CORRELATIVE ANALYSIS OF A DATA ACQUISITION SYSTEM FOR A BUILDING INTEGRATED PHOTOVOLTAIC SYSTEM

University of Fort Hare
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STUDENT: **BUMA CARINE LEHTEM**

SUPERVISOR: **PROF. MEYER EDSON LEROY**

CO-SUPERVISOR: **DR. TAZIWA RAYMOND**

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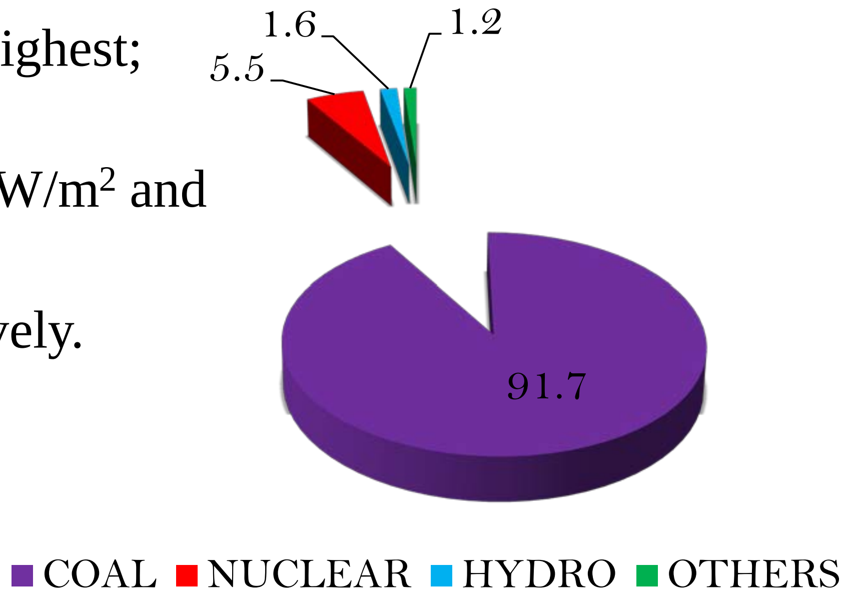
Background

- ❖ Rapid increase in world's energy needs due to industrialisation and population growth with just 18% from renewable sources
- ❖ Over 90% of South Africa's energy comes from coal
- ❖ However, SA's solar resource is one of the highest;
- ❖ 24hrs average 220 W/m^2 as opposed to 150 W/m^2 and 100 W/m^2 for parts of U.S and Europe respectively.
- ❖ South Africa's 2015 energy statistics



Background

- PV systems could be grid-interactive or stand-alone
- PV systems could also be building integrated, building attached or rig-mounted.
- History of BIPV systems date back to the 1970's and claims just about 1% share of global PV installations

- Challenges faced by this niche technology;
  - High installation cost
  - Codes and standards
  - Market limitations
  - Inadequate performance data

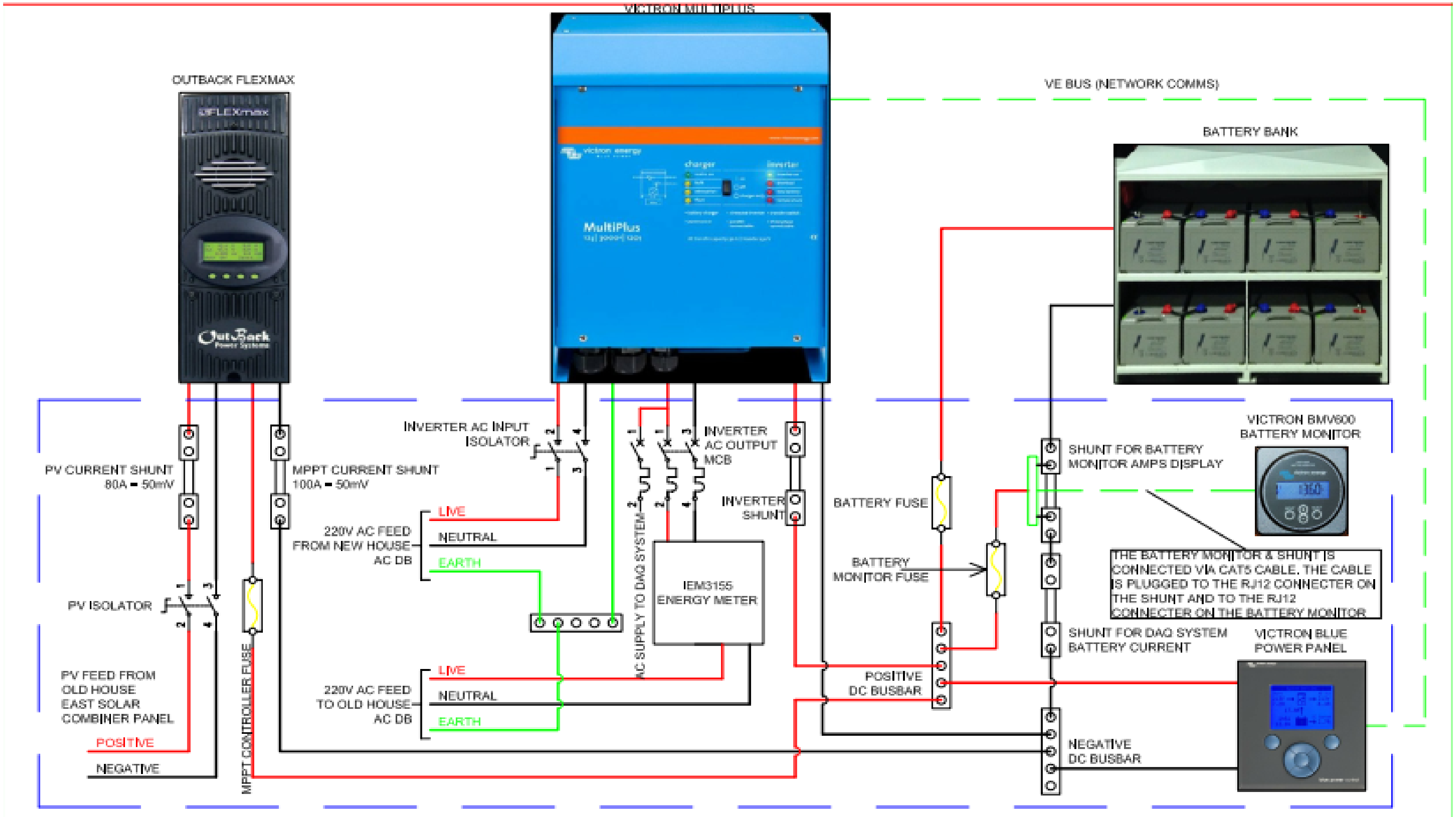
Aim and Objectives

Correlate the performance of a building integrated photovoltaic system to the ever changing meteorological conditions

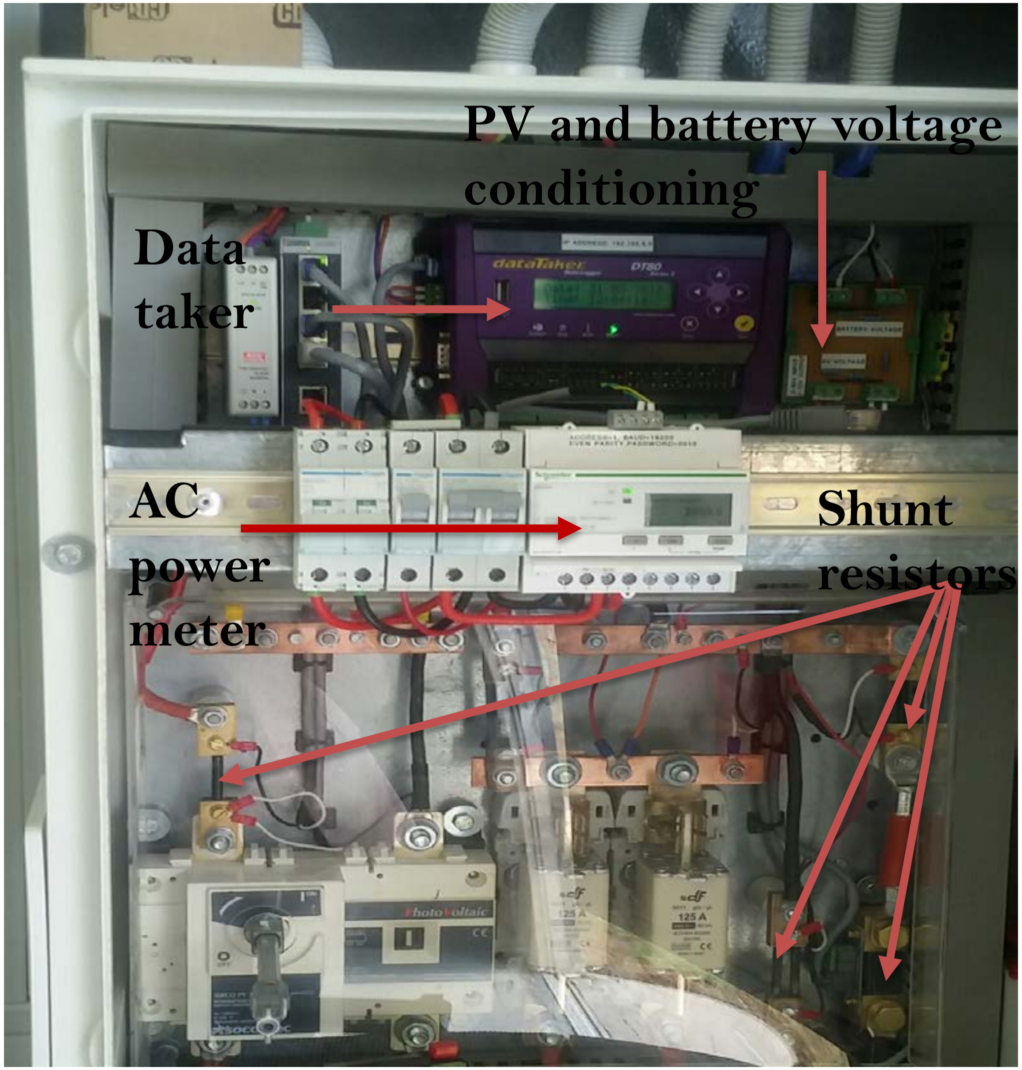
This will be achieved by:

- Building an appropriate data acquisition system for the electrical parameters and the meteorological predictors of the system
- Monitoring and evaluating the performance of the system
- Correlating the performance of the system to outdoor conditions

System Description



Data acquisition system (DAS)

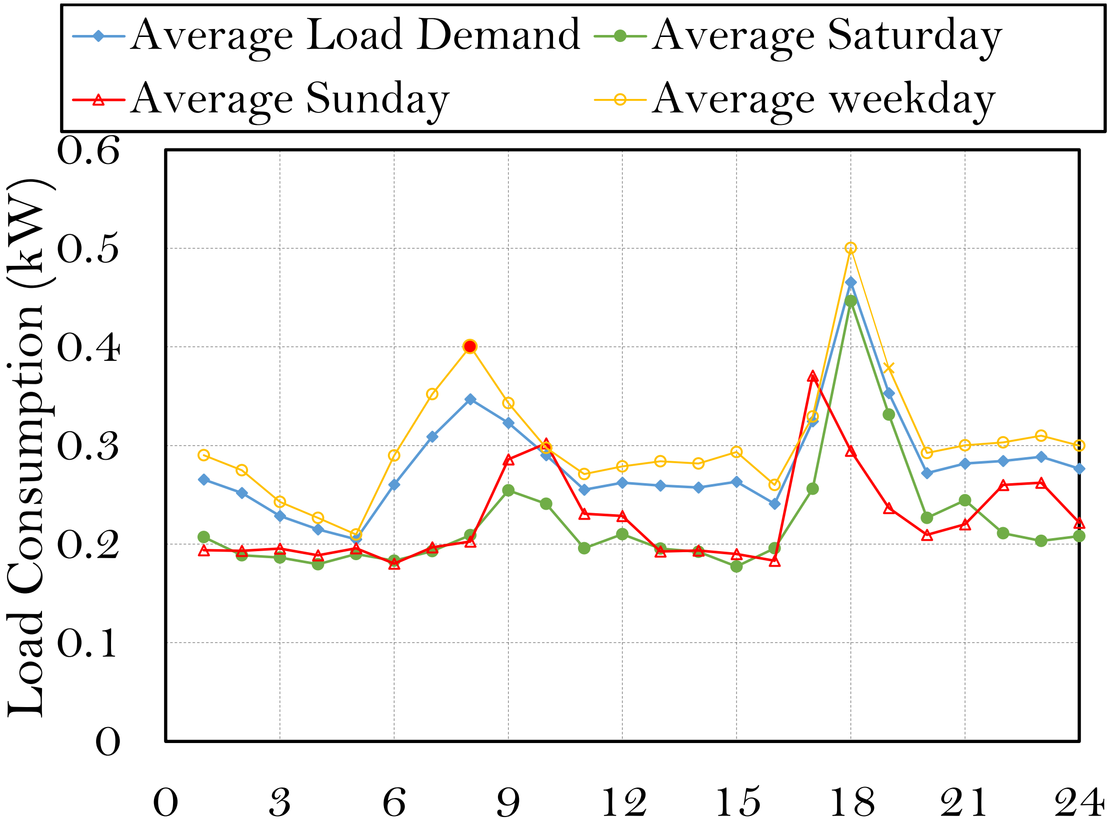


Methodology

- Data for both the electrical and meteorological parameters was collected for five months
- The data was averaged over 30 minutes intervals and saved in the data loggers

Results – Load profile

- During the analysis period, the building was occupied by two adults and three children



	Morning peak		Evening peak	
	Time	Power (kW)	Time	Power (kW)
Av. Weekday	7 am	0.40	5 pm	0.50
Av. Saturday	8 am	0.25	5 pm	0.45
Av. Sunday	9 am	0.3	4 pm	0.37
Average	7 am	0.35	5 pm	0.45

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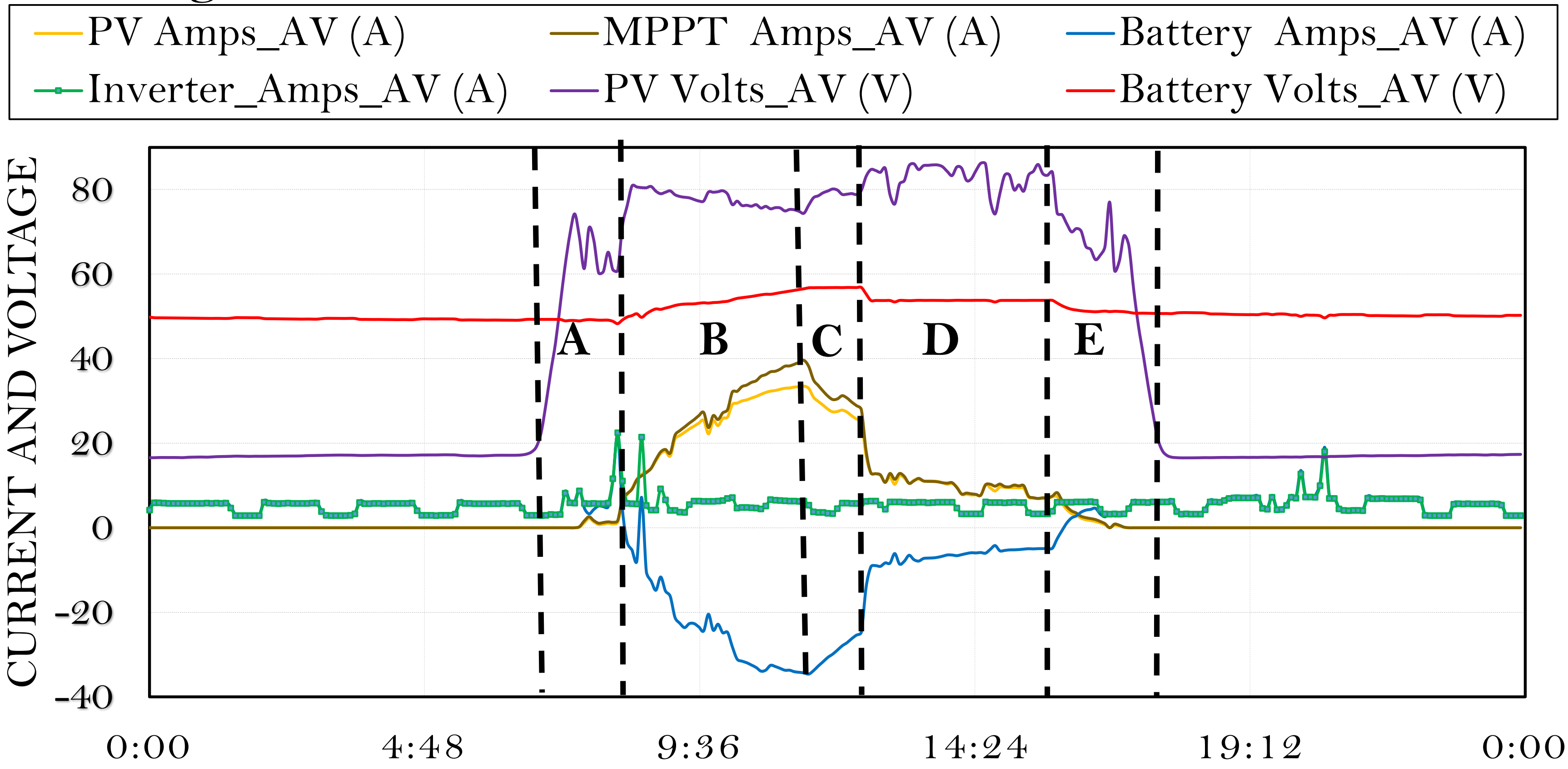
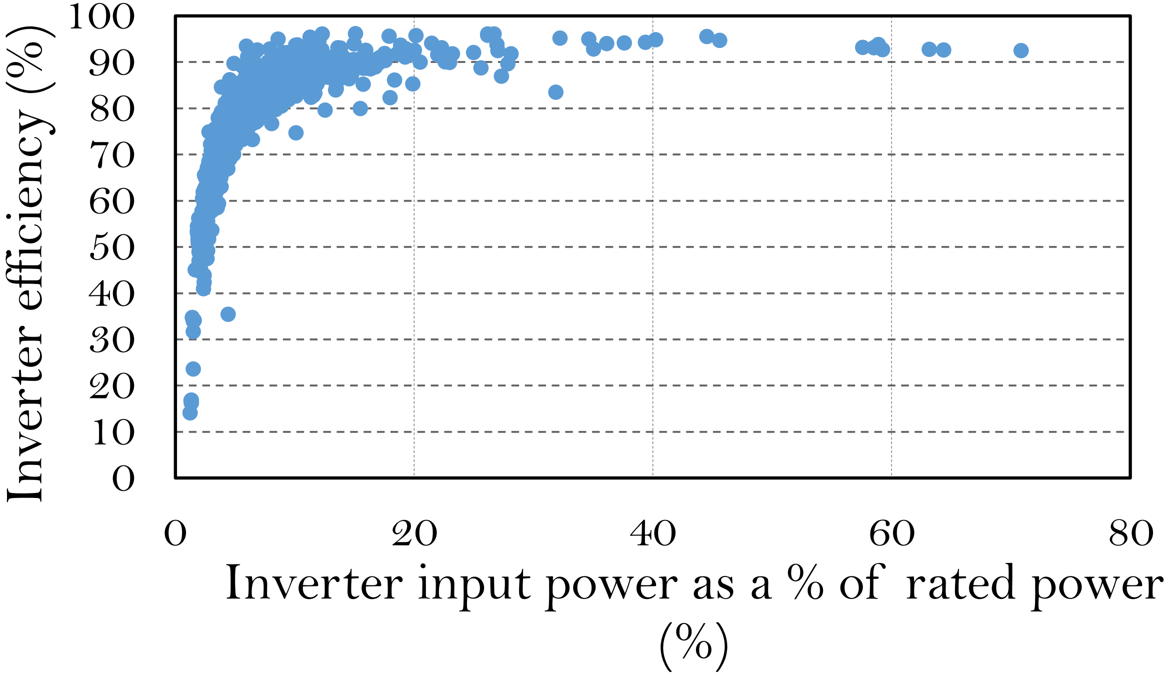
Results – Correlation of parameters

- Correlation between PV, MPPT, battery current, PV and battery voltage with demand



Results _ Inverter performance

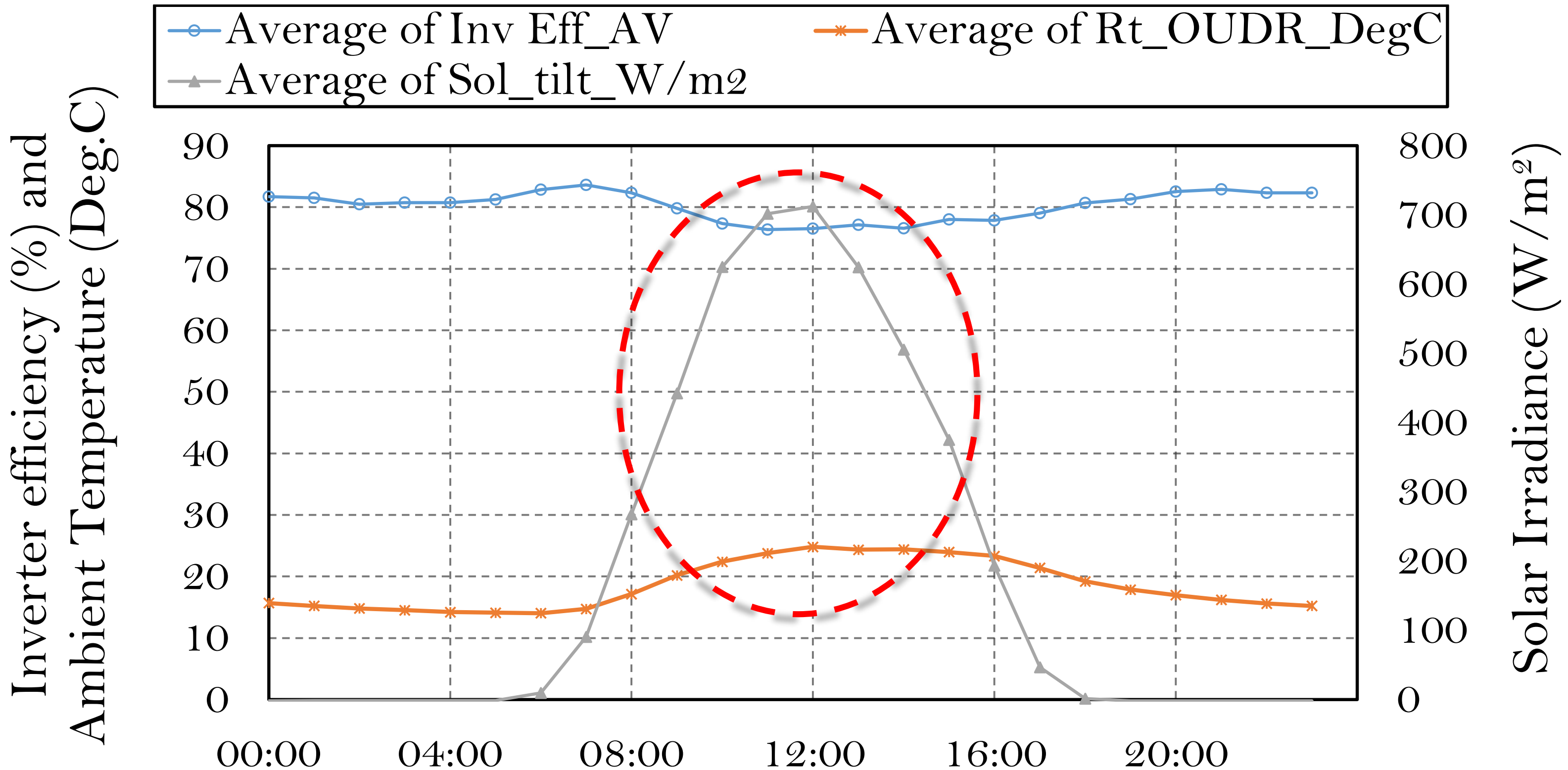
- Inverter performance depends on
  - Input power
  - Temperature
  - Solar insolation



- Inverter efficiency varies between 14% and 96%
- Inverter efficiency highest at night; 81.9%

Inverter performance Cont

- Variation of inverter efficiency with ambient temperature solar irradiance



Battery performance

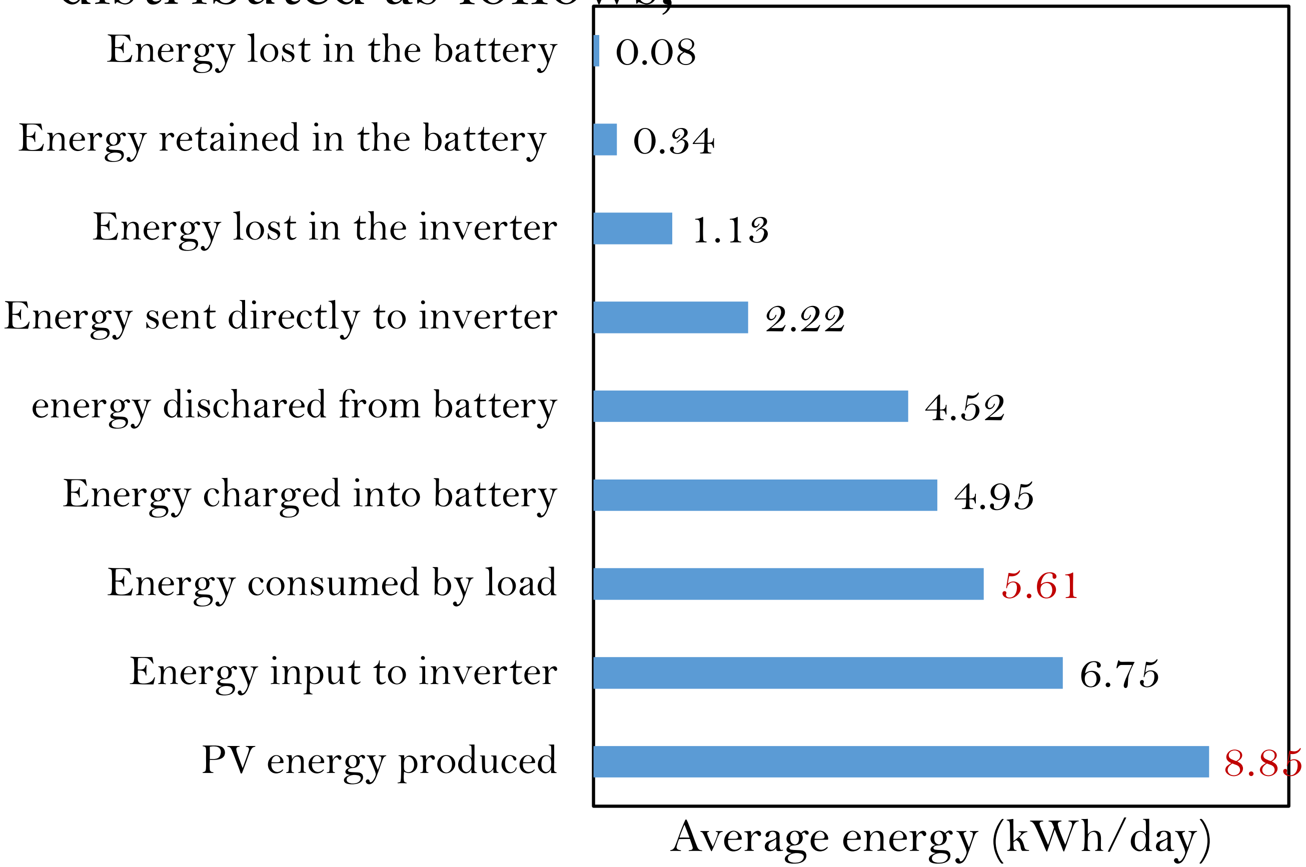
- The battery is the "weak-link" in every PV system typically requiring replacement every five years
- The round trip efficiency of the battery is given by:

$$\eta_E = \frac{V_D I_D \Delta T_D}{V_C I_C \Delta T_C}$$

- Where: V_D, I_D and T_D are the voltage, current and time during the discharging mode while V_C, I_C and T_C are the voltage, current and time during the charging mode.
- Battery round trip efficiency was 91.5%.

Energy balance in the BOS components

- The energy produced by the modules on an average day is distributed as follows;



- 11.5% of the energy produced is lost in the system
- Just about 62.4% of this system's potential is used on average

Results _ Feed-in-tariffs

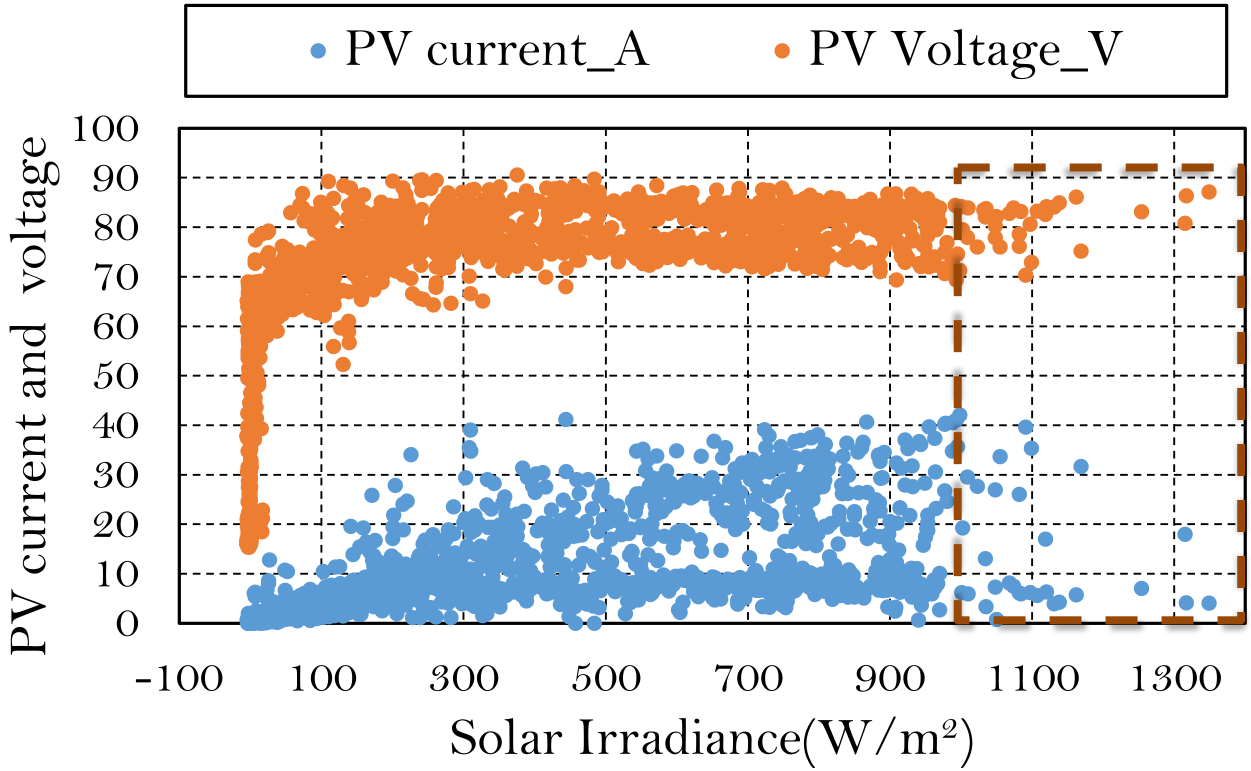
- Feeding the energy lost due to charge controller regulations into the grid will generate monetary savings
- Feed-in-tariff = R 0.4972/kWh for small-embedded generation

Av. Radiation	Inverter eff.	Module efficiency	Array area
4.5 kW/m²/day	83.2%	16.1%	23.36m²

Full potential production	Current production	Unused potential	Financial worth	
14 kWh/day	8.73 kWh/day	37.6%	R 2.6/day	R 78/month

Correlation between meteorological and electrical parameters

- PV systems in general are affected by outdoor conditions such as irradiance, ambient temperature, relative humidity, wind speed amongst others.

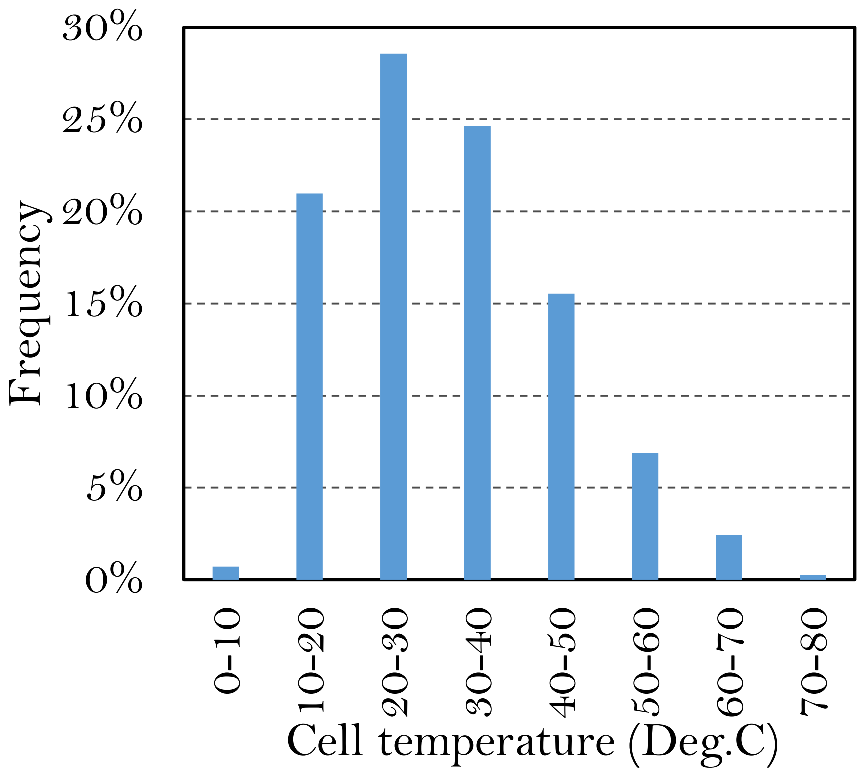


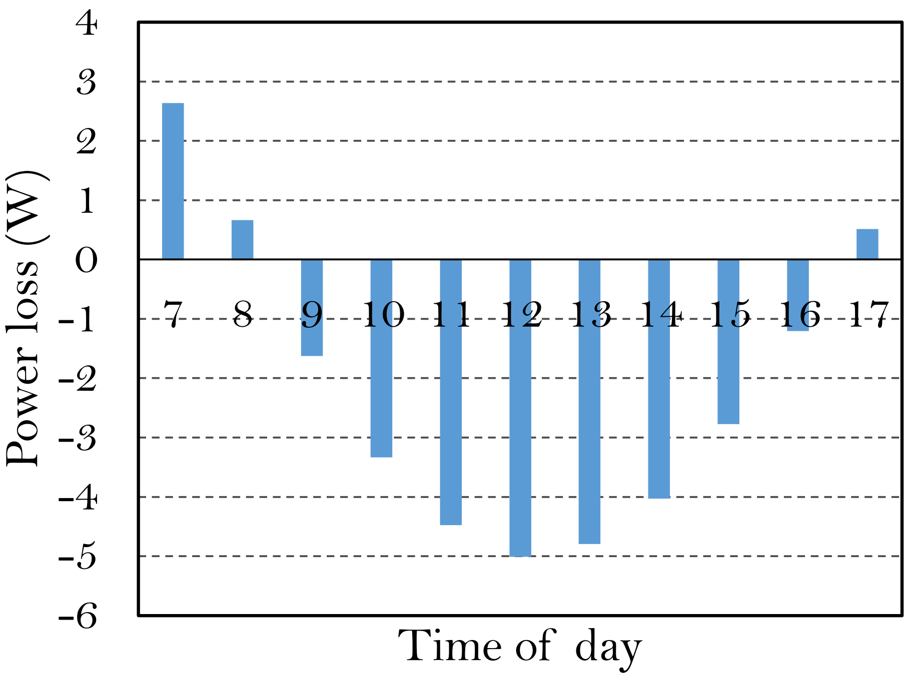
$$V_{oc} = \frac{nK_BT}{q}\ln\left(\frac{KE_e}{I_o}\right)$$

$$I = I_{ph} - I_s\left(e^{qV/nkT} - 1\right)$$

Effect of cell temperature

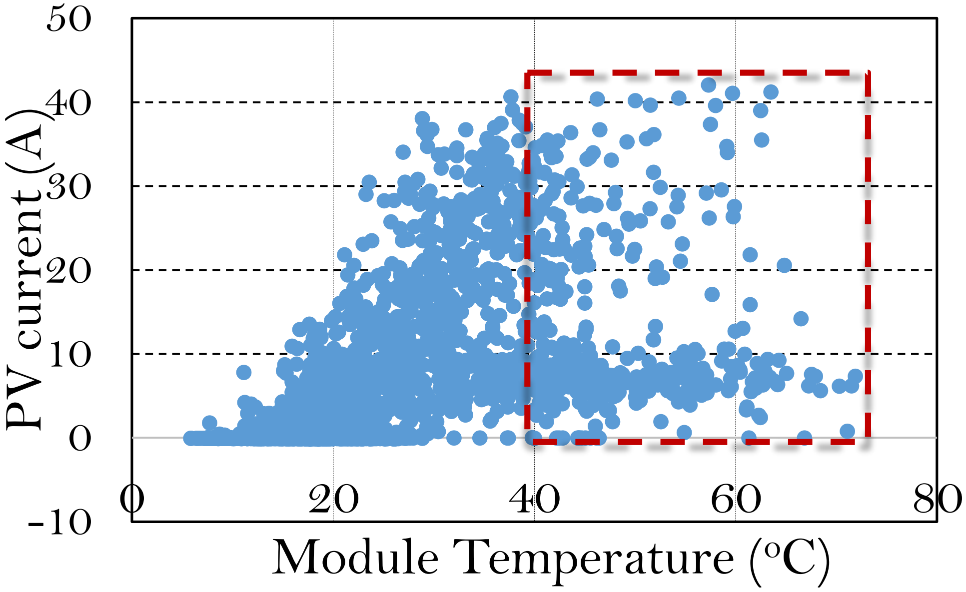
- Cell temperature frequency distribution and power loss due to high temperatures is illustrated below
- PV cell temperature coefficient = - 0.33 W/°C

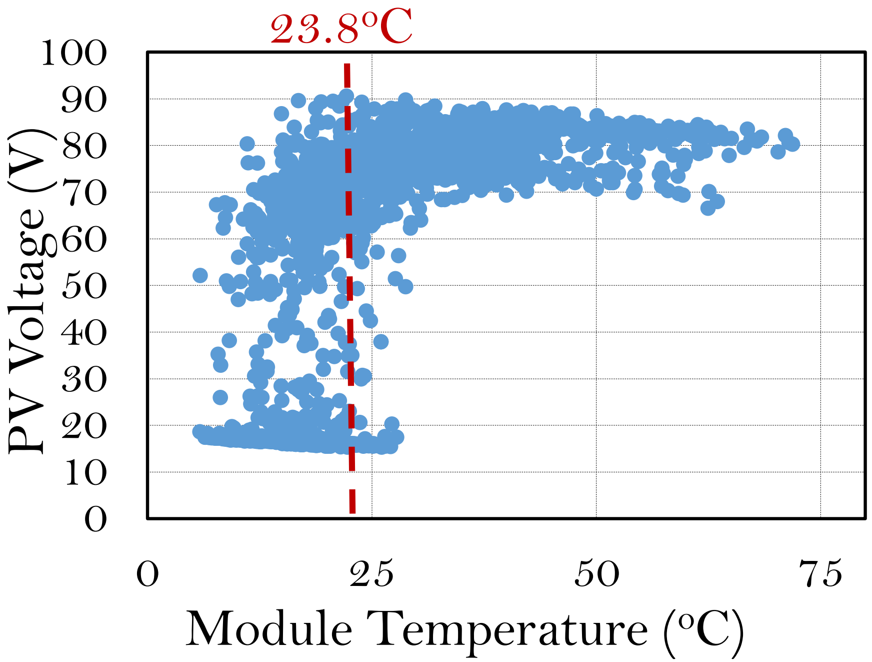




Effect of cell temperature cont'

- There exist a higher tendency for temperature build-up in BIPV systems
- Increasing cell temperatures reduce power output by reducing output voltage





Conclusion

An average morning and evening peak demand of 0.35 kW and 0.45 kW at 7 am and 5 pm respectively

Inverter efficiency increases with increasing input power, and reduces with high ambient temperatures above 25°C. Higher efficiency levels of 81.9% at night.

37.6% of this system's potential is unused daily, which is worth R 2.6/day and R 78/month.

Increasing levels of irradiance leads to a logarithmic increase in output voltage and a linear increase in output current

High cell temperatures above 23.8°C leads to a decrease in output voltage, a slight increase in output current and overall decrease in output power.

References

- Lasnier F and Ang, T G (1990), photovoltaic engineering handbook. Asian institute of technology, Bangkok, Thailand. Pp 69 -82.
- Meyer E.L. (2002). *On the reliability, degradation, and failure of photovoltaic modules.* PhD thesis. University of Port Elizabeth.
- Michael Simon (2009). On the evaluation of spectral effects on photovoltaic modules performance parameters and hot-spots in solar cells. *PHD thesis.* University of Fort Hare.
- P. Torcellini, S. Pless, and M. Deru (2006), Zero Energy Buildings: A Critical Look at the Definition. National Renewable Energy Laboratory. ACEEE Summer Study Pacific Grove, California.
- P.Manimekalai R.Harikumar S.Raghavan (2013). An Overview of Batteries for Photovoltaic (PV) Systems. International Journal of Computer Applications. Vol. 82, nº 12. Pp 28-32.
- South African Alternative Energy Association (2016). "Current regulations regarding the connection and synchronization of embedded generation systems", 2016, [Online] Available: http://www.saaea.org/news/category/net%20metering on: 03/11/16. [Accessed: 20-Oct-2016].