The Networks Perspective: Grid Integration of PV issues and Solutions



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- Technical Integration Challenges
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  - System stability due to PV system variability
  - Other LV PV integration issues
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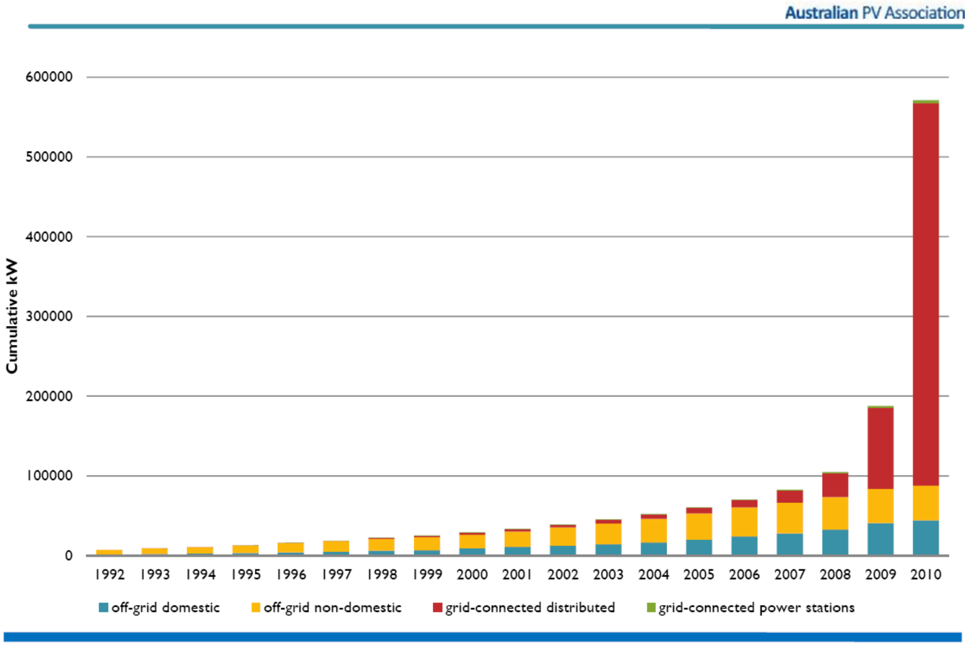
- Cultural Challenges

PV and Australian Network Utilities



PV and Australian Network Utilities – Responsibilities

- Ensure the safety of everyone who is on or interacts with the network
- Maintain quality of supply
- Maintain reliability of supply
- Incorporate PV systems into the mix

Potential PV System Integration Benefits For Utilities

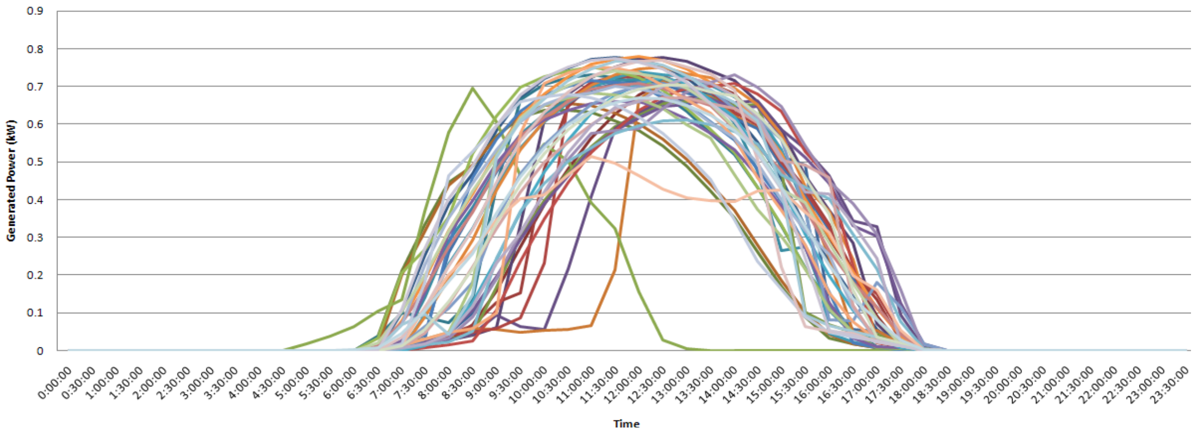
- Ohmic transmission losses reduced
- Delayed network expenditure due to load reduction
- Consumers are generally supportive of PV systems

Financial Implications

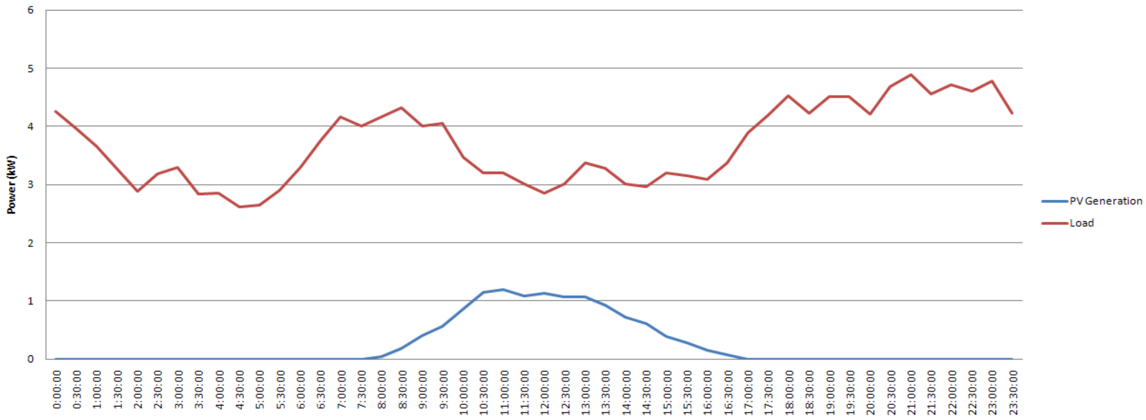
- Costs:
  - Installation
  - Network studies and possible augmentation
  - Feed in Tariff
  - Reduced utility income
  - R&D to reduce the impacts of PV
- Benefits
  - Clear customer benefits if they have a system
  - Possible network savings if peak loads match
  - Reduced generation
  - Reduced network losses

PV system installation

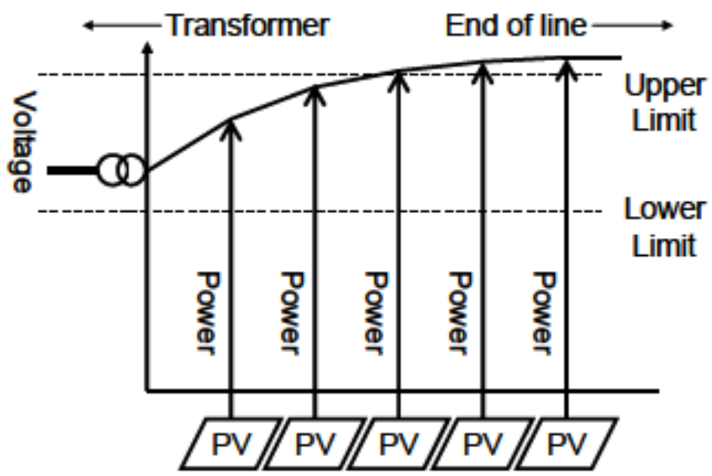
PV system installation



PV system installation

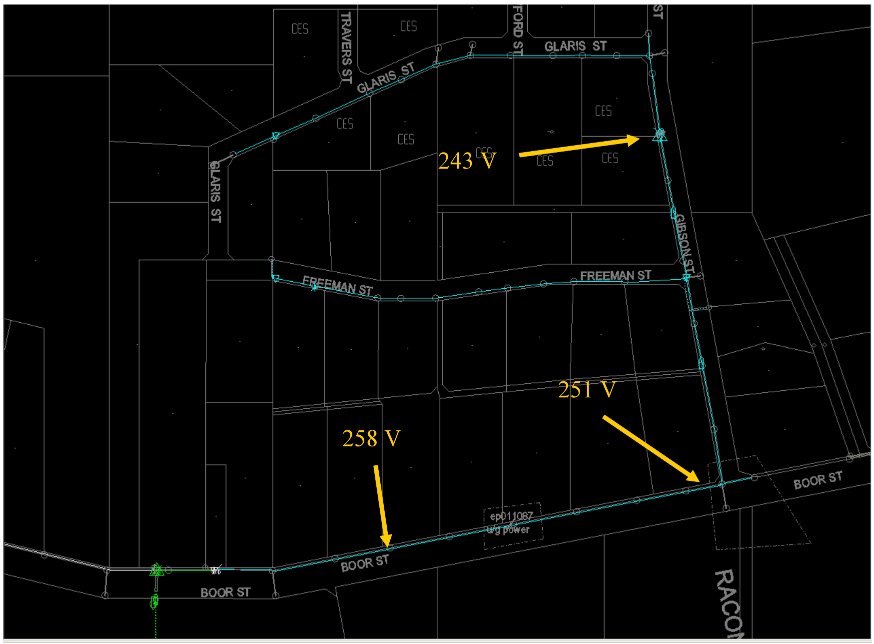


Technical Integration Challenges - Voltage



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

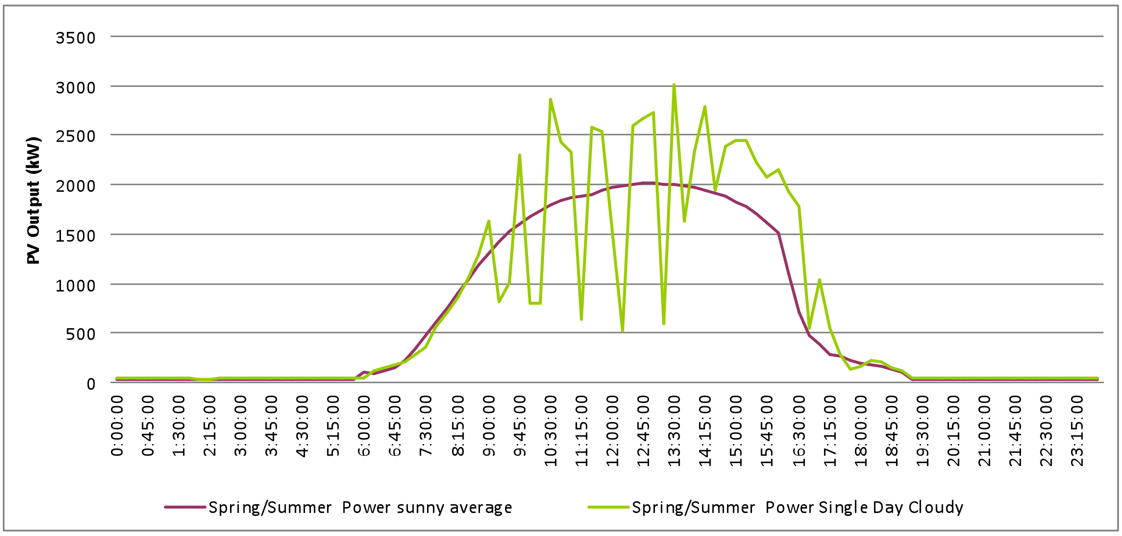
Technical Integration Challenges - Voltage



Technical Integration Challenges – Voltage Management

- Balance generation across the phases
- Lower Distribution transformer tap
- Augment the network
- Inverter reactive power support
- Revision of standards

Technical Integration Challenges – System Stability



Technical Integration Challenges – System Stability

- Cascaded Inverter Disconnection

  Frequency Fluctuation (system event)

  +

  Inverter anti islanding protection inside system protection

  =

  Extra strain on the generator

Technical Integration Challenges – System Stability

- Management
  - Spinning Reserve Strategy
  - Storage
  - Uniform Standards
  - Utility Inverter Control
  - Cloud Sensing

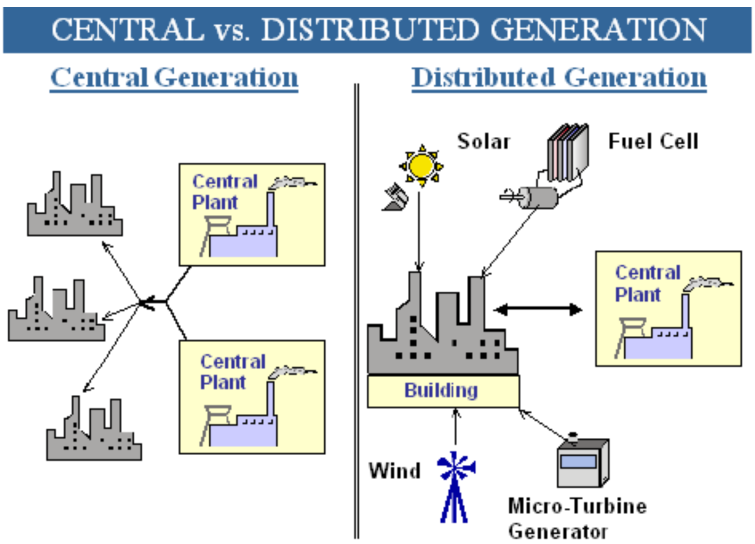
Other Technical Integration Challenges

- Harmonics
- Reactive power management
- Reverse power flow
- Protection

Limitation of PV systems on the network

- Response of some utilities has been to limit the amount of PV on the network

Cultural Challenges



National Fuel Cell Research Centre. (2009). *Fuel Cell Applications & Issues*. Retrieved April 2010, from National Fuel Cell Research Centre: http://www.nfcrc.uci.edu/2/FUEL_CELL_INFORMATION/FCexplained/stationary.aspx

Cultural Challenges

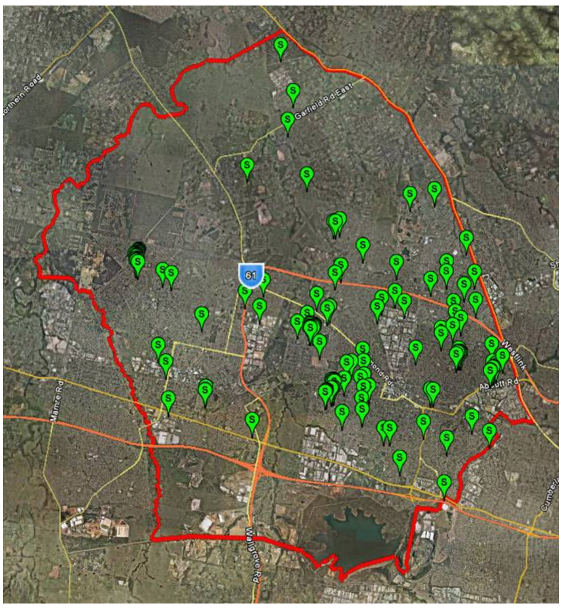
- Consumer backlash to utility innovation
- Rising electricity prices
- No consistent approach amongst utilities

Further Discussion?

Concluding Remarks

- Utilities are being mandated to allow PV systems to connect to the network
- However the net benefits are seen to be low and costs are escalating
- Current penetrations are too low to see significant issues however
- Significant thinking and collaboration between key stakeholders is integral to the success of PV systems in Australia

Appendix – Clustering of PV Systems



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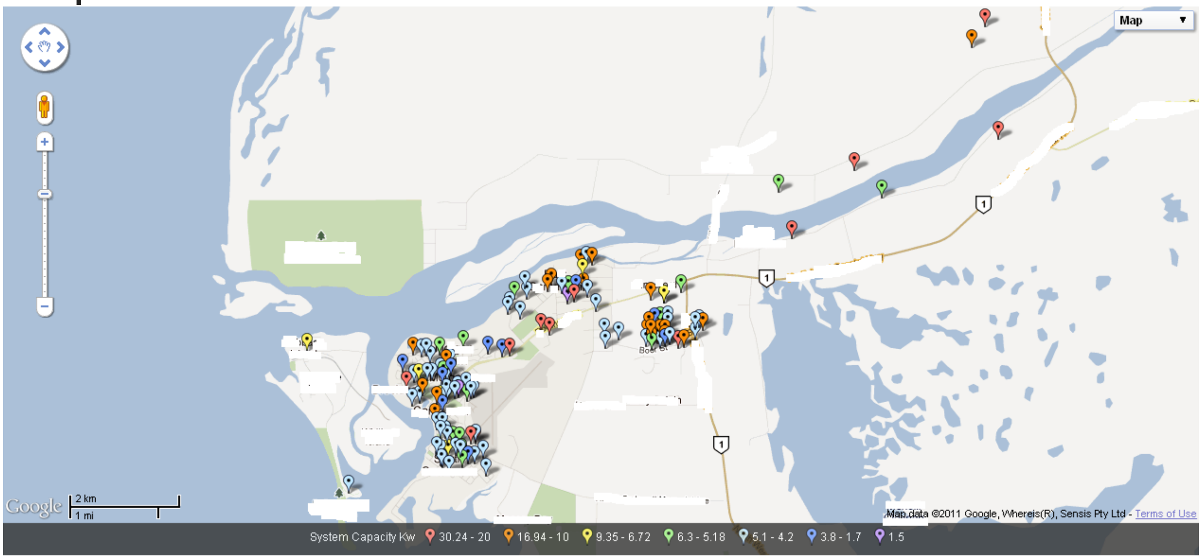
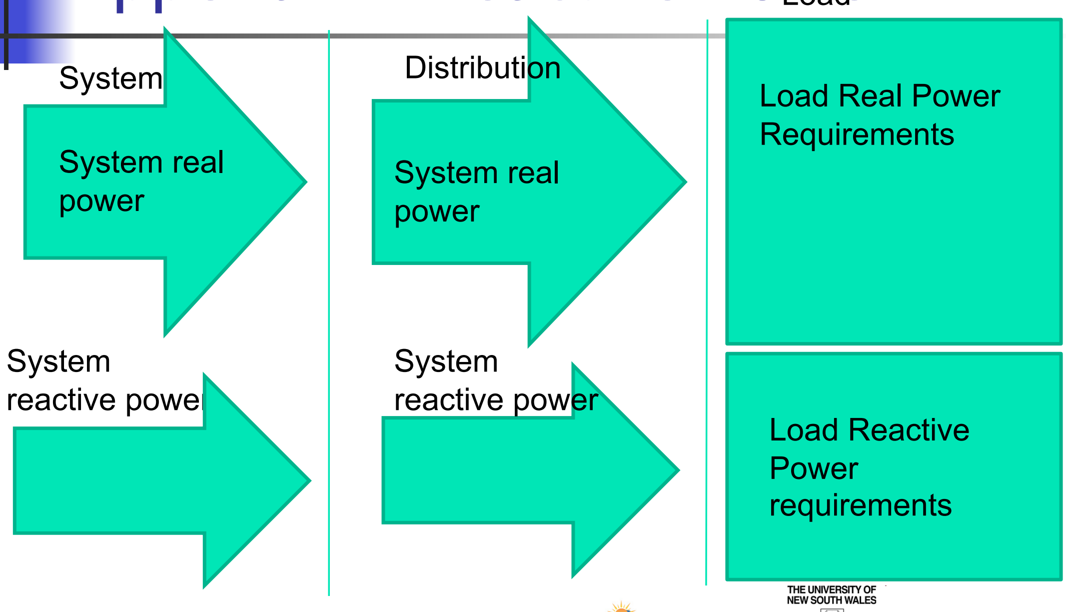


Appendix - Reactive Power



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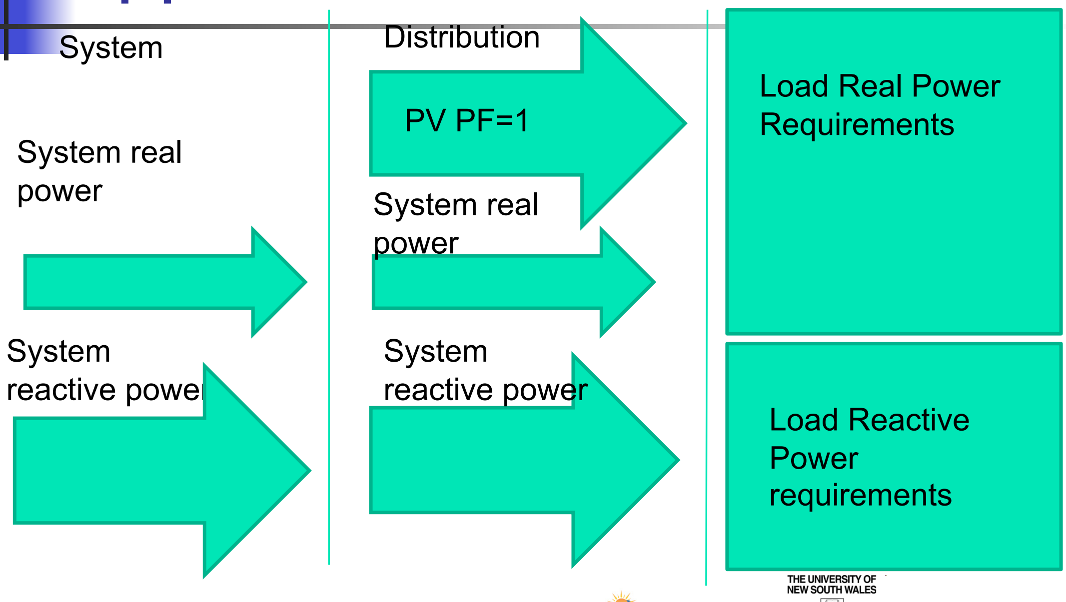
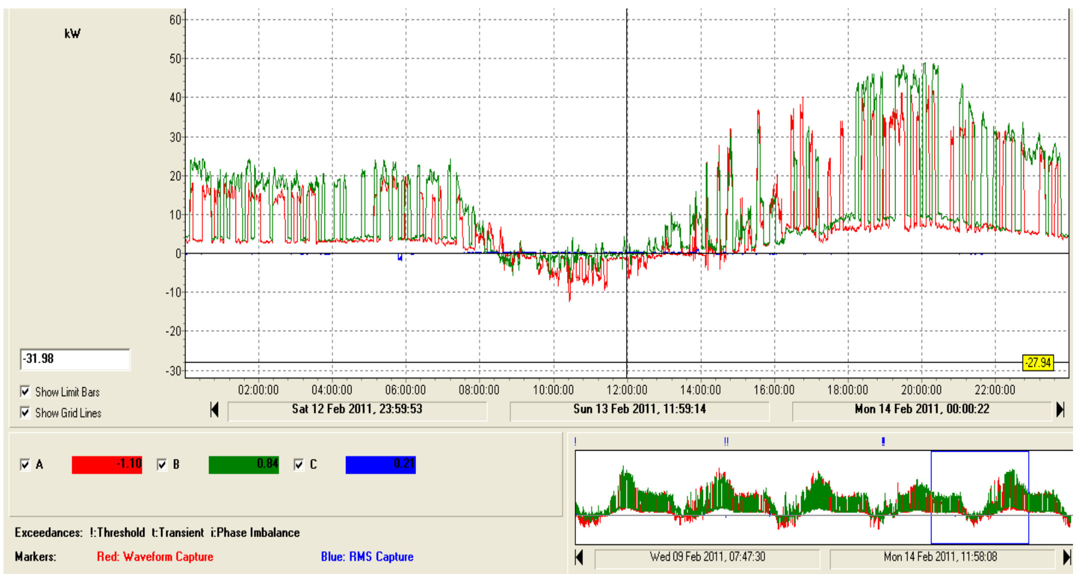


Endeavour Energy   ASI   Centre for Energy and Environmental Markets   Australian PV Association   THE UNIVERSITY OF NEW SOUTH WALES SCHOOL OF ELECTRICAL ENGINEERING & TELECOMMUNICATIONS

Appendix – Network Power Flows



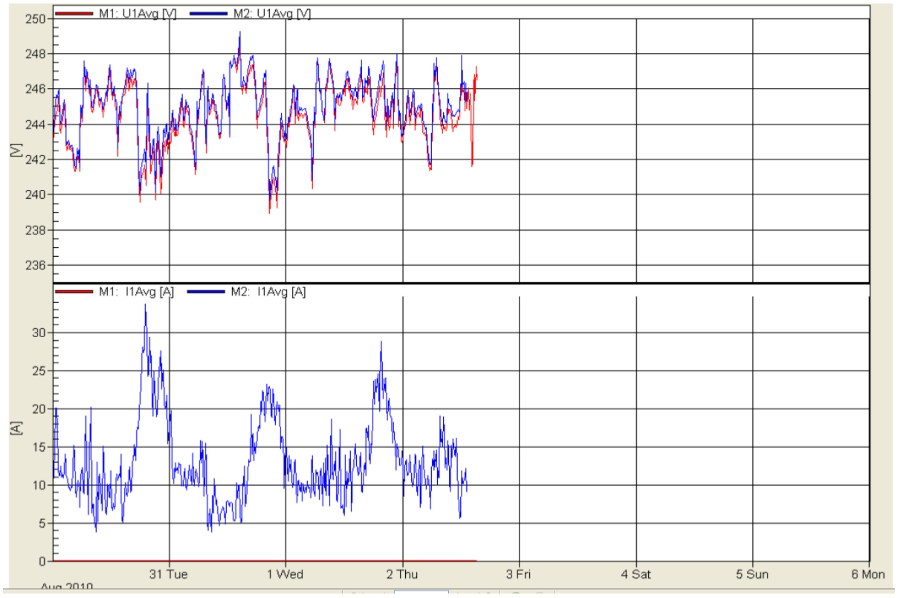
Appendix – Voltage Standards

State	Power Company	Nominal (Volts)	Range		Conditions	Required By
			Upper	Lower		
QLD	Energex	240	+6%	-6%	Nil	Electricity Regulation 2006 (QLD)
	Ergon Energy	240	+6%	-6%	Nil	
NSW	Country Energy	230	+10%	-2%	95% of the time (10 minute averages). +10%,-6% for 99% of the time. +14,-10% 100% of the time. Typically one week survey.	NSW Dept. of Water & Energy's Code of Practice – Electricity Service Standards requires each electricity distributor to detail their own service standard.
	Energy Australia	240	+6%	-6%	95% of the time for 95% of customers measured over a week. Otherwise 216-264 V at all times.	
	Integral Energy	230	+10%	-2%	For most of the customers, most of the time. Normal conditions - +14%,-6% (10 minute averages) at the PCC but may exceed these in abnormal or emergency conditions.	
ACT	ACTEWAGL	240	+6%	-6%	Nil	ACTEWAGL Service and Installation Rules
VIC	Citipower Jemena Powercor SPAusNet	230	+10%	-6%	<1 minute - +14%,-10% <10 seconds Ph-E +50%-100%, Ph-Ph +20%-100%	Electricity Distribution Code (VIC)
TAS	Aurora Energy	230	+10%	-6%	5 minute averages. ±10% <1 minute. <+50%,-100%<10s Ph-E +20%,-100% <10s Ph-Ph Unless otherwise agreed by the customer.	Electricity Code (TAS)
SA	ETSA Utilities	230	+10%	-6%	Under normal conditions.	Electricity (General) Regulations 1997 (SA) specifies AS 2926. ETSA Utilities Service & Installation Rules

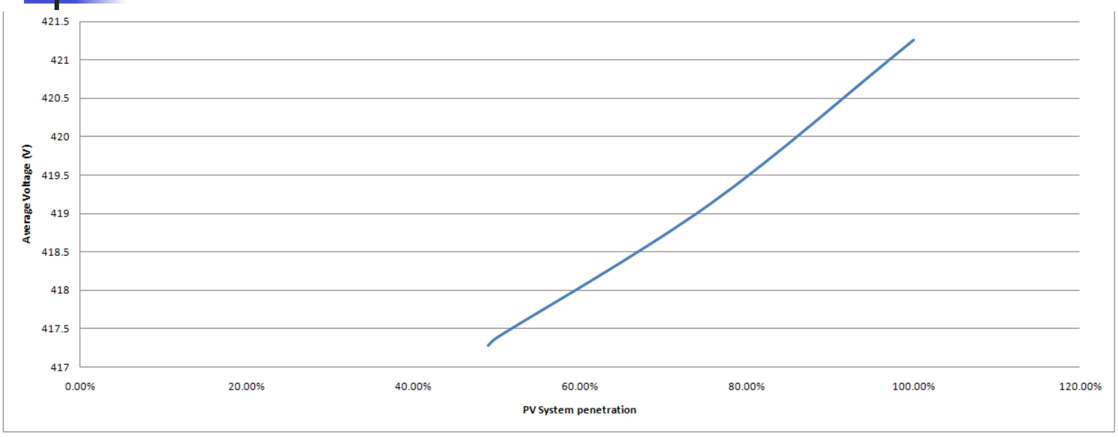
Appendix – Standards

- New AS4777
- New 61000.3.100
- Individual state wiring rules

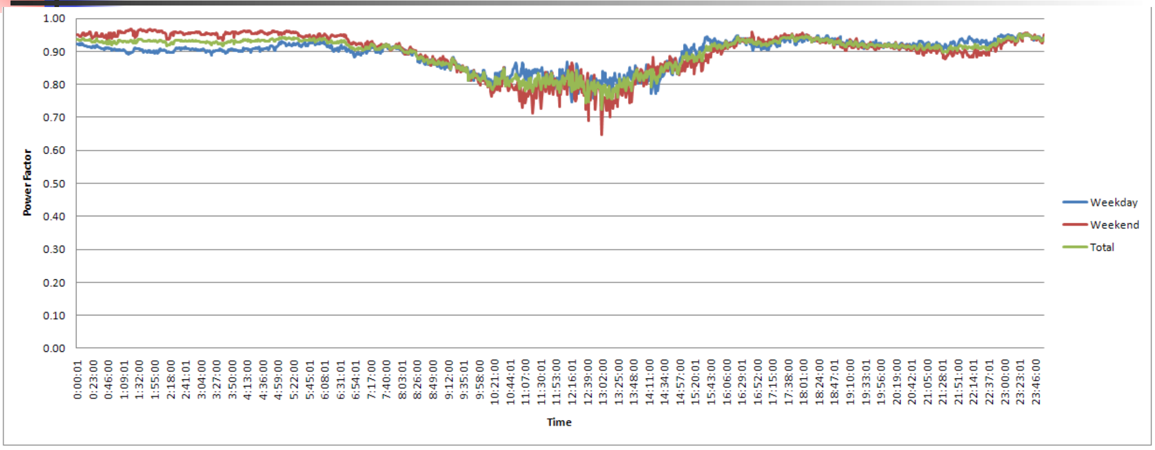
Voltage



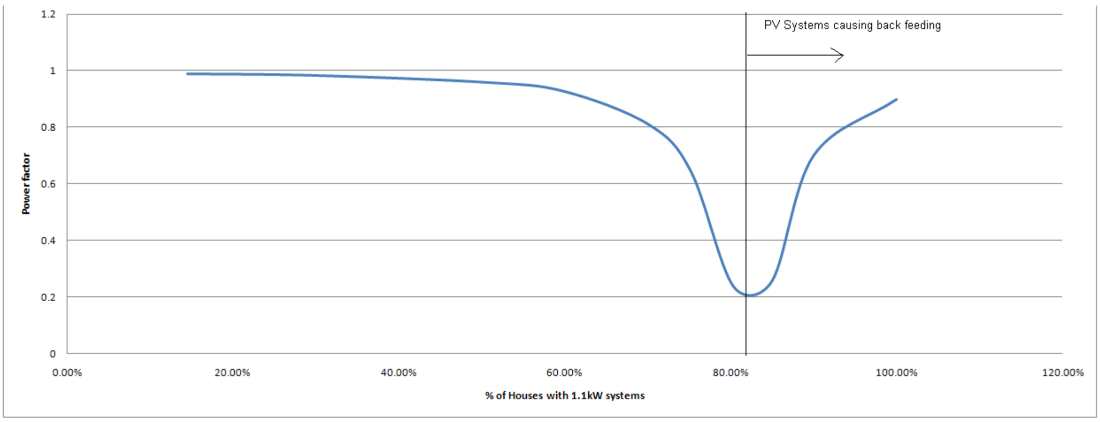
Voltage



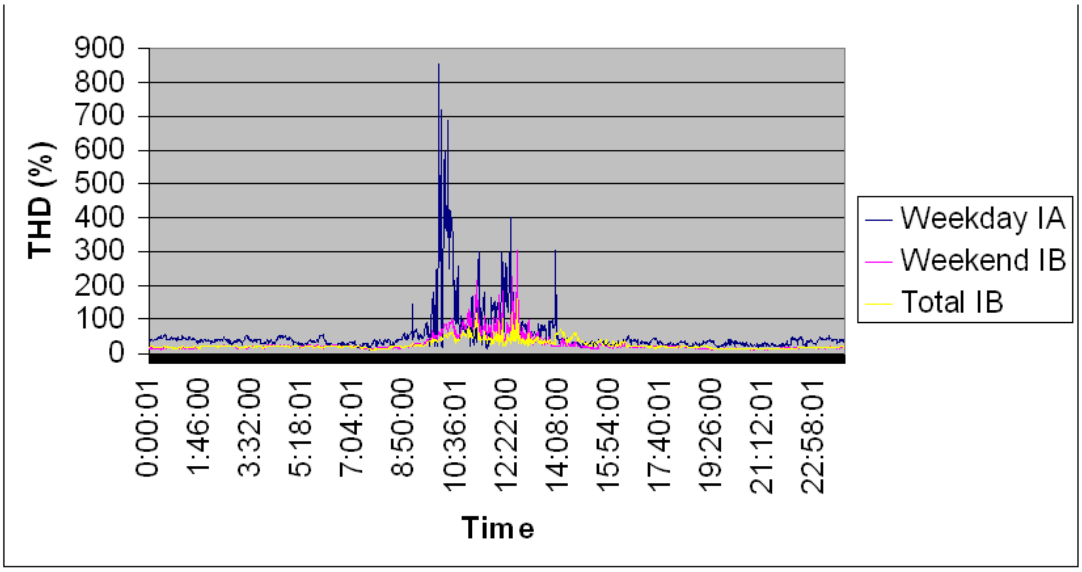
Reactive Power Management



Reactive Power Management

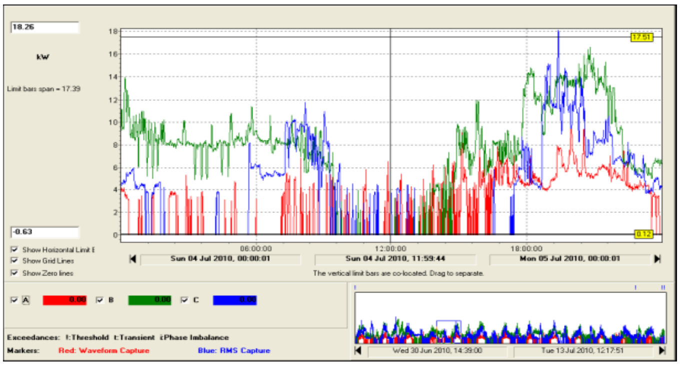


Harmonics



Harmonics

Reverse Power Flow



Current Swings