Analysis and Management of the Impacts of a High Penetration of Photovoltaic Systems in an Electricity Distribution Network

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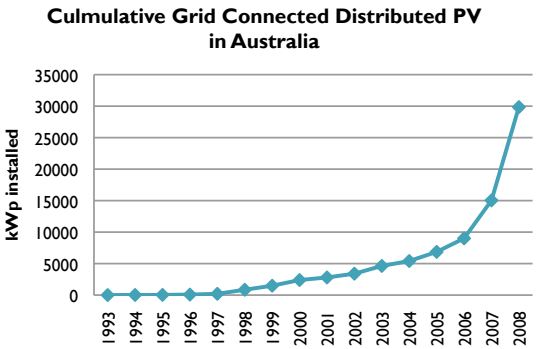
This paper was produced with great assistance from the following: Iain MacGill (CEEM), Kevin Nuner (Endeavour Energy), Australian Solar Institute, Australian PV Association and the University of New South Wales

Content

- PV and Australian Network Utilities
- PV Integration Benefits and Issues
- Case Study – "Blacktown Solar Cities"
  - PV Output
  - Data Analysis and Modelling Results
- PV Integration Management Strategies

PV and Australian Network Utilities

- The prevalence of PV systems in the grid is increasing
- This has resulted in growing concern amongst utilities as to what these systems are doing to the network.



Watt, M. (2009). National Survey Report of PV Power Applications in Australia 2008. Sydney: Australian PV Association

Potential PV System Integration Benefits

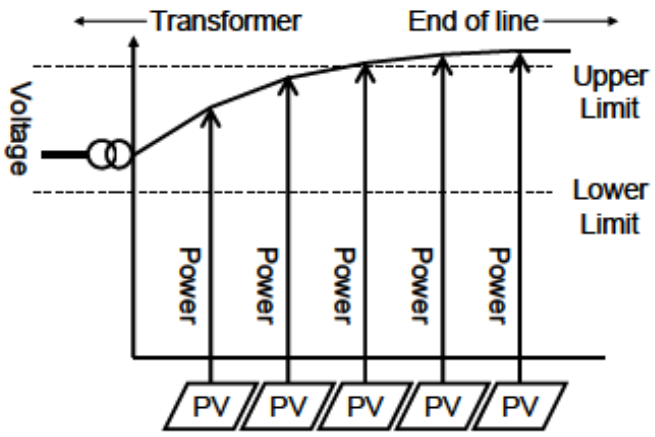
- Ohmic transmission losses reduced
- Delayed network expenditure due to load reduction
- PV systems generate renewable power
- Reduction in electricity bills

Potential PV System Integration Issues

- Voltage
- Harmonics
- Reactive power management
- Reverse power flow
- Protection (not a focus of this paper)

Potential PV System Integration Issues

- Voltage



Y.Ueda, T. K. (2009). *Detailed Performance Analyses Results of Grid-Connected Clustered PV Systems in Japan.* Tokyo: University of Agriculture and Technology.

Potential PV System Integration Issues

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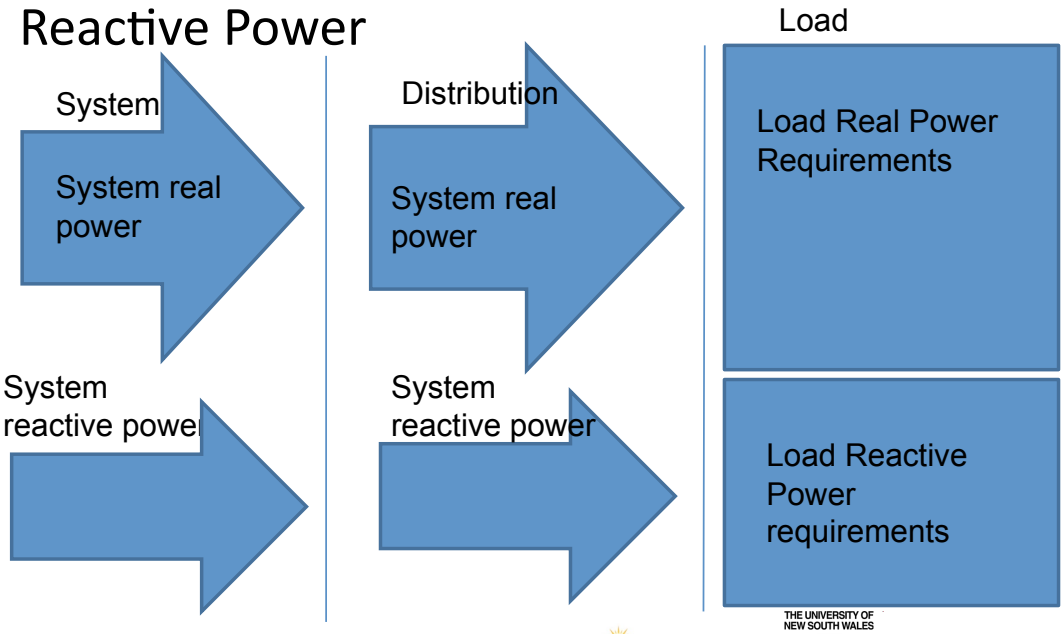
- Protection and system stability (not a focus of this paper)

Potential PV System Integration Issues

- Reactive Power



Potential PV System Integration Issues

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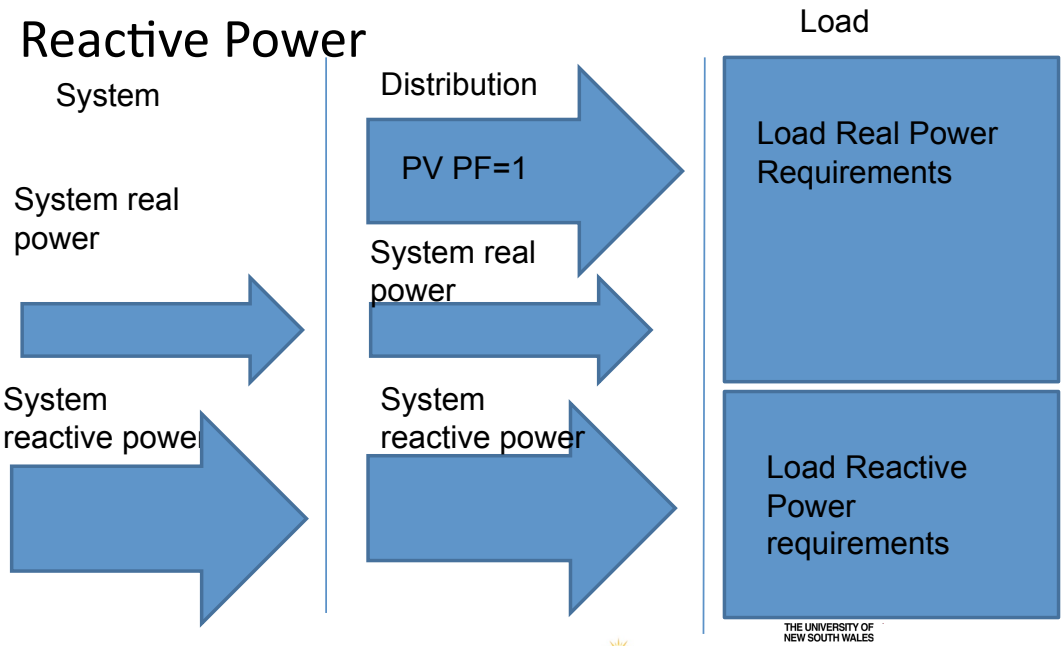

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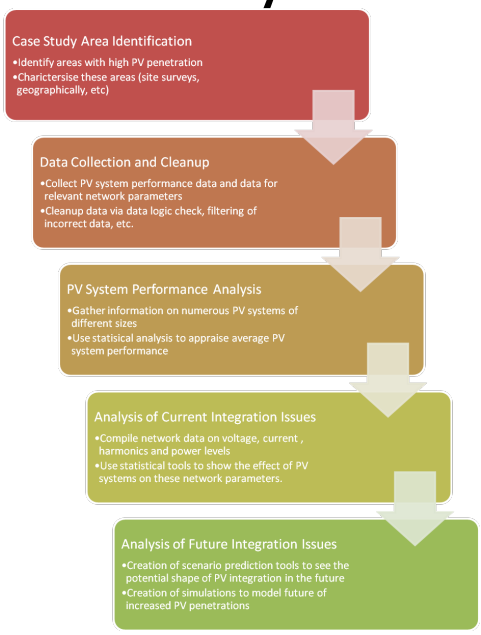
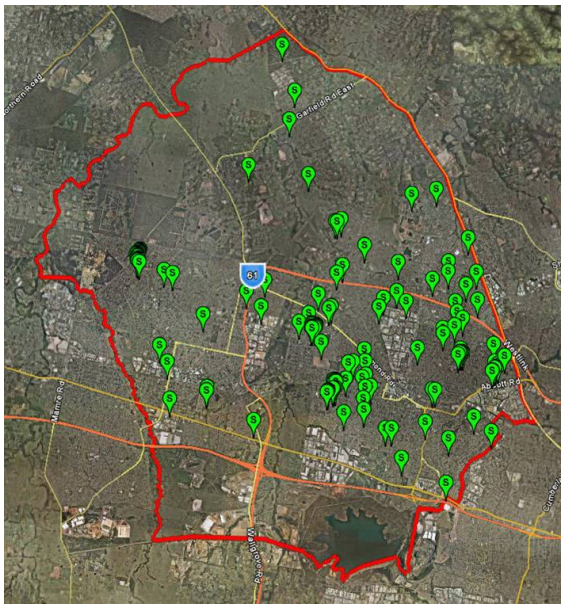
Case Study Process

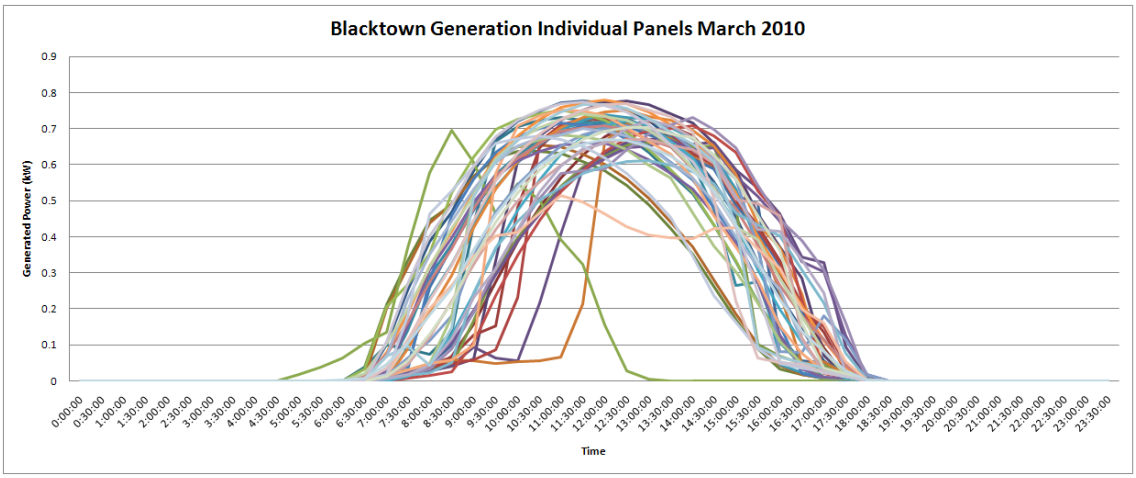


Endeavour Energy Case Study

- Study focussed on the "Blacktown Solar City"
- Case study area features a diverse network
- The network was receiving approximately 150 new PV applications/day in June 2010
- Systems available are predominately residential (1.1kW) with some commercial systems

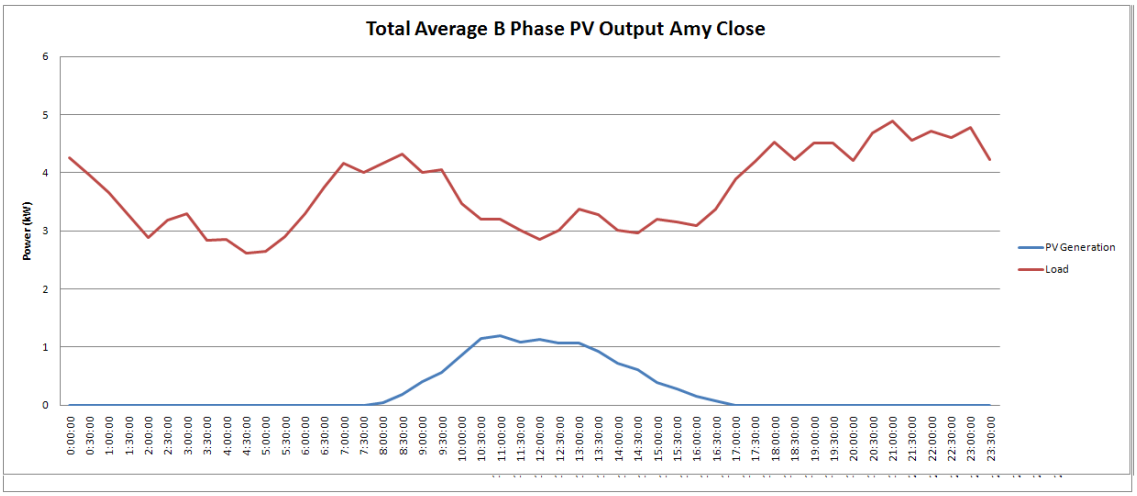


PV system output

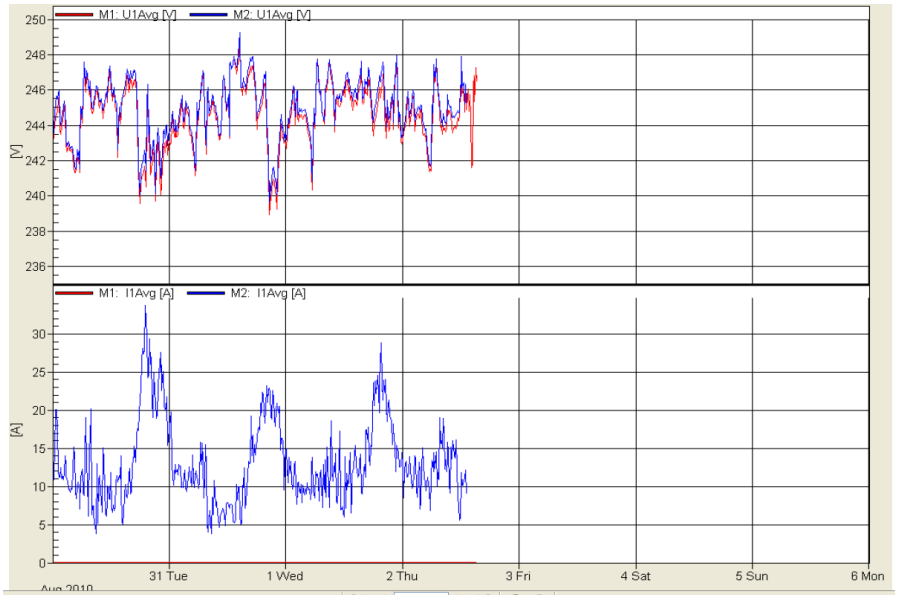


PV system output

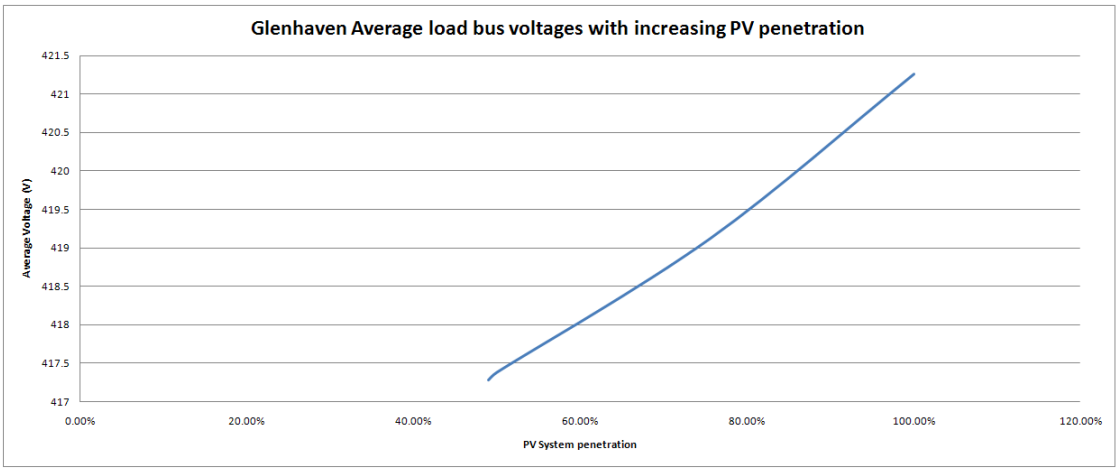
PV system output



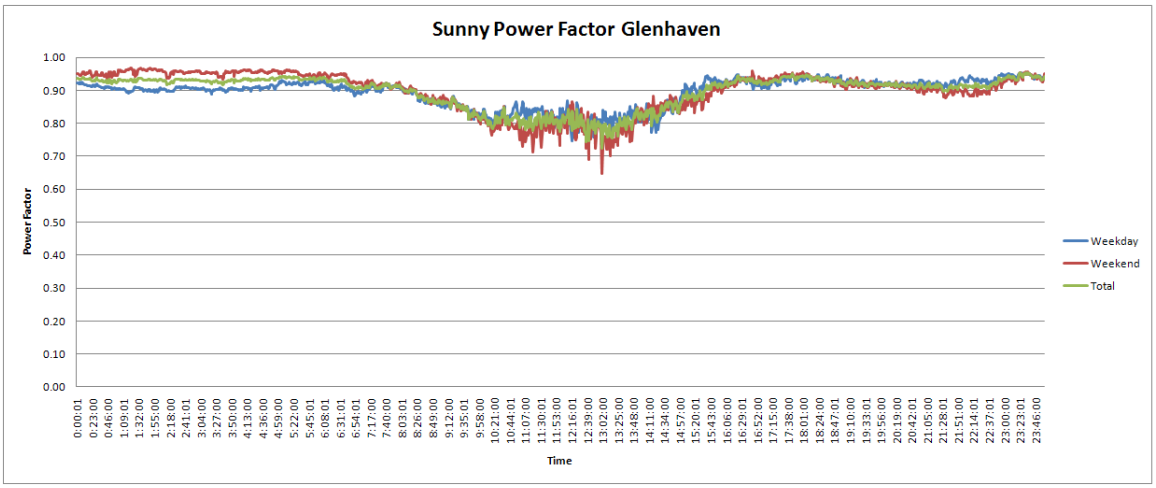
Voltage



Voltage



Reactive Power Management



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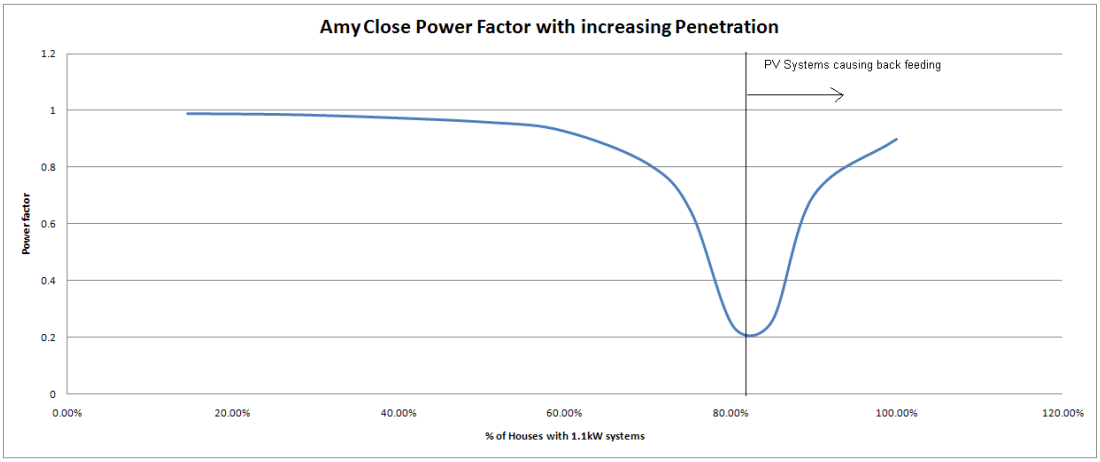
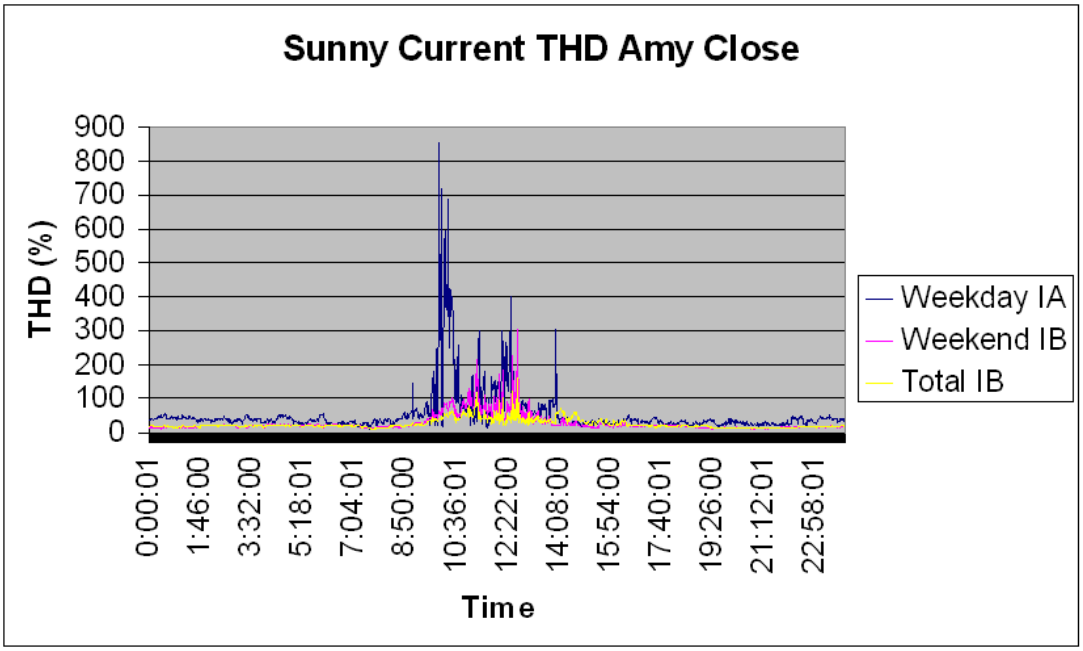
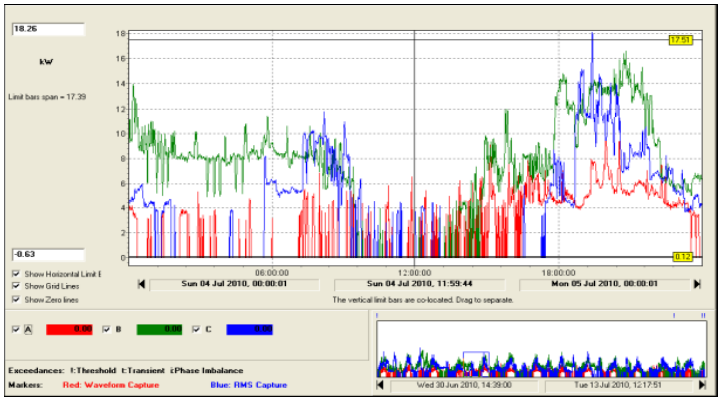


Harmonics

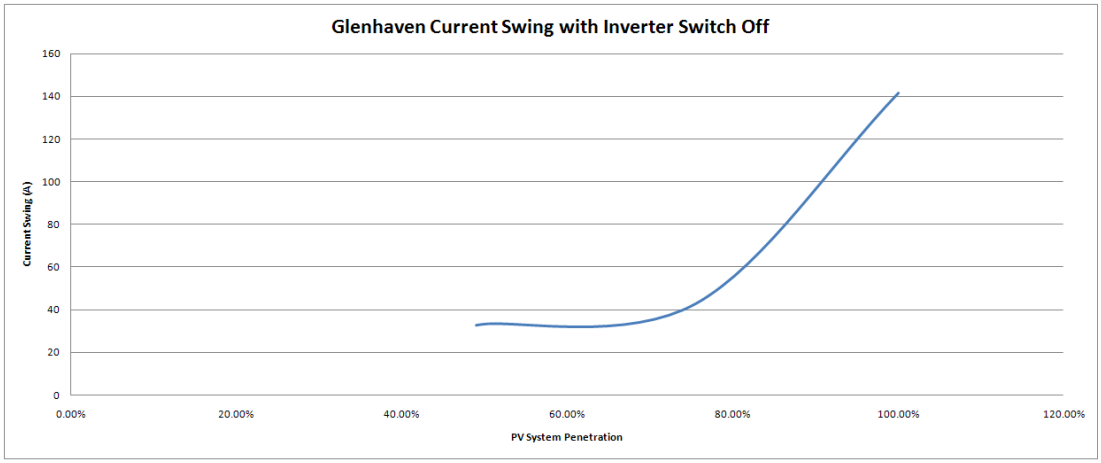


Harmonics

Reverse Power Flow



Current Swings



Management Strategies

- Proactive management
- Monitoring Program
- Storage
- Reactive power compensation
- PV Penetration Limitation
- Standardisation/control of inverter protection schemes
- System voltage modification
- Protection system design

Conclusions

- Current PV system penetrations weren't high enough in the case study area to show significant problems, possibly due to lower then expected PV system generation levels
- Increased PV penetrations in the future have been shown to cause problems, thus it is imperative for utilities to implement strategies now to maximise the benefits and minimise the problems.

Questions?