and subsidies available to consumers were obtained independently. Sensitivity analysis on variations to assumptions of the financial analysis was also completed as necessary.

The key results from the financial analysis are as follows:

- the Net Present Value (NPV) of the PV systems in Newington village is negative $12,151, indicating that these PV systems were not financially feasible as an investment in themselves;
- even when incorporating the Renewable Energy Certificates scheme, and with the Australian Greenhouse Office PV Rebate Programme cash rebate, the NPV remains negative at -$8,222;
- large-scale developments have lower costs than small, individual home developments, although both options resulted in a negative NVP.
- The level of per KW-hr subsidy necessary to negate the negative NPV would be in the order of 87 cents per KW-hr (compared to the current price of 10.57 cents per KW-hr), over 25 years. The cost to Government of applying this subsidy is essentially around $12,151 per PV cell over the lifecycle of the product.

Discussions with industry indicated the cost of retro-fitting PV to existing homes was essentially the same as installing PV on a new house. As such, there is no difference in the financial performance of retrofitted systems compared to new homes.

The analysis demonstrates that the costs of installing a PV system far outweigh the value of any energy savings that would result to the consumer. The net-present value estimate provides the best measure of financial performance, indicating that an investment in a $13,500 PV system would likely deliver a net loss to the purchaser of $12,151. In simple terms, PV technology as it stands was not determined to be a cost-effective method of energy generation (in its current form). To the extent that the assumptions reflect the typical installation decision, the findings have strong implication for broader policy decisions relating to PV technology.

Analysis in previous reports suggested that the electricity generation profile of PV technology was generally not well suited to demand management objectives. Generation peaks typically occur during the middle of the day and do not well match the typical peak residential consumption periods in the early morning and evening when residents return from work. The PV generation profile was better matched to the local substation at Newington due to the area's industrial consumption profile. The PV generation profile might also be better matched to areas where energy is largely consumed during the day (commercial areas etc). This does not however imply that PV would be a cost-effective method of addressing demand management issues in these areas. Attempting to off-set energy consumption using PV technology would generally be far too expensive to be considered economically viable.

The third party benefits of encouraging usage of PV systems as an alternative energy generation option relate primarily to environmental benefits. A kilowatt (KW) of electricity generated using PV technology in theory offsets the need to generate the same unit of technology using traditional technologies which generate pollution. The problem is that use of PV technology to achieve these benefits is not the most cost-effective way of delivering environmental benefits. In simple terms, there are much cheaper ways of generating 'clean energy' in a metropolitan context. If the same environmental benefits can be delivered using another 'clean energy' technology at a lower unit cost, then investing in solar technology to deliver the same environmental benefits is not desirable (all else being equal).

In this context, the case for government subsidy of purchase of existing PV systems is difficult to justify. Whilst support for development of environmentally friendly technologies is to be commended, any subsidy must be carefully targeted to ensure maximum environmental benefits. If government is confident in the potential commercial viability of PV technology at some point in the future, then funds currently allocated to subsidising PV purchases might be better allocated towards research and development activities targeted at delivering more cost-effective PV systems. Alternatively, if subsidisation of 'clean energy' is the goal of government, then the results suggest that the subsidisation of other 'clean energy systems' will achieve the same benefits at a lower cost.

1.1 Context

The Demand Management and Planning Project (DMPP) is a joint initiative of the NSW Department of Planning, Energy Australia and TransGrid, who are working together to enable the cost-effective deferral or avoidance of major new electrical infrastructure works by providing accurate and reliable information on available electrical demand reduction opportunities.

DMPP have commissioned URS to investigate the effectiveness and efficiency of Photo Voltaic (PV) solar systems as a contributor to reducing peak demand in NSW. The question of effectiveness relates to whether PV systems align well with the demand management goals of the DMPP. The question of efficiency relates to whether PV technology is currently a cost effective and reliable way of delivering any identified benefits in the broader context of energy policy development.

This study is intended to investigate the effectiveness and efficiency of PV technology by considering previous studies and investigation of the financial viability of a typical PV installation decision. The analysis is primarily based on information gleaned from the case study of a large scale PV installation in Newington, Sydney.

1.2 Previous Newington Studies

The 2000 Sydney Olympics Athletes Village, located in the suburb of Newington, was planned as a "green" village with environmentally sustainable facilities. Newington Village now includes 979 homes that are equipped with solar power (photovoltaic or PV) systems and solar water heaters.

The DMPP commissioned two previous technical reports on aspects of the Photo Voltaic project at Newington Village. These reports involved:

- technical review and desk top analysis of load profile, energy consumption, and PV effectiveness on peak demand (from a sample of 30 homes); and
- demographic review of 15 sites explaining the difference in load profiles and energy consumption.

This report is intended to build on the two previous studies and to compile a financial analysis of a typical PV installation decision, based on the findings of the previous technical analysis. The report concludes by then comparing PV technology with other alternatives available and considering the potential non-financial benefits of PV technology as a potential energy source.

1.3 Report Structure

This report will be structured in the following sections:

- Section 2 – provides a contextual analysis of PV solar systems at Newington village, including summarising the results of the two previous technical reports;

- Section 3 – details the process undertaken and results of the financial analysis of the PV business case;
- Section 4 – compares PV energy generation with alternative energy technologies;
- Section 5 – presents environmental, social and economic benefits of PV technology; and
- Section 6 – summarises the outputs of this study and provides recommendations on the PV business case.

2.1 Introduction

This section provides a background to PV technology and a summary of the relevant technical information from the previous Newington studies. It is generally structured as follows:

- About PV technology
- About the Newington village PV systems
- Previous studies
- Key findings
- Implications of this contextual analysis

Unless otherwise noted, all statistics and information provided in this chapter is referenced to the previous Newington studies themselves.

2.2 About PV Technology

About Solar Power in Australia

PV technology has been used for a number of years in Australia to generate electricity for sites remote from an electricity grid. In recent times, as some consumers are becoming more aware of the environmental impacts of traditional forms of electricity generation, they are looking to reduce their electricity consumption from conventional generation sources in favour of solar energy. Currently PV panels are the only commercially available technology to generate electricity from solar energy.

PV Panel Performance

The performance of any electricity generation system is reduced by losses of energy inherent within that system, and PV panels are no different. The electrical output from the panels falls below the maximum generation if the operating conditions vary from the optimal design conditions.

A useful measure of PV system performance is the Performance Ratio (PR). The PR is calculated by dividing the electricity output over a year by the maximum output of the PV panel under ideal conditions. The PR reflects the total losses from all the factors described above.

The main factors which affect the performance of PV panels are:

- Commercial PV panels range in efficiency from 5 to 20%, depending on the PV technology used. The PV panels used at Newington are around 15%;

- PV panels need maximum exposure to incoming solar radiation in order to produce the maximum amount of electricity. Fixed PV panels in Australia are faced North and ideally tilted at an angle to catch the maximum amount of sunlight. However, roof angles vary from the ideal tilt and therefore electrical output is reduced; and

- Electrical losses through conversion to alternating current (AC) electricity and other losses in wiring can also reduce the output.

- Weather conditions will also impact on the generation levels of PV systems on a day to day basis. As the study was conducted over a long period, it is assumed that these impacts are effectively ‘averaged out’ over the course of the year for the purposes of the financial analysis (although other locations might experience different weather conditions).

- Panel mal-functions can lead to halting of PV energy generation. If the consumer is not aware of the change in energy generation, the malfunction may go undetected. The impact of panel malfunctions across the study area has been factored into ‘maintenance costs’ for the purpose of the financial analysis.

The financial analysis was completed based on ‘real data’ and ‘actual results’ over the course of the study period which reflect the impact of practical considerations rather than just hypothetical performance estimates. These results are outlined in the later sections.

Further detail on the factors that impact on the PV panel performance is available in the original Newington studies.

2.3 About the Newington Village PV Systems

The use of PV systems at Newington is a good example of urban scale deployment of PV technology. Consequently, the suburb presented itself as the most relevant area for the DMPP to analyse the use of PV panels in NSW.

In Newington all 979 free-standing houses include PV systems. The majority of these (780 homes) have a 9m^2, nominal 1kWp PV array comprising 12 panels. The remaining 199 houses have a 0.5 kWp PV array. The PV systems have an expected operating life of 25 years. For the 30 houses examined in the study all are nominally 1 kWp and faced predominantly North – North West. Based on the annual average solar radiation in Sydney if the 1 kWp Newington systems were optimally oriented each could produce an average 5.2 kWh per day. The performance of the PV systems is discussed in Section 2.4.1.

For this project data on electricity use and PV output were collected from 30 homes in Newington over 12 months from the beginning of July 2004 to the end of July 2005. The data consisted of half hourly PV output, with import and export of electricity from the grid measured separately.

Newington is connected to the electricity network via the Homebush Bay Zone substation. The Homebush Bay Zone substation also supplies electricity to a large number of industrial and commercial customers which are located in the area.

2.4 DMPP Studies to Date

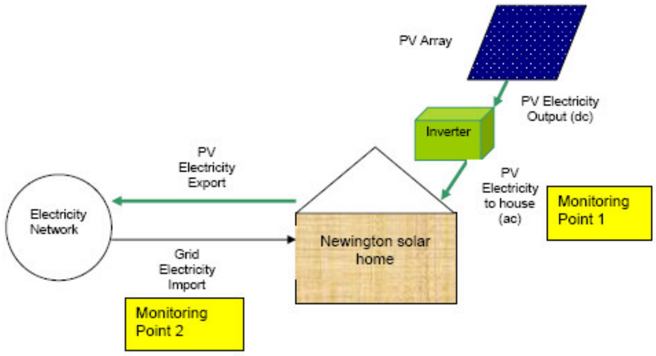
2.4.1 Report 1 – Technical Analysis of PV

The first report commissioned by DMPP was a UNSW, Centre for Energy and Environmental Markets project that involved a PV and Assessment Program at Newington. Interval meters were installed in June 2004 to monitor electricity consumption patterns in 30 homes equipped with roof top PV panels and solar water heaters, in order to analyse the household electricity consumption patterns of the homes.

The aim of the study was to assess the overall impacts of urban-scale use of PV panels on the electricity network, examine different electricity consumption patterns and analyse how PV outputs could reduce household electricity demand from the network.

Figure 2.1 shows a schematic of the electrical connection and monitoring points for the 30 homes in the study. Monitoring Point 1 measures the electricity output (AC) of the solar panels (PV Output). Monitoring Point 2 measures electricity imports and exports to and from the network.

Figure 2.1 – Layout and Monitoring Points for the Newington Solar Home Systems



Source: Centre for Energy and Environmental Markets Report 2006

The resulting report *An analysis of photovoltaic output, residential load and PV's ability to reduce peak demand* (February 2006) showed that electricity consumption patterns were highly variable across the 30 houses.

2.4.2 Report 2 – Electricity Demand Study

The second study was completed by the Institute of Sustainable Futures (ISF) at the University of Technology, Sydney (UTS). This involved an investigation of the demographic, behavioural and infrastructure-related factors that were responsible for those variations in electricity consumption patterns observed in the first study.

This study used a mail survey of 30 homes, the same 30 monitored as part of the first DMPP study, to collect data on the demographic, behavioural and attitudinal characteristics of the households and their installed appliances and equipment. A total of 15 households returned completed surveys, giving a final response rate of 50%.

The DMPP provided two load profiles for each of the 30 homes – one for a hot week in March 2005 and one for a cold week in June 2005. The study sought to find ways to explain these load profiles using the information collected in the survey.

2.4.3 Outstanding Information

The DMPP reports described above do not provide an analysis of the financial aspects of the Newington PV systems with regards to electricity consumption. There is also no discussion about how the benefits of PV systems in reducing household electricity consumption compare to those provided by other demand management options i.e. household energy efficiency, small scale wind turbines, etc.

2.5 Key Findings

2.5.1 Report 1 – Technical Analysis of PV

The key findings from this report include:

- household electricity consumption was higher than expected;
- PV output is only a small proportion of total electricity consumption;
- performance of PV systems is reduced by a number of factors; and
- PV systems are more effective in reducing peak electricity demand for commercial/industrial area than residential areas.

These issues are discussed in further detail below.

Household electricity consumption higher than expected

Over the period July 2004 to July 2005 the 30 houses monitored had an average daily consumption of 16.12 kWh per house. This level of electricity 'demand' was much higher than the consumption rate of 7.5 kWh that was originally expected (possibly due to the presence of a number of luxury appliances in the houses studied).

Electricity demand is very peaky with about half the load occurring 5% of the time. The maximum loads occur on winter evenings, although summer loads can also be high. Approximately half of the maximum load days occurred on weekends. The peak loads occur between 6pm and 10pm.

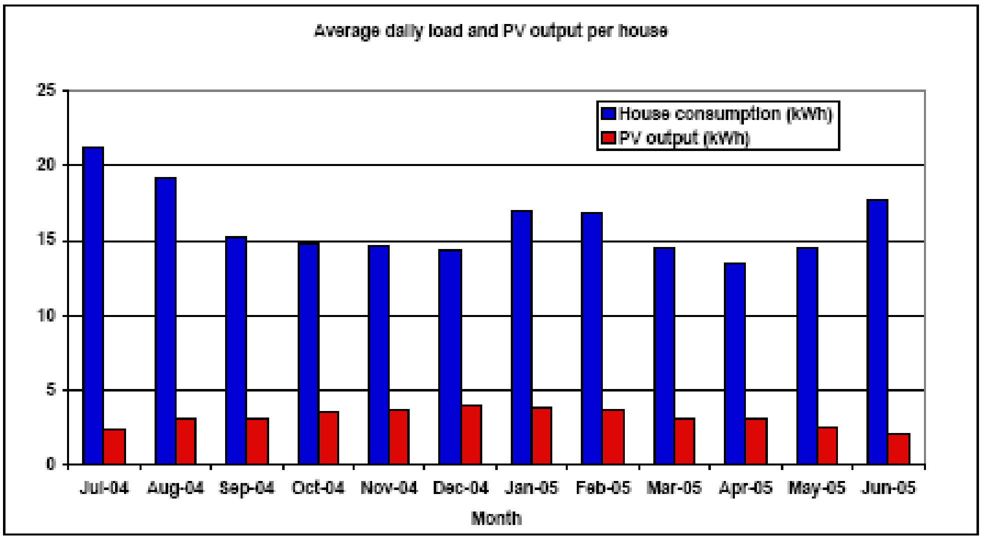
The implication of higher than expected demand and consumption is that the ability of PV units to cover demand is lower than anticipated (leading to less exporting to the grid) and demands on the base network are higher than forecast, delivering lower electricity cost savings.

Report 2 addresses the possible reasons why electricity consumption is higher than expected.

PV output is a small proportion of total electricity consumption

The average daily PV output per house was 3.16 kWh. This represents approximately 19.6% of average daily consumption. Figure 2.2 shows the average daily load and PV output per house. The household consumption is highest in winter months.

Figure 2.2 – Average Daily Load and PV Output per House – July 2004 to June 2005

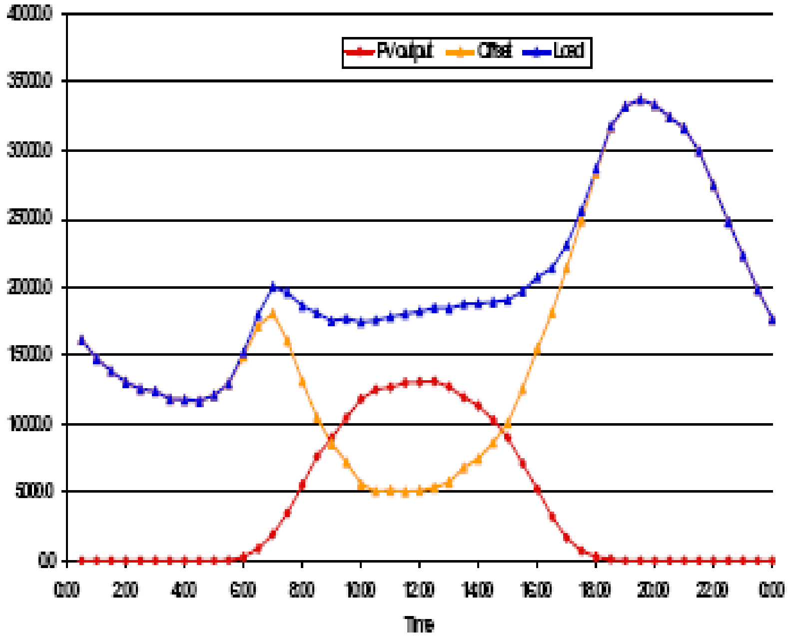


Source: Centre for Energy and Environmental Markets Report 2006

Electricity Exported by PV systems

The study found that on average (over the 12 months of monitoring) the PV systems did not export electricity to the grid (but it did provide some relief to the grid) i.e. household electricity demand is greater than the electricity generated by the PV system. Figure 2.3 shows the average daily PV Output for the 30 homes against the household electricity demand. At the peak time for PV Output (12.00pm) there is approximately 5,000 Watts required to be imported from the grid to satisfy household electricity demand.

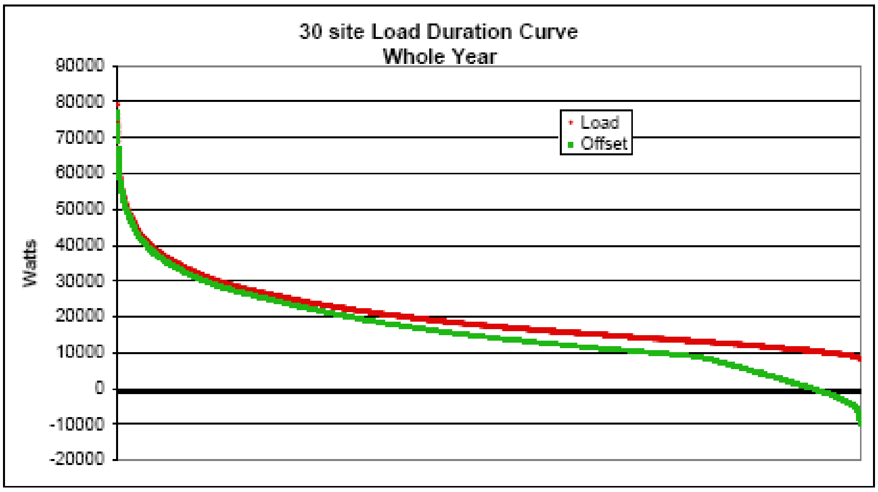
Figure 2.3 – Annual Average Daily Load, Estimated PV Output and Residual Load (Offset) for Homebush Bay – July 2004 to June 2005



Source: Centre for Energy and Environmental Markets Report 2006

Due to variability in the amount of electricity generated by the PV systems and the level of household demand, there are periods throughout the year where the PV systems export electricity to the grid. Figure 2.4 shows the proportion of time which the electricity demand from the 30 houses is above a particular level. The Offset line shows that for a small percentage of time the household demand is less than zero i.e. the PV systems are exporting electricity to the grid.

Figure 2.4 – Load Duration Curve for 30 Sites – July 2004 and June 2005



Source: Centre for Energy and Environmental Markets Report 2006

It is also noted that the amount of electricity sold back to the grid by a household PV system is offset against the cost of the household's electricity bill. At this stage there is no mechanism by which households could sell the electricity at the National Electricity Market (NEM) spot price.

Performance of PV systems

Monitoring of the electricity output of the PV systems showed that the systems are performing below expected levels. Based on the capacity of the systems, the monitoring indicates that the Newington systems have an average performance ratio of 0.61. An accepted international average for PV systems installed after 1996 is 0.70[1].

The overall performance of the PV systems was reduced by the following factors:

- inverters converting electricity from DC to AC are typically 85-95% efficient;
- efficiency of the panels drops by about 0.5% as the temperature of the system increases above 25°;
- electricity losses in wiring;
- non-optimal orientation of panels relative to the direction of the sun's rays; and
- monitoring accuracy errors.

In addition, two of the PV systems were found to be faulty: one was not operational, and the other had only very low output. If the two non-functional systems were removed the remaining systems would have a PR of 0.65.

Given electricity production performance was lower than forecast and lower than design capability, the ability of households to save on electricity costs, and to deliver supply back to the network, was diminished. This has a negative impact on the feasibility of the technology in the financial analysis (financial performance would be marginally higher if the performance rate could be improved).

Effectiveness of PV systems to reduce peak electricity demand

As shown in Figure 2.3, the PV output is highest during the day when household electricity demand is lower than in the morning and evening peak. Consequently, the installation of PV systems does not reduce the peak household electricity demand.

The Homebush Bay substation which services Newington also provides electricity for a large commercial and industrial load that has a peak electricity demand between 11am and 2pm. The output of the PV panels matches well with the corresponding commercial and industrial peak load times. Consequently, it

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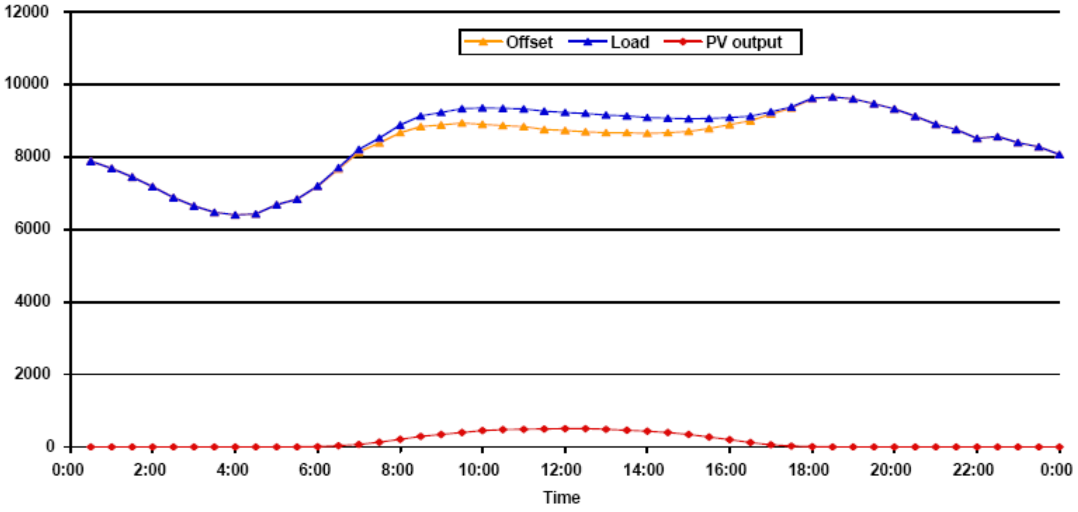
[1] Refer p4 CEEM Newington report. Note also that the Newington ratio of 0.61 included the impacts of 2 malfunctioning PV systems.

is considered that deployment of PV aimed at reducing peak demand would be most effective in areas where the peak load corresponds with the PV output i.e. commercial and industrial premises.

The CEEM report states that '*The relationship between PV output and the NSW load is better than for the 30 site load'*. The chart below illustrates the PV generation profile against the NSW load profile.

Figure 2.5 - Annual average daily PV output at Homebush Bay (x1000) against NSW load - July 2004 to June 2005



Source: Centre for Energy and Environmental Markets Report 2006

As can be seen, the NSW energy consumption peaks do not appear to be as pronounced than at the Homebush substation, suggesting that PV's generation profile may better suit the NSW load profile as a whole. Note that the PV load has been multiplied by a factor of 1000 to demonstrate an identifiable impact on the chart. URS notes there would in practice be a substantial cost (in roll out of large numbers of PV cells) in achieving the corresponding level of peak demand offset.

If the installation of PV technology does not adequately lead to a reduction in peak electricity demand from the network, it does not allow existing energy suppliers to avoid capital expenditure on upgrades to the existing network to increase supply to meet the peak.

2.5.2 Report 2 – Electricity Consumer Study

The key findings from this report include:

- the Newington homes surveyed vary from a typical Sydney home;
- the range in electricity usage between the homes surveyed was significant;
- a range of variables appeared to contribute to the overall electricity usage of a household; and

- the most effective way to reduce residential electricity consumption is not through technology, rather alter peoples behaviour to use less electricity.

These issues are discussed in further detail below.

Newington homes vary from a typical Sydney home

All the Newington homes were designed and constructed to be more energy efficient than a typical Sydney home. In addition to the solar panels the houses included a range of energy efficiency features including gas-boosted solar hot water heater, gas heating and gas cook-tops. Other appliances (eg. toasters, fridges, plasma TV’s, etc) installed at the time of construction were electric, and of average efficiency.

Demographic analysis indicated that the occupants of the participating homes were not representative of the Sydney average with differences including:

- higher number of adults;
- smaller household size;
- higher incomes than average;
- lower proportion of young and elderly people;
- lower proportion of couple families with children;
- lower proportion of people reporting a disability.

This difference in demographics may explain why energy consumption was different to the original forecasts.

Some households consume much more electricity than others

The findings from the analysis highlighted the variation in electricity consumption between different households. For example:

- the household with the highest **average** electricity demand required four times more electricity than the household with the lowest demand; and
- the household with the highest **peak** electricity demand required ten times more electricity than the household with the lowest demand.

Based on the efficiency measures in these homes, it is reasonable to expect that Sydney homes outside Newington would demonstrate even greater variation in electricity consumption patterns. Homes outside of Newington would likely have a wider range of income levels and demographics than the Newington sample. The wider range of appliances and usage habits in homes across all of Sydney would be expected to drive a wider range of energy consumption patterns.

No single variable easily explains variation in electricity demand

The findings of the study show that even for a sample of similarly designed houses there is no one single variable which determines household electricity demand. However, the study shows that there is sufficient evidence to support the theory that behaviour and lifestyle have a major impact on patterns of electricity consumption.

The variables that appear to have the most impact in predicting average demand are:

- occupancy rates (i.e. the total person hours spent at home and the person hours spent at home during the day);
- the number and efficiency of key appliances in particular air conditioners, heaters, refrigerators and home entertainment equipment; and
- the usage patterns for these appliances.

The number and efficiency of heating and cooling appliances and home entertainment equipment, and their usage patterns, appear to have the biggest influence on the residential peak demand.

What are the implications for energy efficiency policy?

Although the study sample size was limited and may not be statistically representative of the wider population, it is clear that policy initiatives focused on the thermal efficiency of the building envelope and the efficiency of appliances installed at the time of construction only address one source of variation in average and peak demand. Household behaviour, demographic characteristics, appliances installed by occupants and attitudes are other major sources of variation that need to be considered in a comprehensive policy approach.

Technology alone will not bring about desired reduction in average and peak electricity demand. Policies focused on awareness-raising and behaviour modification, through education, regulation and incentives, are critical to bring about desired reductions in average and peak demand.

2.6 Implications of this Contextual Analysis

2.6.1 Implications for Financial Analysis

The studies reviewed in this section of the report have been used to determine key parameters and inputs for financial analysis undertaken in Section 3. At a broad level, the inputs and parameters used have included the following:

- technical background and understanding of the PV systems installed in residential homes at Newington;
- output levels per household and for the Newington community as a whole;
- load data for the sampled homes (providing total energy consumption and PV output as a proportion of total consumption);.
- averaged value for import versus export of PV;
- items for sensitivity analysis; and
- characteristics of an ‘average’ home that were employed throughout the financial analysis.

2.6.2 Implications for Policy Decisions

The two studies identify common observations with regards to reducing average and peak demand through the use of residential solar power systems and other energy efficiency features:

- Report 1 highlighted that residential electricity daily load profiles are not well matched to average daily PV output because residential loads tend to be highest early and late in the day when PV Output is unavailable. However, PV Output can be well matched to loads which have a mix of commercial and daytime industrial loads. Consequently, it would be advised to examine substation load profiles when planning PV deployment to target areas of the network where PV contribution would be most useful;

- The results of both studies indicate that residents of the Newington houses have little knowledge or understanding of the PV systems installed on their houses. It is suggested that further PV deployment should include information regarding routine inspection and maintenance of the systems to ensure that they are operating as efficiently as possible.

Despite the energy efficient design features of the Newington houses the average demand was higher than expected. Policies focused on awareness-raising and behaviour modification, through education, regulation and incentives, are critical to bring about desired reductions in average and peak demand. In this regard, a simple initiative that should raise consumer awareness of their PV system would be inclusion of PV output for the billing period on their energy bill.

3.1 Introduction

The financial component of this report aims to present a feasibility analysis of the PV systems at Newington. In order to carry out this analysis, the costs and revenues of PV unit purchase (investment), installation and operation have been collated into a discounted cash flow model for development of a PV business case.

The section is structured as follows:

- About financial analysis;
- Financial parameters;
- Cost and revenue inputs to financial modelling;
- Base Case Financial Modelling Results;
- Sensitivity analysis; and
- Conclusions.

3.2 About Financial Analysis

Financial analysis aims to measures the direct effects of an investment decision on the cashflow of the investor (in this case a typical ‘homeowner’ at Newington) over a defined period of time. This current study involves discounted cash flow analysis in order to determine the Net Present Value (NPV) of a PV investment (essentially the future stream of benefits and costs converted into equivalent values today).

The results of the discounted cash flow analysis will also allow generation of relevant performance measures for any investment in PV technology. The Net Present Value (NPV), Payback Period and Benefit Cost Ratio (BCR) are tools of feasibility analysis that will enable this performance measurement. Detailed sensitivity analysis of alternative options will also expand analysis to test PV’s feasibility in terms of specific scenarios (e.g. with or without government grants, and in a new or retrofit home).

The limitation of financial analysis is that it is focused primarily on the benefits that flow to the individual rather than society as a whole. For this reason, the financial analysis has been supplemented by comments on the likely benefits to third parties (refer Section 5). This allows for consideration of the wider social, environmental and economic benefits of PV Technology.

3.3 Financial Parameters

There are a number of assumptions and parameters that have been used as the basis for this analysis. The two key parameters are shown in the table below:

Table 3.1 – Financial Analysis Parameters

Parameter	Value
Real Discount Rate	7%
Evaluation Timeframe	25 years

In the context of this analysis, the discount rate represents the opportunity cost of a household investing in a PV system as opposed to having their money elsewhere, such as having their money in a savings account or in a property investment. This rate is used in the financial analysis to account for the time value of money over the course of the evaluation[2].

The timeframe of analysis is 25 years, and this is based on the expected life of a PV system being 25 years[3]. The ability to analyse a PV system over its entire life means that all costs and revenues can be included in the present value of cashflows. The start date for the financial evaluation has been set at year 0, when PV purchase and installation is expected to occur, and then operations begin 6 months later, in the middle of year 0, and continue to the middle of year 25. Due to the 25 year timeframe, no replacement costs are required for inclusion in this analysis, as expenditure on replacement of a PV system is assumed after 25 years of operation. The unit is assumed to have a life expectancy of 25 years and therefore has no remaining value at the end of the evaluation period.

3.3.1 Base Case for Analysis

The financial analysis of the PV systems at Newington Village has been conducted based on one average home that has PV technology installed. The Centre for Energy and Environmental Markets February 2006 study on the *Analysis of Photovoltaic Output, Residential Load and PV's Ability to Reduce Peak Demand*, and the Institute for Sustainable Futures' March 2006 study on *Factors Influencing Electricity Use in Newington,* enabled the formation of key assumptions on this 'average' home, as the typical home for our financial analysis has been based on the sites that were sampled for these previous studies.

The assumptions for an 'average' home with PV at Newington (based on the 30 sites sampled and surveyed in both previous reports) include:

- three or four bedrooms;

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[2] Note: This rate is in accordance with NSW Treasury Guidelines.

[3] Interview with Mirvac, June 2006

- two-storeys;
- facing north - northwest;
- timber framed, brick veneer, with concrete tiles;
- two bathrooms upstairs and a WC downstairs;
- fitted with a gas-boosted solar hot water system;
- natural gas heating and cooktop installed;
- oven and other appliances are electric and of average energy efficiency;
- roof and wall insulation is installed;
- no curtains are in place unless fitted by purchaser;
- glazing is standard gauge glass;
- no ceiling fans; and
- fitted with 1 kWh peak electricity PV solar system (Institute for Sustainable Futures 2006, p.8).

The photovoltaic systems installed in the 30 sample sites, and that have been assumed in our 'average' home, are 1. 9sqm, nominal 1 kWp PV array systems comprising 12 BP Solar 80-85 Wp laminates, which are unframed PV panels. Each 1 kW PV array is connected to the household power supply via a 0.85 kW grid-interactive inverter (Centre for Energy Report, p.13). Characteristics of these systems were referred to in Section 2, however more detail is available in the original Newington reports.

As such, the following assumptions have been the basis for base case financial analysis:

- one average house;
- 1kWh system;
- 0.85 kW grid-interactive inverter;
- 0.61 Performance Ratio;
- PV output of 1,152 kWh per annum;
- developed on a large-scale along with a number of other homes; and
- life of system is 25 years.

Variations to this base case average home will be assessed in Section 3.5 below containing sensitivity analysis, which will allow insight to some alternate scenarios.

3.4 Cost and Revenue Inputs to Financial Modelling

The inputs into the financial analysis are the costs and revenues that an average Newington household pays and receives over the life of a PV system. The collation of all of these into net annual cashflows enables an overview of the financial investment required and revenues received for a PV solar system.

The costs and revenues can be split into the following forms:

- cost of unit purchase and installation;
- ongoing cost of system operation; and
- cost savings and revenues from PV energy production.

3.4.1 PV System Purchase and Installation Costs

Purchase and installation costs are those costs required to acquire and fit a PV system to an average house. In the case of the Newington systems, this cost was added to the packaged house price that a homebuyer paid for the house. These homes were not marketed as having solar energy technology, so it is likely that homebuyers were not aware they were paying this cost. The cost of installation was provided by the developer Mirvac, and was confirmed through discussions with BP Solar and PV Solar, the providers of the PV systems installed at Newington.

Purchase and installation capital costs reflect that these houses have been built in large-scale developments. It should be noted that installation costs for a retrofit home, or for installation into a single new home are slightly higher (large scale developments allow for bulk purchase of systems and installation efficiency savings although this difference was reported to be minor). Section 3.6 provides information gathered on the precise level of savings per system and a sensitivity analysis on the overall financial results.

Table 3.2 – Capital Cost of 1kWh PV System in Average Home

Capital Item (Year 0)	$
1kWh PV system purchase and installation cost	13,000 – 14,000 (approx.)

Source: Mirvac 2006

As seen in Table 3.2 above, the cost of purchasing and installing a 1kWh PV solar system was approximately $13,000 to $14,000 for an average house at Newington. This includes all equipment, labour, utilities and safety costs, but excludes GST and does not include any rebate or grant considerations. The developer of the homes at Mirvac received a grant on some of the PV systems that were constructed at Newington, which in some cases reduces this capital cost by $3,500 to $4,000 per home. The base analysis assumes no grant available so as to understand the inherit economies of the PV system itself. The impact of a grant will be addressed in a sensitivity analysis in a later section of this report.

Installation takes approximately 3 days in a new house as it is integrated into roof tiling. Roofing occurs at a reasonably early stage of new house construction, with the total construction timeframe for Newington homes taking approximately 6 months, hence operation of the PV systems is assumed to occur six months into year zero. The costs related to operations are discussed below.

3.4.2 Operating Expenditure

The annual costs for ongoing operation of a PV system in an average home are shown below in Table 3.3.

Table 3.3 – Operating Cost of 1kWh PV System in Average Home

Annual Operating Cost	$
1kWh PV system maintenance cost	$10.00

Source: URS Analysis & PV Solar 2006

According to PV Solar and BP Solar, there are minimal operating costs for a PV system for the homeowner, with the only cost being a maintenance cost. Discussions with PV Solar indicated that PV systems are generally only maintained if a failure occurs (Personal Communication[2] 2006). In the year-long sampling analysed in the Centre for Energy and Environmental Markets report (2006, p.3) there were 2 homes of the total 30 monitored, that were faulty or non-operational over the 1 year[4]. This has been the basis used to determine an annual maintenance cost for an average Newington house: there is a 2 in 30 chance of failure for each house per year, and given that the cost of a maintenance callout is approximately $150 per callout, this would equal $10 per annum ($150 x 7% chance of failure). This is shown in the table above. Operations only occur for 6 months in year 0, and for 6 months in year 25, so the operating costs for these 2 years are $5.00.

3.4.3 Operating Revenue

There are two forms of revenue generated for the owner of a PV system:

- cost savings from reduced electricity sourced from the Grid; and
- revenues from exporting excess PV energy back to the Grid.

As was indicated in the Centre for Energy and Environmental Markets report (2006, p.14), when PV energy production and consumption are aggregated over the year, there is no apparent exporting activity (on average). This is not to say that no exporting occurs, as some exporting may occur on a small number

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[4] Note: Two of the systems were found to be faulty, with one not operating at all, and the other showing very low input.

of days a year, however, the average home will consume all PV produced (e.g. when temperature is high and consumption is low). As a result, the total annual PV output has been assumed to encompass both consumption savings and export revenues, and has been used to determine the net revenue/cost saving for the home owner of an average Newington house.

Following URS discussions with Energy Australia (EA) and with PV Solar, it was found that in NSW, EA operates a 'net billing' buy back process for PV-created excess energy. This system of billing has been in place for more than 10 years. Under net billing, EA will buy back energy at the same price as the customer's principal tariff (excluding GST). This means that any revenue customers earn from exporting PV energy back to the Grid, is bought back by EA at the same rate that they buy Grid energy for, which is the current retail regulated tariff of 10.5794c/kWh (Personal Communication[3] 2006). In a practical sense this system means customers receive a monthly electricity bill from their electricity company, which is lower due to some of their electricity needs being provided by their PV system, and then if any excess energy was sold back to the Grid, this amount is subtracted from their electricity bill.

In terms of the financial analysis, the average PV output per house encompasses a net figure of exported PV and consumed PV - and so applying the energy tariff of 10.5794c/kWh to this volume of PV energy, provides the net dollar savings for a PV consumer. As the average annual PV output per house is 1,152 kWh for each year of operation, this converts to $121.87 of savings per annum based on the 10.5794c/kWh retail regulated tariff (Personal Communication[3] 2006 and Centre for Energy and Environmental Markets report 2006, p.14).

Table 3.4 – Operating Revenues of 1kWh PV System in Average Home

Annual Operating Revenue	**$**
Savings from reduced energy purchased	$121.87

Source: URS Analysis, Energy Australia 2006,
and Centre for Energy and Environmental Markets report 2006, p.14

Operations only occur for 6 months in year 0, and for 6 months in year 25, so the operating revenues for of these 2 years are $60.94.

Grants, Subsidies and Funding Available

It should be noted that the base case analysis does not include the benefits that homeowners and developers can currently receive for installation of a PV system.

There are four schemes and programs that may potentially be available for the purchase and installation of a PV system in NSW:

- AGO Photovoltaic Rebate Programme (PVRP) grant;
- Renewable Energy Certificates – (Office of the Renewable Energy Regulator);

- NSW Greenhouse Abatement Certificates (NGACs); and
- AGO Remote and Renewable Power Program.

The **Australian Greenhouse Office (AGO) grant** is a payment made to householders, owners of community use buildings, display home builders and housing estate developers who install grid-connected or stand-alone photovoltaic systems. This is a cash rebate known as the Photovoltaic Rebate Programme (PVRP) (AGO Website 2006). Based on discussions with the AGO, the currently available grant is set at a rate of $3.50 per peak watt (ppW) installed for developers, and $4.00 (ppW) installed for individual home owners undertaking PV installation. The residential rebate is proposed to be gradually reduced from $4.00 to $3.50 ppW for households and from $3.50 to $3.00 ppW for housing estate developers and display home builders.

The **Renewable Energy Certificates (RECs)** from the Office of the Renewable Energy Regulator are tradeable certificates that can be created and traded by the owner of a PV system, or assigned to a registered Agent in return for some benefit, such as a rebate or price reduction. As will be discussed in the sensitivity section below, a typical (1kWh) Newington home would be able to receive between $400 to $430 for the 20 RECs they are eligible to receive - for an initial payment of 15 years' operation (the maximum years allowed). As the majority of the Newington homes were constructed prior to April 2001 (when the scheme began), Mirvac estimated that only 400 of the 1,500 homes at Newington were eligible to receive RECs. As Mirvac created their own certificates but have not yet sold them to receive any monetary benefit, it is not anticipated that the Newington homeowners received any monetary benefits from the RECs. For this reason the financial analysis of these certificates will not be included in the base case, but will instead be included in a sensitivity analysis in Section 3.5. It should be noted that the RECs amounts and calculations in Section 3.5 are related to the amounts an individual homeowner may be eligible to receive. For developers such as Mirvac, they would be considered a power station if they are generating more than 100kWh in total and the RECs calculations would be different.

NSW Greenhouse Abatement Certificates (NGACs) is a scheme allowing generators to create certificates for producing lower emission intensity electricity, or for improving the efficiency of electricity production. All generators which use Renewable Energy Sources can sell either NGACs or RECs for each MWh of eligible generation, but not both. For this reason, it is highly unlikely that a homeowner with a PV system would claim NGACs. Discussions with the Department of Energy, Utilities and Sustainable Energy (DEUS) indicated that the monetary benefits would be considerably smaller than a 15-year RECs. Approximately $14 is received per tonne of abatement, which is generated per MWh of energy generation. Considering that a typical Newington home generates approximately 1.15 MWh per annum, this would only result in $16 per year.

The **Renewable Remote Power Generation Programme (RRPGP)** provides rebates for the installation of renewable generation equipment in remote parts of the country that presently rely on fossil fuel for electricity generation. Based on discussions with Department of Energy, Utilities and Sustainable Energy (DEUS), this program is mainly for off-grid energy production related to displacing fossil fuels, so would not be applicable to Newington, or for PV systems on residential homes in general. In addition, the AGO indicated that most states are running low on funding, with NSW nearly out of funding.

3.5 Base Case Financial Analysis Results

The previous analysis in Section 3.3 and 3.4 highlighted the types of costs incurred in installation and monitoring of a PV system over the life of the system. It also included an analysis of the range of revenues (specifically energy savings) that might result from the decision to install a PV system.

These previous sections have outlined the assumptions and inputs used in the financial modelling process. These inputs have been compiled by URS into a discounted cash-flow model which allows for a comparison of these costs and benefits in a way that generates the performance measures necessary to evaluate the financial viability of the installation decision.

As noted earlier, the most relevant performance measure in this instance will be the Net Present Value (NPV), which provides an indication of the overall net loss or benefit to a potential purchaser considering an investment in a PV system. A number of other performance measures are also considered.

Table 3.5 below provides the summary of the financial results for the base case analysis and includes a range of relevant performance measures.

Table 3.5 – Base Case Performance Measures

Performance Measure	**7%**
Net Present Value (NPV)	-$12,151
Present Value of Revenues	$1,470
Present Value of Costs	$13,621
Benefit Cost Ratio (BCR)	0.11
Discounted Return on Investment (NPV/I)	-0.90
1st Year Rate of Return	0.90
IRR	N/A

Source: URS Analysis

The Net Present Value (NPV) of PV installation and operation sums the discounted cashflow outcomes of benefits and costs. As a negative NPV (NPV>0) of -$12,151 has resulted, this indicates that PV systems are not financially feasible as an investment in themselves. This is due to the project having more cash outflows than inflows over the lifespan of a PV system, indicating that a home owner with a PV system will not make enough energy savings or export enough PV energy to cover the costs of system purchase and installation. The present value of costs of $13,621 is considerably higher than the present value of revenues ($1,470 discounted over the 25 years).

The Benefit Cost Ratio (BCR) compares the proportion of benefits to costs of a particular project. As shown in Table 3.5, PV installation and operation has a BCR lower than one, which indicates a negative return to a project and hence investment in the project is inadvisable.

The discounted return on investment indicates the ratio of the NPV to the initial capital investment in year 0, and indicates that there is a negative return on investment into a PV solar system.

The Internal Rate of Return (IRR) is the discount rate at which the present value of net cashflows is equal to zero so that outflows equal inflows (NPV=0). In the case of PV systems, there is no discount rate that will result in an NPV of zero. In addition there is no Payback Period (the length of time required to recover the cost of an investment), as the investment will not be recovered over the 25 years that a PV system is operational.

In simple terms, according to the financial analysis undertaken in this study, the investment will not pay for itself over its productive lifespan.

A summary spreadsheet of the financial analysis which provides further information on the financial analysis calculations and inputs is provided in Appendix C.

3.6 Sensitivity Analysis

About Sensitivity Analysis

Sensitivity analysis has been undertaken to determine how variations in the Base Case impact the financial feasibility of installing and operating a PV solar system. The sensitivity analysis essentially involves variations in the relevant inputs to the financial analysis in a way that reflects a slightly amended scenario to see how that variation affects the overall results of the financial analysis. It is an important tool for gauging the importance of different factors in driving the overall financial result. The sensitivity analysis has considered variations to the following factors:

- Panel size
- New home v retrofit installation
- Inclusion of available AGO grant/ subsidies
- Inclusion of revenue from renewable energy certificates (REC’s)
- Inclusion of AGO and REC revenues
- Performance Ratio
- Per KW- Hr subsidy to consumers necessary to negate investment loss (over 5, 15 and 25 year periods)

The findings of this sensitivity analysis are discussed below in turn.

Panel Size Comparison

The majority of the homes at Newington were installed with 1kWh systems, so this sensitivity compares the feasibility of installing 0.5kWh systems. Some of the systems at Newington are 0.5kWh, however these were not included in the site monitoring project, hence we have had to draw some assumptions from the 1kWh system results:

- one average house;
- 0.61 Performance Ratio (same as 1kWh system);
- system produces half of the 1kWh system output (i.e. 576 kWh per annum);
- developed on a large-scale along with a number of other homes;
- life of system is 25 years;
- need for maintenance has a probability of 2:30, and cost of approximately $150 per callout; and
- discount rate of 7%.

Based on discussions with the system providers and the Newington developer, the cost of purchasing and installing a 0.5kWh PV solar system in a large-scale development is approximately $6,000 to 7,000 for an average house[5]. The systems can generally be considered modular so the size of the panel (0.5 KWh or 1 KWh) is not a significant factor in determining proportional financial performance[6].

Table 3.5 – Panel Size Sensitivity

Performance Measure	**0.5kWh PV System**	**Base Case (1kWh)**
Net Present Value (NPV)	-$5,886	-$12,151
Present Value of Revenues	$735	$1,470
Present Value of Costs	$6,621	$13,621
Benefit Cost Ratio (BCR)	0.11	0.11
Discounted Return on Investment (NPV/I)	-0.91	-0.90
1st Year Rate of Return	0.94	0.90
IRR	N/A	N/A

Source: URS Analysis

As shown in the above table, the NPV and other performance measures of a 0.5kWh PV system indicates that the present value of cash outflows is greater than the present value of cash inflows, and the project is

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[5] Mirvac interview, May 2006

[6] PV Solar Interview, August 2005, At larger sizes (5 KWh plus) there may be installation and inverter cost efficiences

not financially feasible. In comparison to the Base Case 1kWh system NPV, the 0.5kWh is negative by a smaller amount (-$5,886 in comparison to -$12,151), however this also coincides with a reduced PV output. Technically, this indicates that the less PV that is produced, the more financially feasible the project is for an individual household. In practice, the difference in financial performance between the two options is marginal in terms of BCR and annual rate of return. The only difference is in the size of the initial investment and thus the overall investment loss.

New Home Installation vs Retrofit

The Newington homes have been constructed on a large-scale basis whereby the developer has been able to achieve economies of scale through purchasing a number of PV systems at once, and installing them as part of new house construction.

For a single homeowner as opposed to a large-scale developer, the decisions related to PV installation will be for either:

- retrofit installation in an existing home; or
- installation included in new home construction.

PV Solar and BP Solar have indicated that the costs to purchase and install a PV system into a new home or retrofit into an existing home, is generally the same cost. The significance of this point is that this indicates a homeowner considering PV installation into their existing home will face the same cost decisions as a homeowner including PV installation into a new home.

The principal cost differences related to installation of a PV system are related to a small-scale (single home) development versus a large-scale development (such as the Mirvac development at Newington). A small-scale development could be new home or retrofit installation, however a large-scale development would only be new home installations.

Based on discussions with Mirvac, BP Solar and PV Solar, the cost differences for installing a PV system in a single home compared to a large-scale development have been analysed in the sensitivity shown in Table 3.6 blow. The following assumptions (based on the Base case) have been used in the sensitivity analysis of a small-scale development:

- could be either new home or retrofit installation;
- one average house;
- 0.61 Performance Ratio;
- system produces 1,152kWh system output (same as large-scale development);
- developed on a small-scale or individual basis;
- life of system is 25 years;
- need for maintenance has a probability of 2:30, and cost of approximately $150 per callout; and

- discount rate of 7%.

Based on discussions with the system providers and the Newington developer, the costs of purchasing and installing a PV solar systems for a small-scale (single house) development are approximately $14,400 for a 1kWh system, or $9,900 for a 0.5kWh system. (In comparison, large-scale development costs for a 1kWh system are about $13,500, and for a 0.5kWh system are about $6,500.) The results of this sensitivity are shown below:

Table 3.6 – Small-scale Development Sensitivity

Performance Measure	Small-scale Development		Large-scale Development	
	1kWh system	0.5kWh system	1kWh system (Base Case)	0.5kWh system
Net Present Value (NPV)	-$13,051	-$9,286	-$12,151	-$5,886
Present Value of Revenues	$1,470	$735	$1,470	$735
Present Value of Costs	$14,521	$10,021	$13,621	$6,621
Benefit Cost Ratio (BCR)	0.10	0.07	0.11	0.11
Discounted Return on Investment (NPV/I)	-0.91	-0.94	-0.90	-0.91
IRR	N/A	N/A	N/A	N/A

Source: URS Analysis

As Table 3.6 indicates, installation of a 1kWh PV system in a small scale development has an even greater negative NPV than the base case large-scale development. This result essentially relates to the higher installation costs of a retro-fitted PV cell (despite the revenues and maintenance costs remaining the same as in the large-scale base case analysis). The 0.5kWh PV system installed in a small-scale development has a negative NPV that is slightly less, however this is still a greater loss on investment when compared to the large scale development's 0.5kWh system NPV (of -$5,886) – see Table 3.5 above.

What this small versus large-scale comparison indicates is that the large-scale housing developments result in a better NPV result due to the lower installation costs, however whether a large or small-scale development, the net present value of the PV unit is substantially negative in each case.

Available Grant or Subsidy Sensitivity

There is currently a grant available to householders, owners of community use buildings, display home builders and housing estate developers who install grid-connected or stand-alone photovoltaic systems. This is a cash rebate of the Australian Greenhouse Office (AGO), which is known as the Photovoltaic Rebate Programme (PVRP) (AGO Website 2006). The Base Case of our financial analysis did not take into consideration that some houses at Newington received a grant from the AGO due to their PV systems installation (this is dependent on criteria such as the house having other energy efficiencies). Based on discussions with the AGO, the grants relevant to this analysis include the currently available grant set at a rate of $3.50 per watt installed for developers, and $4.00 per watt installed for individual home owners undertaking PV installation.

This PVRP programme has been extended to June 2007, so after this time it is uncertain if grants will still be available to households or developers. In addition, the residential rebate is proposed to be gradually reduced from $4.00 to $3.50 ppW (per peak watt) for households and from $3.50 to $3.00 ppW for housing estate developers and display home builders. In this sense, this sensitivity analyses a cost rebate to support investment in PV systems.

The following assumptions (using the Base Case) have been used in the sensitivity analysis of a small-scale development:

- one average house;
- 0.61 Performance Ratio;
- PV output of 1,152kWh pa (1kWh system);
- life of system is 25 years;
- need for maintenance has a probability of 2:30, and cost of approximately $150 per callout; and
- discount rate of 7%.

The results of this sensitivity are shown below in Table 3.7:

Table 3.7 – AGO Grant Sensitivity

Performance Measure	**Large-scale Development ($3.50 grant)**		**Small-scale Development ($4.00 grant)**		**Base Case (no grant)**
	1kWh	**0.5kWh**	**1kWh**	**0.5kWh**	**1kWh**
Value of Grant	$3,500	$3,500	$4,000	$4,000	$0
Net Present Value (NPV)	-$8,651	-$4,136	-$9,051	-$7,286	-$12,151
Present Value of Revenues	$1,470	$735	$1,470	$735	$1,470
Present Value of Costs	$10,121	$4,871	$10,521	$8,021	$13,621
Benefit Cost Ratio (BCR)	0.15	0.15	0.14	0.09	0.11
Discounted Return on Investment (NPV/I)	-0.87	-0.87	-0.87	-0.92	-0.90

Performance Measure	**Large-scale Development ($3.50 grant)**		**Small-scale Development ($4.00 grant)**		**Base Case (no grant)**
	1kWh	**0.5kWh**	**1kWh**	**0.5kWh**	**1kWh**
IRR	N/A	N/A	N/A	N/A	N/A

Source: URS Analysis, AGO Website, DEUS

This table indicates that while the PVRP rebate assists to reduce the costs to a homeowner, the net present value and other performance measures still indicate that PV system installation and operation is financially unfeasible.

Renewable Energy Certificates Sensitivity

Renewable Energy Certificates (RECs) are tradeable certificates that can be created and traded by the owner of a PV system, or assigned to a registered Agent in return for some benefit, such as a rebate or price reduction. RECs are purchased by liable parties, such as electricity retailers, seeking to offset their liability under the Act so that they meet their renewable energy percentage targets.

As the majority of the Newington homes were constructed prior to April 2001 (when the scheme began), Mirvac estimated that only 400 of the 1,500 homes at Newington were eligible to receive RECs. As Mirvac created their own certificates but have not yet sold them to receive any monetary benefit, it is not anticipated that the Newington homeowners have received any monetary benefits from the RECs.

The sensitivity analysis in Table 3.7 below will indicate the impact on the NPV of a development with a range of RECs levels. As the market prices for RECs are traded on the market, they have undergone significant variation in recent years, so the following prices will be included:

- $22.45 - Current market price[7];
- $20.00 - Price currently paid by an agent[8]; and
- $36.00 - Price 18 months ago[9].

Discussions with Office of the Renewable Energy Regulator (ORER) indicated that the reason for price decreases in recent months, particularly the past 18 months, may be due to the large numbers of RECs that have been generated, meaning that there is a large supply for RECs that surpasses demand.

The RECs cash rebate has been calculated based on the ORER Fact Sheet *Calculating Renewable Energy Certificates for Small Solar Panel Systems*. This calculation is based on a zone rating (determined by

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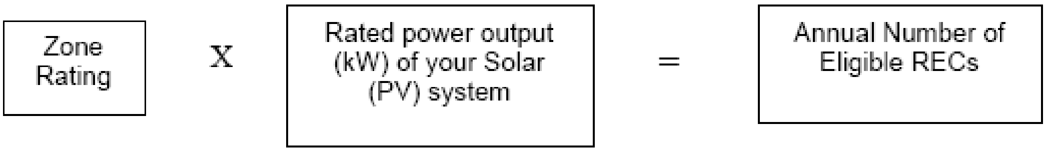
[7] AFMA Spot Price for 24 May 2006, http://www.afma.com.au/

[8] Discussion with RECs Traders Pty Ltd, 26 June 2006

[9] Discussion with the Office of the Renewable Energy Regulator, 26 June 2006

Newington’s postcode), then is multiplied but the kW output of the system, and the annual number of eligible RECs (See Figure 3.1 below). Assuming that the maximum of 15 years is chosen for the annual number, then the number of RECs that a 1kWh PV system is eligible for is 20. A $20 fee is charged to create RECs via the ORER, so this payment will be reduced from the calculation of the current market price and price 18 months ago. If RECs are sold to an agent, this $20 fee is normally not paid (however the price per RECs is lower), so this creation fee is not applicable to that option.

Figure 3.1 – Calculation of PV Solar System RECs



Source: ORER Website

The sensitivity analysis below show the impacts on the base case analysis if the RECs are claimed by the homeowner, and sold at any of the three prices indicated above.

In addition, the following assumptions have been used in the sensitivity analysis of a small-scale development:

- one average house;
- 0.61 Performance Ratio;
- 1,152kWh system pa for 1kWh systems, and 576 kWh pa output for 0.5kWh systems;
- life of system is 25 years;
- need for maintenance has a probability of 2:30, and cost of approximately $150 per callout; and
- discount rate of 7%.

The results of this sensitivity are shown below:

Table 3.8 – RECs Sensitivity

Performance Measure	**Agent Price $20.00 RECs**	**Current $22.45 RECs**	**Past Price $36.00 RECs**	**Base Case (no RECs)**
RECs Potential Benefit	$400	$429	$700	$0
Net Present Value (NPV)	-$11,751	-$11,722	-$11,451	-$12,151
Present Value of Revenues	$1,470	$1,470	$1,470	$1,470

Performance Measure	**Agent Price $20.00 RECs**	**Current $22.45 RECs**	**Past Price $36.00 RECs**	**Base Case (no RECs)**
Present Value of Costs	$13,221	$13,192	$12,921	$13,621
Benefit Cost Ratio (BCR)	0.11	0.11	0.11	0.11
Discounted Return on Investment (NPV/I)	-0.90	-0.90	-0.89	-0.90
1st Year Return Rate	0.93%	0.93%	0.95%	0.90%
IRR	N/A	N/A	N/A	N/A

Source: URS Analysis

This table indicates that while the RECs benefits assist to reduce the costs to a homeowner, the net present value and other performance measures still indicate that PV system installation and operation is financially unfeasible. In addition, the lower the RECs spot price falls in the market, the lower the benefits for the PV owner. And considering the trend of price decreases in the market recently, the future benefits are currently unknown. It is interesting to note that the AGO grant provides a greater benefit than the RECs benefit, indicating that it may be important for this grant to be continued past June 2007.

RECS + AGO Grant Sensitivity

Table 3.8 below indicates the implications on the financial analysis if a PV homeowner received both RECs and the PVRP AGO grant (when compared with the base case where no grants or subsidies are received). As both of these schemes are available to a homeowner, they are applicable (note that grants often go to a property developer in practice).

Table 3.9 – AGO Grant + RECs Sensitivity

Performance Measure	**$22.45 RECs & $3,500 Grant**	**Base Case (no RECs or Grant)**
RECs Potential Benefit	$429	$0
PVRP AGO Grant	$3,500	$0
Net Present Value (NPV)	-$8,222	-$12,151
Present Value of Revenues	$1,470	$1,470
Present Value of Costs	$9,692	$13,621
Benefit Cost Ratio (BCR)	0.15	0.11
Discounted Return on Investment (NPV/I)	-0.86	-0.90
1st Year Return Rate	1.27%	0.90%
IRR	N/A	N/A

Source: URS Analysis

The results shown in Table 3.8 indicate that the combination of both schemes that PV owners are able to receive still does not result in a positive NPV for PV system purchase and installation. It does improve the NPV result significantly (effectively by the amount of the grants themselves as they are assumed to be received in year 1 of the analysis).

Performance Ratio Sensitivity

Table 3.9 below illustrates the implications on the financial analysis if the generation efficiency of PV cells was improved from a performance ration of 0.61 (in the current study) to 0.70 (the reported international average).

Table 3.9 – Performance Efficiency Sensitivity

Performance Measure	**Performance Ratio 0.70**	**Base Case (Performance Ratio 0.61)**
Net Present Value (NPV)	-$11,934	-$12,151
Present Value of Revenues	$1,687	$1,470
Present Value of Costs	$13,621	$13,621
Benefit Cost Ratio (BCR)	0.12	0.11
Discounted Return on Investment (NPV/I)	-0.88	-0.90
1st Year Return Rate	-11,934	0.90%
IRR		N/A

Source: URS Analysis

The results shown in Table 3.8 indicate that improvement of the performance efficiency of PV cells (possibly through better alignment with the sun, maintenance to avoid malfunctions and other initiatives) from performance ratio of 0.61 to 0.70 delivers an improvement in financial performance. The NPV of the project rises marginally (from -$12,151 to -$11,934), which reflects the marginal increase in power output. In practice, a substantial increase in the value of power output or reduction in unit cost would be required to have a significant impact on overall financial performance.

Subsidy per KW-Hr Sensitivity

The negative NPV to an investor in a PV system could be negated if government provided a subsidy sufficient to repay the investor for the net loss identified in the previous analysis. This subsidy could in theory be paid ‘up-front’ or on a per KW-hr generated basis.

In Germany, the ‘feed-in law’ and the amended Renewable Energy Act of 2004 operates to provide a subsidy to PV operators in the order of 45-60 Euro cents (typically closer to 55 Euro cents), depending on the type of installation. At an exchange rate of 0.60 Euro/s per AU dollar, this equates to a subsidy of around 92 cents (AUD) per MW-Hr generated.

Table 3.10 below illustrates the level of subsidy within Australia necessary for a PV investor in Australia to breakeven (NPV = 0), based on the current financial analysis and assumptions.

Table 3.10 – Subsidy per KW-Hr Sensitivity

Time-frame	**25 years (Base Case)**	**15 Years**	**5 years**
NPV	-12,151	-12,425	-12,985
PV Rev	1,470	1,171	561
PV Cost	13,621	13,596	13,546
BCR	0.11	0.09	0.04
NPV/I	-0.90	-0.92	-0.96
Subsidy for NPV = 0	0.87	1.12	2.45

Source: URS Analysis

The financial analysis has generally assumed a payment to the consumer of 10.58 cents per KW-hr (as per Energy Australia interviews). As can be seen, under the base case, the subsidy per MW-hr required to achieve a breakeven NPV of zero is around 87 cents (on top of the 10.58 cents per KW-hr rate already paid to consumers for PV electricity exported to the grid). This level of subsidy is similar to the subsidy offered in Germany of 92 cents per KW-hr (in Australian dollar terms).

The NPV of the decision to invest in an NPV system does not change substantially with variations in the timeframe for the investment consideration, as the NPV is largely driven by the high-upfront capital cost with relatively small savings each year over time. In contrast, the subsidy necessary to equate the NPV to zero is highly reliant on the associated time-frame for investment consideration, more than doubling (to $2.47 per Kw-hr) when the investment time-period is reduced from 25 years to 5 years.

Many consumers will have a relatively short timeframe in which to consider their investment. For example, they may only plan to live in a certain house for 5 years and thus discount the potential energy savings that might arise in the later 20 years (especially if this value of the PV system is not realised in the re-sale value of their house). If consumers view their decision to invest in PV over a shorter time-frame, the necessary subsidy for Government to negate any negative impacts will be much higher than the theoretical level over a 25 year time-period.

An alternative to either of these subsidies would be an upfront payment to consumers equal to the negative NPV (for the relevant time-period) of the PV investment. Either option should in theory cost the Government the same amount. They are merely different ways of administering the same subsidy. In other words, there are no additional savings to Government from providing the subsidy on a per KW-hr generated basis (other than avoiding any risks inherent in generating the actual electricity).

A problem does however arise when the Government's time-frame varies from the consumers. If the consumer demands a higher subsidy due to a reduced time-frame for investment consideration but the

Government is committed to pay the subsidy over the longer 25 year time-frame, the cost of the Government to Government over the full 25 years would be much higher than if they had merely provided an up-front capital cost subsidy (equal to the negative NPV over 25 years).

While it may be true that some power generation methods are effectively subsidised for one reason or another (or that they impose negative externalities on the environment), it would be unlikely that these subsidies or externalities would be in the same order (over 800% of original electricity price) of the subsidy necessary to deliver a positive NPV on a PV system investment. The implication is again that subsidisation of other more cost-effective clean/ green power generation methods would be more a effective method of achieving environmental outcomes in the current circumstances.

3.7 Conclusions

The key findings of the financial analysis are listed below:

- the Net Present Value (NPV) of the PV systems in Newington village is negative at -$12,151, indicating that these PV systems are not financially feasible as an investment in themselves;
- even with RECs certificates claimed and sold, and with the AGO PRVP cash rebate, the NPV remains negative at -$8,222;
- retrofit or new home installations of PV systems generally have the same cost; and
- Large-scale developments have lower costs than small, individual home developments, although both options resulted in a negative NVP.
- Improving the performance ratio to reflect international averages delivers a marginal impact on overall financial performance, but still results in a negative NPV.
- The level of per KW-hr subsidy necessary to negate the negative NPV would be in the order of 87 cents per KW-hr, over 25 years. The cost to Government of applying this subsidy is essentially around $12,151 per PV cell over the lifecycle of the product.

PV Comparison With Other Energy Saving Options

4.1 Introduction

This section of the report provides an itemisation of competing energy generation technologies, an analysis of their average costs of generation and a commentary on how PV technology compares to the identified alternatives.

The section is structured as follows:

- Competing energy generation technologies
- How does PV compare financially?

4.2 Comparison of PV with other Energy Generation Technologies

In order to compare the cost of PV energy generation with a range of other alternative technologies, a number of energy technologies have been identified.

A list of comparative technologies that and their generation cost per MWh of energy produced are provided in Table 4.1 below.

Table 4.1 – Energy Generation Costs for Alternative Technologies

Technology	**$/MWh**
Bagasse (Sugar Biomass)	30-100
Biomass	65
Coal - Black Coal	30-37
Coal - Brown Coal (SC)	36-40
Coal - Clean Coal (Geosequestration)	104
Gas - Integrated Gasification Combined Cycle	40-60
Gas - Landfill Gas	48
Gas - Natural Gas	40
Gas - Natural Gas Combined Cycle (NGCC)	35-45
Geothermal	40-70
Geothermal HDR (large scale)	40
Nuclear	100-150
Nuclear (Generation III)	50
Pulverised fuel - Base SC	30
Pulverised fuel - Lignite SC	24-42
Small Hydro	50-70
Solar - Photovoltaic[10]	250-400
Waste Energy	60
Wave	104
Wind	60-80
Wind (<20% electricity supply)	55-80

Sources: 2004 Energy White Paper (2004), CSIRO presentation - Australian Institute of Energy (2003),
BSCE Media Release (2006), CCSD Technology Assessment Report (2006)
(See complete list of sources in Appendix A)

As Table 4.1 indicates, in the 2004 Energy White Paper generation costs for PV solar energy range from $250-400 per MWh generated. The table demonstrates that PV has the greatest cost of all other alternative energies compared in this report. Compared with other low-emission technologies such as wind, small hydro and wave, which range between $60/MWh to $104/MWh, PV solar energy still has a significantly higher generation cost.

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[10] Note: Other solar comparative cost data sources as well as a complete list of sources for all generation costs can be found in Appendix A.

For the Newington Village PV solar systems, URS calculated the generation cost per MWh at $472[11], which is slightly higher than the $250-400/MWh range shown in Table 4.1. Details as to the calculations used in the comparative data were unavailable.

4.3 Comparison of PV with Other Energy Saving Products

A comparison of PV solar systems with other energy saving products that homeowners can install themselves will enable the analysis of some of the options available to a consumer considering a purchase decision.

Table 4.2 – Comparative Costs of Energy Saving Products

Product / Technology	Installation Cost ($)	Potential relative savings	Potential Annual Savings ($)	Estimated Annual Return	Lifetime (years)
Solar Hot Water	$3,700-5,000	20-30% of energy bill	$220-330	7%	15-25
Ceiling Insulation	$2,000	35% of heating and cooling costs	$162[12]	8%	Not included
Water Tanks	$3,000	29% of water bill	$150	5%	25
PV (Newington)	$13,500	19% of electricity bill	$122	1%	25

Source: Ecological Homes Interview, Dept Sustainability Victoria, EnergySmart, Productivity Commission report into Energy Efficiency 2005 , www.energy.com.au, Sydney Water Website and URS Financial Analysis (See complete list of sources in Appendix B).

Table 4.2 below contains information from a range of sources related to their costs, savings and estimated annual return. This comparison indicates that PV has the highest installation cost, but the lowest estimated annual return, and potential savings on the related energy bill. Ceiling insulation, Solar Hot Water and Water Tanks all delivered similar rates of returns with Ceiling insulation appearing to offer the best rate of return by a small margin.

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[11] Present value cost of PV system $13621, Daily PV output 3.16 kWh over 25 years equates to 28.84 MWh, implying $472 per MWh.

[12] Assumes $1110 energy bill (Energy Australia Calculator), 42% on heating/ cooling split of total energy bill (Productivity Commission) and 35% reduction in heating cooling costs (Dept Sustainability Victoria and EnergySmart website). URS notes variability between different sources for this analysis likely due to different house types, circumstances etc.

5.1 Introduction

In addition to the financial costs and revenues analysed in the section 3 of the report, which considered the financial benefits and costs to individual households only, there may be social, environmental or economic benefits that may be attributable to a PV scheme that could eventuate for the wider community.

The existence of third party benefits arising from PV uptake within the community, may encourage governments to provide incentives for installation and use to fund the cost-revenue gap in order to assist the feasibility of PV installation.

In this section a qualitative overview of identified third party benefits has been undertaken. These benefits can be market based or non market based. The discussion is based on available data and previous reports undertaken on the operation of PV systems.

Focus will be on the following categories of benefits:

- environmental benefits;
- social benefits; and
- economic benefits.

5.2 Environmental Benefits

An environmental benefit is considered to be anything that results in an improvement of environmental conditions or results in the avoidance of environmental degradation. In the context of third party benefits, the environmental impacts will be received by society as a whole, rather than individual home owners. The use and installation of PV technology provides various environmental benefits when compared to other electricity generation technologies. Some of the benefits of PV technology are that it is:

- **Renewable**: renewable energy resources, defined as natural resources that can replenish themselves over time, for example PV, geothermal, tidal and wind powers, can slow the depletion of natural resources.
- **Emission free**: solid, gaseous and liquid fuels' combustions, including traditional coal and natural gas technologies, are significant sources of greenhouse gas emissions. PV technology involves no combustion and produces energy with zero emissions. According to *Australian Greenhouse Office Factors and Method Workbook*, December 2005, the consumption of 1 kWh of electricity purchased

in NSW corresponds to the emission[13] of 0.985 kg of CO_2-equivalent, which includes carbon dioxide, methane and nitrous oxide.

- **Operating waste neutral**: PV technology generates energy with no major operating waste outputs. Nevertheless, PV's manufacturing process uses toxic and flammable/explosive gases and toxic metals like cadmium, but current control technologies appear sufficient to manage wastes in today's production facilities.
- **Soundless**: PV power generation is a silent process unlike wind technology for which acoustic emissions is one of the main obstacles to siting wind turbines close to inhabited areas.
- **Limited landscape impacts**: PV technology does not involve the construction of a major plant or any significant landscape alteration, contrary to wind power where turbines create a visual impact that limits social acceptance. Small scale PV systems can be easily integrated into buildings, an advantage in comparison with other power generation modes. However, large-scale ground-based PV may become a future issue where land is scarce.

In an economic benefit cost analysis, an attempt can be made to quantify the environmental benefits and costs associated with any project using unit costs developed through willingness to pay assessment techniques.

5.3 Social Benefits

Social benefits are considered to be anything that results in an improvement in social wellbeing of the community or reduces some societal adversity. Social benefits are typically measured in terms of there qualitative impacts and can include things like employment improvements, population trends or social wellbeing. Many of the social benefits can be proxied by environmental or economic measures. The use and installation of PV technology may provides a social benefit when compared to other electricity generation technologies.

From a qualitative perspective, it is suggested that the individual household and the community at large gain an improvement in 'well-being' when sustainable energy equipment is used to produce energy requirements as opposed to traditional international methods of energy production (coal and nuclear) which are perceived to have negative environmental impacts. In other words, consumers, businesses and governments may 'feel better' when they believe they are doing something tangible to reduce negative environmental impacts.

The 'social value' of well-being is essentially up to the individual. It is however important to note that the evidence suggests that the same reduction in negative environmental impacts could be achieved more cheaply by focus on other 'clean energy technologies' or initiatives. In simple terms, if the PV purchaser

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[13] This Greenhouse Gas full fuel cycle emission is estimated as the sum of emissions from fuel combustion at the power station and emissions from the extraction, production and transport of that fuel, given the fuel mix used to produce electricity within NSW in 2005.

spent their investment in PV technology on other environmentally sound technologies, they would likely achieve much higher environmental benefits as a result. In practice however, the individual often has a limited range of options to ‘make a difference’, with PV often appearing as the most obvious ‘clean energy’ imitative an individual can pursue.

5.4 Economic Benefits

For the purposes of this report economic benefits to third parties are considered to include the financial impacts that are attributable to PV installation and use. Economic benefit cost analysis will often include the social and environmental impacts of a project, particularly when the impacts can be quantified, but in this report the financial third party impacts have been termed as economic. The use and installation of PV technology provides various economic third party benefits when compared to other electricity generation technologies. Some of the benefits of PV technology are that it is:

- **Demand Management:** one of the main benefits put forward by proponents of PV technology and other forms of alternative energy generation is that they can help to offset the ‘spikes’ in energy prices resulting from increased demand during peak periods. This can be regarded as a form of ‘demand management’. Generating electricity during peak demand periods can reduce demand spikes and effectively delay the need to upgrade energy infrastructure (for example a new coal fired power plant). The analysis suggests that because most of the PV power is generated during the middle of the day, PV is not a very efficient tool for achieving demand management goals. This is conclusion is re-enforced when the costs of producing any offset and the relatively low levels of energy generation available through PV systems are considered.

  URS notes that in extreme circumstances the marginal cost of peak period energy consumption might be very high (where a small incremental increase in peak demand leads to the need for a large investment in infrastructure upgrade- ie new power station). While this situation would make any form of demand reduction technology attractive, the key point to note is that there are likely to be more cost-effective ways of achieving this demand reduction than PV.

- **Isolated areas:** in isolated areas the use of PV technologies might be economically feasible form of energy provision for government or electricity network operators. This is particularly if the cost of extending the existing network to serve the isolated area is very expensive. Use of PV systems in this case may remove the requirement for extension of the existing network. The benefit in terms of third parties is that the cost of network extensions are generally borne either by governments (and hence the community) or if provided by private corporations are then transferred through higher service pricing.

- **Technological Advance:** an argument for supporting PV technologies, as they currently perform, is that this support will lead to technological advances within the industry leading to PV operation which is financially feasible. For this to be an accepted argument, the social and environmental benefits of PV must be of an order significant enough to be equal to the value of the financial cost of subsidising the industry. If this is the policy goal of government, then targeted investment in the research and development process might also be a more effective way of achieving these results.

- **Balance of trade implications:** where PV energy can be used as a substitute for imported energy products, in particular oil, renewable energies can reduce the negative balance of trade impacts. PV production tends to be used as a substitute for coal or gas fired power production methods. With coal and gas usually sourced from the local market, it is unlikely that this product will be a substitute for imported energy products.

In an economic benefit cost analysis the financial implications of the impacts above would be quantified and included in the analysis.

Context

DMPP have commissioned URS to investigate the effectiveness and efficiency of Photo Voltaic (PV) solar systems as a contributor to reducing peak demand in NSW. This study is intended to investigate the effectiveness and efficiency of PV technology by considering previous studies and investigation of the financial viability of a typical PV installation decision. The analysis is primarily based on information gleaned from the case study of a large scale PV installation in Newington, Sydney.

Financial Results

URS' financial analysis has primarily incorporated information from the previous Newington technical reports. Supplementary information has been gathered from government and industry in compiling a financial model for a typical PV installation investment decision.

The analysis demonstrates that in itself, PV technology is not a viable financial investment. In other words the costs of installing a PV system far outweigh the value of any energy savings that would result to the consumer. The net-present value estimate provides the best measure of financial performance, indicating that an investment in a $13,500 PV system would likely deliver a net financial loss to the purchaser of $12,151. In simple terms, PV technology as it stands was not determined to be a cost-effective method of energy generation (in its current form).

These findings were based on the assumptions and inputs to the financial modelling as outlined in Section 3, with a focus on the Newington experience. To the extent that these assumptions reflect the typical installation decision, the findings have strong implication for broader policy decisions relating to PV technology.

Demand Management Effectiveness

Analysis in previous reports highlighted that the electricity generation profile of PV technology was not perfectly suited to demand management objectives. The PV generation profile is generally be better matched to areas where energy is largely consumed during the day (commercial areas etc).

This does not however imply that PV would be a cost-effective method of addressing demand management issues in these areas. Attempting to off-set energy consumption using PV technology would generally be far too expensive to be considered economically viable.

Benefits to third parties

The third party benefits of encouraging usage of PV systems as an alternative energy generation option relate primarily to environmental benefits. A KW of electricity generated using PV technology in theory offsets the need to generate the same unit of technology using traditional technologies which generate pollution. The problem is that use of PV technology to achieve these benefits is not the most cost-effective way of delivering environmental benefits. In simple terms, there are much cheaper ways of generating ‘clean energy’ in a metropolitan context (e.g. wind or biomass). If the same environmental benefits can be delivered using another ‘clean energy’ technology at a lower unit cost, then investing in solar technology to deliver the same environmental benefits is not a sensible decision (all else being equal).

PV technology can in theory be financially viable in ‘unique’ circumstances. In isolated or remote areas, PV technology may be the preferred method of energy generation if no other electricity source is available. For example a consumer on a remote farm or research post may value the electricity generated by a PV cell at a far higher rate than the current market price of electricity Sydney. In these circumstances, investment in PV system may be a sensible commercial decision, however when other options are available (whether traditional or clean energy) PV does not appear to compare well. Despite this evidence the existence of a market for PV technology (however small) suggests that PV solar cells are being purchased for non-financial and economic reasons.

Implications for Government Policy

The necessary Government subsidy per KW-hr to off-set the financial loss to the consumer of investing in a PV system was identified to be around 87 cents per KW-hr (over a 25 year period). In present value terms, this per KW-hr subsidy would essentially cost the Government $25,151 per system installed.

In this context, the case for government subsidy of purchase of existing PV systems is difficult to justify. Whilst support for development of environmentally friendly technologies is to be commended, any subsidy must be carefully targeted to ensure maximum environmental benefits. If government is confident in the potential commercial viability of PV technology at some point in the future, then funds currently allocated to subsidising PV purchases might be better allocated towards development of more cost-effective PV systems.

It could be argued that the current subsidy to the purchaser acts as an indirect motivator for technology development of PV systems, in that it leads to higher volumes of PV sales and a larger market for PV producers, which in turn is better able to support investments in technology improvements. The counter argument is in-fact that provision of a subsidy can actually operate as a disincentive to invest in cost-reduction technologies in that there is less pressure for PV producers to deliver a PV technology that is cost-effective (as the government is expected to make up the difference with its subsidy). Either way, if technological improvement of PV is the goal, it makes more sense to subsidise the research itself than to subsidise the purchaser. If subsidisation of ‘clean energy’ is the goal of government, then the results suggest that the subsidisation of other ‘clean energies’ will achieve the same benefits at a lower cost.

Need for Further Comparative Analysis

The current study has provided an opportunity for a general review of the immediately available information on financial and economic performance of different types of energy generation, energy efficiency and ‘environmental products’ available. Unfortunately it is apparent that the range and quality of detailed, reliable information available for comparative analysis is not comprehensive.

For consumers there is very little information available on the financial costs and benefits of any decision to invest in an energy efficiency or environmental product. There is a wealth of ‘general information’ duplicated across a number of government and non-government organisations which promote energy and environmental initiatives for consumers in general terms, however useful financial information relating to these decisions is lacking.

Similarly, for Government policy makers, there is limited information on financial and economic aspects on how energy generation and energy efficiency technologies compare. This absence of reliable economic benchmarking information is probably explained by the variations in costs and benefits for different technologies implemented in different areas and circumstances.

While benchmarks were compiled in the current report, the process required reference to multiple sources, often with conflicting data. Unfortunately, the current study did not allow for detailed investigation of these issues and differences.

Although there are difficulties faced in compiling reliable benchmarks, resolution of these issues would go some way to providing a clearer picture to policy makers when considering policy options in the energy sector. Indeed the productivity commission has highlighted the impacts of imperfect information on consumers in its report into energy efficiency[14]. Further research in this area would assist in better understanding the place of PV technology compared to its alternatives.

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[14] Productivity Commission, The Private Cost Effectiveness of Improving Energy Efficiency, August 2005.

References

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Institute for Sustainable Futures 2006, *Study Factors Influencing Electricity Use in Newington*, Final Report, March 2006, Prepared for Demand Management and Planning Project, Prepared by Institute for Sustainable Futures, University of Technology, Sydney

Appendix A
Electricity Generation Costs in Australia

Technology	**A$/MWh**	**Source**
Bagasse	30-100	2004 Energy White Paper
Biomass	65*	CSIRO presentation, Australian Institute of Energy, Apr2003
Coal - Black Coal	37*	CSIRO presentation, Australian Institute of Energy, Apr2003
Coal - Black Coal (SC/USC)	30-35	2004 Energy White Paper
Coal - Brown Coal (SC)	36-40	2004 Energy White Paper
Coal - Clean Coal (Geosequestration)	104	BSCE Media Release, May06 citing IEA
Gas - Integrated Gasification Combined Cycle (IGCC)	40-60*	CCSD Technology Assessment Report Apr06
Gas - Landfill Gas	48*	CSIRO presentation, Australian Institute of Energy, Apr2003
Waste Energy	60*	CSIRO presentation, Australian Institute of Energy, Apr2003
Gas - Natural Gas	40*	CSIRO presentation, Australian Institute of Energy, Apr2003
Gas - Natural Gas Combined Cycle (NGCC)	35-45	2004 Energy White Paper
Geothermal	40-70	BSCE Media Release, May06 citing CSIRO&Geodynamics
Geothermal HDR (large scale)	40*	CSIRO presentation, Australian Institute of Energy, Apr2003
Nuclear	100-150	BSCE Media Release, May06 citing CSIRO+UK Env Committee
Nuclear (Generation III)	50*	CCSD Technology Assessment Report Apr06
pulverised fuel - Base SC	30*	CCSD Technology Assessment Report Apr06
pulverised fuel - Lignite SC	24-42*	CCSD Technology Assessment Report Apr06
Small Hydro	50-70	2004 Energy White Paper
Small Hydro	66*	CSIRO presentation, Australian Institute of Energy, Apr2003
Solar	150*	CSIRO presentation, Australian Institute of Energy, Apr2003
Solar - Concentrated Solar Thermal	120*	CCSD Technology Assessment Report Apr06
Solar - Photovoltaic	250-400	2004 Energy White Paper
Wave	104*	CSIRO presentation, Australian Institute of Energy, Apr2003
Wind	60*	CCSD Technology Assessment Report Apr06
Wind	81*	CSIRO presentation, Australian Institute of Energy, Apr2003
Wind (<20% electricity supply)	55-80	2004 Energy White Paper

Appendix B
Comparative Costs of Energy Saving Products

Product / Technology	Installation Cost (A$)	Potential relative savings	Potential Annual Savings (A$)	Estimated Annual Return	Lifetime (years)	Source
Solar Hot Water	$3,700-5,000 (material $2,500-3,500)	20-30% of energy bill	220-330	7%	15-25	Ecological Homes, June 2006
Ceiling Insulation	$2,000	35% of heating and cooling costs, heating and cooling making up 42% of total energy bill ($1100 pa)	$162	8%	Not available	Dept of Sustainability Victoria, Productivity Commission, EnergyAustralia, June 2006 Calculator Tool energy.com.au, Ecological Homes
Water Tanks	$3,000	29% of water bill	$150	5%	25	Sydney Water website and Ecological Homes, June 2006

Appendix C
DCF Financial Model
Base Case- Summary

Results - New Home 1kWh system

		Costs ($)					
Period	**Year**	**Capital**	**Operating**	**Total Cost**	**Total Revenue**	***Net Cashflow***	***NPV***
0		13,500	5	13,505	61	-13,444	-13,444
1	2007		10	10	121.87	111.87	105
2	2008		10	10	121.87	111.87	98
3	2009		10	10	121.87	111.87	91
4	2010		10	10	121.87	111.87	85
5	2011		10	10	121.87	111.87	80
6	2012		10	10	121.87	111.87	75
7	2013		10	10	121.87	111.87	70
8	2014		10	10	121.87	111.87	65
9	2015		10	10	121.87	111.87	61
10	2016		10	10	121.87	111.87	57
11	2017		10	10	121.87	111.87	53
12	2018		10	10	121.87	111.87	50
13	2019		10	10	121.87	111.87	46
14	2020		10	10	121.87	111.87	43
15	2021		10	10	121.87	111.87	41
16	2022		10	10	121.87	111.87	38
17	2023		10	10	121.87	111.87	35
18	2024		10	10	121.87	111.87	33
19	2025		10	10	121.87	111.87	31
20	2026		10	10	121.87	111.87	29
21	2027		10	10	121.87	111.87	27
22	2028		10	10	121.87	111.87	25
23	2029		10	10	121.87	111.87	24
24	2030		10	10	121.87	111.87	22
25	2031		5	5	60.94	55.94	10
Total		13,500	250	13,750	3,047	-10,703	-12,151
NPV		13,500	121	13,621	1,470	-12,151	

Summary Table

	5%	**7%**	**10%**
NPV	-11,884	-12,151	-12,434
PV Rev	1,761	1,470	1,162
PV Cost	13,644	13,621	13,595
BCR	0.13	0.11	0.09
NPV/I	-0.88	-0.90	-0.92
IRR		***#NUM!***	