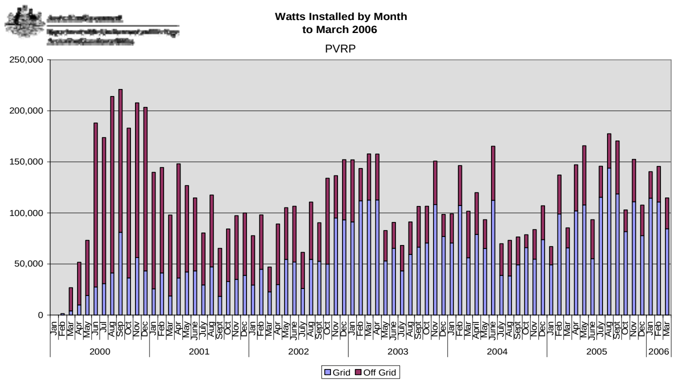
Experiences with Residential Grid-Connected PV Systems in Australia

Dr Muriel Watt - SPREE UNSW m.watt@unsw.edu.au
Dr Rhys Morgan BP Solar rhys.morgan@bp.com
Dr Robert Passey CEEM UNSW

Contents

Introduction

- Over 6 MW of grid-connected PV in Australia connected to date.
- Majority domestic homes direct purchase or pre installed e.g. Newington
- Boom in Europe, Japan USA -> silicon shortage, causing problems with supply and price.
- Australia - market moderate growth, driven by PVRP & Green Power



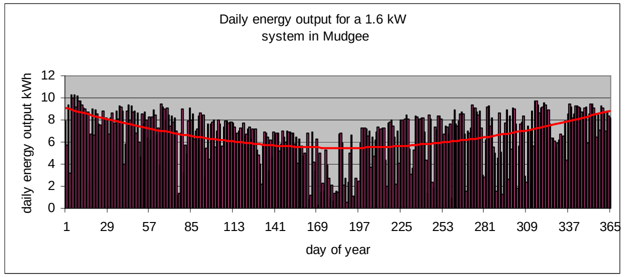
By 2005, PVRP contributed to ~ 88% of GC PV being installed
Since 2000 > 3000 systems ~4.6 MWp of GC PV installed
PVRP Rebates reduced from $5,000 per kW to $4,000

System Cost Trends

- Data from BP Solar's Envirocashback – manufacturers' database
- Analysis shows end user cost has decreased since 2003 by 8%
- Average system cost $/W per watt has decreased from $13.05 in 2003 to $11.89 in 2005, despite PV module price rises
- So - reductions in BOS, installation, standardisation?
- Domestic electricity tariffs increased by 15% for the household monitored here since PV installed, and are expected to continue to increase at 5% per year above CPI

Envirocash Back Trends

Analysis of a 1.6 kW System



- Energy delivered in 2005 was 2426kWh, 1515kWh/kWpn, 1571kWh/kWp
- Compares well with ORER 1382kWh/kWp and 1376kWh design prediction
- Avg daily energy 6.65kWh, 10.28kWh max (6.4 PSH)

UNSW } ENGINEERING ANZSES 2006 bp solar

Daily energy statistics

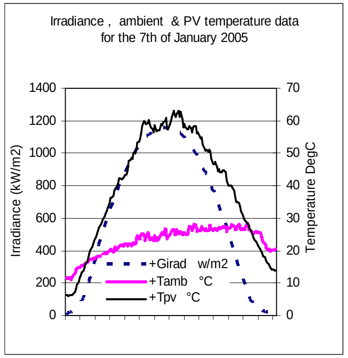
Month	Sum	Ave'	Max'	Min'	Std Dev
1	251.81	8.12	10.3	2.49	1.83
2	216.86	7.74	9.37	3.96	1.51
3	221.99	7.16	9.47	1.21	2.17
4	208.36	6.95	8.62	2.80	1.44
5	186.18	6.01	7.36	2.19	1.37
6	114.11	3.80	6.91	0.05	2.32
7	148.88	4.80	7.33	0.51	2.42
8	197.18	6.36	8.42	1.37	2.16
9	206.97	6.90	9.35	0.92	2.24
10	201.72	6.51	9.30	1.30	2.60
11	211.53	7.05	9.74	2.29	2.23
12	261.20	8.43	9.49	4.39	1.16
-	2426	6.65	10.28	0.05	-

Energy delivered over 2005

- Energy = power & time
- Availability of PV plant is as important as peak capacity
- Kogarah availability was low
- Presently availability is not rewarded in $ (1 week ~ $7)
- PVRP is a payment based on potential to generate
- Need to move to a delivered energy payment "feed in tariff"

UNSW } ENGINEERING ANZSES 2006

System performance - temperature

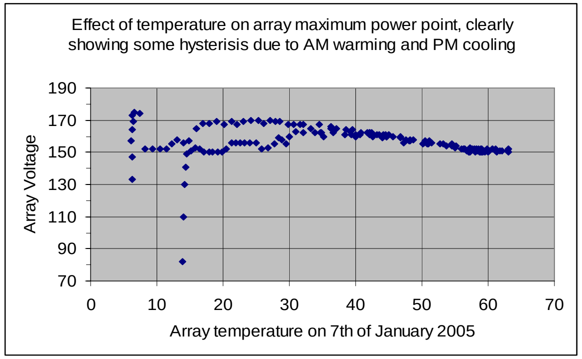


- Irradiance and temperature main factors in PV power
- 4157 hours of data logged
- Tarray > 25ºC 66% of time,
- Tarray > 50ºC 23% of time,
- Tarray > 60ºC 8% of time,
- Tarray > 70ºC 0.4% of time,
- Tarray > NOCT (47) 29%

- High temps' = low voltage
- Tarray of Tamb+30 ~ to 4.8Vdrop per 72 cell module
- Inverter may "bottom out" or "flat line" on P-V curve
- Non optimum operation

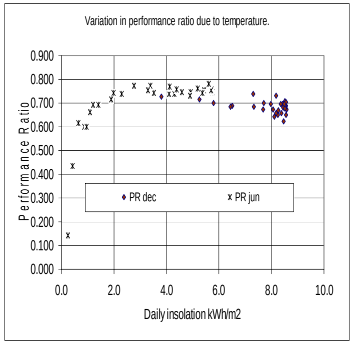
UNSW } ENGINEERING ANZSES 2006 bp solar

System performance - temperature



UNSW } ENGINEERING ANZSES 2006 bp solar

System performance – PR



- PR quantifies the overall effect of losses on the rated output
- Effect of temperature clearly visible as the lower daily insolation of June compared to December.
- For Dec. & Jun average daily PR is 70% - indicates good overall system performance
- Daily max of 74% in Dec. and 78% in June.

UNSW } ENGINEERING ANZSES 2006 bp solar

Case Study

NSW Department of Planning

Newington Solar Village

UNSW } ENGINEERING ANZSES 2006 bp solar

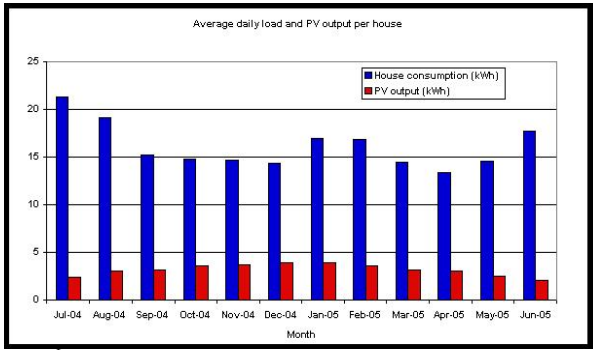
Newington Solar Village

- 780 homes with 1000Wp of PV and 199 houses with 500Wp
- Passive solar design features, energy efficient appliances
  - Loads nevertheless av 16 kWh/day cf 7.5 design
  - Load profile much 'peakier' than for normal houses, thus providing less opportunity for PV to reduce peak
- 30 homes monitored July 04-June 05
  - Average daily PV output per house 3.2 kWh (~20% of load)
  - 2 systems faulty -> 3.4 kWh/house, about 10% lower than expected (although 2005 may not have been a typical year)
  - Zone substation peak demand reduced by 30% of rated PV capacity

UNSW } ENGINEERING   ANZSES 2006   bp solar

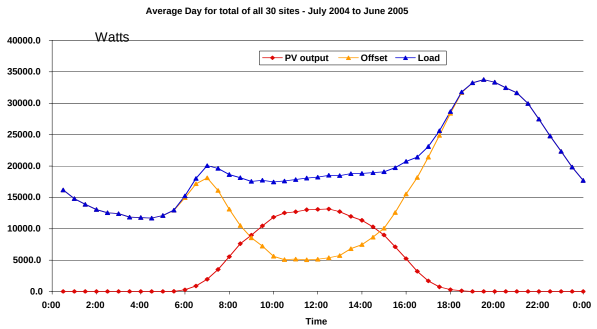
Household Load and PV Output

average over 30 houses
(NSW Dept of Planning, Newington study)



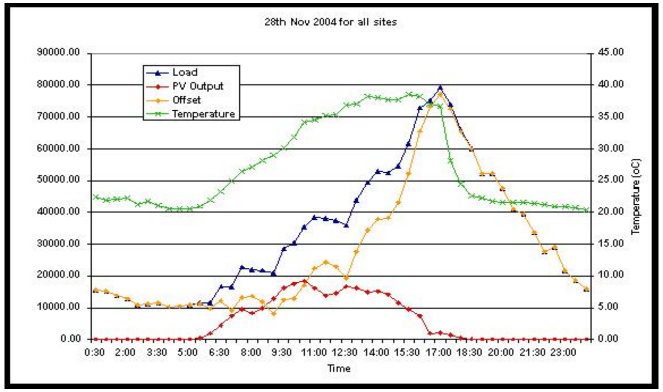
UNSW } ENGINEERING   ANZSES 2006   bp solar

Annual Average Daily PV Output, Household Load and Offset, Newington

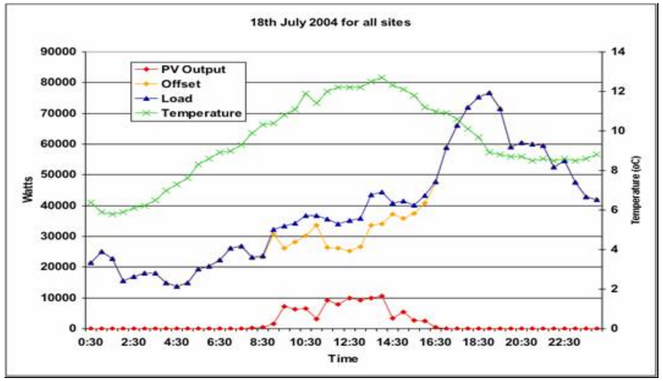


UNSW } ENGINEERING   ANZSES 2006   bp solar

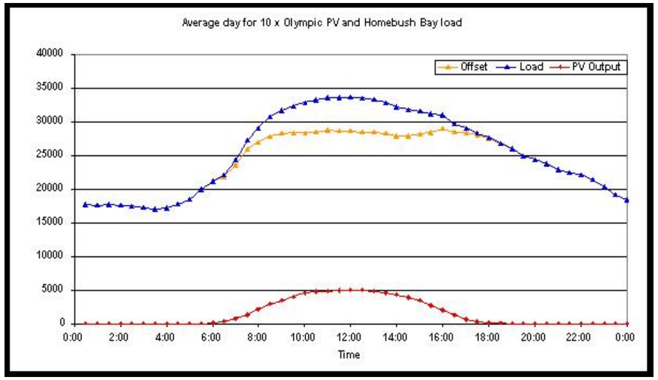
PV Output, Household Load and Temperature - Peak Summer Day, Newington



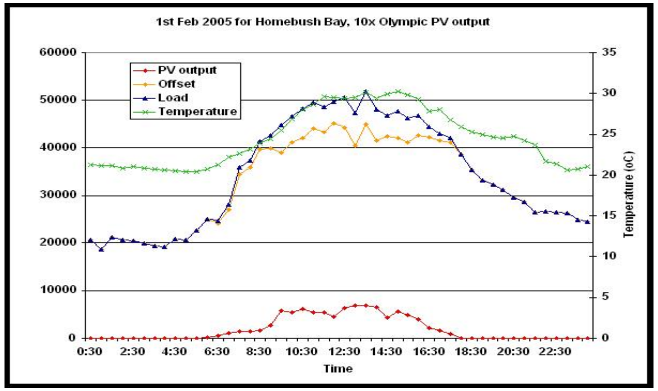
PV Output, Household Load and Temperature - Peak Winter Day, Newington



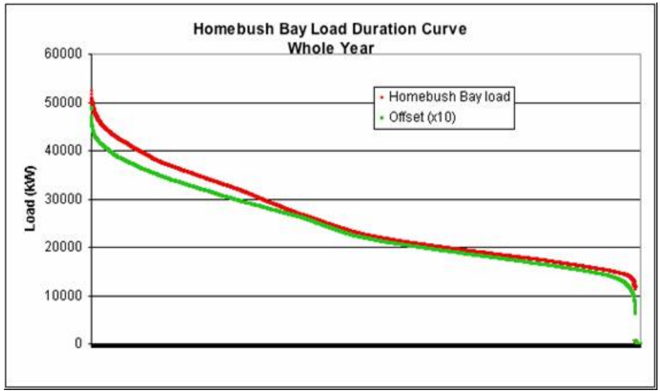
Annual Average PV Output (X10) and Homebush Bay Substation Load



PV Output, Homebush Bay Substation Load and Temperature - Peak Load Summer Day



Load Duration Curve Homebush Bay with impact of 10X current PV Output



Conflicting expectations and objectives

- Buy back rates 4 to 14 c/kWh and minimal (zero!) reward to PV systems for daytime contribution
- Net metered systems - owner encouraged to maximise PV output
- No incentive to maximise grid benefits.
  - North West - 4% reduction in owner's income
  - West - 13% reduction
- Newington - reduction in substation peak load due to PV
- Split benefits, no carbon price
  - Difficult to argue in favour of grid-connected PV
- Electricity retailers moving away from net metering in sharp contrast to international trends to high feed-in tariffs for PV, now adopted in 41 jurisdictions

System performance and customer expectations

- Failure of system equipment, especially if undetected, contribute to customer expectations not being met.
- More common - system operating, but not at optimum.
  - Owner often unaware, especially if inverter in poor location and no remote display is available.
  - Net metering and a lack of weather data can contribute to ignorance.
- Knowledge of module voltage and temperature can be used to ascertain whether system is operating at maximum power point
- System owners could be provided with a simple table showing PV output range expected at various temperatures
  - If output falls outside range, a simple maintenance checklist could be used, with a maintenance call as the final option.
- Without some indicator of system output, however, even this simple check cannot be undertaken.

Conclusions

- Grid-connected PV market just beginning in Australia.
- Over 6 MW now installed, but potential market very large,
- With a minimal level of system checking, it is possible to ensure high system availability and good performance ratios.
- High temperatures in Australia indicate a need to ensure appropriate system design, wiring and component placement.
- PV systems reported here each displace 1.3 - 1.6 tonnes of CO_2 per kWp per year and could be expected to do so for 30 years or more.
- Increased uptake of grid-connected PV could play a useful role in reducing Australia's greenhouse gas emissions.
- Alternative support structures, which provide more incentive to maintain high output and reduce greenhouse gas emissions would assist in future market development.

Recommendations (1)

- Meeting customer expectations is critically important if this market is to meet its potential.
- Customers need clear and easy-to-understand information which explains key aspects of system design and expected performance.
  - maintenance checklists,
  - expected output at different temperatures
  - significance of aspects such as shading, dust build-up, loose connections and inverter over-heating.
- Discussion and explanation needed, not just a manual.
  - Video/DVD based information
  - Displays
- Establishment of a PV owners' networks, email or telephone-based help lines.

Recommendations (2)

- Mandatory net metering as minimum buy-back rate
- High buy-back rates or ‘feed-in-tariffs’
  - encourage optimum system operation
  - encourage maintenance contracts and longer warranties
  - reduces up-front costs, since these are not subsidised
  - more cost effective means of technology support than more generic mechanisms such as MRET
  - no need for annual budget allocations
  - tariff can be adjusted as prices change and can also be varied by location, for instance, to encourage PV in grid-constrained areas

UNSW } ENGINEERING   ANZSES 2006   bp solar