SOLAR PV YIELD RESULTS
FOR SYSTEM INSTALLED IN INVERLOCH, VIC.

The yield data presented in this document is taken from a system installed in Inverloch in August 2011. It is a 2.64 kWp system using Solar Frontier thin-film CIS panels and an SMA 2500HF inverter. This actual data may assist those considering the purchase of a PV system to decide what size of system is needed to achieve their objectives bearing in mind yield fluctuation. ***In particular it shows how yields vary significantly not only on a predictable seasonal basis but also on unpredictable day-to-day and annual bases.*** The data for the total yield is presented both as the actual yield from the system and normalized to a notional 1 kWp which may be more helpful in calculating the size of system required.

WHAT'S IN THE DOCUMENT? (In order of appearance)

Monthly Yield Totals Summary (Page 2)

This first page of actual yield data shows the total power generated in the16-month period covered by this document. It also compares the results with the long-term average theoretical results as calculated using NREL's online PVWatts solar calculator. (See p.6)

Normalized Monthly Yield Totals Summary for Notional 1kWp System (Page 2)

This is exactly the same data as presented in the Monthly Yield Totals Summary page but with the results divided by 2.64 to provide what can be expected from a notional 1 kWp system. Simply multiplying these results by the kWp nameplate power rating of a proposed system will provide the yield that can be expected from such a system.

Monthy Yield Pages (Pages 4 & 5)

The above pages are followed by monthly yield by day data. This has been included to show how dramatically yields vary on a day-by-day basis according to solar radiation. All the Monthly Yield charts use the same vertical axis scale so that summer and winter months can also be readily compared.

NREL Data (Page 6)

This page provides information about the calculated theoretical yield that is used on subsequent pages to compare with the yields actually obtained. It is particularly useful for estimating the yield for a specific panel orientation and tilt angle, and proves that roof orientations and pitch angles significantly different to the optimum nevertheless realise excellent yields. It should be remembered that solar radiation can vary significantly (up to 30%) on a year-by-year basis and that the calculated results are a long-term average guide only.

Note: When comparing Actual vs. Theoretical Yields in summary pages (pages 2 and 3) Remember the theoretical yields are based on ***long-term*** (30-year) ***average climate conditions.*** If significant differences are seen between actual and theoretical yields it is worth checking the daily yields on the relevant Monthly Yield chart (pages 4 & 5) before worrying about a possible system problem. A larger number of days with low yields due to weather conditions is the most likely cause of low monthly yields; days of normal maximum yield for that time of year are a strong indication that the system is operating normally. By contrast, a system problem such as dirt on the panels or a faulty panel will tend to result in consistently low actual vs. theoretical yields.

HOW DATA IS COLLECTED

There is a Bluetooth wireless link between the SMA inverter and a PC running SMA's (free) Sunny Explorer software. This permits the download of detailed data to plug into a spreadsheet and create this document. Not only does this communication ability and software permit such data to be collected, it also provides excellent diagnostic capabilities to easily verify that there are no system problems.

PV PANEL TYPES

The performance of various types and brands of PV panels and inverters can be compared on the Desert Knowledge Solar Centre website at
http://www.dkasolarcentre.com.au/
Solar Frontier panels are not represented, but other brands of CIGS thin-film panels are. The desired panel type can be selected via the Technologies drop-down window. The Solar Frontier website is at
http://www.solar-frontier.com/eng/
It is fair to say that good quality panels with the same power output rating of any technology will provide similar results. Some of the factors to consider are listed below.

Parameter	Best Performer
Yield per square meter	Silicon
Embedded energy	Thin Film CIS/CIGS
Shade tolerance	Thin Film CIS/CIGS
Overcast/cloudy conditions performance	Thin Film CIS/CIGS
Output drop with increased temperature	Thin Film CIS/CIGS
Longevity in market (track record)	Silicon

It is perhaps worth mentioning that unless a system is selected that is very close to that required to meet the objectives with little or no "safety margin" the choice of panel technology is probably not of great significance. If roof space is limited silicon panels will currently be the preferred option.
An often-overlooked fact is that PV panels change significantly as technology advances. Thus if a panel is damaged or develops a problem more than a few years after purchase a replacement may well not be available and the warranty can then be of questionable value. The resulting panel wiring configuration changes needed to work around the failed panel can result in a significantly lower yield system. This eventuality should be discussed with the prospective system provider. Overall, given that the biggest part of the cost of a PV system is the panels, selecting a reputable brand is likely to be a good investment.

INVERTER OPTIONS

Since this system was installed *Micro-Inverters* have become available. These inverter-per-panel inverters generate 240V~ at the panel rather than from the combined panel DC output at a single inverter mounted close to the breaker cabinet. The comparison of these two very different approaches is far too big to cover here! Needless to say there is no obvious "winner"; both have advantages and disadvantages.

System Location:	Inverloch, VIC	Nominal Inverter DC Input Voltage:	340V at Pmax
Panel Type:	32x Solar Frontier CIS 82.5 W	Nominal DC Input Power:	2640 W
Panel Configuration:	2 strings; 2 chains of 8 panels per string	Inverter:	SMA SB2500HF
Array Orientation:	40 degrees	Commission Date:	20 August 2011
Array Tilt:	20 degrees		

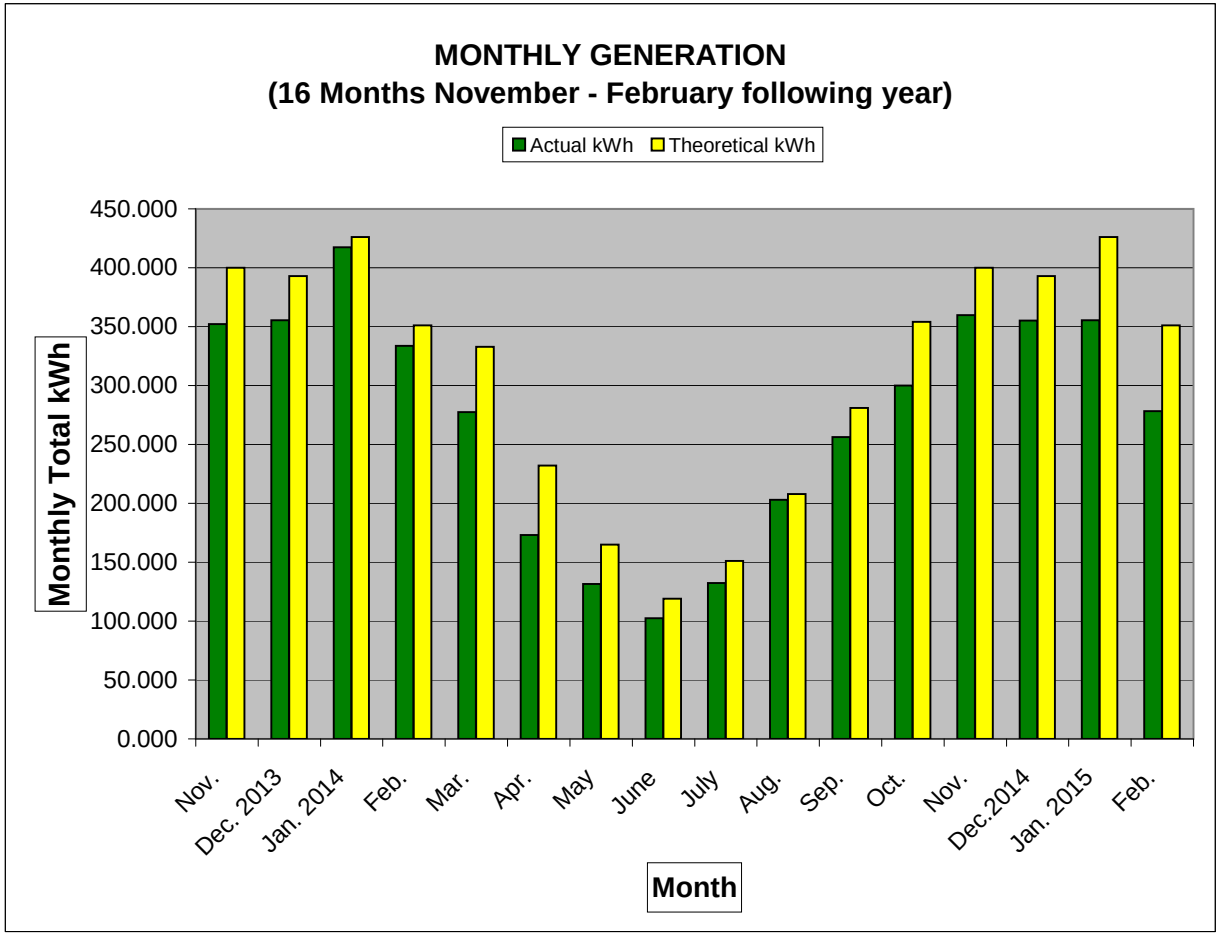
• To see yields on a daily basis for individual months see the Monthly Yield pages on pages 4 & 5. The most recent months appear first.

• This document will be updated on a 6-monthly basis. Most recent data can be provided upon request.

MONTHLY TOTAL YIELDS SUMMARY (16 Months November 2013 - February 2015)

Year	Month	Actual Yield (kWh)	Theoretical Yield (kWh) (see Note)
2013	Nov.	352.149	400
	Dec. 2013	355.306	393
2014	Jan. 2014	417.298	426
	Feb.	333.739	351
	Mar.	277.581	333
	Apr.	173.197	232
	May	131.615	165
	June	102.494	119
	July	132.461	151
	Aug.	202.994	208
	Sep.	256.253	281
	Oct.	300.019	354
	Nov.	359.776	400
	Dec.2014	355.091	393
2015	Jan. 2015	355.392	426
	Feb.	278.316	351
12-month Yield (1 Jan 2014 to 31 Dec 2014):		**3043**	**3413**

Note: For Calculated Theoretical Yields see Theoretical Generation by Month (page 6).



Month Totals Compared Year-Year	January	February	March	April	May	June	July	August	September	October	November	December	2104-2013 Change
2013	426.4	347.1	314.8	206.5	154.1	130.0	145.6	174.4	234.9	304.1	352.1	355.3	**3145.383**
2014	417.3	333.7	277.6	173.2	131.6	102.5	132.5	203.0	256.3	300.0	359.8	355.1	**3042.518**
Diff. 2014 - 2013 (kWH)	-9.1	-13.4	-37.2	-33.3	-22.4	-27.5	-13.2	28.6	21.4	-4.1	7.6	-0.2	**-102.865**
Diff. 2014 - 2013 (%)	-2.1%	-3.8%	-11.8%	-16.1%	-14.6%	-21.2%	-9.1%	16.4%	9.1%	-1.4%	2.2%	-0.1%	**-3.3%**

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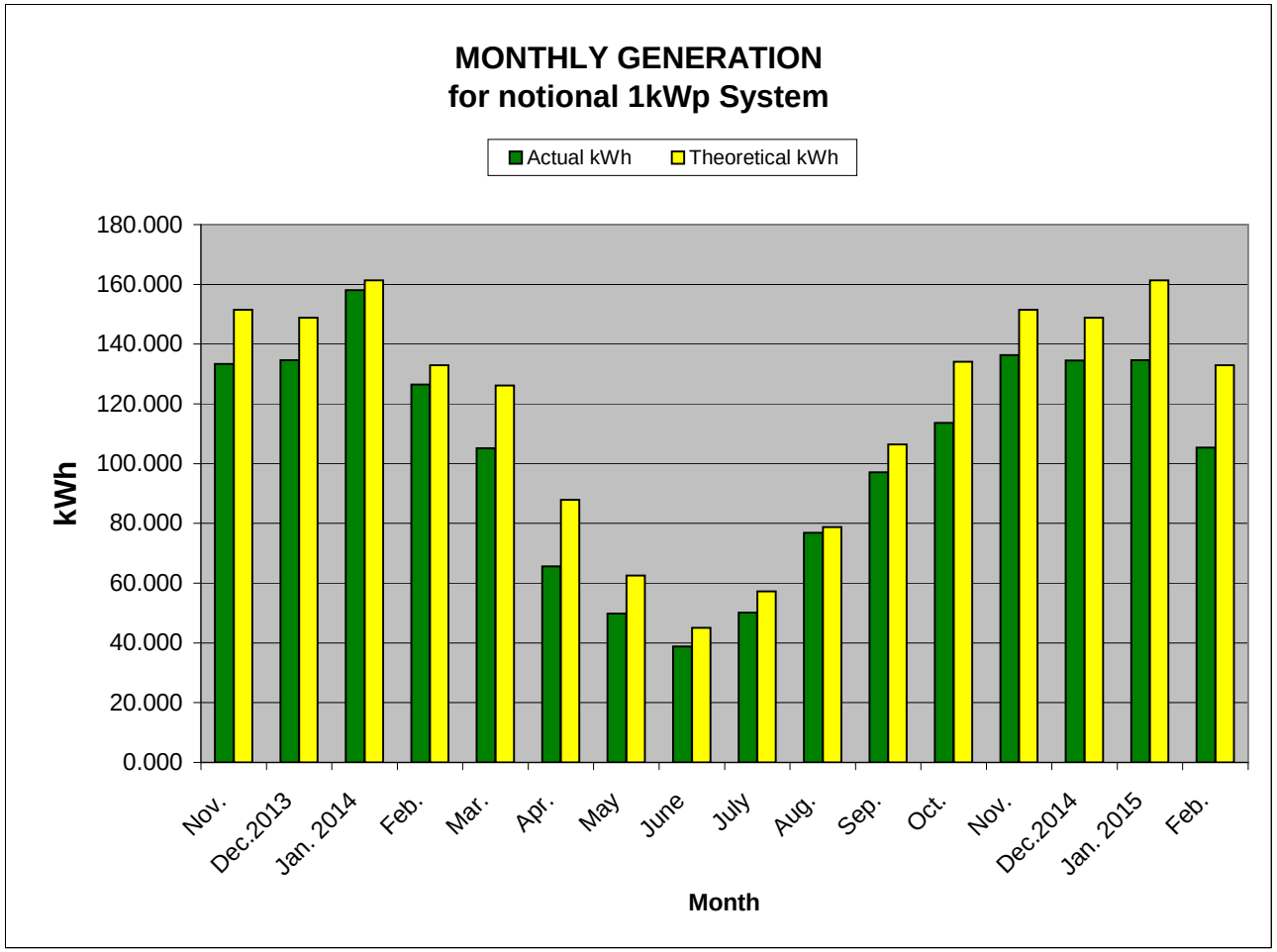
MONTHLY TOTAL YIELDS SUMMARY (16 Months November 2013 - February 2015)

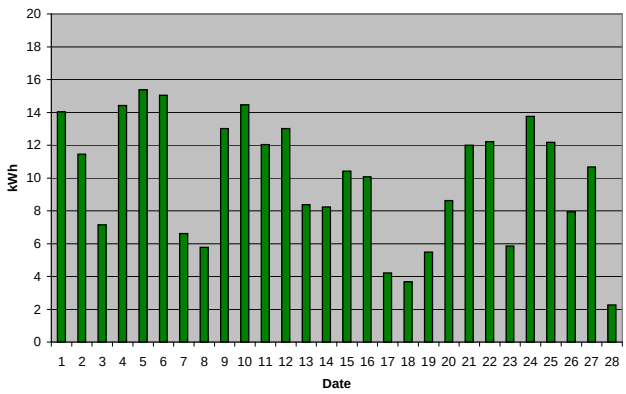
Normalized for Notional 1kWp System

Year	Month	Actual Yield (kWh)	Theoretical Yield (kWh) (see Note)
2013	Nov.	133.390	151.5
	Dec.2013	134.586	148.9
2014	Jan. 2014	158.067	161.4
	Feb.	126.416	133.0
	Mar.	105.144	126.1
	Apr.	65.605	87.9
	May	49.854	62.5
	June	38.823	45.1
	July	50.175	57.2
	Aug.	76.892	78.8
	Sep.	97.066	106.4
	Oct.	113.644	134.1
	Nov.	136.279	151.5
	Dec.2014	134.504	148.9
2015	Jan. 2015	134.618	161.4
	Feb.	105.423	133.0
12-month Yield (1 Jan 2014 to 31 Dec 2014):		1152	1293

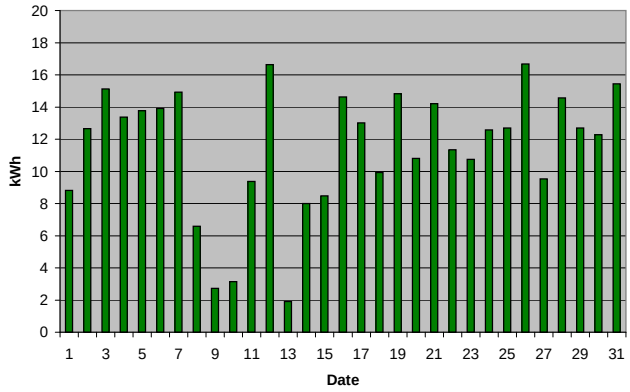
Note: For Calculated Theoretical Yields see Theoretical Generation by Month (page 6).



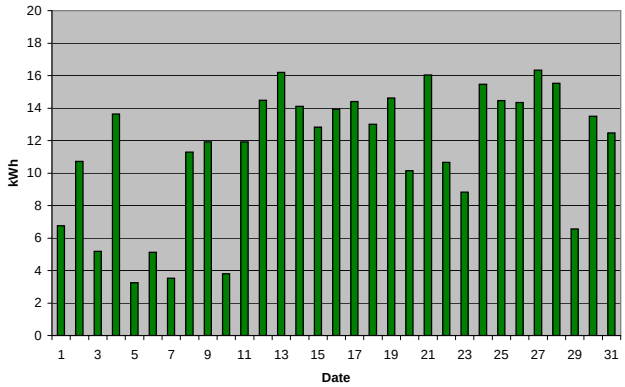
February 2015 Yield



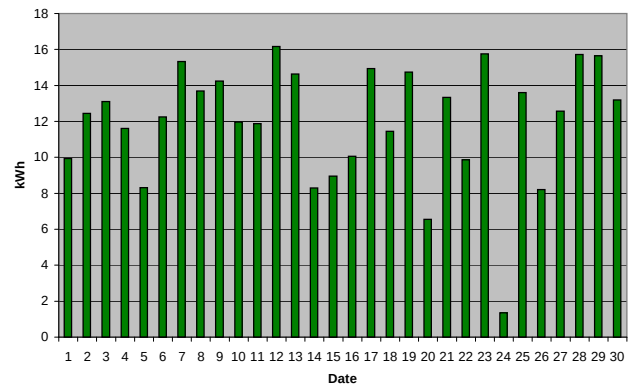
January 2015 Yield



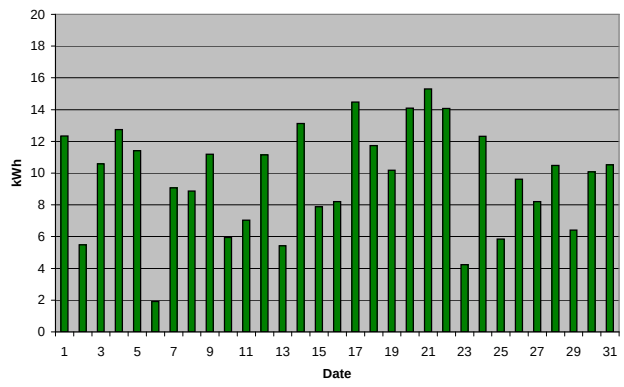
December 2014 Yield



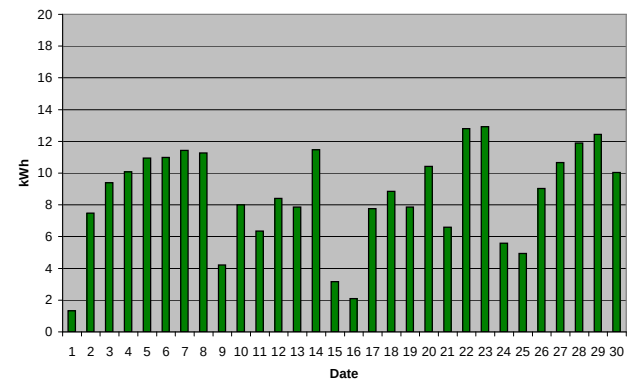
November 2014 Yield



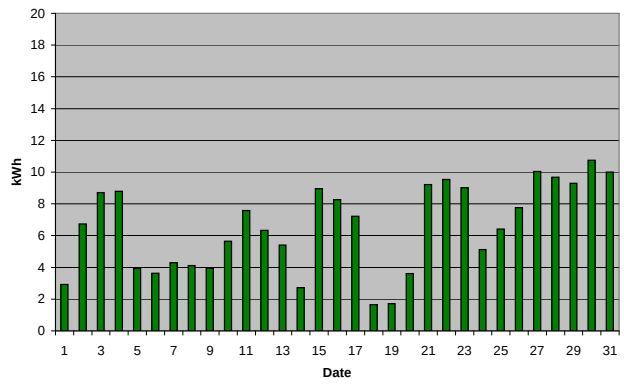
October 2014 Yield



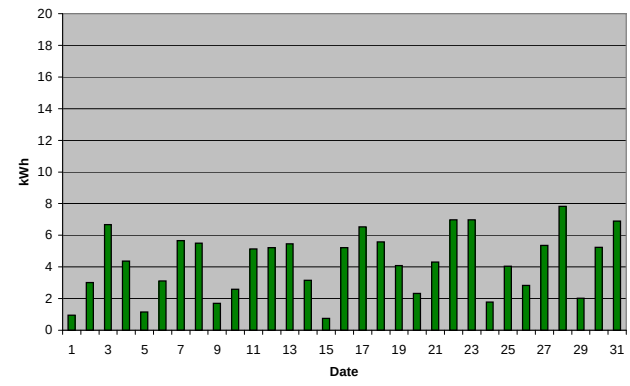
September 2014 Yield



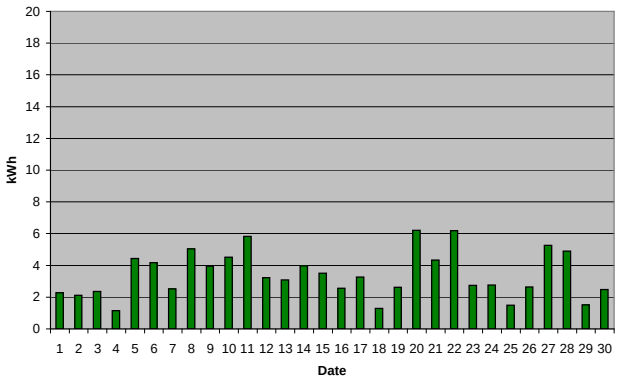
August 2014 Yield



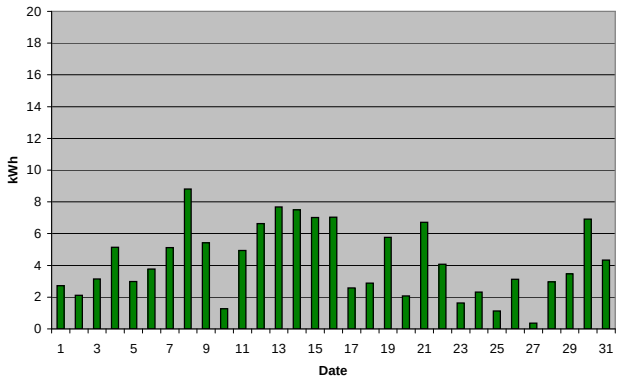
July 2014 Yield



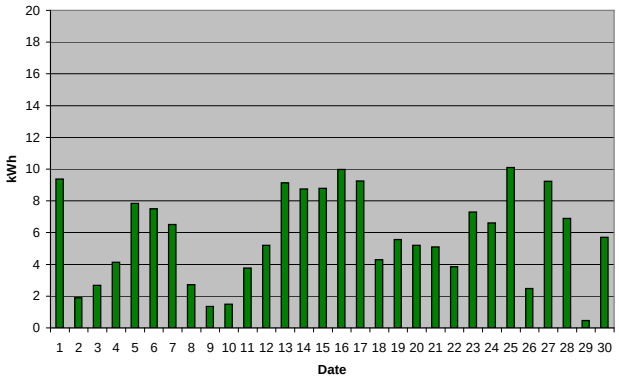
June 2014 Yield



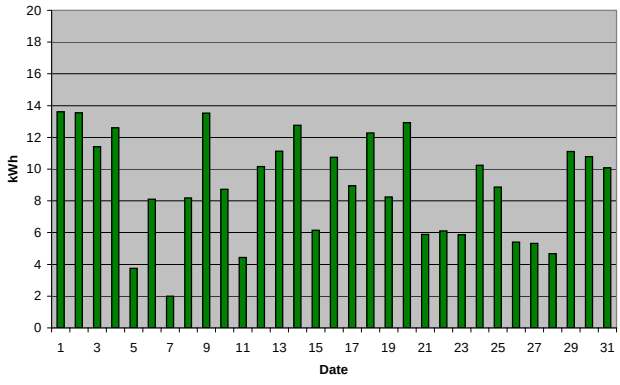
May 2014 Yield



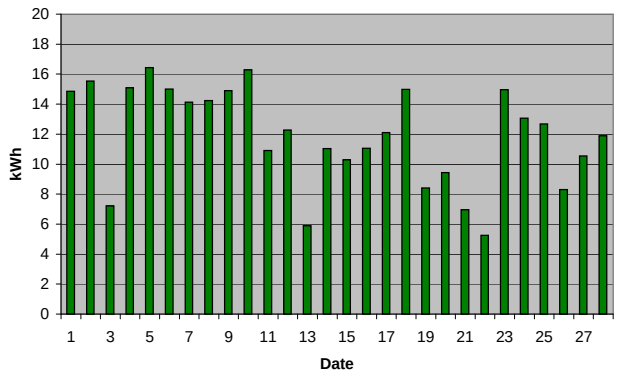
April 2014 Yield



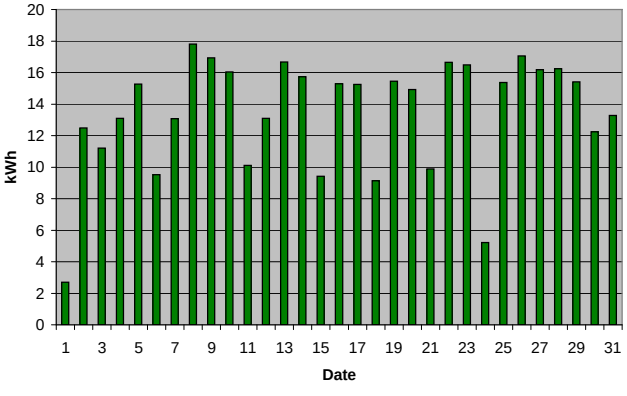
March 2014 Yield



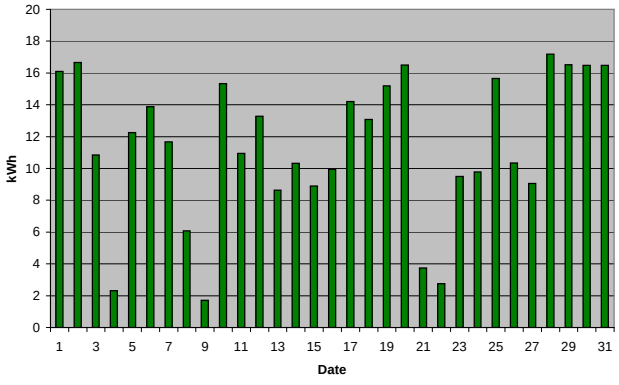
February 2014 Yield



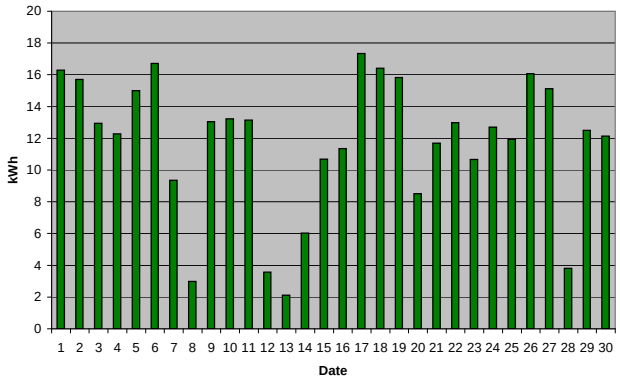
January 2014 Yield



December 2013 Yield



November 2013 Yield



THEORETICAL GENERATION BY MONTH
per PVWatts Solar Calculator on National Renewable Energy Laboratory (NREL) Website

● These calculated theoretical generated yields were derived using the PVWatts solar calculator available on the NREL website. This has International capability and includes data for Melbourne and a number of other major cities in Australia. The calculator uses local statistical weather data. The website can be accessed at:

http://pvwatts.nrel.gov/

Enter Melbourne, Australia in the Get Started/Location window.
(INTL) MELBOURNE, AUSTRALIA should appear in the Selected data window. Click on the Go To System Info arrow.. The data for your site and system can then be entered and calculations performed.

● A useful and illuminating capability is the ability to modify parameters affecting the DC to AC conversion efficiency. While *maximum* inverter efficiencies of around 96% under test conditions are expected and generally understood, actual efficiency and other factors such as cable losses (and losses in combiner and fuse/breaker boxes mandated in Australia) are frequently overlooked. The combined effect of several individual derating factors of 0.98 or 0.99 have the nasty ability to significantly reduce the overall DC-AC conversion efficiency to around 0.8. This 80% efficiency is a far cry from the 95% one can be conditioned to expect when considering only the inverter efficiency.

● The derating factors used for the Theoretical Calculted Yields in the Grand Total tab of this spreadheet are listed below. Alternative numbers can be entered to calculate an alternative DC-AC derating factor, for example to accommodate the effect of partial shading of the PV array.

System Info	
DC System Size	2.64
Module Type	Thin Film
Array Type	Fixed (Roof Mount)
System Losses (see below)	14.51
Tilt (deg)	22
Azimuth	43
Advanced Parameters	
DC to AC Size Ratio	1
Inverter Efficiency (%)	93
Ground Coverage Ratio *	0.4*
* This parameter not used for Fixed array types	

System Losses Breakdown	
Soiling (%)	2
Shading (%)	3
Snow (%)	0
Mismatch (%)	2
Wiring (%)	2
Connections (%)	1
Light-Induced Degradation (%)	1.5
Nameplate Rating (%)	1
Age (%)	0
Availability (%)	3

NREL Theoretical Calculated Yield Results (kWh) (Results taken from calculator on NREL website using above data)		
Month	Solar Radiation (kWh/m^2/day)	AC Energy (kWh)
January	6.77	426
Feb ruary	6.21	351
March	5.33	333
April	3.79	232
May	2.58	165
June	1.91	119
July	2.34	151
August	3.23	208
September	4.53	281
October	5.56	354
November	6.53	400
December	6.25	393
Year Averages	**4.59**	**3,413**