Centre for Energy and Environmental Markets

The Value Of Distributed, Urban Residential Photovoltaic Electricity In The Australian National Electricity Market

- A Case Study

Marc Pop

>The Value of PV<

Field Period Oct04 – Mar 05

UNSW
THE UNIVERSITY OF NEW SOUTH WALES
SYDNEY • AUSTRALIA

Marc Pop is a visiting student from Germany, and has been working (professional practicum program) on this project at the CEEM since October 2004 with Muriel Watt, Hugh Outhred and Iain MacGill.

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Information about these Centres is available at www.ceem.unsw.edu.au and www.pv.unsw.edu.au.

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I. Introduction & Explanatory

A. Abstract (Management Summary)

This work evaluates the potential value of photovoltaic (PV) systems to residential customers in Australia, as well as their potential value to retailers - in particular, could PV contribute to coping with increasingly peaky demand in the residential sector.
The research makes use of actual PV system performance data, load scans of a typical household and NEM prices over a full year. For the value to residential customers, various continuous, time-of-use and "green" tariff structures in NSW, SA and VIC have been analysed. Results indicate that residential customers in NSW can achieve savings of up to 35% of the electricity bill, through a combination of installing a 1kWp PV system and opting for the most favourable tariff. Those savings make PV systems economical viable.

The value to retailing companies has been assessed by the saved NEM purchases. NEM data for NSW and SA has been analysed, in order to identify the coincidence of PV output with periods of high NEM demand and consequent high wholesale electricity prices. Results indicate that patterns in the different states vary. In NSW, peak loads and regional prices are occurring mainly in summer, whereas high price events in SA have occurred mainly during the winter. The work includes an evaluation of the potential value of west-facing PV setups.

This Report is intended to be based on empirical data. The author is fully aware of the advantages and drawbacks that are inevitable. Thus this work is rather to be seen as a case study that gives indication, but can not deliver universal conclusions.

• Background

PV output reducing external electricity demand

The idea for this case study was initiated by Muriel Watt and Hugh Outhred from the CEEM, as they have been working on several studies that aimed to identify whether PV can contribute to reduce electricity demand peaks that occur due to increased air conditioning use in summer (M. Watt et al, 2004, “Analyses of Photovoltaic System Output, Temperature, Electricity, Loads and National Electricity Market Prices – Summer 2003-04”).

- “Electricity demand has grown rapidly in Australia over the past decade and has been accompanied by an exacerbation of the “peakiness” of electricity demand patterns, with increased air conditioning load considered to be the major cause”
- “”Recent peaks have resulted in supply disruptions and, on some occasions, extremely high spot prices on the National Electricity Market

To analyse empirical PV output pattern and electricity demand throughout an entire year would be a valuable contribution to this assessment, based on the assumption that Australian utilities most likely won’t implement large-scale, centralized PV systems during the next decade, this project will focus on distributed PV systems which, at present, connect into the network on a distribution level.

Liberalization of AUS electricity market

Secondly, the liberalization of the electricity market has an impact. Nowadays, customers are free to choose their electricity retailer and to change. Under this circumstances, the market has become more dynamic. This work is also aiming to analyse the existing possibilities and the consequences for a private PV owner.

Introduction of time-of-use tariffs

Thirdly, an analysis of the most suitable tariff for residential, grid connected PV owners was targeted, inspired by the study “Are Photovoltaic Systems Worth More to Residential Consumers on Net Metered Time-of-Use Rates?” (Hoff, Margolis, SOLAR 2004 Conference Proceedings, “Are Photovoltaic Systems Worth More to Residential Consumers on Net Metered Time-of-Use Rates?” by the American Solar Energy Society, July, 2004).

B. Introduction

The Perspective of PV in Australia

Photovoltaic (PV) is the technology of converting sunlight into electricity. It is a renewable energy source. The generation of electricity does not produce any emissions. Since electricity prices are rising and concerns about global warming are growing, public interest in this technology has risen.

Internationally the industry is growing rapidly at a rate of roughly 30% per year.

Australia offers excellent solar resources - it is the sunny continent! At present, Australia is 1 of only 4 net exporting countries of solar energy systems. Some of the best solar researchers in the world are based here. Traditionally, off-grid non-domestic applications dominate. The cumulative installed capacity of this segment is about 58 % by 2003.

However, the Australian photovoltaic industry is only growing at about 15%p.a. The grid-connected market segment is only about 11 %.

The cause for the difficulties of grid-connected systems are that electricity prices are some of the lowest in the world and that electricity pricing to customer does not reflect real cost of supply and production (eg peak power). In addition, governmental support is low compared to the other PV-exporting nations, only few drivers for PV development from government, as renewable energy in general is not a priority (e.g. non-signing of Kyoto Protocol).

For grid-connected PV systems, the key determinant is “costs”, as there is the option of obtaining regular electricity from the grid, whereas stand-alone-applications have only few alternatives. This work is trying to assess the actual value of small, grid-connected PV systems that private, residential customers would typically install. For a holistic picture, two aspects have to be evaluated:

A) Value to the owner/ electricity end-user

and

B) Value of such distributed systems to the electricity supply industry.

C. Objective

The objective if this work is to identify the real value of distributed, grid-connected PV systems.
The basis of this assessment is empirical data– of a PV system, a "typical" household and NEM demand and prices throughout an entire year as well as actual retailer tariffs and conditions for integrating private PV systems.
The work focuses on the states NSW, VIC and SA.
The results are quantitative and based on electricity consumption of a typical urban Australian household. Thus the direct value of applying PV systems is being assessed – it is not a full economical evaluation. Impact on economy (jobs, taxes, etc through PV companies (manufacturer, installing companies, traditional electricity industry), environmental benefits (GH Gas reductions), etc are not taken into account.

The work is aiming to identify:

- Analysing urban residential tariff structures in NSW, SA and VIC: Which conditions and tariffs are actually offered to residential PV owners by retailing companies
- Which tariff is the most suitable/favorable in each of the examines state, calculating value of PV output
- Calculating rate switch effects
- Assessing the electricity demand of a "typical" household and the associated pattern of a PV system output and A/C use pattern
- Assessing whether time-of-use (TOU) tariffs are beneficial for PV systems
- Evaluating „Green" tariff options, assessing whether those tariffs are financially a better option then privately installed PV systems
- Ultimately assessing the commercial viability of the investment in a PV systems

However, the value of distributed PV systems does not stop at the owners electricity bill. The electricity grid is affected through the use of PV systems, as less electricity is being demanded and electricity even fed in at times.
To assess the consequences to the electricity supplying is the second scope of this work. The idea is that distributed PV systems might deliver additional value by deferring investments into the

grid and the electricity generation capacity. The focus lies on retailing companies, as distributed PV systems are impacting those companies in the most direct way.

➔ Analysis of National Electricity Market - Spot Market demand and price (RPR) data
➔ Potential of PV to contribute reducing loads and spot market extreme events
➔ Potential of West facing PV systems

Unfortunatley, the required data was not available; the work is restricted as there was no insight into companies & industry. Therefore, the analysis had to be limited to publicly available data. Thus, this analysis can only deliver indications. Quantitative and qualitative analysis has been undertaken by assessing NEM Spot Market Data.

II. Methodology & Definitions

A. Methodology

This work is distinguished by being based on empirical data of one entire year, from 1 April 2002 to the 30 March 2003. Thus all advantages and disadvantages that typically are associated with empirical analysis occur: The data sets have certain characteristics are not reproducible and can not be regarded to apply in general.
However, as empirical data is very difficult to obtain, the author was forced to base all calculations on the existing data sets of the PV and the HH. Although scientifically questionable, as data is not consistent by being applied for various settings, it is the only possible way, especially as the PV system data and household data are very specific and thus very limited. Therefore the work is not scientifically correct – but in order to evaluate trends justified

This work is aiming to give indications in the electricity markets of NSW, VIC and SA.
To achieve this goal, the PV-electricity output pattern of the Queanbeyan PV site and the household's demand pattern have been taken as a basis and been "normalized", i.e. assumed all phenomenal influence is linear.

For the assessment of the value to the electricity supplying industry (Part B), traditional analysis has been applied.
The author's analysis, based on NEM Spot Market data, can be considered being traditional as the real value of PV lis lying in the risk reduction and deference of network investments and not in the straightforward value by NEM Spot market prices. Nevertheless, under these circumstances of a third party perspective, the analysis of NEM RPRs can give indications.

B. Assumptions

- PV system performance is the same for all locations
- SA Household data is used for calculations in all 3 states
- All PV system sizes are calculated proportional to original Queanbeyan PV system data
- Normalisation Process of PV system output:
  - Assuming all phenomenal influence is linear
  - Effect of temperature on array efficiency is not being regarded further
- Examined period is not a calendar year – as determined by available data

Note: Further details about the data sets and it's processing to be found in chapter: "Data – Sources and first analysis"

Tools: Exel, MathLab

C. Abbreviations:

PV	Photovoltaic
HH	Household
Instantaneous power	Total measured HH load
A/C, AC	Air Conditioner
TOU	Time-of-use tariff
Flat tariff	Continuous tariff
AUS	Australia
NSW	New South Wales
SA	South Australia
VIC	Victoria
EnergyAus	Energy Australia
Origin	Origin Energy
Country	Country Energy

III. Data

This Report is intended to be based on empirical data. Following I will give some background information and rough analysis.

A. Household

Data source:

The household is a household in SA. It can be classified to be fairly representative as an average Australian household.

Specifications, as far as possible:

- 2 adults, 2 children
- Not low income
- Urban area (Adelaide area)
- House built in the current past, approx. 180 square meter surface, constructed using an energy saving score sheet
- Large A/C units

Source for the data is Lachlan Mudge from the Uni of SA, who has gathered the data by installing monitoring equipment in the household himself. Due to privacy reasons the detailed location of the HH can not be disclosed.

Methodology:

- Original data scans transformed to 30min intervals to fit PV data set
- "Instantaneous power" from original data sets is the calculated total electricity consumption of the HH
- "Daily average" is the average power over a 24 hour period

Data set

- Entire year in 15 min interval scans, from 1 Apr 02 to 31 Mar 03
- All appliances are separately monitored

Figure III-A-1: Summary of household load scans

per month	KWh	relative
Min	255	3.92%
Max	1,043	16.06%
Average	541	8.33%
Total	6,496	100.00%
April	255	3.92%
May	323	4.97%
June	425	6.54%
July	451	6.94%
August	465	7.16%
September	451	6.94%
October	454	6.98%
November	556	8.56%
December	858	13.20%
January	1,043	16.06%
February	727	11.18%
March	491	7.55%

per quarter	KWh	relative
Min	1,002	15.42%
Max	2,261	21.03%
Average	1,624	28.74%
Total	6,496	100.00%
1st Quarter	1,002	15.42%
2nd Quarter	1,367	21.03%
3rd Quarter	1,867	28.74%
4th Quarter	2,261	34.80%

kWh per 30min scan over 12 month period	
Min	0.01
Max	4.31
Average	0.37

Missing original scans	
scans missing	305
h missing	76.25
days missing	3.18
% of total	1.74%

Note: Missing scans have been replaced with analogue data that is closest to the gaps, either before or after

B. NEM Spot Market

Data source:

The data, RPRs and demand, has been taken for all three states from the publicly available data on the NEMMCO website.

Methodology:

Data is provided in 30min intervals in monthly blocks, which have been put together to match the one-year period of the PV data

Data set

Price and demand of the markets in NSW, SA and VIC have been analysed for the period 1 April 2002 to 31 March 2003

Figure III-B-1: Summary of NEMMCO demand and price in 30min intervals , from 1 Apr 2002 to 31 March 2003

	NSW		SA		VIC	
	Demand (MW) per 30min interval	RPR ($/MW)	Demand (MW) per 30min interval	RPR ($/MW)	Demand (MW) per 30min interval	RPR ($/MW)
Min	4,976	$3.09	960	-$246.57	3,736	-$228.01
Max	12,331	$8,047.61	2,787	$4,453.65	8,041	$4,906.09
Average	8,190	$40.62	1,494	$35.41	5,482	$32.56
Sum	143,492,692		26,168,377		96,047,728	

During the examined period, the NSW electricity market had by far the biggest demand, followed by the Victorian and with a far lower demand, the South Australian market. Also in NSW, the highest maximum and average RPRs occurred, with the maximum being above 8,000 $ and an average of 40 $. Victoria had the lowest average RPRs with 32.56$, although the maximum RPR was slightly higher then in SA, but still far below the maximum in NSW. The NSW electricity market was the most extraordinary during the examined period- the extremely high RPRs indicate problems.

Assumption

No daylight saving shifts in the NEMMCO data could be found, therefore I assume it has been cleared of daylight saving shifts.

C. PV System - QUEANBEYAN SOLAR FARM

1. Facts and figures

Figure III-C-1: Queanbeyan Solar Farm

Figure C-1The Country Energy solar farm in Queanbeyan consists of 720 Solarex MSX 83 and MSX 77 solar panels arranged in nine separate modules. Each solar panel has a 77 watt capacity, with a

➔ **total system capacity of 50 kilowatts**

Each module in the solar farm has a 6kW inverter that converts the direct current (DC) of electricity generated by the solar panels to alternating current (AC) which is fed directly into the Country Energy grid via a 3-phase, 100 amp circuit breaker.

➔ **Multi-string configuration, with 9 x 6kW inverters**

Orientation and Location:

➔ **North Facing**

➔ Latitude 35.45, Longitude 148.56

➔ NSW, close to Canberra

Each year, the solar farm produces 100,000 kWh of electricity – enough to supply about 20 energy efficient homes. It produces no greenhouse gases and saves about 100 tonnes of greenhouse gas emissions (that would otherwise have been created by coal-fired power stations) annually.

(Source: Country Energy)

2. Data

Half hourly interval meter readings from the 11 Mar 2002 up to the 31 Mar 2004 are available. From this set, I have extracted a data set covering

> One entire year, from the 1 April 2002 to the 31 March 2003.

NOTE: Effect of temperature on array efficiency is not being regarded further in this report

Figure III-B-2: Summary of original PV output throughout the examined period (one year)

	kWh	% of nominal	MWh
Min	-0	-1%	-0.000
Max	42	83%	0.042
Average	8	16%	0.008
Sum	140,085		140.085

The total output during the examined period is higher then indicated by Country Energy, with 140MW. The PV farm reaches a maximum performance of 83% of the nominal capacity.

Methodology

In order to obtain a data set that is easily comparable, I transformed the output to a 1 kWp PV system:

Figure III-B-3: Summary of calculated 1 kWp PV output throughout the examined period (one year)

Day	kW	iW	kWh
Min	-0.006	-0.000	-0.003
Max	0.833	0.001	0.417
Average	0.160	0.000	0.080
Sum	2,801.698	2.802	1,400.849

The calculated 1 kWp PV system would generate 1.4 MWh of electricity in the one year period.

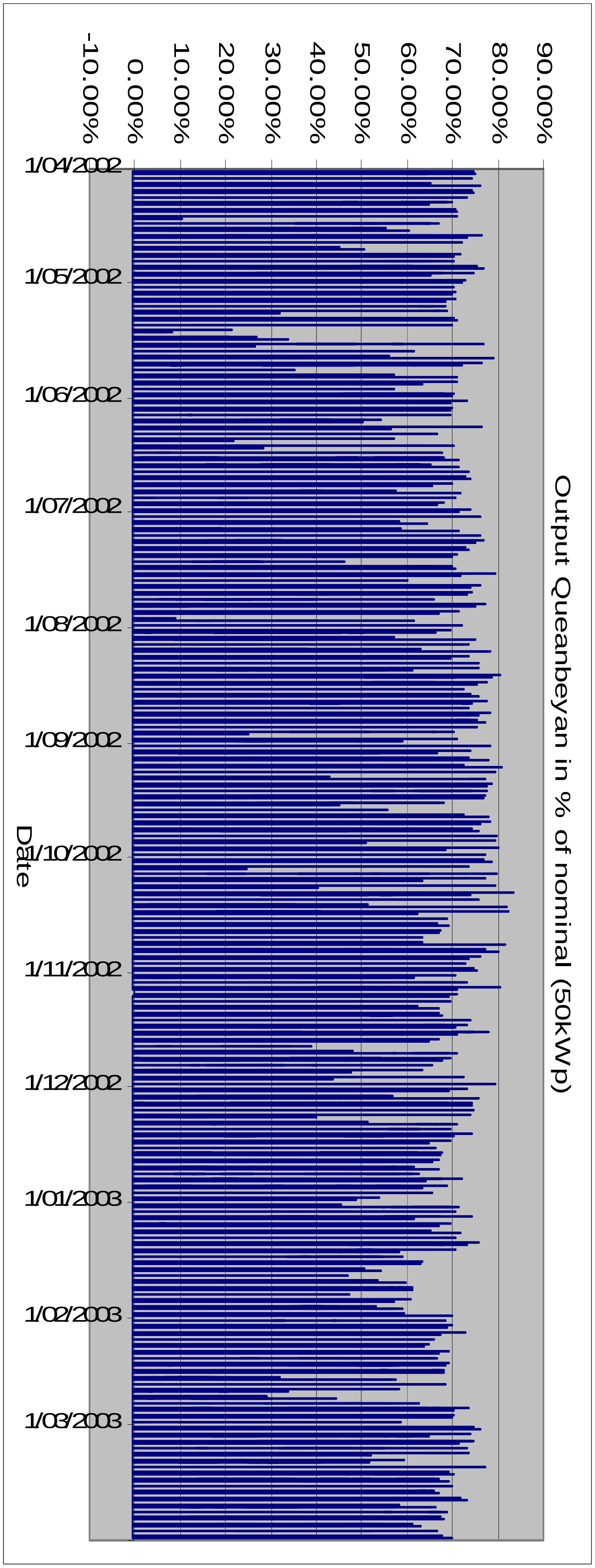


Figure III-B-4: Output of PV system relative to nominal capacity, 30min intervals, 1 Apr 2002 to 31 March 2003

Figure III-B-5:

Monthly summary of 1 kWp PV system

	kWh	percentage
Min	84.683	6.045%
Max	134.088	9.572%
Average	116.737	8.333%
Total	1,400.848	100.000%
April	116.114	8.29%
May	93.908	6.70%
June	84.683	6.05%
July	100.632	7.18%
August	126.982	9.06%
September	124.162	8.86%
October	134.088	9.57%
November	128.999	9.21%
December	132.040	9.43%
January	123.830	8.84%
February	126.445	9.03%
March	108.964	7.78%

Figure III-B-6:

Quarterly summary of 1 kWp PV system

	per quarter	
Time	kWh	percentage
Min	294.706	21.04%
Max	395.127	28.21%
Average	350.212	25.00%
Total	1,400.848	100.00%
1st Quarter	294.706	21.04%
2nd Quarter	351.776	25.11%
3rd Quarter	395.127	28.21%
4th Quarter	359.239	25.64%

The highest output is being generated during the spring month (3rd quarter), especially October and November.

The Output difference between July to October > 35%!

This is probably due to losses due to high temperatures during the core summer month. However, the extremely low output in output in March 03 is surprising.

No weather data was available to analyse correlations and coherences with temperature and cloudiness.

D. RETAILER TARIFFS

1. METHODOLGY

The tariffs are required to calculate the households assumed electricity bill under various tariff options from various retailers with and without PV system.

Focus on Urban Domestic / Residential customers

In order to calculate the value of a PV system to a electricity customer/ PV owner, information of the existing electricity supply options, tariffs and retailers is required.

To simplify this task, the focus of this investigation is on tariffs for urban residential customers.

Retailing companies in the states

Major electricity retailing companies acting in NSW, VIC and SA have been selected

New South Wales:	South Australia:	Victoria:
→ Country Energy,	→ AGL	→ AGL
→ Integral Energy		→ Origin Energy
→ Energy Australia		

Note: Due to hegemony of AGL in SA, focus on NSW and VIC

Examined Tariffs

For the analysis, I have tried to apply a domestic tariff from the following category for each of the retailing companies:

i. **Continuous (Flat Rate)**
ii. **Time-of-Use**
iii. **Green tariffs**

Continuous tariffs are characterized by a constant rate, regardless of time.

Time-of-Use-tariffs are characterized by differentiated rates, usually by the categories off-peak, shoulder, peak periods.

Green tariffs is a term for electricity supply option that guarantees to generate the electricity from renewable energy sources, at least to a certain percentage or categorized by source (eg. Wind, Solar, Hydro)

Data adjustments:

As tariffs for weekends and public holidays generally differ from working week tariffs, the official holidays had to be regarded in the calculations. The eligible official holidays throughout the one year period have been identified and taken into consideration.

Also, daylight saving has been regarded and the data adjusted.

Assumptions

- ➔ The calculations have been based on tariffs and rates that exclude the GST!
- ➔ If inclining block tariffs were given, I assumed that consumption/output doesn't exceed this barrier
- ➔ Green energy options
  - o Assumed that same tariffs apply for buy back (as is the policy of EnergyAustralia)
  - o Retailers often offer GreenEnergy options in various levels - the green rates that I have taken are the options which are 100% sourced from renewable energy
  - o Some of the included retail companies offer green options, but could not be taken into account as the rates are only given in rough estimates per year and not per kWh consumption (eg Country Energy)

2. General findings from analysing tariff structures

- Australian retailers offer a variety of tariff options, the liberalisation of the market is visible. However, the structures are often complex (eg. IBT, Hot water, summer prices in SA, etc)
- Besides AGL in SA, all of the examined retailers do offer time-of-use tariffs for both residential and commercial, although they are not communicating it clear and effective. In most cases, the only application requirement is a metering system
- New tariff options are being offered: Besides AGL in SA, all of the examined retailers do offer time-of-use tariffs for both residential and commercial, although they are not communicating it clearly on their websites. In most cases, the only application requirement is a metering system
- Green tariffs are differing, but are being offered in a broad variety in all three states by most of the retailing companies
- There are vast differences between tariff classes, with TOU being generally higher (more expensive) then continuous tariffs, green tariffs being in average the highest
- In general, NSW has the lowest tariffs, SA the highest, although NSW NEM spot market averages are the highest!
- Most of the included retailers have introduced an Inclining Block Tariff (IBT), or step rate, whereby electricity is charged at a slightly higher rate once usage reaches a threshold, rather than at a flat anytime rate. The step is usually an average consumption, 1750kWh per quarter for residential customers for example.

3. Tariff details

a) NEW SOUTH WALES

Overview of tariffs that have been applied:

NSW	Energy Australia			
	Tariff Name	Effective	Rates: All prices are cents per kWh except for supply charges, which are charged on a daily basis.	Source
Continuous	**Domestic All Time**	July 2004	System access charge (¢/day) $0.27 All time energy - First 1,750 kWh per quarter (c/kWh) $0.10 Balance $0.11 Level at 1,750	Energy Australia website: pdf: "Regulated Retail and Green Energy Tariffs, Energy Australia Residential Customer Price Guide
Time-Of-Use	**PowerSmart Home**	1/07/2004	System access charge (¢/day) $0.27 Peak Energy: 2pm – 8pm on working weekdays $0.16 Shoulder Energy: 7am – 2pm and 8pm – 10pm working weekdays 8.47 9.32 and 7am – 10pm on weekends and public holidays $0.08 Off-Peak Energy: all other times $0.04	pdf: EnergyAus PriceList Residential 30_06-04 from website www.energy.com.au)
Green Tariff	**PureEnergy 100%**	July 2004	Supply charge 0.2748 All time (first 1750kWh/quarter) 0.1635 remainder 0.1748 Level at 1750 kWh	pdf: "Regulated Retail and Green Energy Tariffs, Energy Australia Residential Customer Price Guide"
METERING	(a) EnergyAustralia will arrange for the installation, maintenance and reading of any *meters* required at the *customer's supply points* and arrange for the provision of any other *metering services* required. **(b) If the *customer's* requirements change or the *customer's* electricity demand requires the installation of further or replacement *meters*, EnergyAustralia may require the *customer* to meet the additional cost (if any) of installing, maintaining and reading the rel** [Source: EnergyAustralia – Standard Form Customer Supply Contract October 2001]			

NSW	Integral Energy			
Continuous	**Domestic**	December 2004	System access charge (¢/day) $0.30 All time energy - First 1,750 kWh per quarter (c/kWh) $0.12 Balance $0.12 Level at 1,750	Integral NSW Energy_Price_Guide_-_1_Dec_04_deposits_changed1 PDF found on http://www.integral.com.au/

This *Pricing Option* will only apply to electricity supplied to a particular point at a *property* which ispredominantly used for one or more of the following purposes:

(i) private dwellings;(ii) boarding houses and lodging houses;(iii) retirement villages;(iv) residential sections of nursing homes and hospitals;(v) living quarters for members and staff of religious orders;(vi) residential sections of educational institutions;(vii) children's homes;

(viii) approved baby health centres, day nurseries and kindergartens;(ix) churches, mosques, temples etc – being buildings or *properties* which are used principally for publicworship or partly for public worship and partly for educational purposes; or(x) approved caravan sites.

Time-Of-Use	**Domestic Time-of-Use**	December 2004	System access charge (¢/day)	$0.35	See above
			Peak Energy: Electricity supplied from 1 pm to 8 pm on business days.	$0.14	
			Shoulder Energy: Electricity supplied from 7 am to 1 pm and from 8 pm to 10 pm on business days and 7am to 10pm on weekends and public holidays.	$0.13	
			Off-Peak Energy: Electricity supplied from 10 pm to 7 am on every day	$0.06	

This *Pricing Option* will only be available to electricity supplied to a particular point at a *property* which has a time-of-use meter installed. A capital contribution towards the cost of special metering may be required prior to supply being made available under this *Pricing Option*.

Inclining Block Tariffs (IBT)

From 1 July 2004, Integral Energy has introduced inclining block tariffs (IBTs) in the Domestic and General Supply *Pricing Options*. For these tariffs, all consumption at or below a threshold (the "First Block") will be charged at a certain ¢/kWh rate and any consumption above this threshold (the "Second Block") will be charged at a higher ¢/kWh rate.

The threshold for the Domestic *Pricing Option* is set at 1,750kWh per quarter and for the General Supply *Pricing Option* is set at 5,250kWh per quarter. For billing purposes, these thresholds are converted to a daily basis.

In any *billing period*, the calculation of consumption charges is illustrated below:

If average daily consumption in the *billing period* is below the daily threshold:

Consumption charge ($) = A x D x P1 / 100 ; or if average daily consumption in the *billing period* is above the daily threshold:

Consumption charge ($) = {T1 x D x P1 + (A – T1) x D x P2 } / 100 Where

A = Average daily consumption (kWh) for the *billing period*

T1 = Daily threshold (kWh) for the first block

P1 = Price for the first block (¢/kWh)

P2 = Price for the second block (¢/kWh)

D = Number of days in the *billing period*

NSW	Country Energy			
Continuous	"Urban Domestic Continuous"	1 July 2004	System access charge (¢/day) $0.35 All time energy - First 1,750 kWh per quarter (c/kWh) $0.13	www.cuntryenergy.com.au , pdf: "Country Energy Regulated Retail Electricity Prices For Small Retail Customers URBAN DOMESTIC"
Time-Of-Use	"Urban Domestic TOU"	1 July 2004	System access charge (¢/day) $0.79 PEAK PERIOD is from 7.00 am to 9.00 am and 5.00 pm to 8.00 pm on weekdays. $0.16 SHOULDER PERIOD is from 9.00 am to 5.00 pm and 8.00 pm to 10.00 pm on weekdays. $0.14 OFF-PEAK PERIOD is at all other times $0.07	
Metering	Time of Use prices (TOU) are available for business or domestic supply. The Time of Use option enables financial benefits for controlled usage at predetermined time periods as listed in definitions below. Urban Domestic Time of Use (TOU): To urban domestic premises where a TOU meter has been provided at the time of connection, no metering charge will be required. Where a new TOU meter is required for this tariff to be applied, a metering charge will apply.			

Figure IV-D-3-1: Structure of residential tariffs in NSW

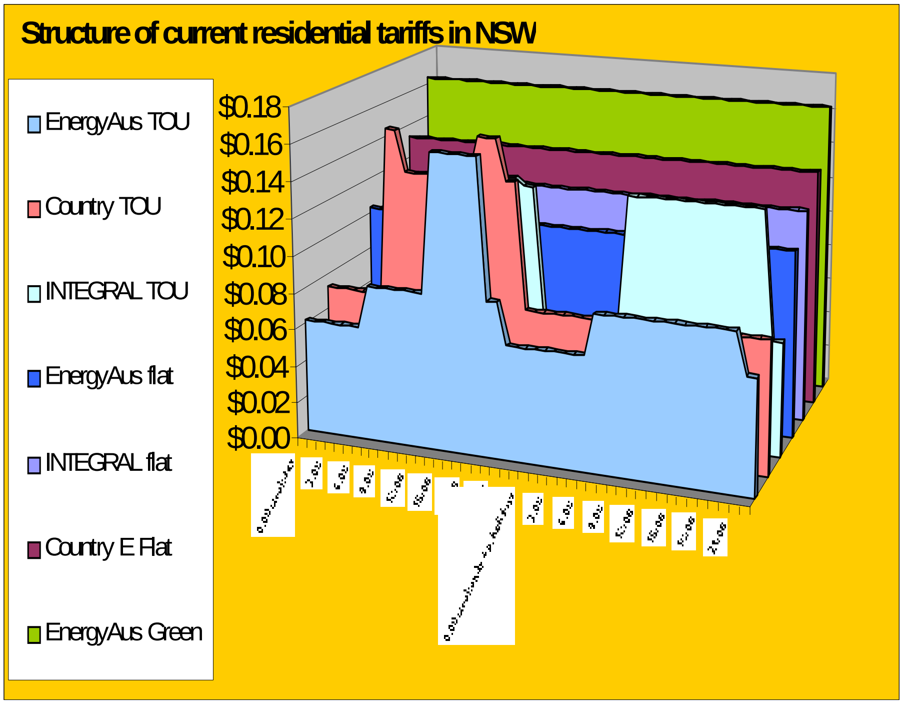
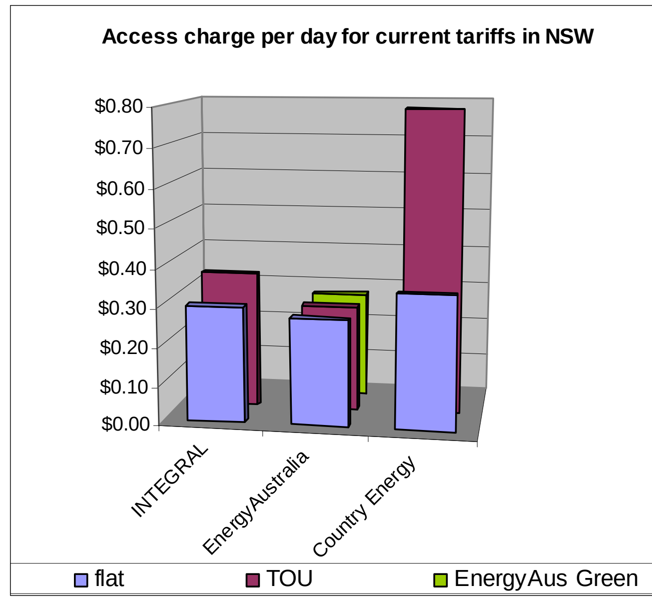


Figure IV-D-3-2: Structure of residential tariffs in NSW



The graphs visualize the vast differences between tariff classes: in price, structure and access charge.

Energy Australia offers the lowest tariffs, followed by integral and the high tariffs of country energy- especially it's TOU-access-charge is extraordinary high.

Key Finding: Peak price of TOU tariffs is generally higher then continuous tariffs.

Green tariffs are in average highest ones

b) SOUTH AUSTRALIA TARIFFS

SA	AGL			
	Tariff Name	Effective	Rates (AUS $)	Source
Continuous	"Domestic Light/ Power 110"		Supply Charge (c/ day) $0.31 Daily Consumption up to and including 3.2877 kWh (¢/kWh) $0.16 Excess- 1 Jan -31 Mar $0.19 Excess- From 1 Apr -31 Dec $0.17 Level at kWh /day 3.2877	"ELECTRICITY STANDING CONTRACT PRICE PRICE DETERMINATION December 2004, The Essential Services Commission of South Australia
Time-Of-Use	AGL Home Weekend Saver (GH/GL) (formerly „Winner“)		Not available for residential customers!	
	Available to all domestic installations. Meter installation or conversion charges generally apply, except for new dwellings which include a permanently wired storage water heater of an approved type meeting load management requirements. No other tariff is available with WINNER.			
Green Tariff	AGL Green Energy 100%	July 2004	Supply Charge (c/ day) $0.36 Daily Consumption up to and including 3.2877 kWh (¢/kWh) $0.21 Excess- 1 Jan -31 Mar $0.24 Excess- From 1 Apr -31 Dec $0.23 Level at kWh /day 3.2877	pdf: "Regulated Retail and Green Energy Tariffs, Energy Australia Residential Customer Price Guide”

Other available tariffs from AGL:

Off-Peak Load Managed Storage, Water Heating Tariff Y6/YT, Off-Peak Storage Water Heating Tariff Y8, Off-Peak Storage Space Heating Tariff J6/JT, Off-Peak Storage Space Heating Tariff J8, Off-Peak Storage Space Heating Tariff J

NOTE: Competition appears to be somewhat limited in South Australia – AGL is the predominant retailer, although other retailers are beginning to penetrate the market, there were no for the handling of this study feasible tariffs available but from AGL.

c) VICTORIA TARIFFS

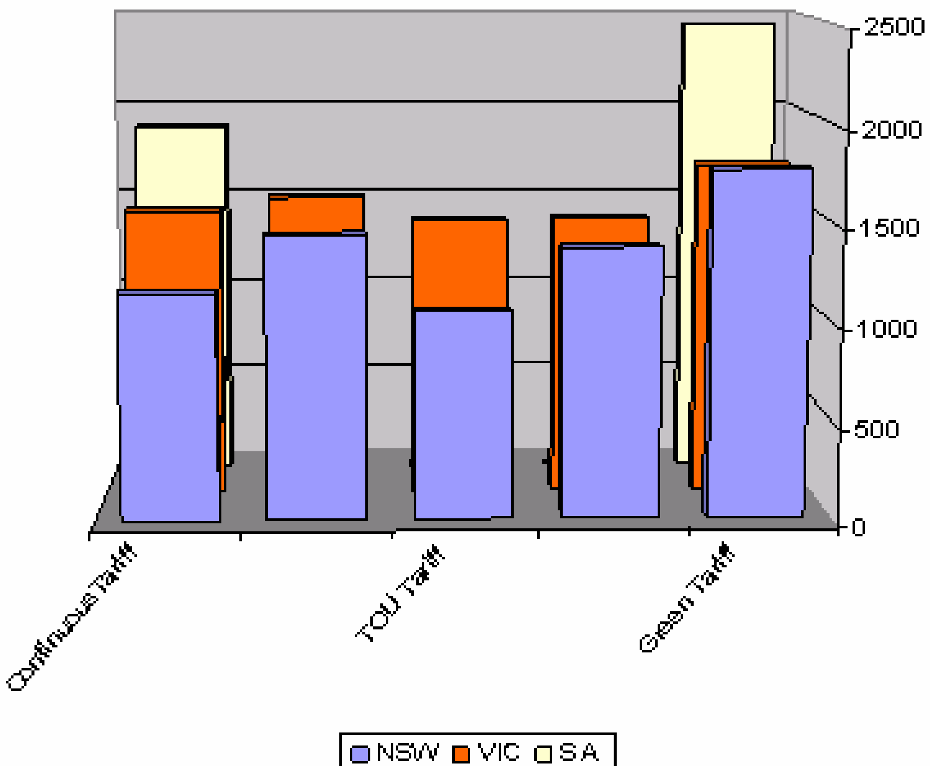
VIC	AGL			
	Tariff Name	Effective	Rates (AUS $)	Source
Continuous	AGL Home (GD/GR)	1st January 2005	Service to property charge ($/quarter) $36.00 All time energy - First 1,750 kWh per quarter (c/kWh) $0.13 Balance $0.14 Level at (kWh) 1,020	www.agl.com.au, ELECTRICITY STANDING CONTRACT PRICE PRICE DETERMINATION December 2004
Time-Of-Use	AGL Home Weekend Saver (GH/GL)	1st January 2005	Service to property charge ($/quarter) $36.00 Peak (7am to 11pm Monday to Friday) $0.19 Off Peak (All other times) $0.06	
Green Tariff	AGL Green Energy™ 100%, based on home weekend saver	1st January 2005	Service to property charge ($/quarter) $36.00 Peak (7am to 11pm Monday to Friday) $0.25 Off Peak (All other times) $0.12	
VIC	Origin Energy			
	Tariff Name	Effective	Rates (AUS $)	Source
Continuous	"Domestic All Time"	July 2004	Supply charge $/quarter) $37.50 All time energy - First 5000 kWh per quarter (c/kWh) $0.14 Balance (c/kWh) $0.15 Level at (kWh) 5,000	Internet: www.agl.com.au,, pdf: "Victoria Government Gazette, No. S 222 Friday 29 October 2004"
Time-Of-Use	Winner Tariff GH/GL	July 2004	System access charge ($/quarter) $37.50 Peak Periods (7 am to 11 pm Monday to Friday) $0.18 Off Peak Periods (All other times) $0.07	
Green Tariff	Green Earth	1st Januar	**Premium: $0.06** Calculation based on ContinuousTariff- GH/GL	Internet: www.agl.com.au, ELECTRICITY STANDING CONTRACT

	100% Solar	y 2005	All time energy - First 1,750 kWh per quarter (c/kWh)	$0.19	PRICE PRICE DETERMINATION December 2004
			Balance	$0.20	

Note: "Green" Tariffs are being discussed in the next chapter. The included green tariff serves only as an indicator for comparison purposes.

4. Interstate Comparison

Figure IV-D-4-1: household electricity bill on various tariffs in the states of NSW; VIC and SA



In general, NSW has the lowest tariffs, SA the highest. Green tariffs are in general the most expensive tariff option, although surprisingly equal in NSW and VIC

No Time-of-Use-tariffs for residential customers were available in SA, nor was any useable tariff information from competitors to AGL SA to be found. Thus, only AGL's flat rate and the offered green tariff could be considered.

PART A- The value to residential PV owner

IV. Methodology

The value of PV systems in this contextevenue is the value of the electricity generated by the PV system in prices of a specified retailer tariff.

As the PV output and the household's consumption are given in 30min intervals, a detailed analysis of the structure is possible. To match this data, only tariffs that are given inexact rates per kWh could be included. As I relied on publicly disclosed data, I was not able to take some tariff options into consideration if only rough estimates of rates were given (eg. through an tariff calculator on the yearly consumption on the retailers website). This occurred especially in South Australia and with Green tariff options.

The electricity bill and revenue was then calculated in excel by multiplying the consumption respectively generation on each 30min data point with the corresponding rate of the tariff. In addition to this, access charges (some based on consumption level) mostly had to be added to calculate the assumed household bill.

I did not take this into account for the calculation of PV revenue, as retailing companies do not pay a "reverse electricity supply charge". Nevertheless, when calculating a household electricity bill including a PV system, first the PV output is being discounted from the household's consumption. Only then the consumption is taken to calculate the bill- i.e. the net consumption is decisive.

Energy Buy Back Options

The "Energy Purchase Rate for Rooftop Solar Panels" (found on Energy Australia website: www.energy.com.au) is the only statement that could be found: The buy back rate is the same as the customer's corresponding principal tariff, with appropriate adjustments where GST is not payable. Buy back arrangements for large systems (=>10 kWp/phase) need to be negotiated individually.

GST

Tariffs and prices are excluding GST.

Official Holidays

As weekend tariffs apply on public holidays, those dates in the examined period had to be identified and the tariffs adjusted.

The holidays were as follows:

2003

Vic:1 Jan, 27 Jan, 10 Mar, 18 Apr, 21 Apr, 25 Apr, 9 Jun, *4 Nov**, 25 Dec, 26 Dec

NSW: 1 Jan, 27 Jan, 18 Apr, 19 Apr, 21 Apr, 25 Apr, 9 Jun, *4 Aug**, 6 Oct, 25 Dec, 26 Dec

SA:1 Jan, 27 Jan, 18 Apr, 19 Apr, 21 Apr, 25 Apr, 19 May, 9 Jun, 6 Oct, 25 Dec, 26 Dec

2002

Vic:1 Jan, 26 Jan, 28 Jan, 11 Mar, 29 Mar, 30 Mar, 1 Apr, 25 Apr, 10 Jun, 5 Nov, 25 Dec, 26 Dec

NSW: 1 Jan, 26 Jan, 28 Jan, 29 Mar, 30 Mar, 1 Apr, 25 Apr, 10 Jun, 5 Aug*, 7 Oct, 25 Dec, 26 Dec

SA:1 Jan, 26 Jan, 28 Jan, 29 Mar, 30 Mar, 1 Apr, 25 Apr, 20 May, 10 Jun, 7 Oct, 25 Dec, 26 Dec

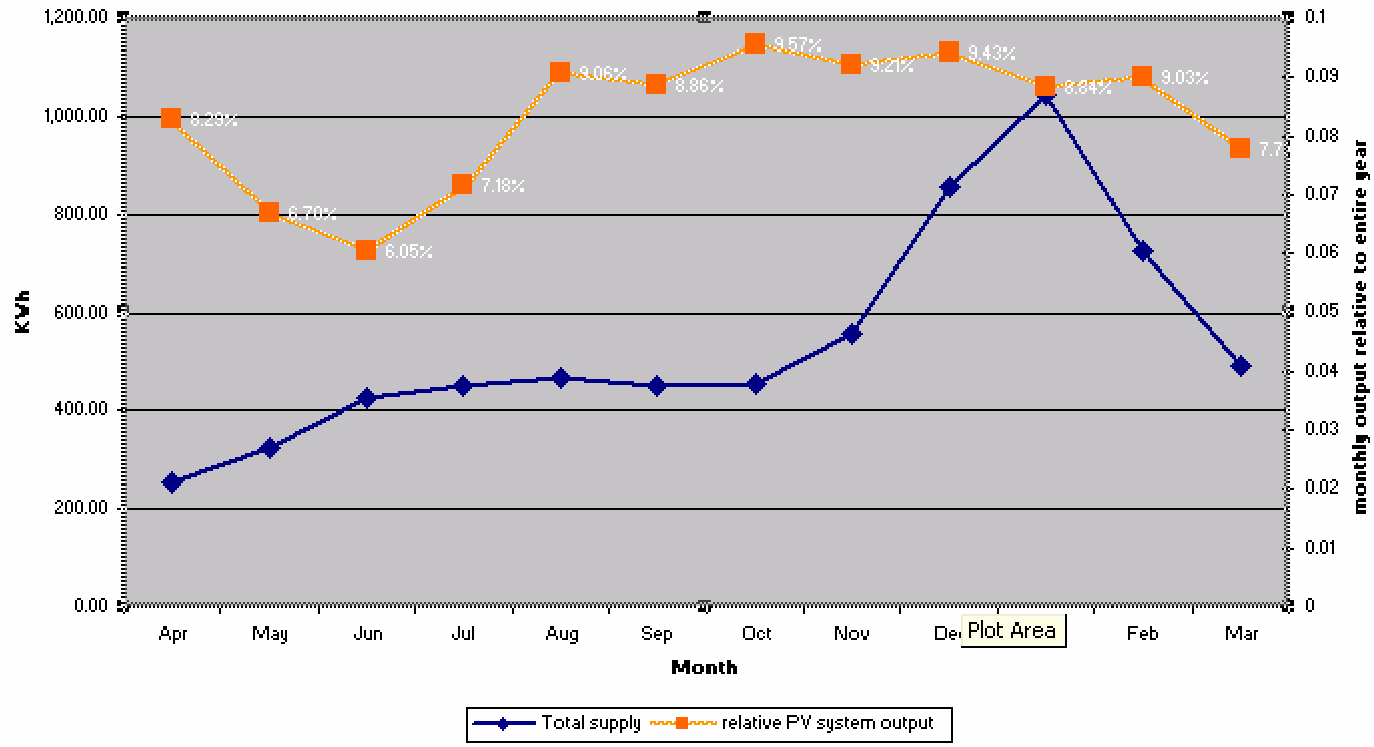
Daylight saving:

Daylight saving is being regarded and has been adjusted.

General Analysis of HH load vs PV output

<u>Figure IV-A-1:</u>

Correlation of electricity consumption of HH (in kWh) and PV output (relative to total output of year) per month April 2002 to March 2003



The household has a very dynamic load pattern, with demand shifting from 250 kWh in April to a peak of more then 1000 kWh in January. The PV output does not correspond to this pattern, but has relatively high output during the high demand period.

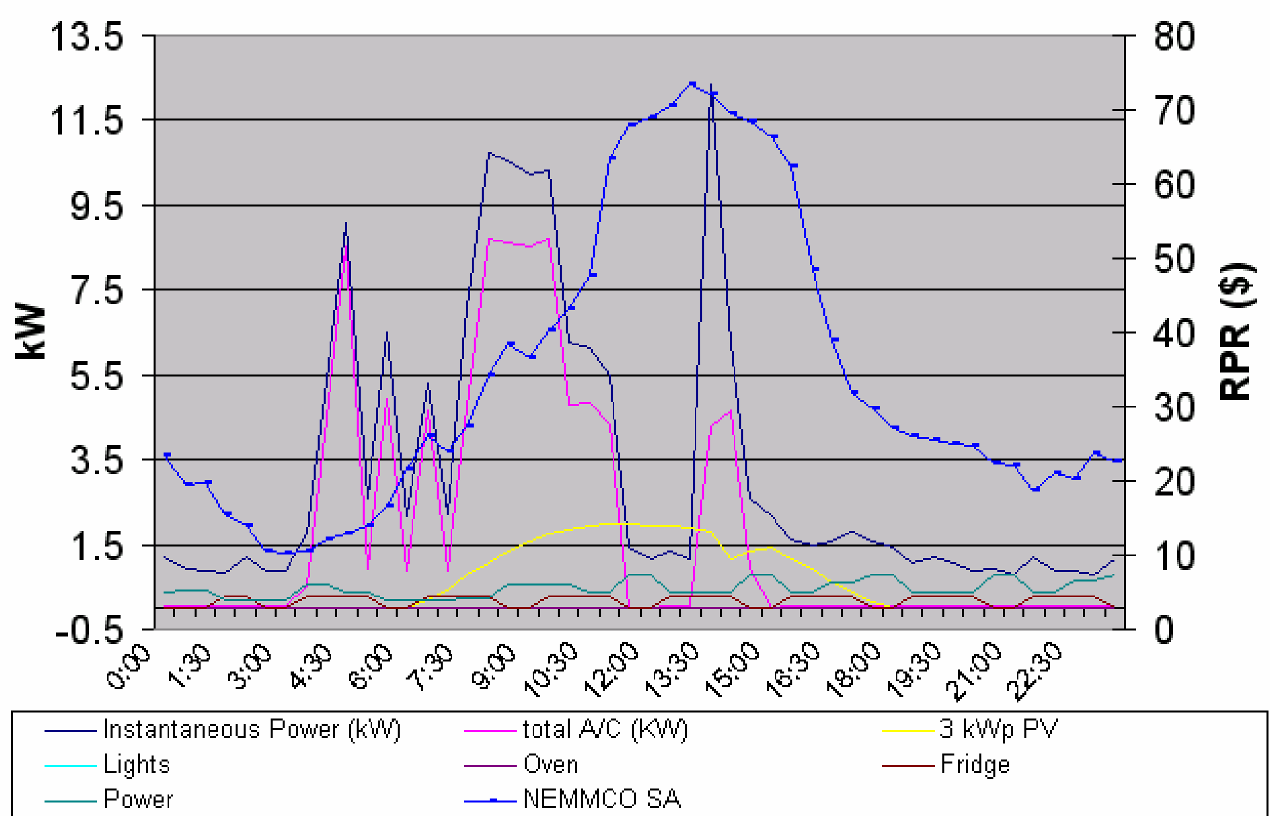
<u>Figure IV-A-2</u>:

Significance of PV output compared to total household load

PV System output	1 kWp PV	3 kWp PV	5 kWp PV	7 kWp PV
proportional to total HH load	22%	65%	108%	151%
proportion that is fed into grid	25%	55%	65%	72%

This table demonstrates the importance of being able to feed excess electricity into the grid for the private PV owner – the part not being consumed immediately is significant, and increasing with the size of the PV system. It also shows that the HH would need a 5 kWp PV system to meet it's electricity demand.

Figure IV-A-3: Load profile for Tuesday, 7 Jan 2003 – maximum load scan of the year

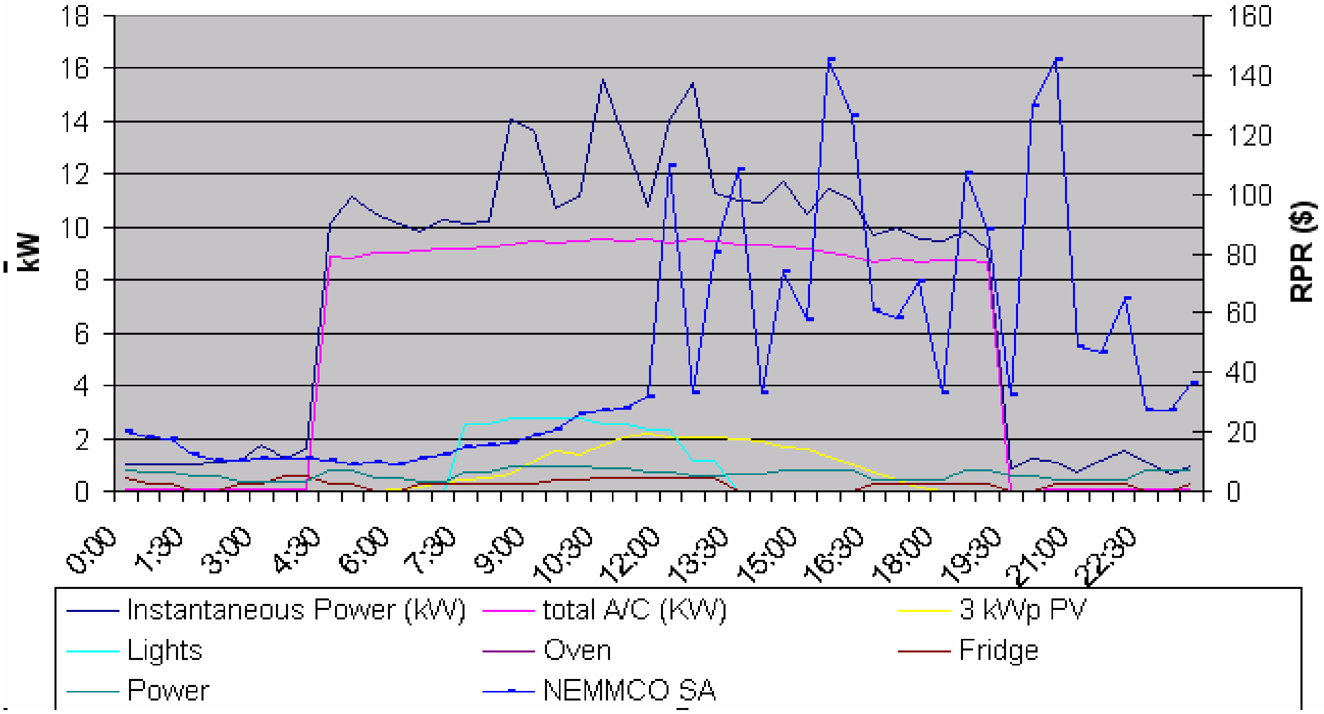


Explanatory to the graphs: Instantaneous Power is the total load of the household that is being measured, besides monitoring the major appliances like lights, power (plugs) air conditioner, oven and fridge.

The South Australian National Electricity market's RPRs have been included as a reference of the general electricity demand for comparison reasons.

The extreme significance of the air conditioner for the total household load is demonstrated in this day load profile. Interestingly, electricity market RPRs are peaking with the household demand at about 2pm, obviously due to AC use. However, PV output is reduced around this period, although it correlates otherwise quite well with RPRs. Nevertheless, the household's morning consumption of electricity can not be satisfied by the PV system, the AC, probably working on an automated control, is being switched on 3 times in the period between 5am and 7:30 am and thus driving demand at an very early hour.

Figure IV-A-4: Load profile Sunday, 12 Jan 03



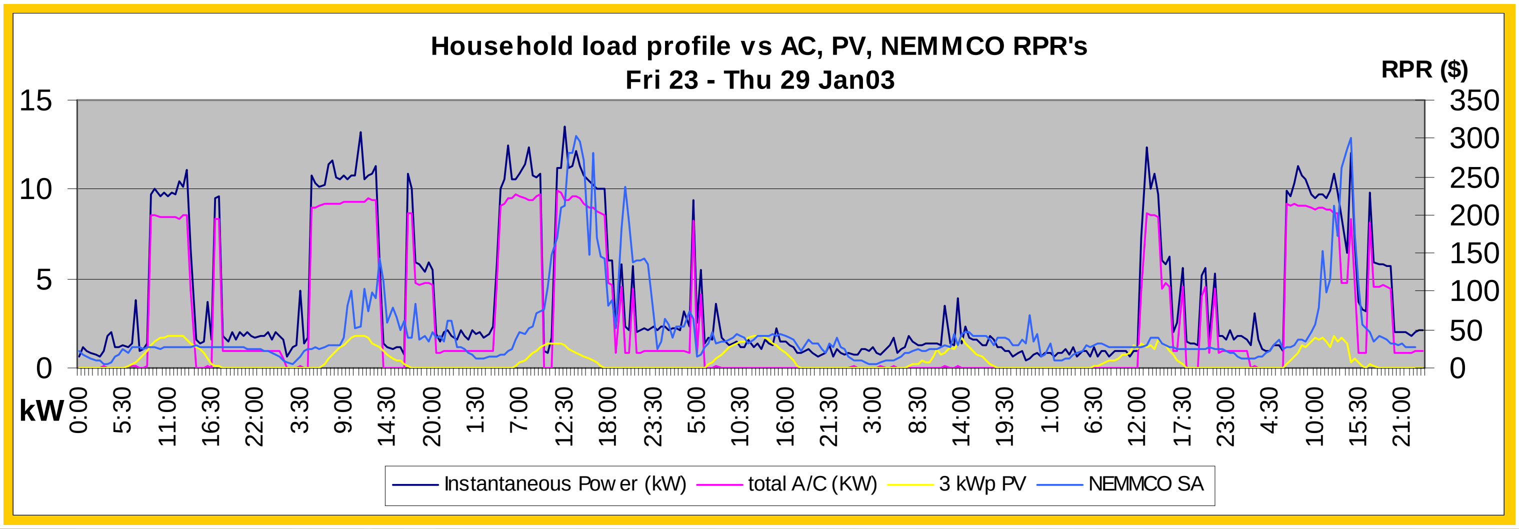
This day is of interest as the highest average of load scans per day occurred.

A glance at the chart reveals that this is mainly due to the constant use of the air conditioner unit from 4:30 am until 8:30 pm. The AC unit is relatively big with a power of 8.5 to 9.5 kW.

On this day, SA NEM RPRs started to rise relatively high, up to 140$- well above the average of 30-40$.

Typically, this high load day is a Sunday: High loads during the weekend are a characteristic of this household, which is confirmed by chart III-6.

Figure IV-A-5:Load profile of HH, AC, PV, SA RPRs, 23–29 Jan 03



A. VALUE OF PV IN NEW SOUTH WALES

1. Savings with PV system

Figure IV-B-1-1:

Possible savings for HH due to PV system – no opting for other tariff

		Continuous Tariff			TOU Tariff			Green T
		INTEGRAL	EnergyAustrali	Country Energy	INTEGRAL	EnergyAustralia	Country Energy	EnergyA
without PV	Total (incl. Supply charge)	$876	$775	$988	$894	$732	$1,005	$1,
	supply charge	$110	$100	$126	$129	$100	$288	$1
	Total (incl. Supply charge)	$710	$627	$802	$704	$593	$836	$9
	Difference (without supply charge)	$166	$149	$186	$190	$139	$169	$2
	Difference (Relative)	22%	22%	28%	25%	22%	27%	2
1 KW PV	Difference (with supply charge)	19%	19%	19%	21%	19%	17%	2
	Total (incl. Supply charge)	$380	$337	$431	$333	$315	$498	$4
	Difference (without supply charge)	$496	$439	$557	$561	$418	$508	$6
	Difference (Relative)	65%	65%	65%	73%	66%	71%	6
3 KW PV	Difference (with supply charge)	57%	57%	56%	63%	57%	50%	5
	Total (incl. Supply charge)	$50	$48	$59	-$41	$36	$159	$
	Difference (without supply charge)	$826	$727	$929	$935	$696	$846	$1,
	Difference (Relative)	108%	108%	108%	122%	110%	118%	10
5 KW PV	Difference (with supply charge)	94%	94%	94%	105%	95%	84%	9
	Total (incl. Supply charge)	-$280	-$241	-$313	-$415	-$242	-$179	-$
	Difference (without supply charge)	$1,156	$1,016	$1,301	$1,310	$974	$1,185	$1,
	Difference (Relative)	151%	150%	151%	171%	154%	165%	15
7 KW PV	Difference (with supply charge)	132%	131%	132%	146%	133%	118%	13

The TOU tariffs are more favourable then the continuous tariff options, also without a PV system. An increasing PV system size favours TOU-tariffs.

A 1 kW PV system reduces the HH electricity bill by up to 21% on Integral's tariff. Interestingly, Country Energy's tariff would be the best option if the access charge wouldn't be taken into account.

With a system size of 5 PV, a negative electricity bill can be achieved on Integral's TOU-tariff.

With a system size bigger then 5 kW the Green tariff option becomes the most favourable, due to the high rates the biggest revenue can be achieved.

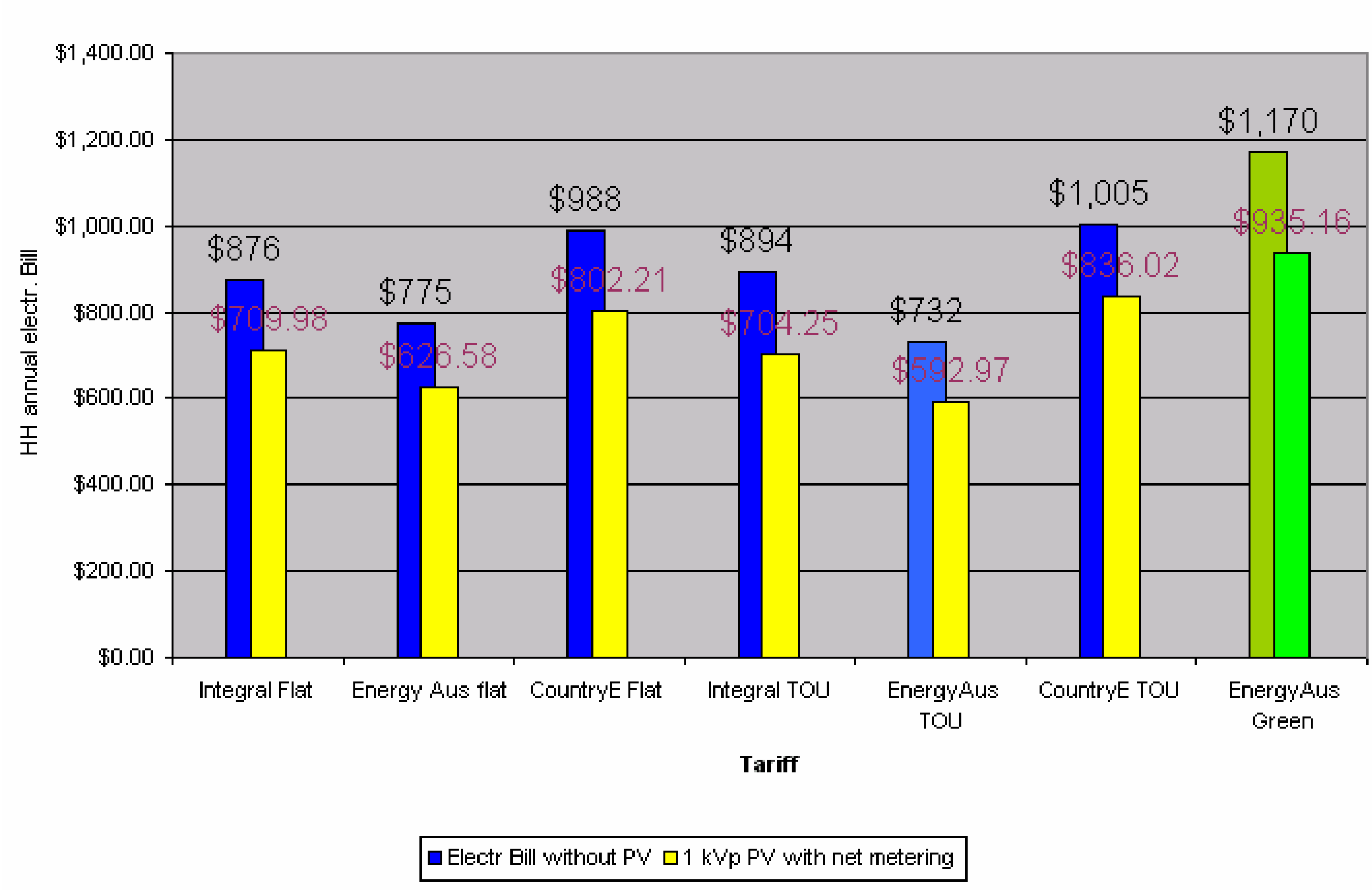
Figure IV-B-1-2: **Reduction of electricity bill with 1 kW PV –without exporting**

	ContinuousTariff			TOU Tariff			Green Tariff
	Integral	EnergyAus	Country Energy	Integral	EnergyAus	Country Energy	EnergyAus
PV solely for HH use (no Export)	$125.11	$112.70	$139.70	$144.02	$108.03	$126.62	$177.27
Relative to HH electricity bill	14.28%	14.54%	14.14%	16.10%	14.76%	12.60%	15.16%

Without a net metering option, the most favourable tariff for the household is Integral Energy's TOU-tariff, reducing the bill by 16%.

Figure IV-B-1-3:

Comparison of HH electricity bill including and excluding 1 kW PV with net metering



Rate switch savings

Figure IV-B-2-1:

Rate switch savings without PV (switching from the most expensive continuous tariff, Country Energy's)

	ContinuousTariff			TOU Tariff			Green Tariff
	Integral	EnergyAus	Country Energy	Integral	EnergyAus	Country Energy	EnergyAus
	$876	$775	$988	$894	$732	$1,005	$1,170
Relative to highest tariff	88.67%	78.47%	100.00%	90.52%	74.10%	101.74%	118.37%
Difference	-11.33%	-21.53%	0.00%	-9.48%	-25.90%	1.74%	18.37%

In NSW, without a PV system installed, a saving of 26% could be achieved just by switching from Country Energy's continuous to EnergyAustralia's TOU tariff.

Figure IV-B-2-2:

Rate switch savings with 1 kW PV (switching from the most expensive continuous tariff, Country Energy's)

switching if PV installed	ContinuousTariff			TOU Tariff			Green Tariff
	Integral	EnergyAus	Country Energy	Integral	EnergyAus	Country Energy	EnergyAus
	$710	$627	$802	$704	$593	$836	$935
Relative to highest tariff	88.50%	78.11%	100.00%	87.79%	73.92%	104.22%	116.57%
Difference	-11.50%	-21.89%	0.00%	-12.21%	-26.08%	4.22%	16.57%

With a net metered 1 kW PV system installed, a saving of 26% can be achieved on Energy Australia's TOU-tariff- just 1 % more then without the system.

Figure IV-B-2-3:

Rate switch savings of switching from highest continuous tariff (Country Energy)s and installing 1 kW PV

	Continuous Tariff			TOU Tariff			Green Tariff
	Integral	EnergyAus	Country Energy	Integral	EnergyAus	Country Energy	EnergyAus
Relative to most expensive tariff	71.86%	63.42%	81.19%	71.28%	60.02%	84.61%	94.65%
Difference	-28.14%	-36.58%	-18.81%	-28.72%	**-39.98%**	-15.39%	-5.35%
in absolute terms	**-$278**	**-$361**	**-$186**	**-$284**	**-$395**	**-$152**	**-$53**

Comparing the possible savings of a HH bill without PV to a HH bill with PV with net metering a maximum saving of 40% is possible, if opting for Energy Australia's TOU tariff. This is an enormous saving potential for residential customers which, if invested in the PV system, could make it financially feasible.

Figure IV-B-2-4:

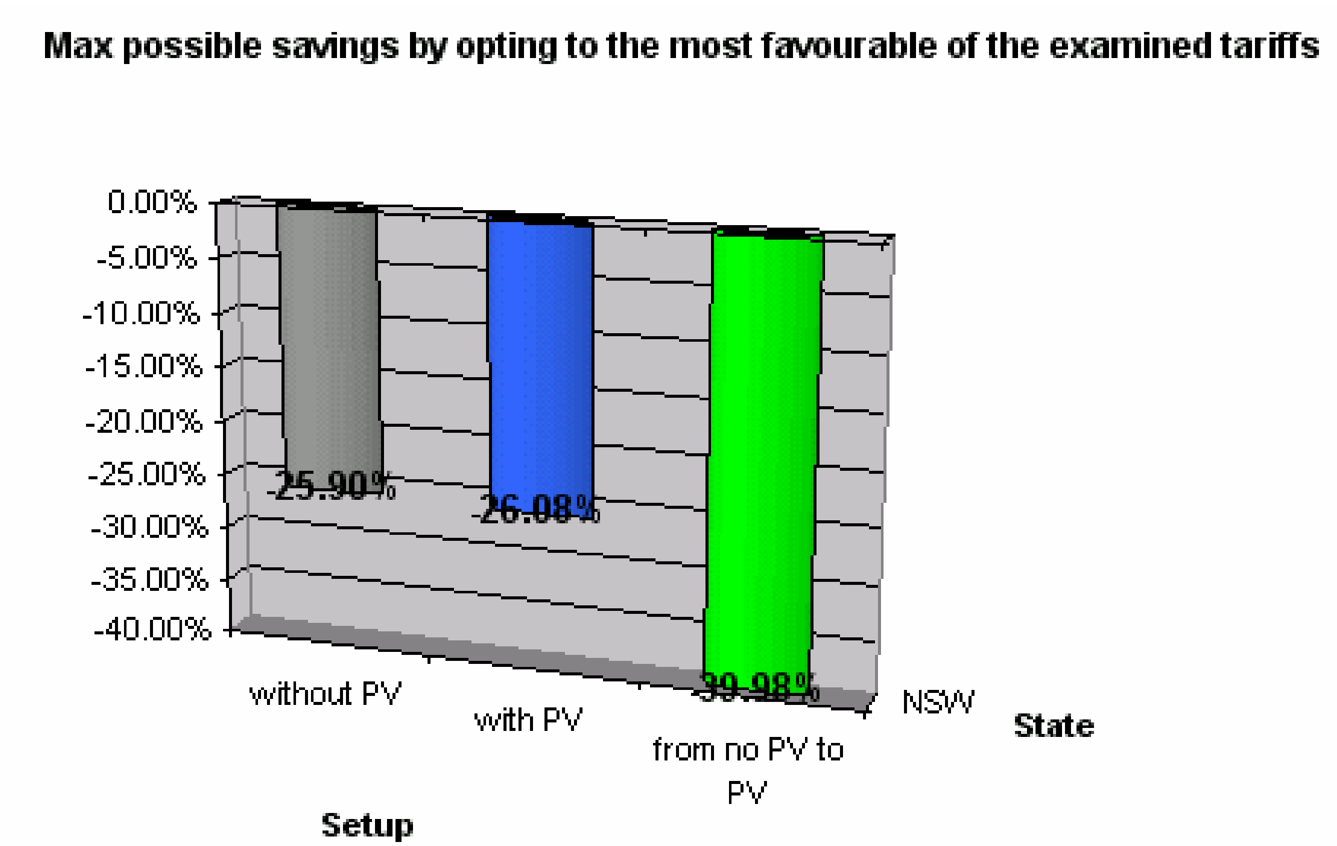


Figure IV-B-2-5:

Reductions in electricity bill for HH by switching from highest flat rate (CountryEnergy) to cheapest TOU rate (Energy Aus) and applying PV system

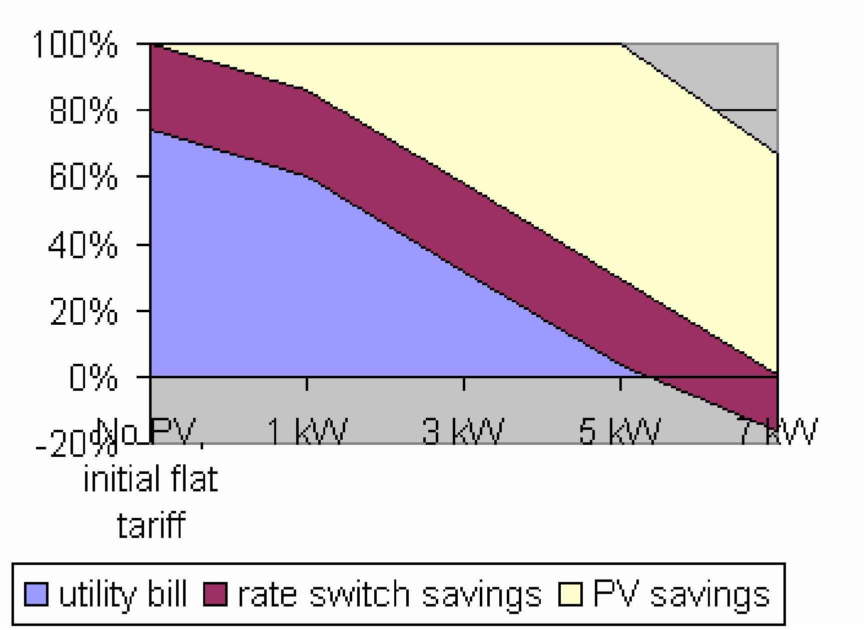
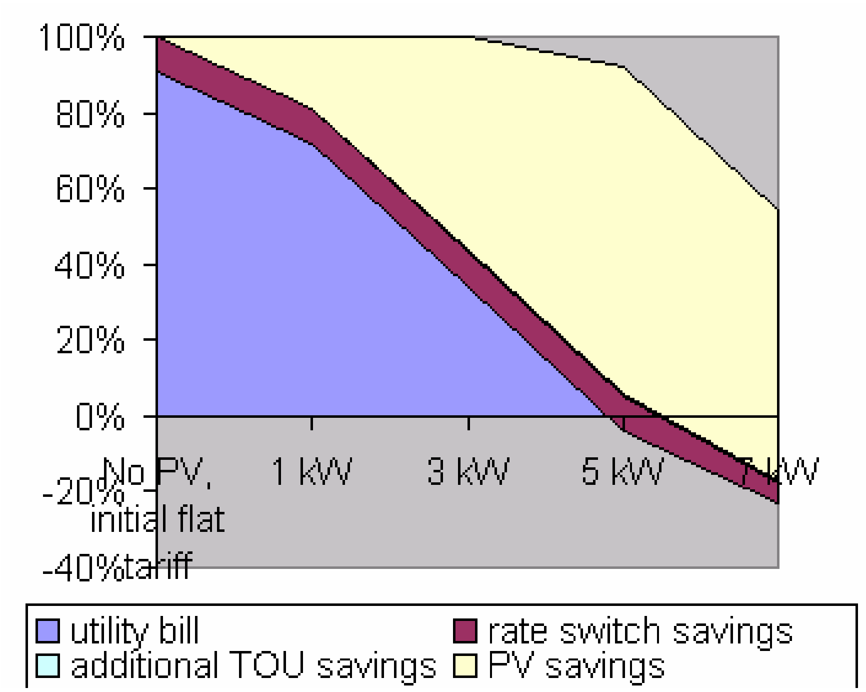


Figure IV-B-2-6:

Reductions in electricity bill for houselhold by switching from highest flat rate (CountryEnergy) to TOU rate with highest revenues for PV output (Integral) and applying PV system



Opting for the most favourable TOU-tariff for the PV, Integral's TOU, reduces rate switch saving, but delivers much higher PV savings with increasing PV system size.

However, as most residential customers are likely to install small PV systems in the range of one to three KWp, the lower initial tariff of Energy Australia, that delivers high rate witch savings, would be the better option.

3. Analysing different PV system sizes:

The available and adequate roof area is obviously crucial when considering the PV system size.

With current technology, an output of 100 Watts per square meter is a reasonable estimate.

To produce the amount of electricity that is being consumed by the household (roughly 6.5 MW), a 5 kW PV system would be necessary, which would requires some 50 square meter roof area, that needs to be North facing.

However, one fact that eases this restriction is that the surface area of new developed residences in Australia has increased dramatically in the last decades. Being one reason for an increased demand, and going in line with the finding of higher demand through air conditioner use, this development delivers one more reason for PV installations.

4. The benefit of TOU tariffs in NSW for PV:

Figure IV-B-4-1:

Relative difference in household's saving on yearly electricity bill through PV on TOU tariff to same retailer's continuous tariff

Relative difference of savings by PV on TOU to Flat rate			
	INTEGRAL	EnergyAustralia	Country Energy
No PV	-2%	6%	-2%
1 kW	14%	-6%	-9%
3 kW	13%	-5%	-9%
5 kW	13%	-4%	-9%
7 kW	13%	-4%	-9%

The first row shows the difference in HH bill without a PV system. Only Energy Australia's TOU-tariff is slightly (6% reduction) more favourable for the HH without a PV.

If applying PV system, it's output is actually more valuable on continuos tariffs for Energy Australia and Country Energy. Only Integral's tariff structure offers a benefit for the PV's output pattern and allows the PV to generate 13% more value then on Integral's flat rate.

Hence, the picture is not consistent – it can't be said that TOU-tariffs are generally more favourable for PV owners.

5. Economical Viability - The value of investment in PV

a) *Assumptions for financial modelling:*

Modules: As Solarex, the company that manufactured the Queanbeyan Solar Modules, has been bought by BP Solar in the meantime and no information about the original price and efficiency rate could be obtained, prices of state-of-the-art solar modules BP Solar polycrystalline, have been assumed. Prices as of autumn 2005, GST included.

Installation of Modules: No exact installation cost estimates have been accounted. I assumed that installing modules adds with 2000$ to the pure module costs, adding 1000$ per additional kW of modules installed.

	Modules (	Installed Modules	fixed costs	TOTAL
1 kW	$10,500	$12,500	$1,250	**$13,750**
3 kW	$31,500	$35,500	$1,250	**$36,750**
5 kW	$52,500	$58,500	$1,250	**$59,750**
7 kW	$73,500	$81,500	$1,250	**$82,750**

fixed costs	
$250	Inverter Enclosure
$550	Bi-directional Metering device
$450	Mobile Tower
$1,250	TOTAL

Fixed costs: It has been assumed that an average of 1250 $ of fixed costs has to be added to installation costs of modules.

Costs for a Bi-directional meter are in the range between 400$ – 600$.

As retailers have a different policies and prices for Bi-directional meter systems, those are taken into consideration at a fixed rate of 550 $.

For instance, Energy Australia is charging customers for installation and purchase of the metering unit, whereas Country Energy does not.

Same applies for a mobile tower and an inverter enclosure. Both are not necessarily needed, but have been put into account.

No maintenance costs have been assumed.

This results in an overall installed cost before rebates and REC's of roughly $12 - $13 per Watt. Thus, the calculations can be classified as fairly conservative.

Net increase in energy prices:

The projection of energy prices over 20 years and further is difficult. For convenience, I applied a linear projection: An increase of 3% p.a., discounted by an inflation rate of 2.5%, resulting in an average net increase of .5% p.a.

Lifespan:

Regular warranty for PV modules nowadays lies in the rage between 20 to 25 years. However, also 30 year warranties are being offered.

To reflect this important aspect, calculations with the life spans 20, 25 and 30 years have been carried out.

Government Rebate:

Quoting Australian Greenhouse Office website: www.greenhouse.gov.au :

"The Commonwealth Government, through the Australian Greenhouse Office, offers rebates for solar power systems through the Photovoltaic Rebate Program (PVRP). The following table outlines the rebates the AGO offers in NSW."

		Rebate	**Minimum solar power system size**	**Rebate cap (maximum amount)**	**Special conditions**
Householders	New solar power systems	$4 per watt*	450 watts	$4,000 (1000 watts)	Must be installed at your principal place of residence
	Upgrades to solar power systems	$2.50 per watt*	450 watts	$2500 (1000 watts)	
Community organisations	New solar power systems	$4 per watt*	450 watts	$8,000 (2,000 watts)	Must be prepared to undertake educational activities around solar power

The Program has been extended for two years on May 17, 2005 extended two years with the announcement of a A$5.7 million per year two-year extension.

The rebate has been taken into account for the calculations. As the rebate is capped at a maximum of 4000 $ (1 kW), the full rebate applied in all cases.

Renewable energy certificates (REC)

Quoting the office of the renewable energy regulator on http://www.orer.gov.au/: "Renewable energy certificates will be created on the basis of accredited renewable energy generation arising from the operation of eligible renewable energy generation assets (using eligible fuels - see below) that deliver renewable electricity to a grid, end point user or directly to a retailer or wholesale buyer. Some installations of solar water heaters may also be eligible for renewable energy certificates. Renewable energy certificates may be traded in financial markets that are separate from the physical National Electricity Market (NEM), so that there is no interference with the operations of the NEM and non-NEM markets.

Eligible generation assets will earn certificates on the basis of their renewable generation from 1 April 2001 (not retrospectively). Each renewable certificate is equal to (or in the case of solar water heaters, equivalent to) 1 MWh of renewable generation available at an agreed measurement point. Owners of renewable energy generation assets will hold the renewable energy certificates in the first instance, until traded among liable or third parties."

Those certificates have been included, as BP Solar has announced this customer incentive program, called "enviro-cashback":

"When customers buy a BP solar electric system they may be eligible for a cashback offer of up to $5000. An enviro-rebate effectively combines a manufacturers rebate from BP Solar with a payment for the benefits of your emission savings (called Renewable Energy Certificates or REC's). BP Solar will register and collect the RECS in accordance with Federal Legislation creating an "asset register" of the environmental benefits that solar electric systems produce. In doing so it will create a much higher profile for the benefits of solar electricity and, put a tangible value on these same benefits. The enviro-cashback offer is applicable to new solar modules made by BP Solar, installed in Australia in systems between 80 and 10,000 watts." (BP Solar, www.bpsolar.com.au)

Possible further reductions:

No further aspects have been taken into account. However, a retailer rebate on PV Modules, as well as discounts on installation costs are conceivable.

The following table summarizes the options of the total PV system costs that were taken as basis for the modelling:

PV system size	REC's over period 0.50 $ per W	Total PV cost	Gov Rebate & REC -$4,000	Gov Rebate, no REC's
1 kW	-$500	**$13,250**	**$9,250**	**$9,750**
3 kW	-$1,500	**$35,250**	**$31,250**	**$32,750**
5 kW	-$2,500	**$57,250**	**$53,250**	**$55,750**
7 kW	-$3,500	**$79,250**	**$75,250**	**$78,750**

b) *Methodology:*

To calculate the value of the PV system over it's lifespan, the yearly revenue of the PV system on the tariff (that has been calculated in the above chapter) is projected into the future with the future value function in excel.

Various sequences with different conditions are examined in categories:

A) Rate switch is possible, i.e. not only PV revenue, but also bill reductions through more favourable tariff are being taking into account. The amount is calculated by identifying the most favourable tariff, which then is being discounted to obtain the amount that is being saved.

B) Rate switch is not possible, only PV can potentially reduce the electricity bill.

Note: A green tariff option has been added in the calculations for comparison reasons, but is not being regarded as a rate switch option.

c) ***Value of PV with rate switch savings***

Household total electricity bills under various tariff options, with and without PV system. Highlighted fields mark the most favourable tariff in the category.

Net HH electricity bill (incl. supply charge)	ContinuousTariffs			TOU Tariffs			Green Tariff
	INTEGRAL	Energy Australia	Country Energy	INTEGRAL	Energy Australia	Country Energy	Energy Australia
No PV	$876	$775	$988	$894	$732	$1,005	$1,170
1 kWp	$710	$627	$802	$704	$593	$836	$935
3 kWp	$380	$337	$431	$333	$315	$498	$475
5 kWp	$50	$48	$59	-$41	$36	$159	$17
7 kWp	-$280	-$241	-$313	-$415	-$242	-$179	-$441

Energy Australia's TOU tariff has been identified as the cheapest tariff for no PV, 1 kWp and 3 kWp PV. From 5 kWp on, Integral's TOU tariff is even better. Although the green tariff option would be even more favourable from 5 kWp on, it is not taken into account here.

Reductions in electricity bill by switching to the most favourable tariff, shown in the field of the initial tariff, red highlighted fields indicating the biggest savin

	ContinuousTariff			TOU Tariff			Green Tariff
	INTEGRAL	EnergyAustralia	Country Energy	INTEGRAL	EnergyAustralia	Country Energy	EnergyAustralia
1 kW	$283	$182	$395	$301	$139	$412	$577
3 kW	$561	$461	$673	$580	$418	$691	$855
5 kW	$917	$816	$1,029	$935	$773	$1,046	$1,211
7 kW	$1,291	$1,191	$1,403	$1,310	$1,147	$1,420	$1,585

Country Energy's TOU tariff is offering with all PV options the highest saving potential, the retailer's continuous tariff the second best saving potential. As both tariffs are the most expensive one's without the PV system, the assumptions can be made that the saving potential is due to this extraordinary high rates and not due to particularly better revenue's of the PV system on the other tariff options. Interestingly, the green tariff savings are actually the highest

First set: No governmental rebate, no REC's

ContinuousTariff			TOU Tariff			Green Tariff
INTEGRAL	Energy Australia	Country Energy	INTEGRAL	Energy Australia	Country Energy	Energy Australia

Lifespan of PV: 20 years

	Net Present value of investment in PV system						
1 kW	-$7,810	-$9,924	-$5,462	-$7,427	-$10,830	-$5,101	-$1,653
3 kW	-$24,970	-$27,084	-$22,622	-$24,587	-$27,990	-$22,261	-$18,814
5 kW	-$40,510	-$42,623	-$38,162	-$40,127	-$43,530	-$37,801	-$34,353
7 kW	-$55,660	-$57,774	-$53,312	-$55,277	-$58,680	-$52,951	-$49,503
Gap to commercial viability of PV installation on the corresponding tariff							
1 kW	-56.80%	-72.17%	-39.72%	-54.01%	-78.76%	-37.10%	-12.02%
3 kW	-67.95%	-73.70%	-61.56%	-66.90%	-76.16%	-60.58%	-51.19%
5 kW	-67.80%	-71.34%	-63.87%	-67.16%	-72.85%	-63.26%	-57.49%
7 kW	-67.26%	-69.82%	-64.43%	-66.80%	-70.91%	-63.99%	-59.82%

Without any form of subsidy, on none of the examined tariffs can a economical feasibility achieved. Switching from Country Energy to Energy Australia's TOU comes closest to break even (besides the switch from the Green tariff), but is still negative with 37% of the initial investment not being amortized.

Lifespan of PV: 25 years

25years	Net Present value of investment in PV system						
1 kW	-$6,230	-$8,906	-$3,258	-$5,745	-$10,053	-$2,801	$1,564
3 kW	-$21,837	-$24,513	-$18,865	-$21,352	-$25,661	-$18,408	-$14,043
5 kW	-$35,392	-$38,068	-$32,419	-$34,907	-$39,215	-$31,963	-$27,598
7 kW	-$48,455	-$51,131	-$45,482	-$47,970	-$52,278	-$45,025	-$40,661
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-45%	-65%	-24%	-42%	-73%	-20%	11%
3 kW	-59%	-67%	-51%	-58%	-70%	-50%	-38%
5 kW	-59%	-64%	-54%	-58%	-66%	-53%	-46%
7 kW	-59%	-62%	-55%	-58%	-63%	-54%	-49%

The picture improves with increasing lifespan., coming close (-3%) at a lifespan of 30 years.

Lifespan of PV:30 years

30 years	Net Present value of investment in PV system						
1 kW	-$4,611	-$7,863	-$997	-$4,021	-$9,257	-$442	$4,863
3 kW	-$18,625	-$21,878	-$15,012	-$18,036	-$23,272	-$14,457	-$9,152
5 kW	-$30,145	-$33,398	-$26,532	-$29,556	-$34,792	-$25,977	-$20,672
7 kW	-$41,068	-$44,320	-$37,455	-$40,478	-$45,715	-$36,899	-$31,594
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-34%	-57%	-7%	-29%	-67%	-3%	35%
3 kW	-51%	-60%	-41%	-49%	-63%	-39%	-25%
5 kW	-50%	-56%	-44%	-49%	-58%	-43%	-35%
7 kW	-50%	-54%	-45%	-49%	-55%	-45%	-38%

Second set: Governmental rebate, no REC's

ContinuousTariff			TOU Tariff			Green Tariff
INTEGRAL	Energy Australia	Country Energy	INTEGRAL	Energy Australia	Country Energy	Energy Australia

Lifespan of PV: 20 years

	Continuous INTEGRAL	Continuous Energy Australia	Continuous Country Energy	TOU INTEGRAL	TOU Energy Australia	TOU Country Energy	Green Energy Australia
	Net Present value of investment in PV system						
1 kW	-$3,810	-$5,924	-$1,462	-$3,427	-$6,830	-$1,101	$2,347
3 kW	-$20,970	-$23,084	-$18,622	-$20,587	-$23,990	-$18,261	-$14,814
5 kW	-$36,510	-$38,623	-$34,162	-$36,127	-$39,530	-$33,801	-$30,353
7 kW	-$51,660	-$53,774	-$49,312	-$51,277	-$54,680	-$48,951	-$45,503
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-39%	-61%	-15%	-35%	-70%	-11%	24%
3 kW	-64%	-70%	-57%	-63%	-73%	-56%	-45%
5 kW	-65%	-69%	-61%	-65%	-71%	-61%	-54%
7 kW	-66%	-68%	-63%	-65%	-69%	-62%	-58%

Lifespan of PV: 25 years

25years	Continuous INTEGRAL	Continuous Energy Australia	Continuous Country Energy	TOU INTEGRAL	TOU Energy Australia	TOU Country Energy	Green Energy Australia
	Net Present value of investment in PV system						
1 kW	-$2,230	-$4,906	$742	-$1,745	-$6,053	$1,199	$5,564
3 kW	-$17,837	-$20,513	-$14,865	-$17,352	-$21,661	-$14,408	-$10,043
5 kW	-$31,392	-$34,068	-$28,419	-$30,907	-$35,215	-$27,963	-$23,598
7 kW	-$44,455	-$47,131	-$41,482	-$43,970	-$48,278	-$41,025	-$36,661
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-23%	-50%	8%	-18%	-62%	12%	57%
3 kW	-54%	-63%	-45%	-53%	-66%	-44%	-31%
5 kW	-56%	-61%	-51%	-55%	-63%	-50%	-42%
7 kW	-56%	-60%	-53%	-56%	-61%	-52%	-47%

Lifespan of PV: 30 years

30 years	Continuous INTEGRAL	Continuous Energy Australia	Continuous Country Energy	TOU INTEGRAL	TOU Energy Australia	TOU Country Energy	Green Energy Australia
	Net Present value of investment in PV system						
1 kW	-$611	-$3,863	$3,003	-$21	-$5,257	$3,558	$8,863
3 kW	-$14,625	-$17,878	-$11,012	-$14,036	-$19,272	-$10,457	-$5,152
5 kW	-$26,145	-$29,398	-$22,532	-$25,556	-$30,792	-$21,977	-$16,672
7 kW	-$37,068	-$40,320	-$33,455	-$36,478	-$41,715	-$32,899	-$27,594
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-6%	-40%	31%	0%	-54%	36%	91%
3 kW	-45%	-55%	-34%	-43%	-59%	-32%	-16%
5 kW	-47%	-53%	-40%	-46%	-55%	-39%	-30%
7 kW	-47%	-51%	-42%	-46%	-53%	-42%	-35%

Governmental subsidies do help to achieve economical viability, by switching form Country Energy's TOU to Energy Australia's, with a lifespan of 25 years, and also becoming viable by switching from Country Energy's flat rate at a lifespan of 30 years. However, this is only true with a 1 kWp PV systems. onwards.

Second set: Governmental rebate and REC's for 5 years, payout at beginning

	ContinuousTariff			TOU Tariff			Green Tariff
	INTEGRAL	Energy Australia	Country Energy	INTEGRAL	Energy Australia	Country Energy	Energy Australia

Lifespan of PV: 20 years

	Net Present value of investment in PV system						
1 kW	-$3,310	-$5,424	-$962	-$2,927	-$6,330	-$601	$2,847
3 kW	-$19,470	-$21,584	-$17,122	-$19,087	-$22,490	-$16,761	-$13,314
5 kW	-$34,010	-$36,123	-$31,662	-$33,627	-$37,030	-$31,301	-$27,853
7 kW	-$48,160	-$50,274	-$45,812	-$47,777	-$51,180	-$45,451	-$42,003
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-0.36	-0.59	-0.10	-0.32	-0.68	-0.06	0.31
3 kW	-0.62	-0.69	-0.55	-0.61	-0.72	-0.54	-0.43
5 kW	-0.64	-0.68	-0.59	-0.63	-0.70	-0.59	-0.52
7 kW	-0.64	-0.67	-0.61	-0.63	-0.68	-0.60	-0.56

Lifespan of PV: 25 years

	Net Present value of investment in PV system						
1 kW	-$1,730	-$4,406	$1,242	-$1,245	-$5,553	$1,699	$6,064
3 kW	-$16,337	-$19,013	-$13,365	-$15,852	-$20,161	-$12,908	-$8,543
5 kW	-$28,892	-$31,568	-$25,919	-$28,407	-$32,715	-$25,463	-$21,098
7 kW	-$40,955	-$43,631	-$37,982	-$40,470	-$44,778	-$37,525	-$33,161
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-0.19	-0.48	0.13	-0.13	-0.60	0.18	0.66
3 kW	-0.52	-0.61	-0.43	-0.51	-0.65	-0.41	-0.27
5 kW	-0.54	-0.59	-0.49	-0.53	-0.61	-0.48	-0.40
7 kW	-0.54	-0.58	-0.50	-0.54	-0.60	-0.50	-0.44

Lifespan of PV: 30 years

	Net Present value of investment in PV system						
1 kW	-$111	-$3,363	$3,503	$479	-$4,757	$4,058	$9,363
3 kW	-$13,125	-$16,378	-$9,512	-$12,536	-$17,772	-$8,957	-$3,652
5 kW	-$23,645	-$26,898	-$20,032	-$23,056	-$28,292	-$19,477	-$14,172
7 kW	-$33,568	-$36,820	-$29,955	-$32,978	-$38,215	-$29,399	-$24,094
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-0.01	-0.36	0.38	0.05	-0.51	0.44	1.01
3 kW	-0.42	-0.52	-0.30	-0.40	-0.57	-0.29	-0.12
5 kW	-0.44	-0.51	-0.38	-0.43	-0.53	-0.37	-0.27
7 kW	-0.45	-0.49	-0.40	-0.44	-0.51	-0.39	-0.32

Including the REC payments, the same options as above become even better. Assuming a 30 year lifespan, also a switch from Integral's TOU-tariff becomes viable, with a 1 kW PV.
However, only the 1 kWp options are becoming viable, not any bigger system size.

d) Value of PV without rate switch savings

Household total electricity bills under various tariff options, with and without PV system.

Highlighted fields mark the most favourable tariff in the category.

Net HH electricity bill (incl. supply charge)	ContinuousTariffs			TOU Tariffs			Green Tariff
	INTEGRAL	Energy Australia	Country Energy	INTEGRAL	Energy Australia	Country Energy	Energy Australia
No PV	$876	$775	$988	$894	$732	$1,005	$1,170
1 kWp	$710	$627	$802	$704	$593	$836	$935
3 kWp	$380	$337	$431	$333	$315	$498	$475
5 kWp	$50	$48	$59	-$41	$36	$159	$17
7 kWp	-$280	-$241	-$313	-$415	-$242	-$179	-$441

Energy Australia's TOU tariff has been identified as the cheapest tariff for no PV, 1 kWp and 3 kWp PV. From 5 kWp on, Integral's TOU tariff is even better. Although the green tariff option would be even more favourable from 5 kWp on, it is not taken into account here.

Reductions in electricity bill by PV system output

Green highlighted fields indicating the biggest savin

	ContinuousTariff			TOU Tariff			Green Tariff
	INTEGRAL	EnergyAustralia	Country Energy	INTEGRAL	EnergyAustralia	Country Energy	EnergyAustralia
1 kW	$166	$149	$186	$190	$139	$169	$234
3 kW	$496	$439	$557	$561	$418	$508	$694
5 kW	$826	$727	$929	$935	$696	$846	$1,152
7 kW	$1,156	$1,016	$1,301	$1,310	$974	$1,185	$1,610

Integral Energy's TOU tariff is offering on all PV system size options the highest saving potential, besides the green option that, due to the higher rates (because eof the premium), delivers the biggest revenues of the PV system.

<u>First set: No governmental rebate, no REC's</u>

ContinuousTariff			TOU Tariff			Green Tariff
INTEGRAL	Energy Australia	Country Energy	INTEGRAL	Energy Australia	Country Energy	Energy Australia

Lifespan of PV: 20 years

	Net Present value of investment in PV system						
1 kW	-$10,265	-$10,629	-$9,852	-$9,762	-$10,830	-$10,200	-$8,832
3 kW	-$26,335	-$27,545	-$25,055	-$24,976	-$27,990	-$26,100	-$22,186
5 kW	-$42,413	-$44,491	-$40,258	-$40,127	-$45,152	-$42,000	-$35,576
7 kW	-$58,491	-$61,437	-$55,461	-$55,277	-$62,314	-$57,900	-$48,966
Gap to commercial viability of PV installation on the corresponding tariff							
1 kW	-0.75	-0.77	-0.72	-0.71	-0.79	-0.74	-0.64
3 kW	-0.72	-0.75	-0.68	-0.68	-0.76	-0.71	-0.60
5 kW	-0.71	-0.74	-0.67	-0.67	-0.76	-0.70	-0.60
7 kW	-0.71	-0.74	-0.67	-0.67	-0.75	-0.70	-0.59

Without any form of subsidy, none of the examined tariffs can achieve economical break even.

Lifespan of PV: 25 years

25years	Net Present value of investment in PV system						
1 kW	-$9,338	-$9,799	-$8,815	-$8,701	-$10,053	-$9,256	-$7,524
3 kW	-$23,565	-$25,097	-$21,944	-$21,844	-$25,661	-$23,267	-$18,312
5 kW	-$37,802	-$40,432	-$35,074	-$34,907	-$41,270	-$37,279	-$29,146
7 kW	-$52,038	-$55,768	-$48,203	-$47,970	-$56,879	-$51,291	-$39,980
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-0.68	-0.71	-0.64	-0.63	-0.73	-0.67	-0.55
3 kW	-0.64	-0.68	-0.60	-0.59	-0.70	-0.63	-0.50
5 kW	-0.63	-0.68	-0.59	-0.58	-0.69	-0.62	-0.49
7 kW	-0.63	-0.67	-0.58	-0.58	-0.69	-0.62	-0.48

Lifespan of PV:30 years

30 years	Net Present value of investment in PV system						
1 kW	-$8,388	-$8,948	-$7,752	-$7,613	-$9,257	-$8,288	-$6,183
3 kW	-$20,725	-$22,587	-$18,755	-$18,634	-$23,272	-$20,363	-$14,341
5 kW	-$33,074	-$36,271	-$29,758	-$29,556	-$37,289	-$32,439	-$22,554
7 kW	-$45,423	-$49,956	-$40,761	-$40,478	-$51,306	-$44,514	-$30,767
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-0.61	-0.65	-0.56	-0.55	-0.67	-0.60	-0.45
3 kW	-0.56	-0.61	-0.51	-0.51	-0.63	-0.55	-0.39
5 kW	-0.55	-0.61	-0.50	-0.49	-0.62	-0.54	-0.38
7 kW	-0.55	-0.60	-0.49	-0.49	-0.62	-0.54	-0.37

Even with increasing lifespan, the PV system can't by far be paid off without any subsidies.

Second set: Governmental rebate, no REC's

ContinuousTariff			TOU Tariff			Green Tariff
INTEGRAL	Energy Australia	Country Energy	INTEGRAL	Energy Australia	Country Energy	Energy Australia

Lifespan of PV: 20 years

	Net Present value of investment in PV system						
1 kW	-$6,265	-$6,629	-$5,852	-$5,762	-$6,830	-$6,200	-$4,832
3 kW	-$22,335	-$23,545	-$21,055	-$20,976	-$23,990	-$22,100	-$18,186
5 kW	-$38,413	-$40,491	-$36,258	-$36,127	-$41,152	-$38,000	-$31,576
7 kW	-$54,491	-$57,437	-$51,461	-$51,277	-$58,314	-$53,900	-$44,966
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-0.64	-0.68	-0.60	-0.59	-0.70	-0.64	-0.50
3 kW	-0.68	-0.72	-0.64	-0.64	-0.73	-0.67	-0.56
5 kW	-0.69	-0.73	-0.65	-0.65	-0.74	-0.68	-0.57
7 kW	-0.69	-0.73	-0.65	-0.65	-0.74	-0.68	-0.57

Lifespan of PV: 25 years

25years	Net Present value of investment in PV system						
1 kW	-$5,338	-$5,799	-$4,815	-$4,701	-$6,053	-$5,256	-$3,524
3 kW	-$19,565	-$21,097	-$17,944	-$17,844	-$21,661	-$19,267	-$14,312
5 kW	-$33,802	-$36,432	-$31,074	-$30,907	-$37,270	-$33,279	-$25,146
7 kW	-$48,038	-$51,768	-$44,203	-$43,970	-$52,879	-$47,291	-$35,980
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-0.55	-0.59	-0.49	-0.48	-0.62	-0.54	-0.36
3 kW	-0.60	-0.64	-0.55	-0.54	-0.66	-0.59	-0.44
5 kW	-0.61	-0.65	-0.56	-0.55	-0.67	-0.60	-0.45
7 kW	-0.61	-0.66	-0.56	-0.56	-0.67	-0.60	-0.46

Lifespan of PV: 30 years

30 years	Net Present value of investment in PV system						
1 kW	-$4,388	-$4,948	-$3,752	-$3,613	-$5,257	-$4,288	-$2,183
3 kW	-$16,725	-$18,587	-$14,755	-$14,634	-$19,272	-$16,363	-$10,341
5 kW	-$29,074	-$32,271	-$25,758	-$25,556	-$33,289	-$28,439	-$18,554
7 kW	-$41,423	-$45,956	-$36,761	-$36,478	-$47,306	-$40,514	-$26,767
Gap to commercial viability of PV instalation on the corresponding tariff							
1 kW	-0.45	-0.51	-0.38	-0.37	-0.54	-0.44	-0.22
3 kW	-0.51	-0.57	-0.45	-0.45	-0.59	-0.50	-0.32
5 kW	-0.52	-0.58	-0.46	-0.46	-0.60	-0.51	-0.33
7 kW	-0.53	-0.58	-0.47	-0.46	-0.60	-0.51	-0.34

The governmental rebate of 4000$ is helping, but still doesn't make any PV system size under any tariff economically .viable

Second set: Governmental rebate, REC's for 5 years, payout at beginning

	ContinuousTariff			TOU Tariff			Green Tariff
	INTEGRAL	Energy Australia	Country Energy	INTEGRAL	Energy Australia	Country Energy	Energy Australia

Lifespan of PV: 20 years

	Net Present value of investment in PV system						
1 kW	-$5,765	-$6,129	-$5,352	-$5,262	-$6,330	-$5,700	-$4,332
3 kW	-$20,835	-$22,045	-$19,555	-$19,476	-$22,490	-$20,600	-$16,686
5 kW	-$35,913	-$37,991	-$33,758	-$33,627	-$38,652	-$35,500	-$29,076
7 kW	-$50,991	-$53,937	-$47,961	-$47,777	-$54,814	-$50,400	-$41,466
	Gap to commercial viability of PV installation on the corresponding tariff						
1 kW	-0.62	-0.66	-0.58	-0.57	-0.68	-0.62	-0.47
3 kW	-0.67	-0.71	-0.63	-0.62	-0.72	-0.66	-0.53
5 kW	-0.67	-0.71	-0.63	-0.63	-0.73	-0.67	-0.55
7 kW	-0.68	-0.72	-0.64	-0.63	-0.73	-0.67	-0.55

Lifespan of PV: 25 years

	Net Present value of investment in PV system						
1 kW	-$4,838	-$5,299	-$4,315	-$4,201	-$5,553	-$4,756	-$3,024
3 kW	-$18,065	-$19,597	-$16,444	-$16,344	-$20,161	-$17,767	-$12,812
5 kW	-$31,302	-$33,932	-$28,574	-$28,407	-$34,770	-$30,779	-$22,646
7 kW	-$44,538	-$48,268	-$40,703	-$40,470	-$49,379	-$43,791	-$32,480
	Gap to commercial viability of PV installation on the corresponding tariff						
1 kW	-0.52	-0.57	-0.47	-0.45	-0.60	-0.51	-0.33
3 kW	-0.58	-0.63	-0.53	-0.52	-0.65	-0.57	-0.41
5 kW	-0.59	-0.64	-0.54	-0.53	-0.65	-0.58	-0.43
7 kW	-0.59	-0.64	-0.54	-0.54	-0.66	-0.58	-0.43

Lifespan of PV: 30 years

	Net Present value of investment in PV system						
1 kW	-$3,888	-$4,448	-$3,252	-$3,113	-$4,757	-$3,788	-$1,683
3 kW	-$15,225	-$17,087	-$13,255	-$13,134	-$17,772	-$14,863	-$8,841
5 kW	-$26,574	-$29,771	-$23,258	-$23,056	-$30,789	-$25,939	-$16,054
7 kW	-$37,923	-$42,456	-$33,261	-$32,978	-$43,806	-$37,014	-$23,267
	Gap to commercial viability of PV installation on the corresponding tariff						
1 kW	-0.42	-0.48	-0.35	-0.34	-0.51	-0.41	-0.18
3 kW	-0.49	-0.55	-0.42	-0.42	-0.57	-0.48	-0.28
5 kW	-0.50	-0.56	-0.44	-0.43	-0.58	-0.49	-0.30
7 kW	-0.50	-0.56	-0.44	-0.44	-0.58	-0.49	-0.31

Even including rebate and REC pay outs, the PV system does not become viable under any tariff option. It is closest to on the green tariff option, but on a TOU option still 34% loss would have to be financed.

NOTE: The analysis for SA and VIC has been undertaken but not included in full detail yet. The completion of this part will be undertaken if further interest on this topic is being expressed.

B. SOUTH AUSTRALIA

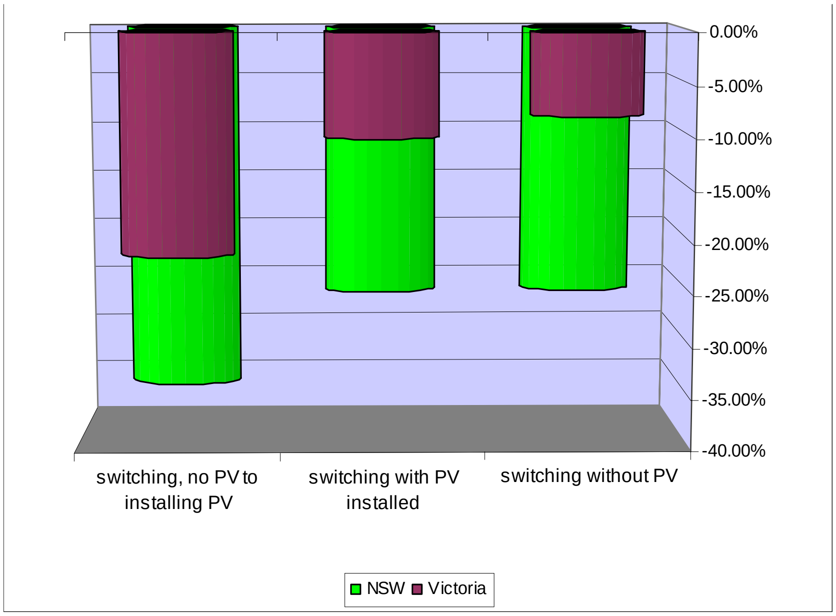
In SA; AGL is the dominating retailer – although other retailers have entered the market, no information regarding their tariffs could be found. Therefore, only AGL's residential continuous and green tariff option have been examined.

C. VICTORIA

The main finding in Victoria in comparison to NSW is:

1. Rate differences between the examined retailers' tariffs are higher in NSW, only very small in VIC.
2. In VIC, both TOU tariffs are lower then the continuous tariffs
3. Despite the generally higher tariffs in VIC, the green tariffs in NSW and VIC are almost equal

Figure IV-D-1: Comparison of maximal saving potential of a HH in NSW and VIC by opting to the most favourable of the examined tariffs



D. CONCLUSION OF THE VALUE OF PV TO RESIDENTIAL CUSTOMERS

1. TARIFF ANALYSIS:

NSW tariffs lowest, followed by VIC and the almost monopolistic SA. In general, tariff structure in AUS is very complex, a variety of tariffs are available.
TOU tariffs are widely available in NSW and VIC, but not for residential customers in SA so far. The precondition is a net meter, which is being supplied under various conditions.
Also, so called green tariffs, for electricity sourced from renewables, are available in a broad variety. Those tariffs are in all cases mire expensive then the corresponding regular tariff from the same retailer. The green tariff options in SA are the most expensive ones. Surprisingly, the option in VIC is cheaper then the one in NSW.

2. VALUE OF PV TO RESIDENTIAL CUSTOMER:

TOU tariffs are favourable for PV with most retailer tariffs, generally the benefit increases with PV system size. For a 1 kW PV system, a benefit of 10% can be achieved, compared with a regular continuous rate.

Generally, for residential consumers it is more favourable to being supplied on a time-of-use-tariff. Possible benefits of switching the retailer respectively the tariff can be dramatic, up to 25%.
Combining rate switch savings with installing a PV system can lead to savings of up to 35% on the electricity bill with a 1 kW PV. In NSW, this saving makes a 1 kW PV system commercially viable!

1. The PV system has the highest value under a net metering option, as it can feed into the grid

2. Financial viability of installing a 1 kWp system can be achieved by switching from the most disadvantageous tariff to the most favourable tariff option.
3. Without the rate switch savings, under the presumed conditions, the calculations have proven no economical viability. Even including the governmental rebate and Rec payments for 5 years and a lifespan of 30 years, a loss of at least 34% has been calculated. Regular tariffs are simply too low respectively prices of PV systems too high.
4. The value of PV is generally highest under the TOU-tariffs. Nevertheless, the above calculations have shown that the advantage is due to the overall lower electricity bill and in most cases not due to better match with PV output pattern.
5. This is especially true for green tariffs- economical viability is achieved more easily for a HH supplied on a green tariff.
6. The previous financial calculations have shown that the saving potential for a household on a green tariff is in general higher then on a regular tariff.

One important aspect that needs to be regarded is that the cell type that has been used here is not state of the art. Thus, modern PV modules would probably come closer to commercial viability. Nevertheless, the value of PV to private customers on regular feed-in tariffs is too low if only regular tariffs are being paid for PV generated electricity. Nevertheless, a PV system is actually not only beneficial for the owner by generating electricity, but also to the electricity industry, as it is an distributed generation. Part B of this report will examine this point further.

NOTE: These results are highly dependent on customer's actual load profile.
Results will change for customers that differ from the profile that has been used.

E. TAKING ANALYSIS FURTHER

1. Improved supply security for PV owner

Monetary appreciation has to be evaluated

2. Green House Gas Emission reductions increasing value

In this analysis only RECs at a relatively low rate and for an initial time period of five years have been assessed. If value of such certificates increases in the future and could be sold by the PV owner for the whole lifespan, this aspect has the potential of bringing the PV system to break even. This aspect is depending on governmental policy/ global emissions certificates trading

3. Assessing PV system cost reductions

This work has not taken into account the ongoing price decrease for PV systems. Recent trends could be assessed to estimate the point of time at which PV systems prices have declined enough to close the gap to commercial viability

4. SOLAR Tariff vs. OWN PV SYSTEM

Comparison of HH bill with a PV system on the most favourable tariff option vs. buying green electricity.

➔ Origin Energy is offering a supply option of 100% Solar electricity. The option of buying 100% Solar electricity is 12% more expensive then the cheapest green option in VIC

➔ First calculations have indicated that the Solar tariff is more favourable.

The household would require roughly a 5 kWp PV system to generate the electricity it consumes per year.

5. Green tariff or own PV

Examine whether more favourable to obtain Green electricity on a continuous or TOU tariff basis

PART B- Value of PV system to electricity retailing companies

I. Introduction

The value of grid-connected, distributed PV systems to retailing companies is far more complex then the value to the residential PV system owners, the households, which has been described in the previous part of this report.

As retailers are being accounted for electricity network losses, additional value of PV systems by avoiding failures (often occurring during peaks) would benefit them.

Retailers are also being held responsible for environmental costs (for instance RET).

Therefore, I am focusing on retailers to assess the value of PV to the Electricity Industry as it is impacting them in the most direct way.

In addition, vale to retailing companies is easiest to asses from the outside.

Although internal data from the companies is not publicly available, publicly available data can be used. The author is basing the analysis on data from NEM Spot Market – demand and RPRs in NSW, SA and VIC. The retailer value is therefore in saved NEM purchases, less reduced revenue from the households.

The reason for evaluating this topic is that electricity pricing to the customer does not reflect the real cost of supply and production any more. The problem is the increasingly peaky load, which is mainly driven by extensive use of Air Conditioners in new urban domestic dwellings.

Besides, demand is rising in general.

A. SCOPE

The scope of the following analysis is to

- ➔ Verify the pattern of residential A/C use
- ➔ Evaluate the contribution that PV could make in meeting this demand by
  - o The correlation of high household demand (caused by A/C use) and NEM high loads / high RPRs
  - o Correlation of PV with NEM load and RPR pattern
  - o Calculating the value of the PV system by NEM prices

B. METHODOLGY:

Since the liberalisation of the electricity market in Australia and the founding of NEMMCO, data of electricity prices to wholesalers is publicly available. As obtaining appropriate data from each and every retailer was not possible under this circumstances, the NEM spot market data has been assessed. However, I am aware that NEM indicators by themselves are not sufficient in evaluating the entire value to retailers, as they do not represent restraints in distribution networks, etc. A full analysis of the value would include an analysis of Spot market prices as well as the derivates market. To simplify the analysis, only NEM RPRs and demand are being assessed.
The conducted analysis is thus traditional, as the real value of PV lies in the risk reduction and deference of network investments. Therefore the focus lies on qualitative analysis.

Due to the complex nature of the market, the necessary data to evaluate this issue could not be obtained.
Thus it can be said that the indications of this report are conservative and the potential of value of distributed PV systems in most cases even higher.

The analysis is focused on the states of New South Wales and South Australia, as none of the PV or HH data is related to VIC in any way.
The analysis is based on empirical data of a PV system and a residential household. It is the same as in part A of this report.

The examined period is analogue to the residential value analysis: 1st April 2002 to 31 March 2003.

As suggested, I generated correlation graphs in order to analyse whether extreme high RPRs are related to high demand or not:

For this analysis, a high RPR event is defined being higher then 300$.

A high demand event being higher then 90% of max load, and a significant PV output exceeding 10% nominal PV system capacity.

C. DEFINITIONS

1. The spot market

"Each retailer, must purchase the energy to supply their customers from the National Electricity Market (NEM) at the spot price set be the National Electricity Market Management Company (NEMMCO).

For every half-hour trading interval in the NEM, generators make offers to NEMMCO to supply the spot market with defined amounts of electricity at particular offer prices. From all offers submitted, NEMMCO selects the generating units and production levels required to produce electricity sufficient to meet forecast demand in the most cost-efficient way and issues dispatch instructions to the generators for every five-minute dispatch interval. A separate pool price is determined for each of the five regions in the NEM. The dispatch price for each five-minute dispatch interval is set by the offer price of the last increment of generation necessary to meet demand. Six dispatch prices are averaged for each half-hour trading interval to determine the *spot price* of electricity for the trading interval. The movement in the spot price can be volatile, reflecting:

- ➔ the non-storable characteristic of electricity — electricity demand and generation has to be kept in balance at all times to maintain power system security
- ➔ the step shape of the generation supply curve;
- ➔ the price inelastic nature of electricity demand in the short term; and
- ➔ bidding behaviour of generators, which is influenced by their contracted positions."

[Source: The Allen Consulting Group- W H O L E S A L E E N E R G Y P R I C E S T U D Y – F I N A L R E P O R T, p 7,8]

2. The NEM Spot Market Price (RPR)

The cost of electricity to the retailers consists of many components. The NEM spot price is not, by itself, the wholesale purchase price for electricity. NEMMCO states that in average only 20% of the end-user tariffs are being made up by the NEM spot market price:

"Only about 20 percent of the price paid by domestic and business consumers for electricity supply is accounted for by the direct cost of the energy. Additional charges are added to retail accounts for network usage, service fees, market charges, the retailer's profit margin and the GST."

(NEMMCO "Introduction to Australian electricity market" www.nemmco.com.au)

The wholesale price for electricity varies for each retailer as it is also determined by

(1) the shape of the retailer's actual half-hourly load,

(2) the extent to which the retailer enters into hedge contracts outside the spot market;

(3) the strike price of these hedge contracts; and

(4) other costs of participating in the NEM and buying energy — NEM fees, bank guarantees, ancillary services, embedded generation and Mandatory Renewable Energy Target (MRET) certificates.

In addition, retailers would add their operating costs and profit margin to calculate the end-user tariffs.

II. Analysis

A. ANALYSIS OF NEM SPOT MARKET

Figure B-III-A-1: Demand and RPR in NSE, SA and VIC from 1 April 2002 – 31 March 2003

	NSW		SA		VIC	
	Demand (MW) per 30min interval	RPR ($/MW)	Demand (MW) per 30min interval	RPR ($/MW)	Demand (MW) per 30min interval	RPR ($/MW)
Min	4,976	$3.09	960	-$246.57	3,736	-$228.01
Max	12,331	$8,047.61	2,787	$4,453.65	8,041	$4,906.09
Average	8,190	$40.62	1,494	$35.41	5,482	$32.56
Sum	143,492,692		26,168,377		96,047,728	

Figure B-III-A-2: Average RPR ($/MW) per year from 1999 to 2004

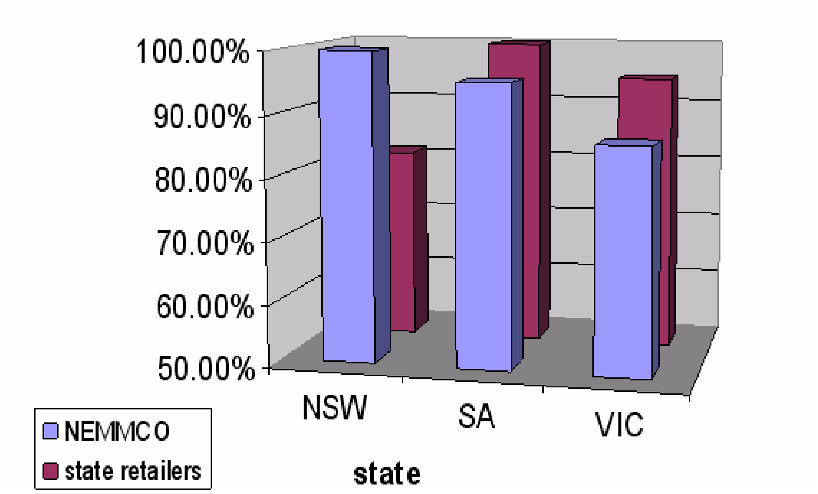
Year	NSW	SA	VIC
1999-2000	$28.27	$59.27	$26.35
2000-2001	$37.69	$56.39	$44.57
2001-2002	$34.76	$31.61	$30.97
2002-2003	$32.91	$30.11	$27.56
2003-2004	$32.37	$34.86	$25.38
Average	$33.20	$42.45	$30.97

RPRs in NSW are extraordinary high in comparison to averages in five years, whereas RPRs in SA are lower.

Table 1 also shows the difference in the size of the three markets, with NSW being by far the biggest, followed by VIC and SA.

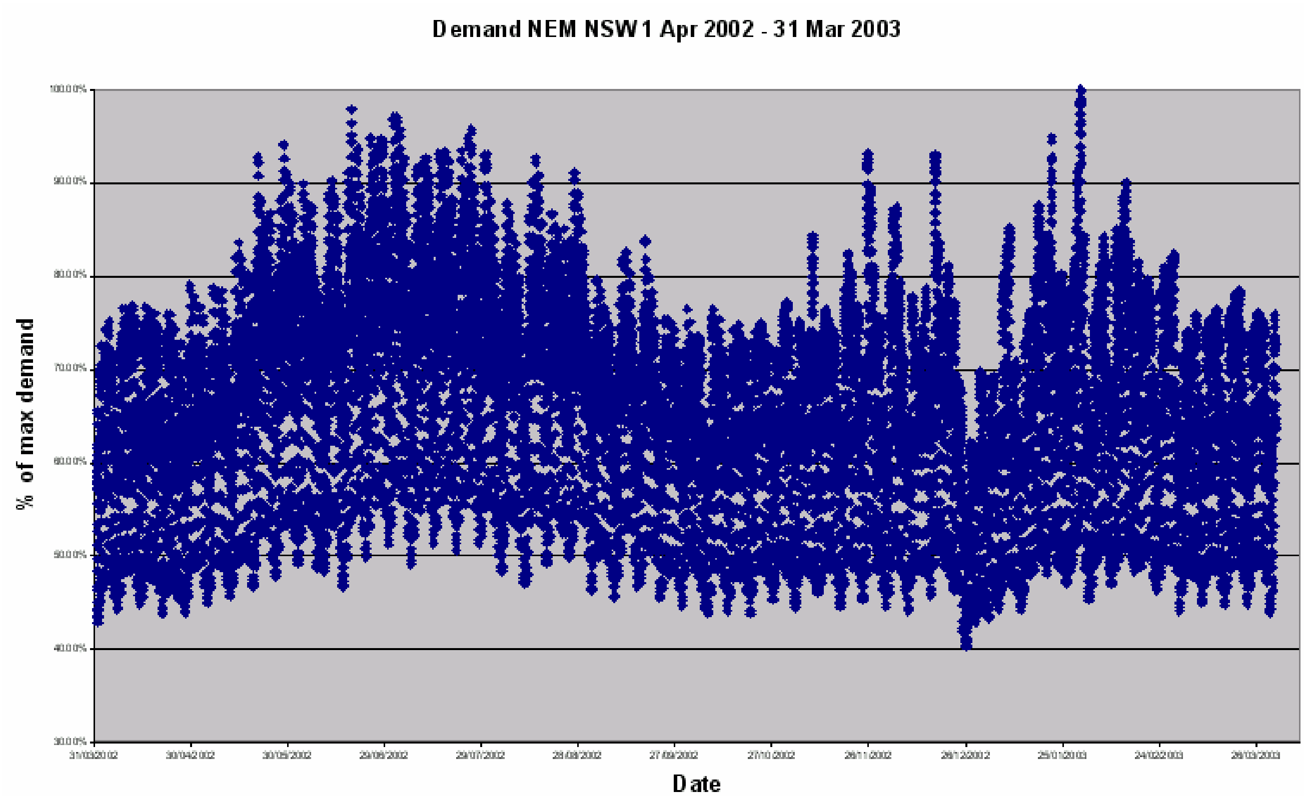
Table 2 indicates that significant variations are occurring in the three NEM markets , with SA being the most volatile during the five years.

Figure B-III-A-3: Comparison of NEM RPR averages in examined period to median of examined residential tariffs per state [highest = 1]
Note: Retail tariffs valid from 2004 and 2005



This chart is showing an contrast in NEM prices and retailing tariffs. Although retailers in NSW offer in average the lowest tariffs to residential customers, the NEM average price is higher then in SA and VIC during the examined year. Although the tariffs are not historical but current tariffs and thus do not correspond, it can be presumed that tariff structure in 200-2003 was not significantly different. Thus, retailing companies in NSW were probably facing much tougher competition then the retailers in the other states, as their margin was apparently much lower.

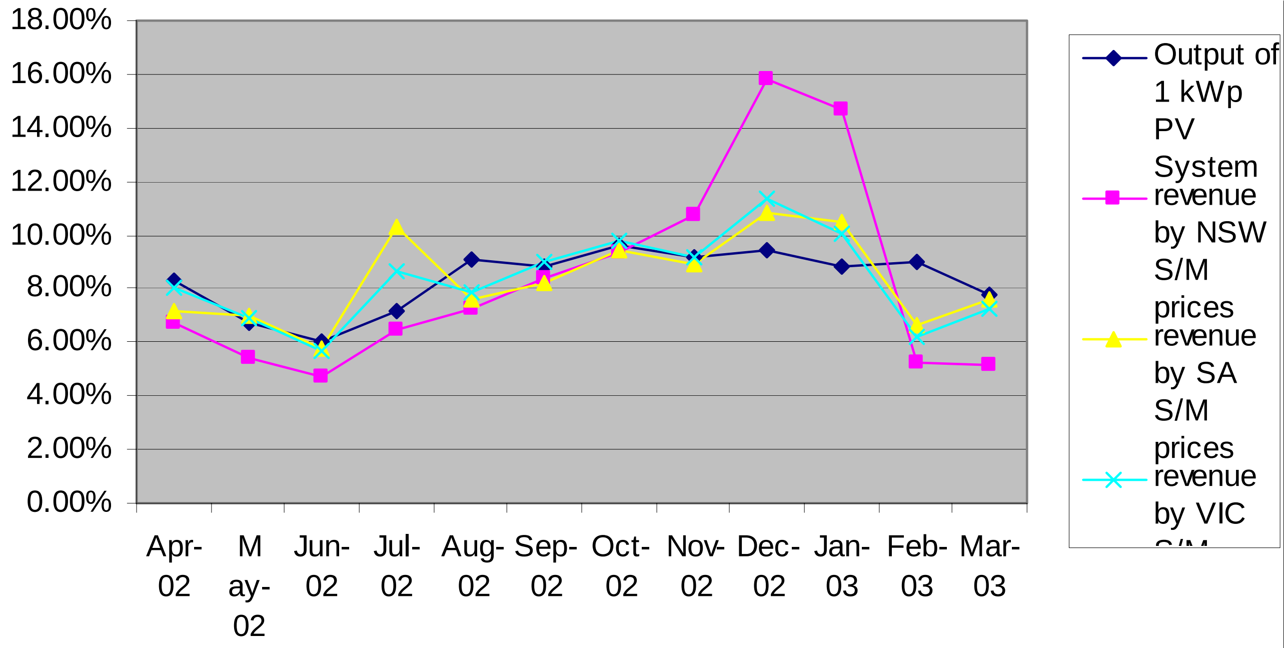
Figure B-III-A-4: Demand in the NSW Spot market in % of maximum demand, 1 Apr 2002 – 31 March 2003



The demand shows it’s peaks during the month of june, july 2002, but the maximum occurring in January 2003. During the late spring and summer month, demand is significantly peakier.

B. VALUE OF PV BY NEM SPOT MARKET PRICES

Figure B-III-C-1: Revenue and output of PV system by NEM Spot market prices per month, relative to total of examined period



The above graph suggests that exceptionally high prices push the revenue of the PV system in Dec 2002 and Jan 2003 in all states, additionally in VIC and SA in July 2002. The decreasing revenue in Feb 2003 is consequently caused by lower prices.

Figure B-III-C-2: Revenue of 1 kWp PV system output per month in SA and NSW and revenue due to extreme high RPR events (>300$)

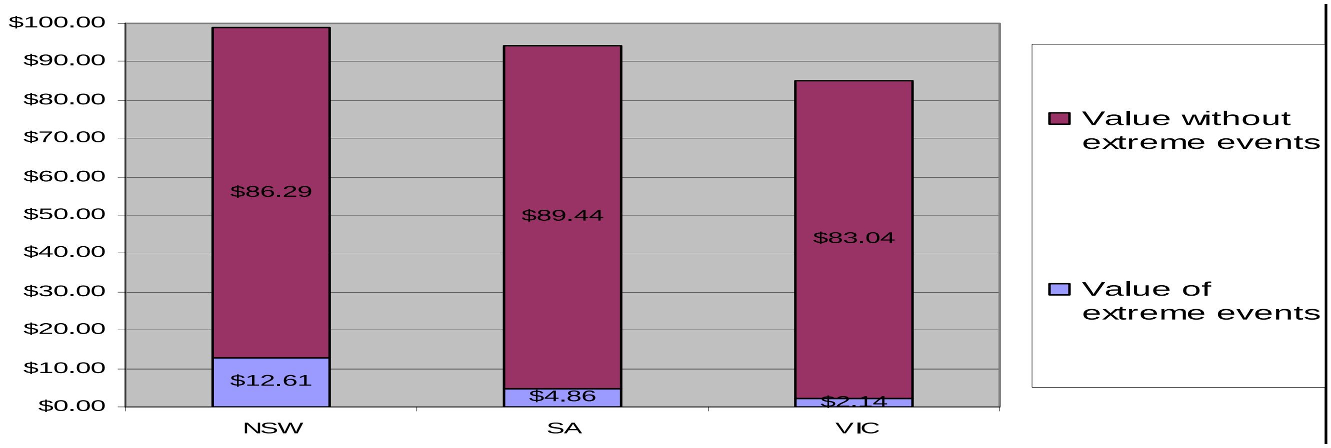
Revenue of 1kWp PV system by NEMMCO Spot Market prices				
	NSW			
Min	$4.70	4.75%	-$0.25	-4.71%
Max	$15.67	15.84%	$5.66	38.95%
Average	$8.24	8.33%	$0.92	5.73%
Sum	$98.90	100.00%	$11.08	
	$ per month	Percent of total revenue	Revenue of solely extreme events	% of revnue due to extreme events
Total	$98.90	100.00%	$11.08	11.20%
Apr	$6.61	6.69%	$0.00	-0.02%
May	$5.39	5.45%	-$0.25	-4.71%
Jun	$4.70	4.75%	-$0.20	-4.27%
Jul	$6.40	6.47%	-$0.08	-1.33%
Aug	$7.20	7.28%	$0.00	0.00%
Sep	$8.29	8.38%	-$0.01	-0.07%
Oct	$9.21	9.31%	$0.00	0.00%
Nov	$10.60	10.71%	$0.69	6.52%
Dec	$15.67	15.84%	$5.28	33.68%
Jan	$14.52	14.68%	$5.66	38.95%
Feb	$5.22	5.28%	$0.00	0.00%
Mar	$5.10	5.15%	$0.00	0.00%

	SA			
Min	$5.45	5.78%	-$0.14	-2.05%
Max	$10.24	10.86%	$2.78	28.56%
Average	$7.86	8.33%	$0.30	3.13%
Sum	$94.29	100.00%	$3.60	
	$ per month	Percent of total revenue	Revenue of solely extreme events	% of revnue due to extreme events
Total	$94.29	100.00%	$3.60	3.82%
Apr	$6.79	7.20%	-$0.01	-0.11%
May	$6.59	6.99%	-$0.14	-2.05%
Jun	$5.45	5.78%	-$0.09	-1.60%
Jul	$9.72	10.31%	$2.78	28.56%
Aug	$7.20	7.64%	$0.00	0.00%
Sep	$7.72	8.19%	$0.00	0.00%
Oct	$8.89	9.43%	$0.52	5.89%
Nov	$8.40	8.91%	$0.00	0.00%
Dec	$10.24	10.86%	$0.09	0.89%
Jan	$9.87	10.47%	$0.07	0.67%
Feb	$6.28	6.66%	$0.00	0.00%
Mar	$7.13	7.56%	$0.38	5.27%

In NSW, November, December and January are the significant month with high revenue, which in December and January is especially high due to high RPRs above 300$, the extreme events. In total, 11% of revenue is due to extreme high RPR events- this is significantly higher then the 3.8% in South Australia. Nevertheless, the significance of extreme RPR events can be seen in SA in the month of July, which is not a month of high solar radiation, but nevertheless returns high revenues, because of high RPRs.

During the Fall and Winter month May and June, extreme RPR events resulted even in negative influence of extreme events in both states.

Figure B-III-C-3: Visual indication of proportion of value of PV by NEM RPRs that is due to extreme high RPRs (>300$) in NSW, SA, VIC



Extreme high RPRs play a significant role for the value of PV in NSW during the examined period, but are almost not relevant in VIC.

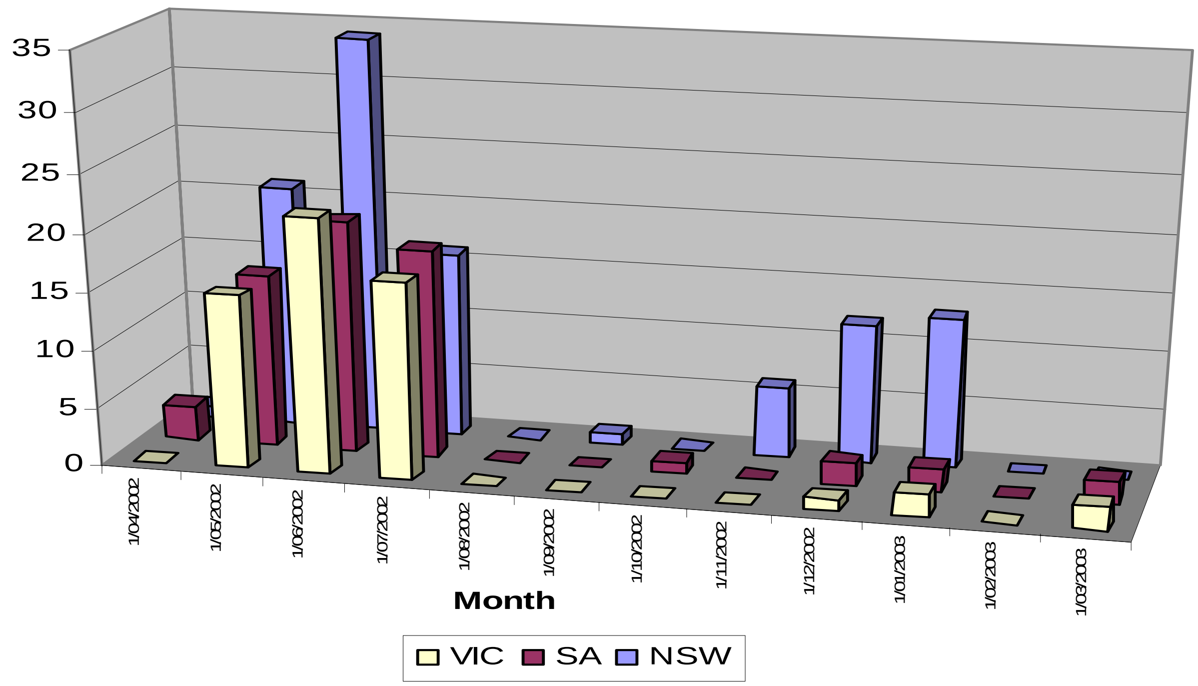
Without extreme events, the PV would even have a higher total value in SA..

Those charts indicate that extreme high RPRs could be a key to for the value of a residential grid-feeding PV-systema and thus need to be analysed further.

C. ANALYSIS OF EXTREME HIGH RPR EVENTS:

1. High NEM spot market prices (RPR > 300$)

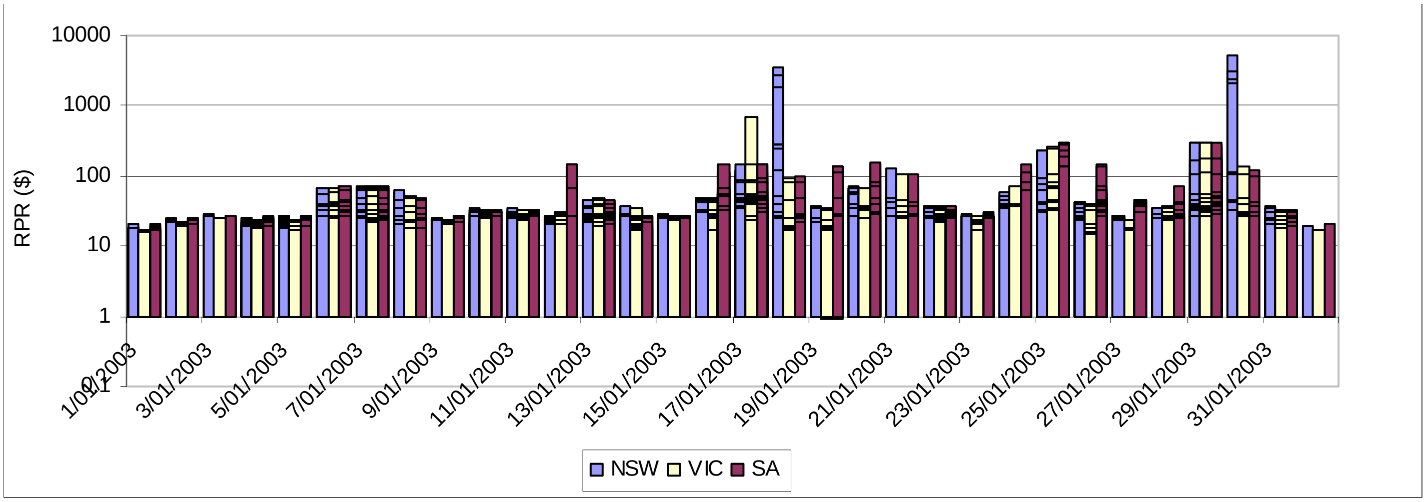
Figure B-III-C-1: Number of extreme RPR events in NSW, SA, VIC



a. The pattern is similar in all three states, although NSW has a higher level; by far most extreme events occur here, followed by SA and VIC

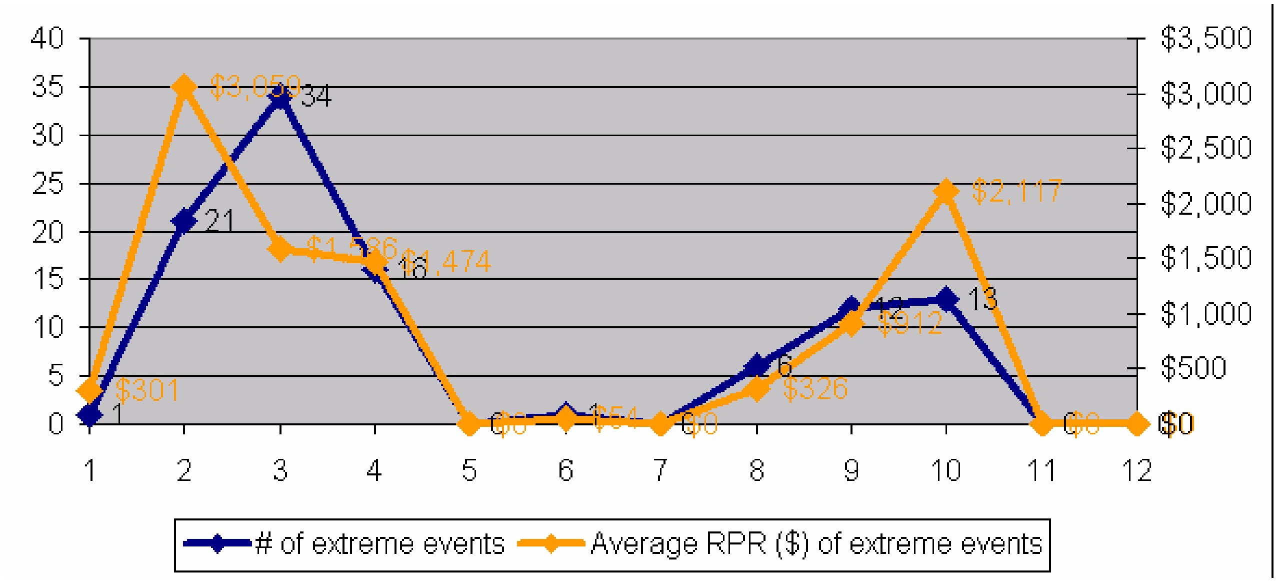
b. Most extreme events occur in the Winter-month May, June and July, only NSW has another block of RPR events in the Nov, Dec, Jan.

Figure B-III-C-2: Value of PV by NEM RPRs in Jan 03 in NSW, SA, VIC



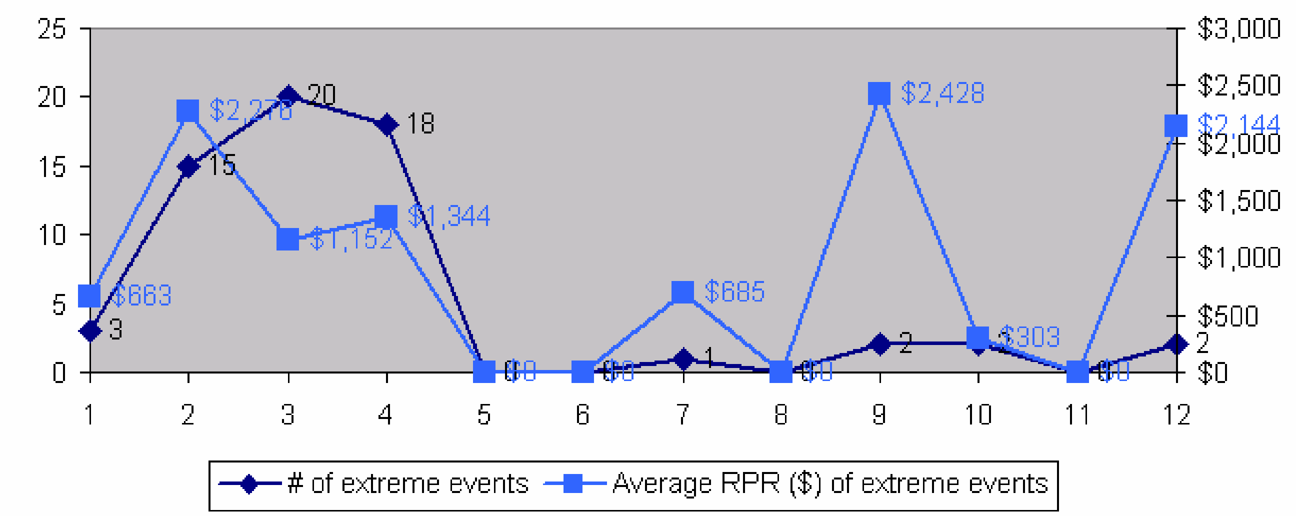
The visualisation shows that the pattern in the three states is similar, but NSW breaking out on two days well above 1000$, whereas otherwise only SA coming close to 1000$ once.

Figure B-III-C-3: Number of extreme RPRs vs. average of RPRs higher then 300$ per month on NSW spot market, 1 Apr 2002 – 31 Mar 2003



The number of events correlates well with the prices, except for May02 and Jan 03, when prices are very high in average although number of events is not cooresponding. The opposite is true during June 2002, many events occur but the average price is relatively low.

Figure B-III-C-4: Number of extreme RPRs vs. average of RPRs higher then 300$ per month on SA spot market, 1 Apr 2002 – 31 Mar 2003



The correlation is less significant in SA, especially due to only few events during the spring and summer month, although the few that due happen in Dec02 and Mar03.

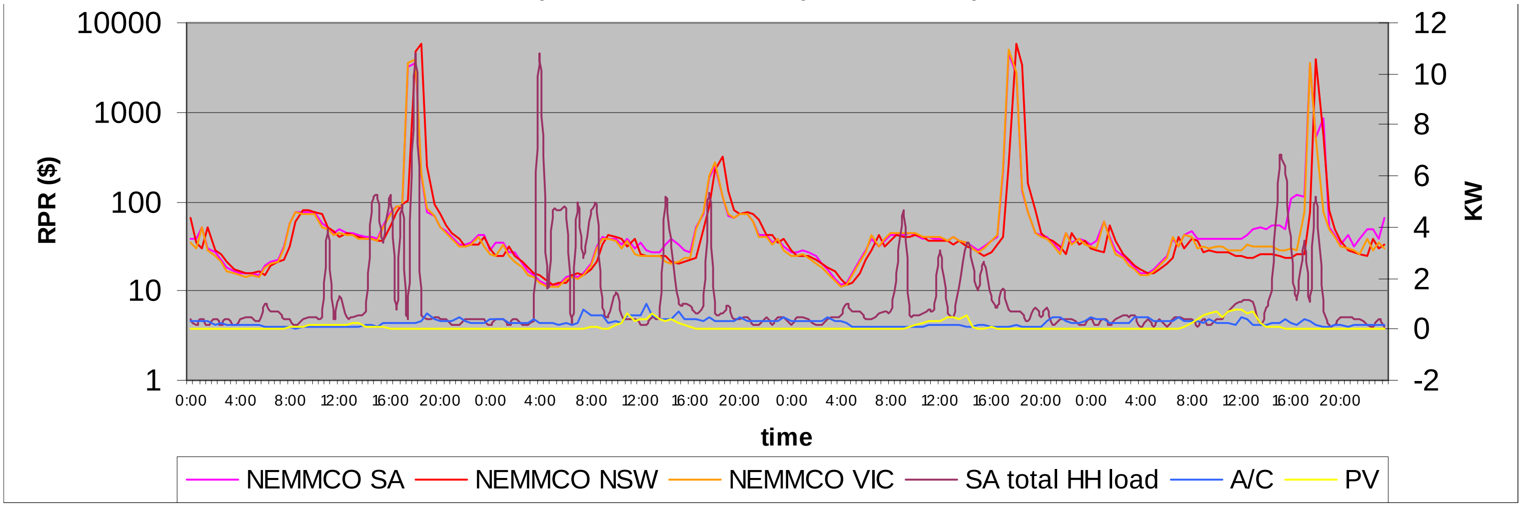
I identified May 2002 as the key month regarding extreme events due to highest average RPRs, although most events occurred in June.

Thus, the following periods are being examined in more detail:

➔ 18 – 22 May 2002

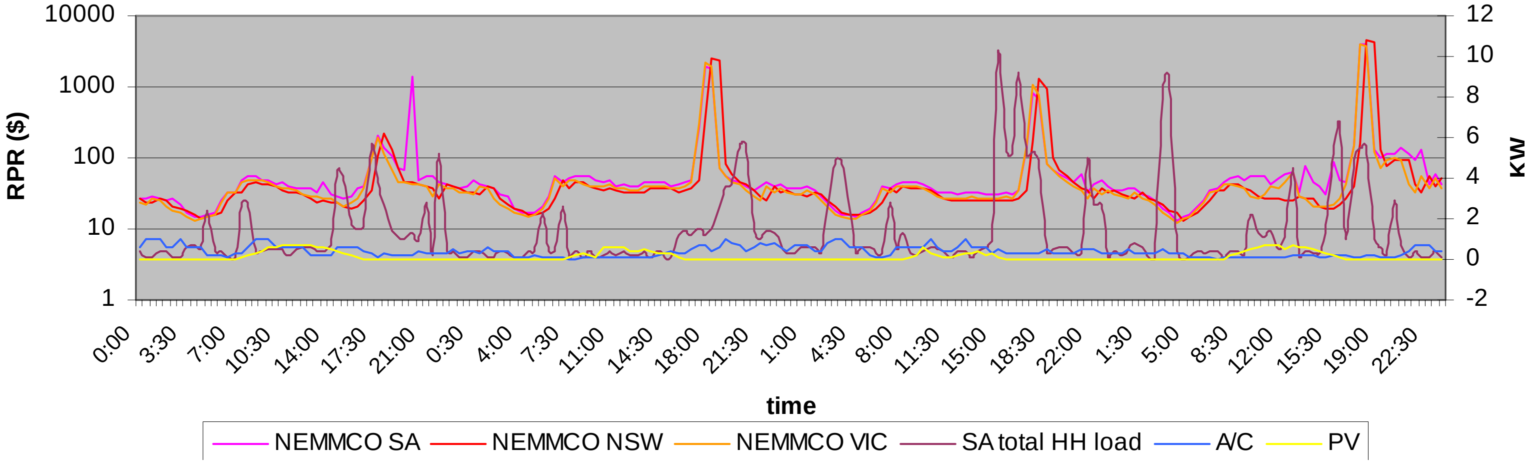
➔ 26 - 31 May 2002

Figure B-III-C-4: Analysis of coincidence of high Spot Market RPRs vs kWp PV, HH load and A/C, 18 – 21 May 2002, Saturday - Tuesday



The high RPRs occur in all three states very simultaneously in this period. The extreme events occur in the evening, with the extreme peaks at about 6pm, at times when PV can not contribute significantly!

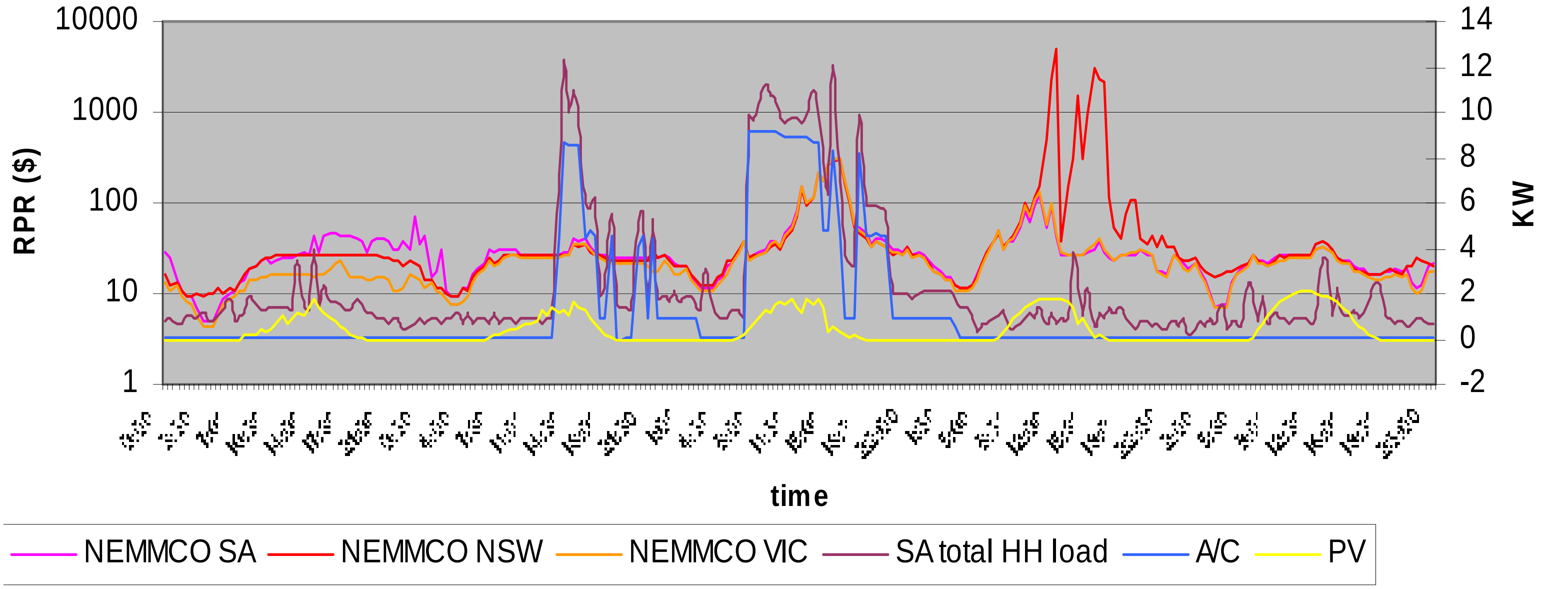
Figure B-III-C-5: Analysis of coincidence of high Spot Market RPRs vs kWp PV, HH load and A/C, 27 – 30 May 2002, Monday - Thursday



The second examined period confirms the results- PV does not show the potential to reduce the extreme peaks, as the occur in the evening. Even the household's consumption during weekdays is hardly at the same time as PV output times.

To analyse whether this is also true during summer, a significant period was identified:

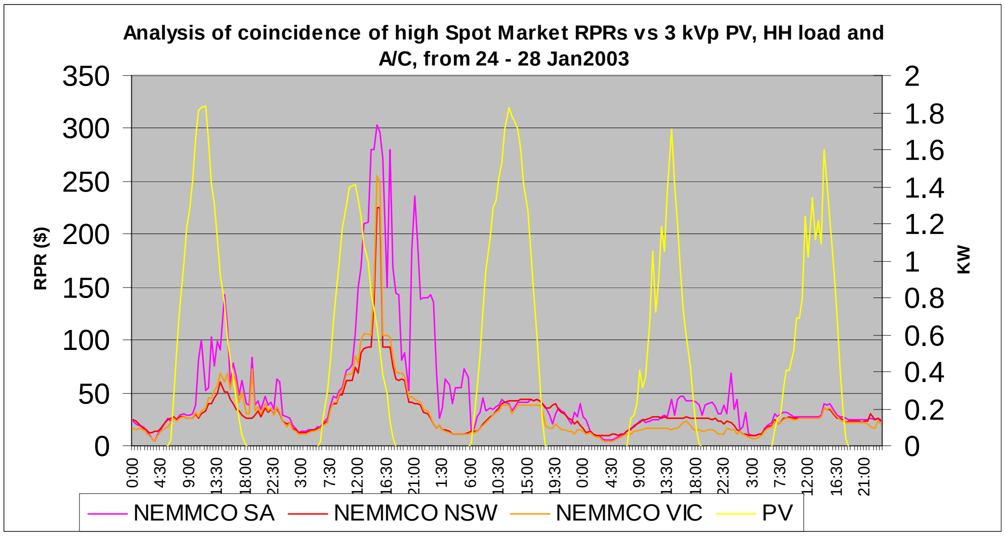
Figure B-III-C-6: HH total load, A/C vs PV output (3 kWp system) vs NEM SA, VIC and NSW period from 27 – 31 Jan03, Mon - Fri



In this period, the NEW RPRs are not showing such synchronous peaks in the evening, but rather during the day, although they are not as parallel. The Air Conditioner use of the family is increasing the HH demand dramatically on Tuesday and Wednesday and runs very closely with the RPR increase in NSW. It seems that the high RPRs are related to the AC use. This period is also including one extremely high RPR in NSW at >5000 $, which, in difference to the events in winter, occurs in the early afternoon, at a time when PV does generate electricity.

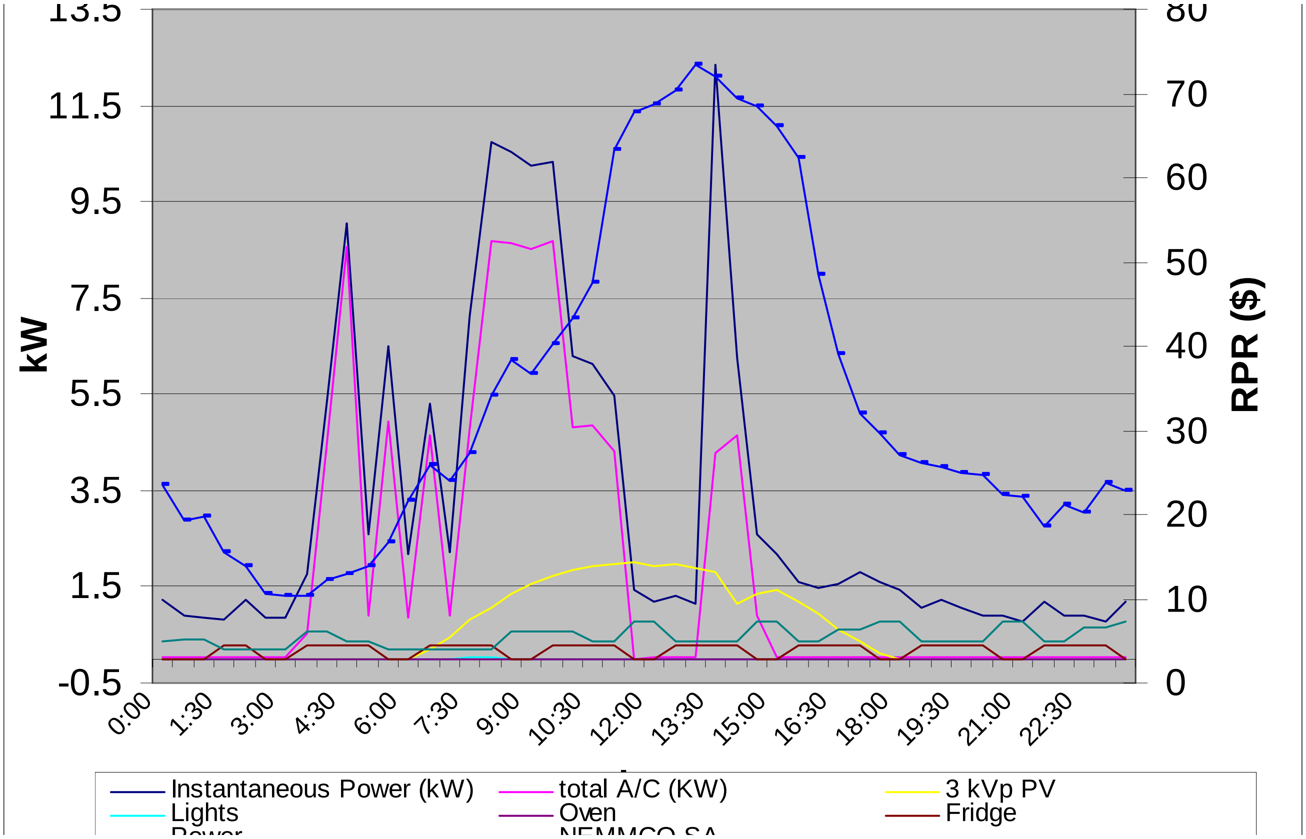
To examine it further whether this is typical in the summer month, a period without extreme high RPRs (period: 24 – 28 Jan 2003) has been examined.

Figure B-III-C-6: 3 kWp PV vs NEM RPRs in NSW, VIC, SA



It does seem as if the peaks of RPRs are shifted to an earlier time during summer, when PV could actually contribute to reduce the peaks. The day of the highest HH single load scan is being analysed further.

Figure B-III-C-7: Load profile of HH, AC vs PV vs NEM SA on Tuesday, 7 Jan 2003



Again, NEM RPR peak does not occur in the evening, but in the afternoon. It occurs exactly at the same time when the household's air conditioner is being used extensively. Thus, it can be presumed that the high RPR is due to high temperature and increased AC use. At this time, PV would be capable of delivering electricity to reduce the households demand.

Overall, my conclusion is: PV does potentially generate in times of relatively high RPRs in summer, which generally occur in the afternoon. However, PV only seldom generates in times of extreme high RPRs. An analysis of the point of time at which the extreme events occur for the entire year is necessary to clarify it fully.

D. ANALYSING NEM EVENTS OF HIGH DEMAND

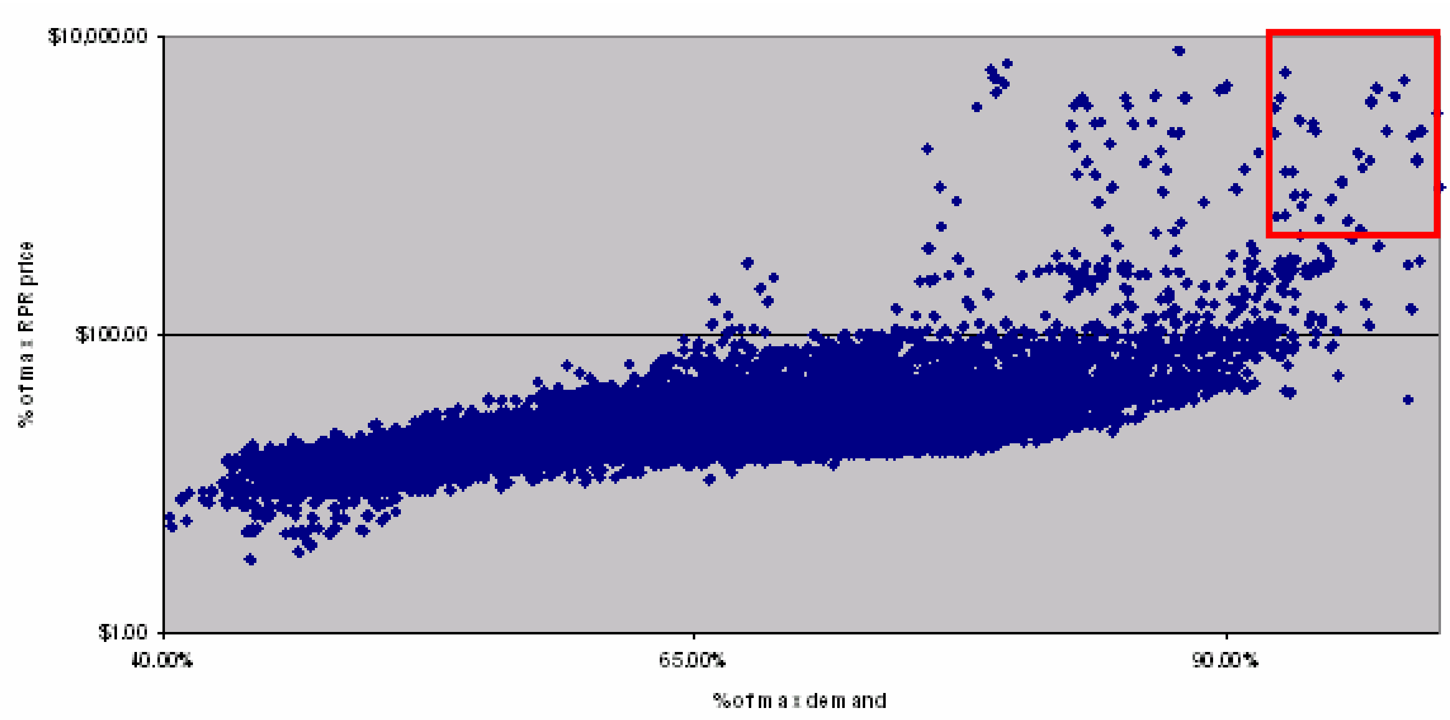
After having assessed the occurrence of high prices, the question is whether high RPRs are linke dot high demand? It was already demonstrated that high RPR events add only marginally to the total PV value. To obtain a complete picture of the value potential of PV, also the coincidence of PV output with demand needs to be assessed.

a) Definition

Analogue to the previous chapter, I have defined extreme events for this analysis. My definition of a extremely high demand is that an event is > 90% of maximum demand of the examined period of one year.

b) NSW

Figure B-III-D-b-1: NEM NSW demand and RPRs 1 Apr 2002 –31 Mar 2003



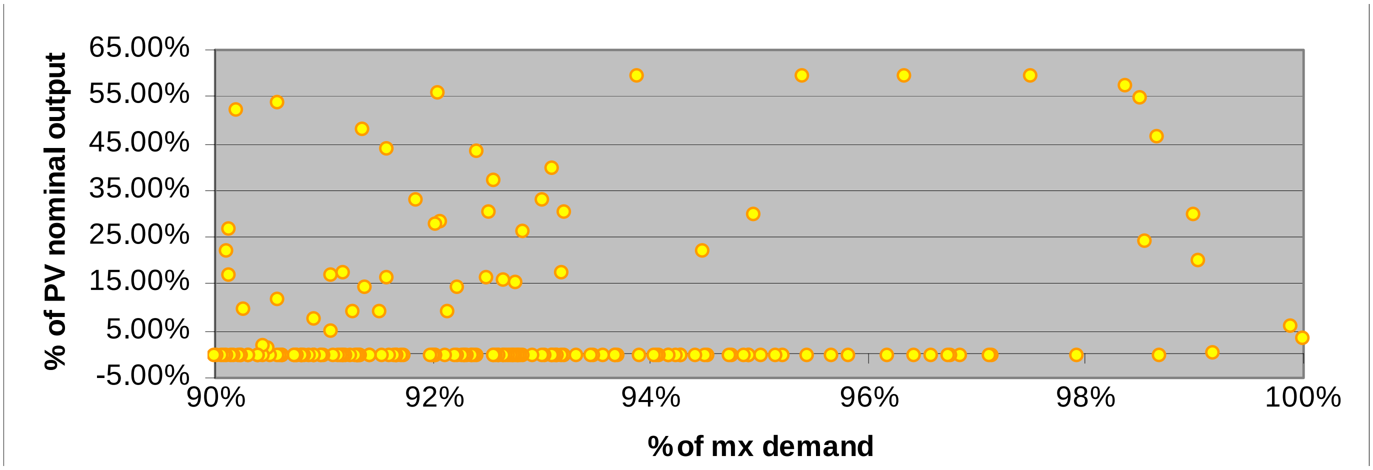
To verify whether NEM RPRs are linked at all to demand, this scatter chart gives a clear indication: only ca. 50% of extreme high PRP events occur at the same time as high demand.

53	high demand events that occur during the "extreme price" cases
50.96%	of the extreme price events also show high demand (>90% of max)

The question is, how well does PV output correlate with high load events?

Figure B-III-D-b-2: PV output on all NEM NSW high demand events

1 Apr 02 – 31 Mar 03



The table gives a better overview of the correlation:

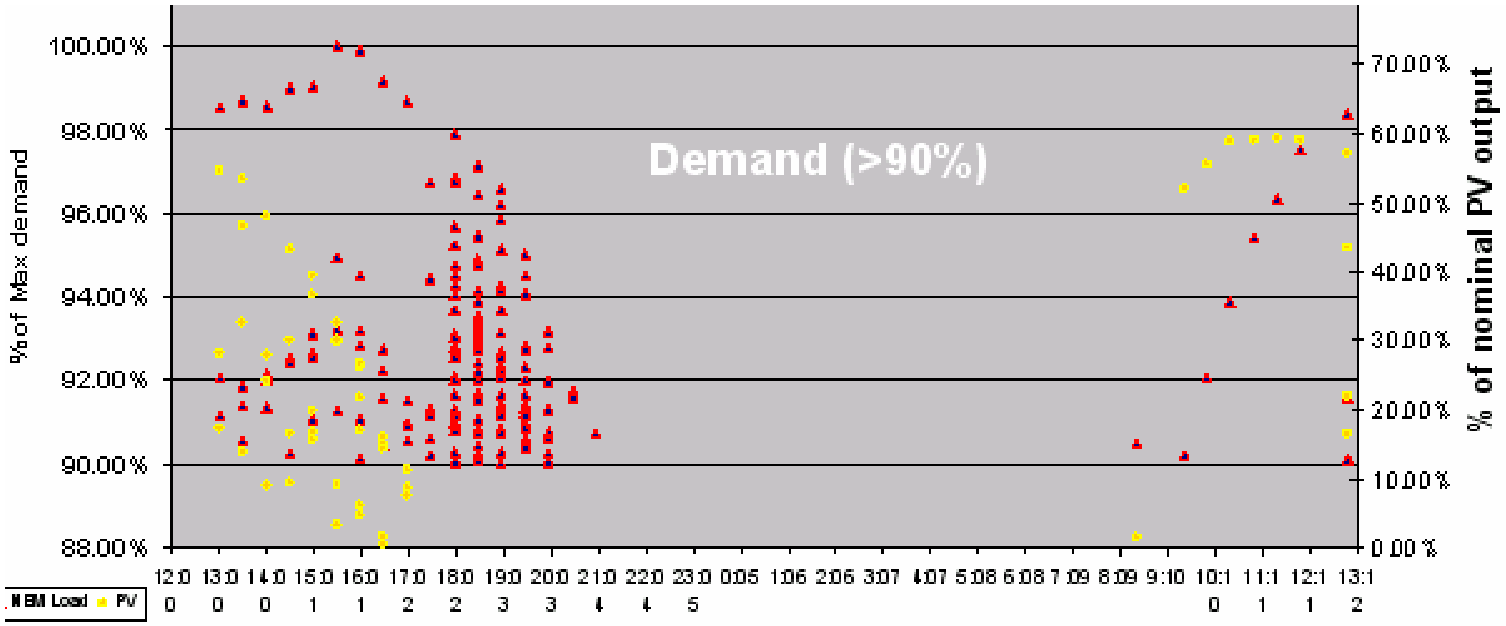
(Definition: significant PV output > 15% of nominal PV system output)

40	significant PV output events that occur during the "high load" period
20.62%	of the high load events also show significant PV output
33.02%	average PV output during those events

Most of those events occur in Jun, Jul and Jan!

The coincidence of PV generating electricity with the high demand events is relatively small, only 20% of the cases, indicating that the contribution that PV could make to reduce those high demands is small.

Figure B-III-D-b-3: Correlation of PV output with high load events on time-of-day throughout the one year period:

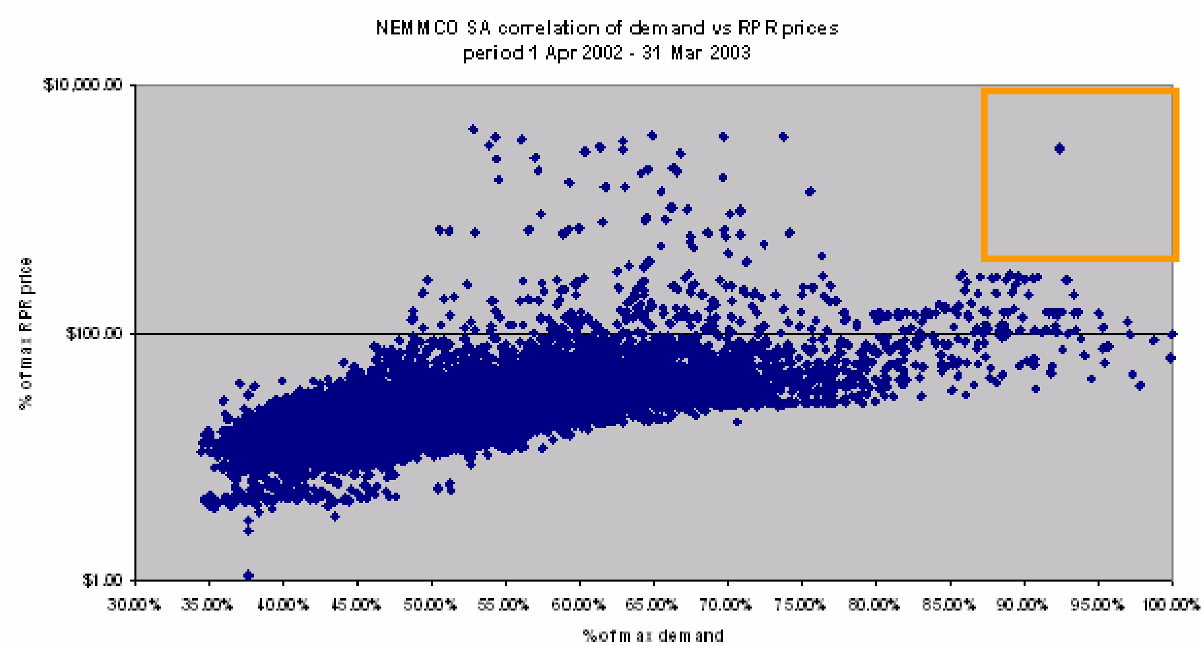


To verify whether the PV system is producing electricity on the high demand events, this chart has been developed. The majority of the evetns occur in the evening hours from 6pm to 8:30pm, only few events occur during afternoon, and even fever in the morning. Thus, the potential of a north orientated PV system to contribute to reduce demands seems to be limited.

c) South Australia

For South Australia, an analogue analysis has been undertaken.

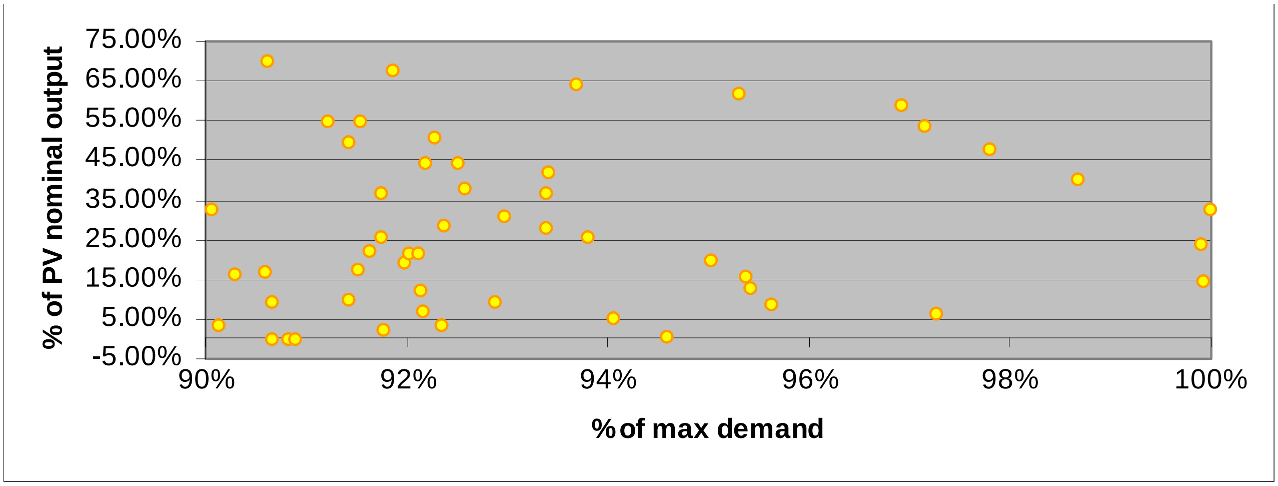
Figure B-III-D-c-1: SA NSW demand and RPRs 1 Apr 2002 –31 Mar 2003



1	"extreme price" events that occur during the high demand cases
1.92%	of the extreme price events also show high demand (>90% of max)

In SA, only one single event is occurring with high RPRs and high demand. This is an indicated that the high RPRs are not due to limited capacity, but the wrong management and planning.

Figure B-III-D-C-2: PV output on high demand events in SA during the examine one-year period



The Perspective of PV contribution to reduce peak demand is better then in NSW:

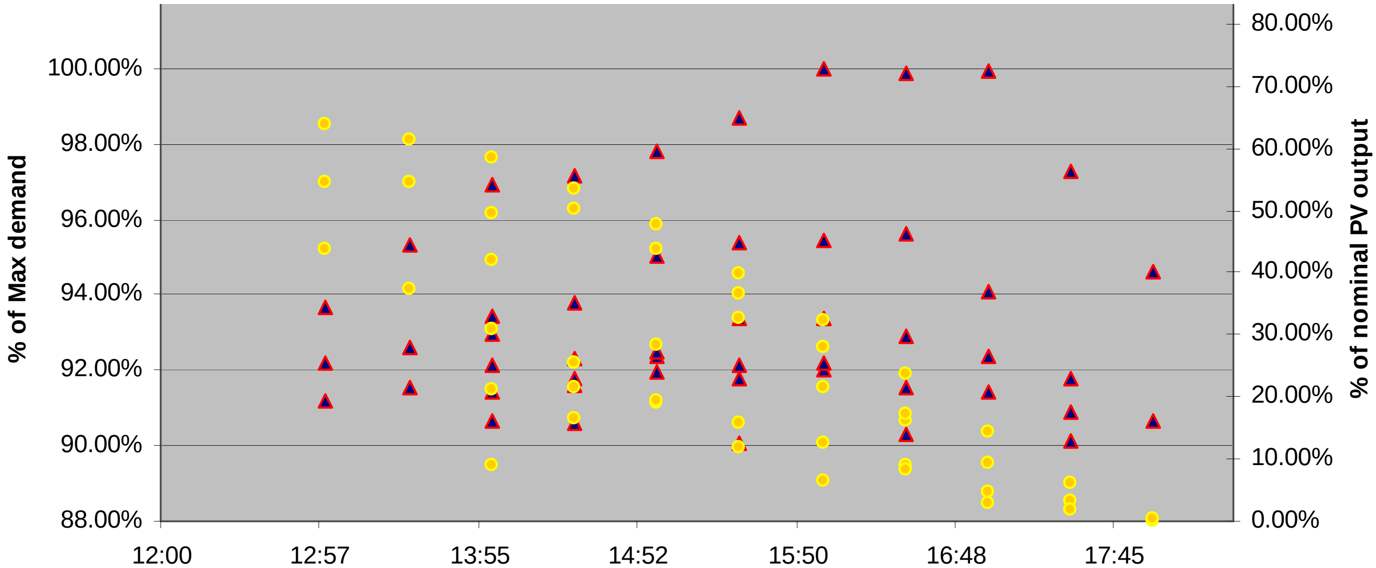
38	significant PV output events that occur during the "high load" period
73.08%	of the high load events also show significant PV output
35.34%	average PV output during those events

All high demand events occurred in summer, in Dec, Jan and Feb, which is probably the reason for the high correlation.

The contribution that PV could make to coping with high demands in SA is promising – 73% of high demand events have significant PV output (average output: 35%)

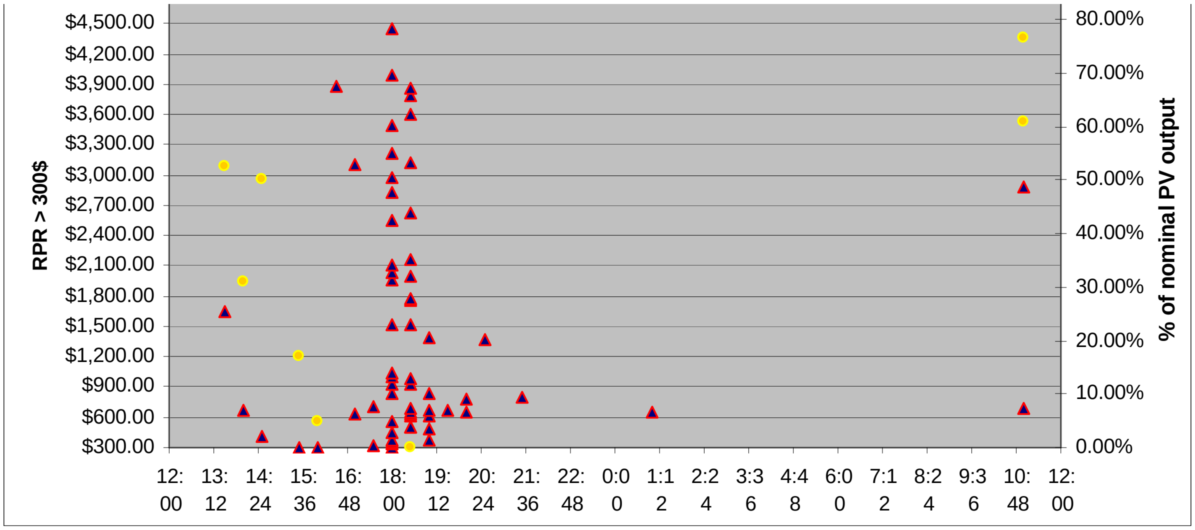
Figure B-III-D-C-3: PV output vs high load events on time-of-day

(52 high load events throughout the year)



The majority of high demand events occur at times when PV is generating electricity. This is a promising result for the PV and needs to be assessed further in SA, as PV has the potential to reduce peak loads. Nevertheless, the highest demand events still take place in early evening hours when PV output is reduced.

Figure B-III-D-b-4: PV output vs high RPRs events on SA NEM on time-of-day throughout examined year:



The 63 events take obviously almost all place in the early evening hour, at a time when PV production is stopped again. Only two of the events took place at times when PV was generating. This underlines the thesis that PV's value potential in SA lies rather in reducing peak demands then reducing high RPR demands.

E. VALUE OF WEST FACING PV SYSTEMS

The logical conclusion is that PV systems might deliver more value to electricity retailing companies if there production would take place in the late afternoon. A west facing PV system potentially shifts the output pattern to a later point of time. To verify the potential, the characteristics of a west facing systems would need to be evaluated. As no such empirical data was available to me, at least a simplistic simulation is being undertake to identify the potential roughly.

An analysis of the UNSW's west facing rooftop PV system was carried out by a fellow student in summer 2004/2005. This work indicated that total output of the system is reduced by 25 % and shifted by approximately +2h. Another difference is also the more abrupt downturn of output in the evenings.

However, this pattern varies throughout the year: during summer month the west facing system generates almost as much electricity as the north facing setup, whereas the main losses occur during the winter month.

As it wasn't possible for me to do a precise simulation, due to lack of time and data, I have undertaken a very rough simulation: I shifted the output of the north facing system by +2h and multiplied it (only the positive output) by 75%.

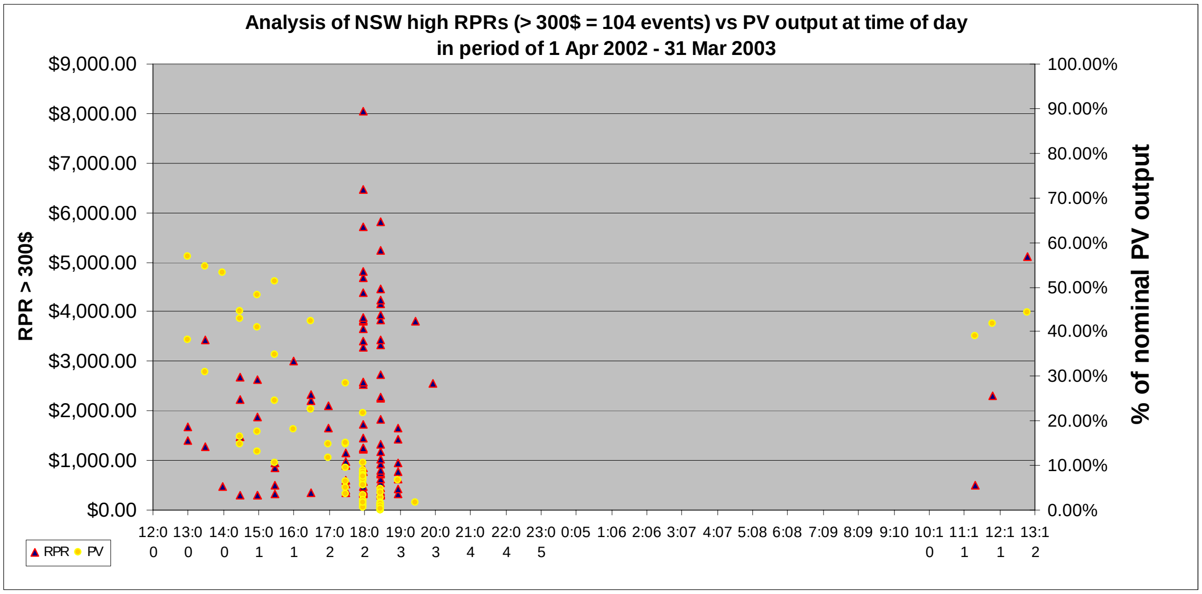
This allows me at least to analyse trends and the total yearly performance.

The main question is: Do the gains in value recuperate the losses in total output.

Losses of West facing 1 kWp PV system in comparison to north facing:

kWh	**-354.50**
%	**-25.31%**

Figure B-III-E-1: West facing PV system vs NEM NSW high RPR events



This visual evaluation shows that PV does now generate more often at times of high RPR events. Nevertheless, the output level is very low at the time when majority of high RPR events take place.

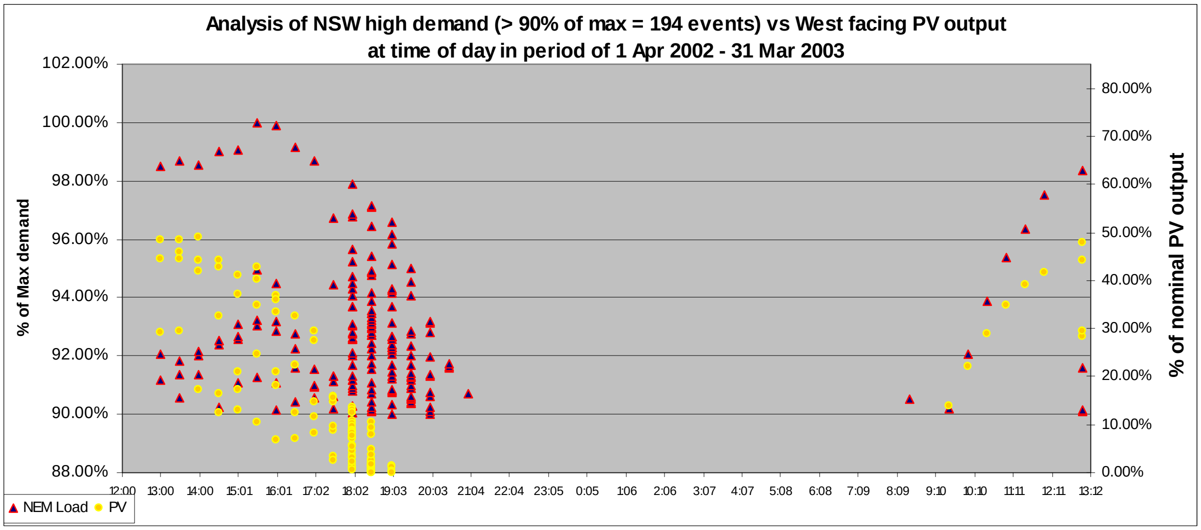
A quantitative analysis for the effect on west facing panels on the load is not possible in the same way.

Therefore, the analysis has been rather undertaken by looking at the # of events of outstanding high loads and the corresponding PV output.

NORTH FACING	WEST FACING
# of cases in which significant PV output (>10%) and high load 40	# of cases in which significant PV output (>10%) and high load 58
just extreme events 20.62%	in percent of total high load events 29.90%
Average output of those event 33.02%	Average output of those event 28.28%
Average output of all high load events 7.73%	Average output of all high load events 9.67%

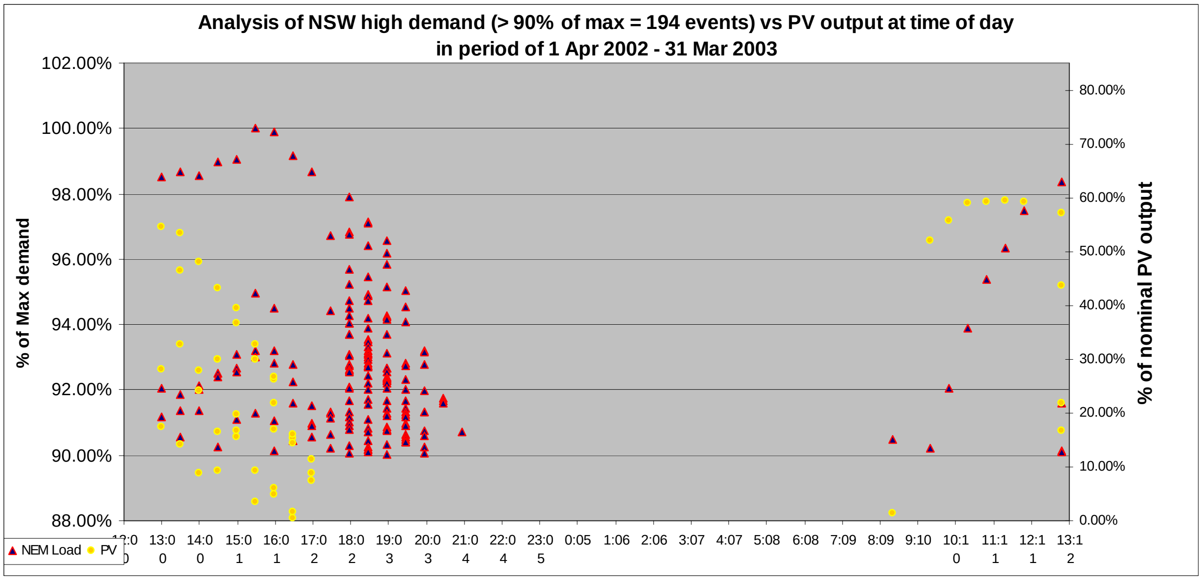
The west facing panel is actually delivering more often output on the high load events then the north facing. Although the average performance is lower, these figures are too rough to be taken into consideration, due to the simulation structure.

Figure B-III-E-2: West facing PV output on high load NEM NSW events



In comparison: North Facing PV

Figure B-III-E-3: North facing PV output on high load NEM NSW events



Although output is shifted, the majority of events in NSW still takes places too late for the PV to be able to deliver high output.

III. Taking the analysis further

1. Peak Demand Reduction

The demand reduction by distributed PV systems would have to be assessed in detail on:

➔ Predominantly residential feeders

➔ Predominantly commercial feeders

to being able to tell whether PV electricity and peaks correlate.

However, the value might vary substantially, depending on the conditions under which the electricity is being acquiring and distributed!

2. Network Benefits

Distributed PV generation and resulting demand reduction has several effect on the electricity network:

➔ Improved resilience of electricity system,

by reducing transformer heating (by reducing load prior to peak demand on feeders with high residential loads), results in a direct monetary value

➔ Avoiding black outs

The value to retailing companies by avoiding black outs in weak networks is controversial:

The set of possibilities with PV installations will be regarded being too narrow by utilities; they are looking for safe solutions for such extreme events

The PV systems would also have to be close to failure stations, which is not necessarily the case

➔ Deferring of network upgrade

➔ VARS

➔ thus benefit of lower risk investment than network augmentation

Suggested Procedure

- Identify the significant sub-networks due to be upgraded
- Confront estimates for costs to utilities with the costs for initializing/ facilitating distributed PV systems

3. Antithetic retail - spot market prices in NSW

Although NSW has the highest NEM RPRs, the domestic tariffs are in average the lowest. IT would have to be analysed whether this is an exceptional phenomenon by assessing further NEM spot market data

IV. Conclusion & Discussion

The undertaken analysis can only give a vague idea of the value to the retailing companies. However, certain trends are recognizable.

In general, the peak demands occur in the evening hours around 7 pm.

However, it has been shown in several cases that demand peaks during summer during the afternoon, at times at which PV potentially can contribute to reduce the demand.

The demand is driven by Air conditioner use, the analysis if the household loads is indicating this.

It was surprising how much of the value of PV was driven by extreme high RPRs in NSW, over 10% of the value. Whereas the value in VIC and SA was hardly affected by high RPRs.

Nevertheless, the key for PV value for the retailers is not to meet such high price events, but to offer a reduction of demand during peak demand hours.

The analysis has shown that a shift of the PV output towards the afternoon would be more favourable.

Therefore, the possibilities of shifting the output would need to be assessed further:

- ➔ Assess peak reduction value of a North facing system with storage (higher year-round output, but (assuming that peak prices occur late afternoon) vs west facing system. Do this warrant the losses through storage or are the short term losses of storing negligible?

- ➔ Model: How many PV Systems are necessary to reach the point of significant benefit to network?

- ➔ Model: Compensation for PV system owners for adjusting arrays to fit optimally to reduce demand peaks

V. Roadmap for further assessment:

A. ENHANCING ANALYSIS BY EXTENDING THE ANALYSIS

1. Adding further PV systems

a) *Western Plains Zoo*

Data available for 5 years, but doubtful due to high level of output during the nights

b) *UNSW EE Building Rooftop System*

Mainly North facing array, but also flat, east and west facing panels.

Info from Mark Silver:

- Orientation of systems might have been messed up through students plugging cables in the wrong order
- Frequent logging failures due to not enough electricity generation by system to supply system, maintenance, hackers

PROBLEM:

Logging failures occurred very often, for 2004 about 40% of the time. Therefore this data sets not useable.

c) *Mudgee*

One year data set will soon be available from Muriel Watt

d) *Queen Victoria Markets Building*

2. Expand timeframe of analysis

At least a second one-year-period should be analysed

3. Full analysis of a west facing systems

Ideally based on empirical data, or more sophisticated simulation of west facing PV output

B. ADHESIVE ASPECTS:

➔ **Tracking Systems: optimal PV output with tracking system, 30 % - 40 % higher output**

➔ **Perspective of using a storage system with the distributed PV system, which:**

- Adds value to the owner by offering a Uninterruptible power supply
- Opens the possibility to store electricity and sell it during peak hours
- If controlled and accessible by the retailing company, could be used to reduce peak demands
- The cconcern with regard to this solution is: Why should the storage be charged through a PV device, as it could be charged much cheaper during low-demand tariff hours? PV is in competition with other technologies and not the only option to refill storages when grid-connected

➔ **Develop optimisation models**

- In a third step, optimisation models including aspects of storage options, orientation, pitch, trackers, etc could be developed to extend the assessment to an more sophisticated level.

➔ **Value to commercial customers**

- Expected that commercial load pattern fits better to PV output pattern. Thus an analysis of commercial tariffs and commercial customer demand is needed

➔ **PV systems on public buildings**

- Schools, Unis, etc. have a demand pattern that supposedly fits PV output very well. Especially the aspect of those institutions having low demand during peak summer due to vacations is interesting, as the PV output could then fully contribute to help reducing demand peaks that is caused by air conditioners.

➔ Impact of PV ownership on customer behaviour

- It can be presumed that PV ownership raises awareness of electricity consumption. The extent and perspective would have to be assessed by comparing a household load pattern before and after PV installation or by interviewing PV owners

➔ Customer Behaviour

Customer is not aware of the effects of effects of own electricity consumption behaviour, acting in absence of information. Behaviour might change if price signals like TOU tariffs. I suggest an assessment of impact on customer behaviour.

➔ Building integrated PV systems

- Role of integrated PV systems needs to be assessed. For instance, by using PV panels as roof tiles, costs for the roof tiles and other constructing materials would be saved and thus would have to be added to PV value

➔ Decline of PV output on hot days

- Unfortunatley, no corresponding meteorological data has been analysed to asses the impact of hot temperatures on PV performance. This effect is already well known, but plays a crucial role in the relation of PV output and air conditioner use.

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