Energy Management System for a Residential Grid-Tied Micro-grid

Category: Effective energy use in the home

Wilhelm Bisschoff and Rupert Gouws
Presenting Author: Wilhelm Bisschoff

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Agenda

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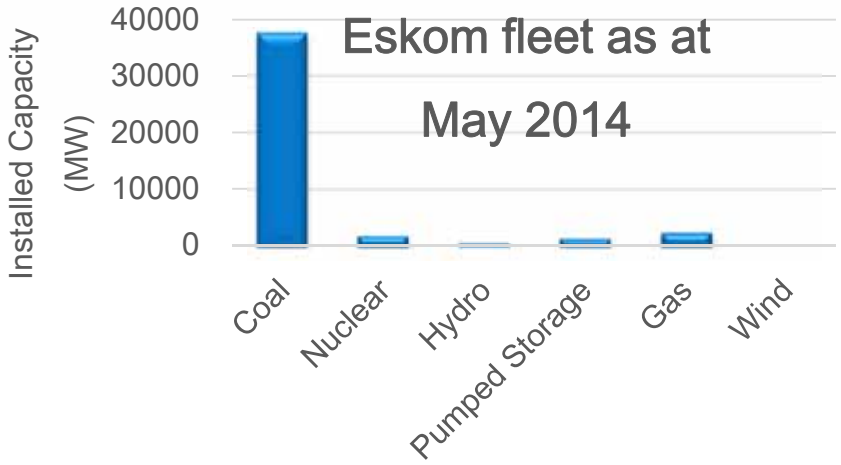
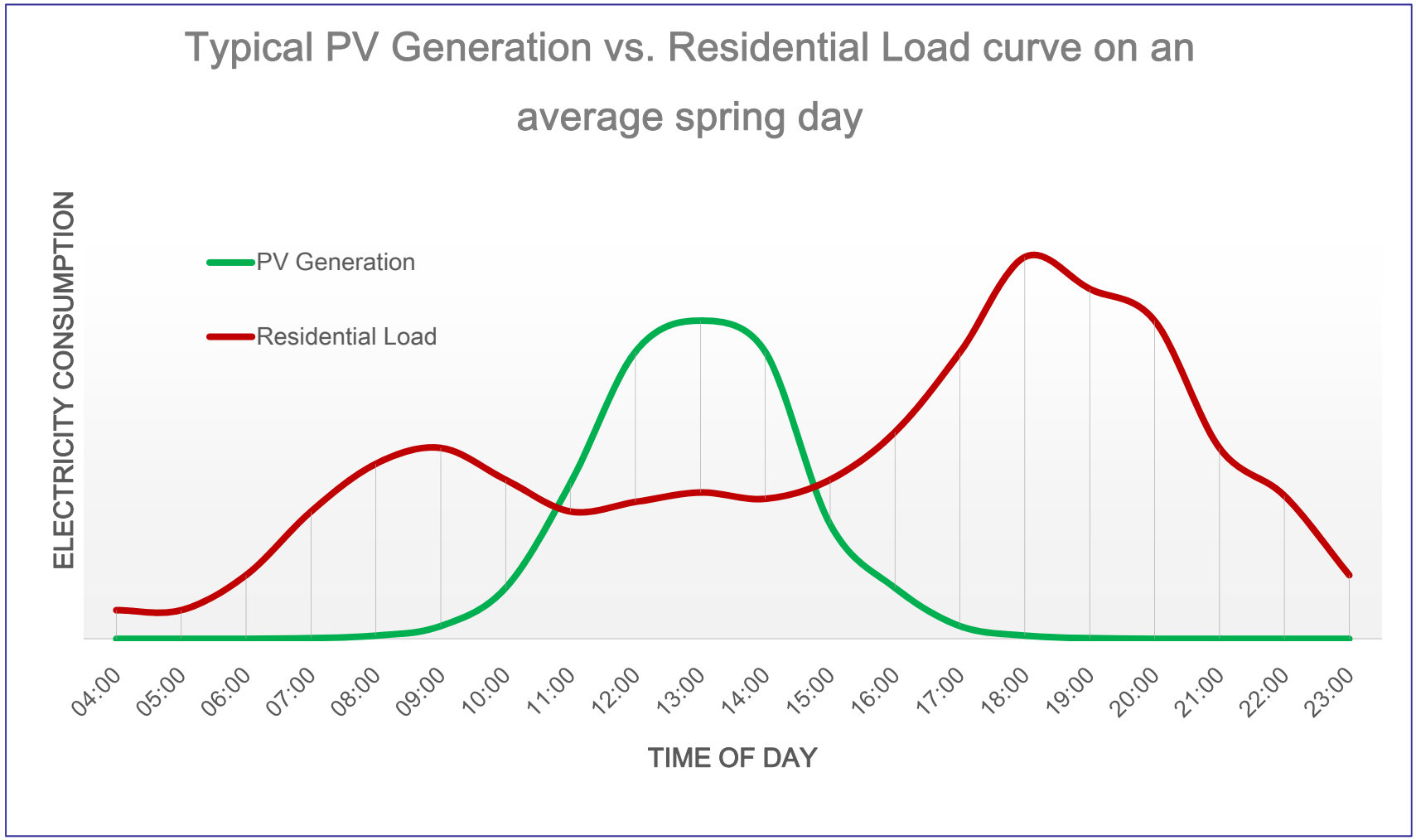
- Study Rationale
- EMS Strategy
- EMS Design
- EMS Simulations and Results
- Discussion

Study Rationale

- Eskom background
  - Supplies 95% of electricity in SA
  - Tariff increases, unreliable
- With rising electricity costs, there are daily enquiries for resi-ential PV systems
  - Standalone
  - Grid-tie
- Standalone popular but very expensive
- Grid-tie not favoured in SA due to feed-in policies
  - Advantages: Load balance, grid backup support
  - Disadvantage: No policy, inefficient



Study Rationale



EMS Strategy

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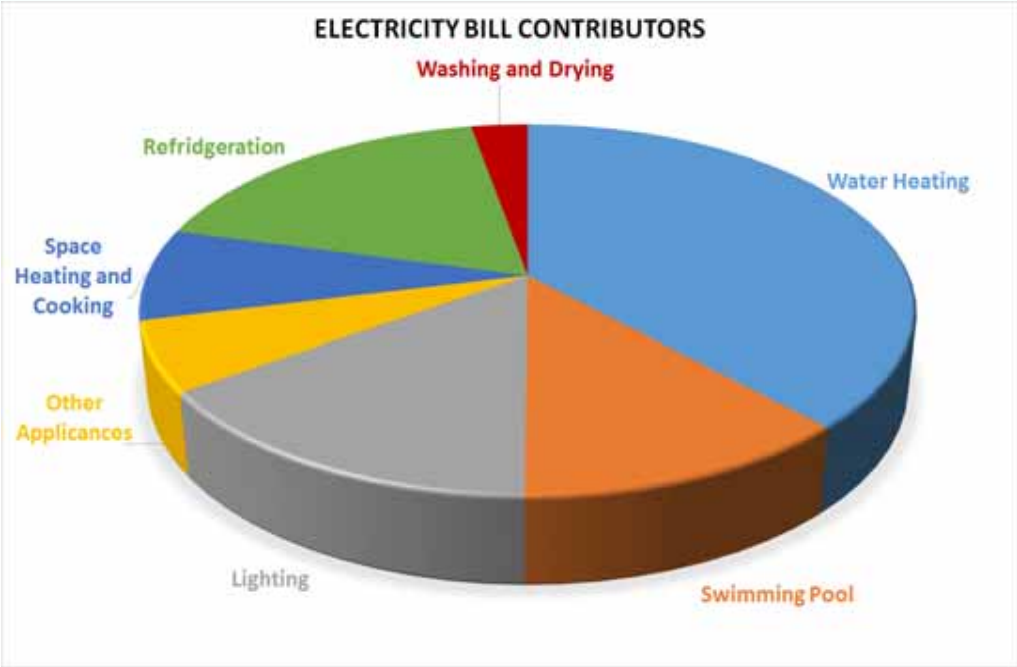
- Primary objective
  - Absorb as much as possible of the PV generated energy locally
- Methodology
  - Determine the LSM (Living Standard Measure) group (according to NRS Load Research) most likely to adopt PV systems
  - Draw up a typical residence floor plan and identify controllable loads according to this LSM group
  - Design the EMS according to the researched techniques and shift the load according to the PV input profile

EMS Design

- Typical LSM Class 7 Controllable Loads
  - Geyser
  - Washing Machine
  - Tumble Dryer
  - Swimming Pool
  - Refrigerator
  - Dishwasher
- Additional: Low voltage DC security light system
  - 50W, 12V LED security light system



EMS Design

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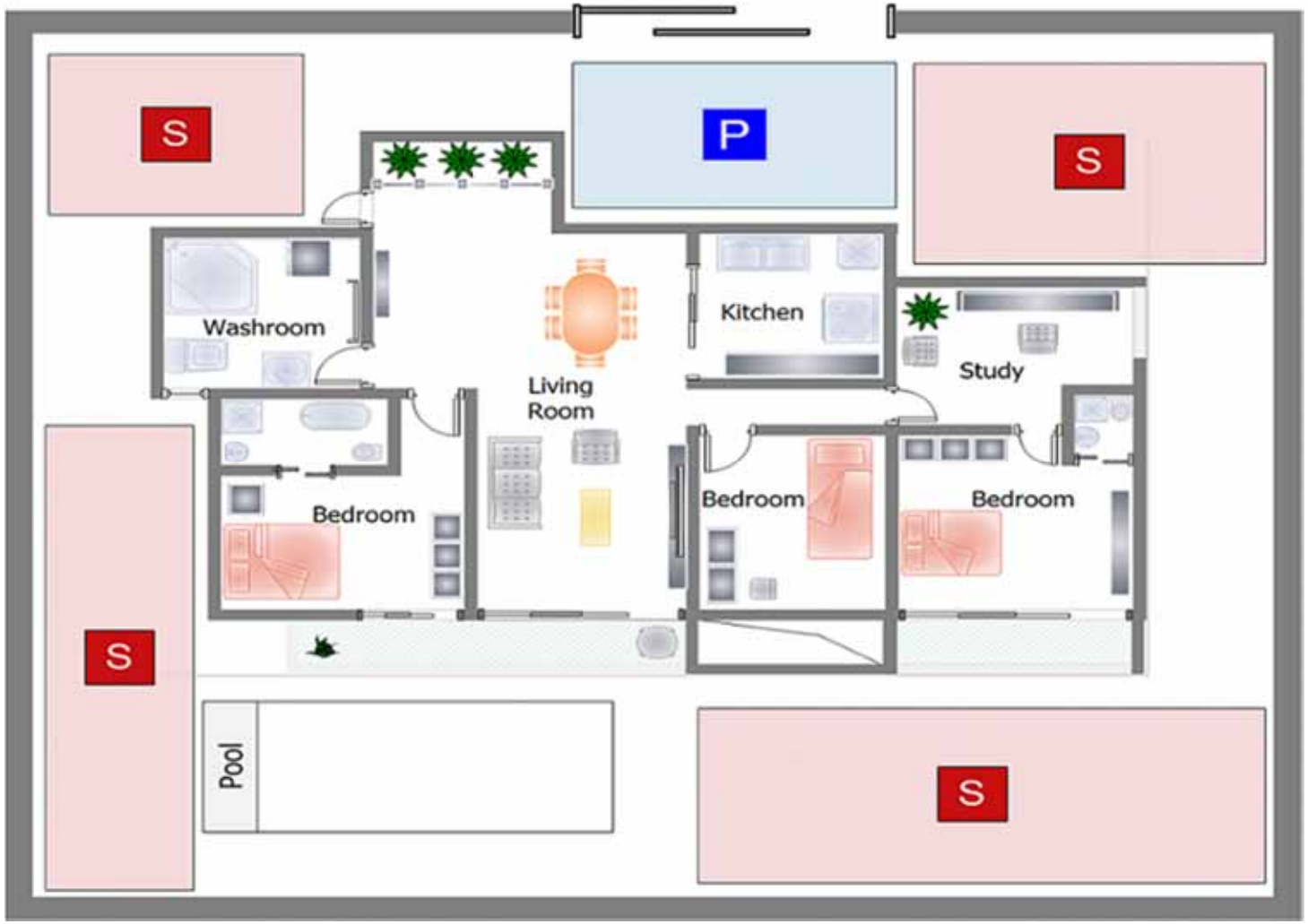
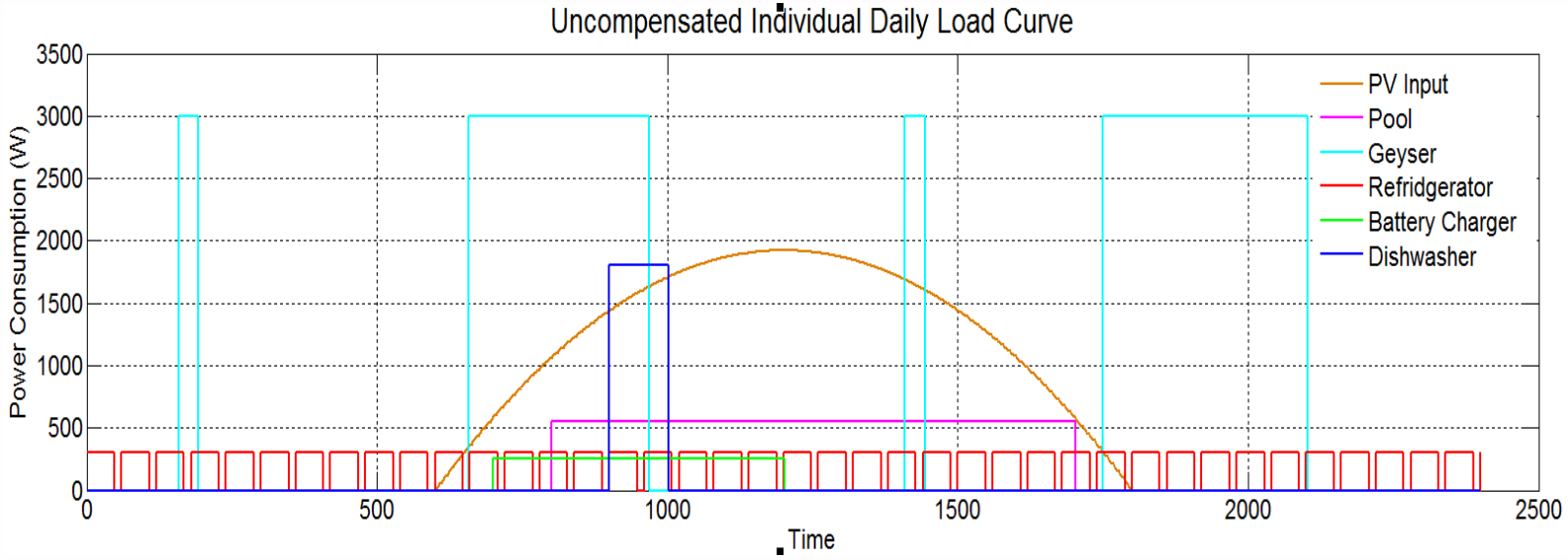
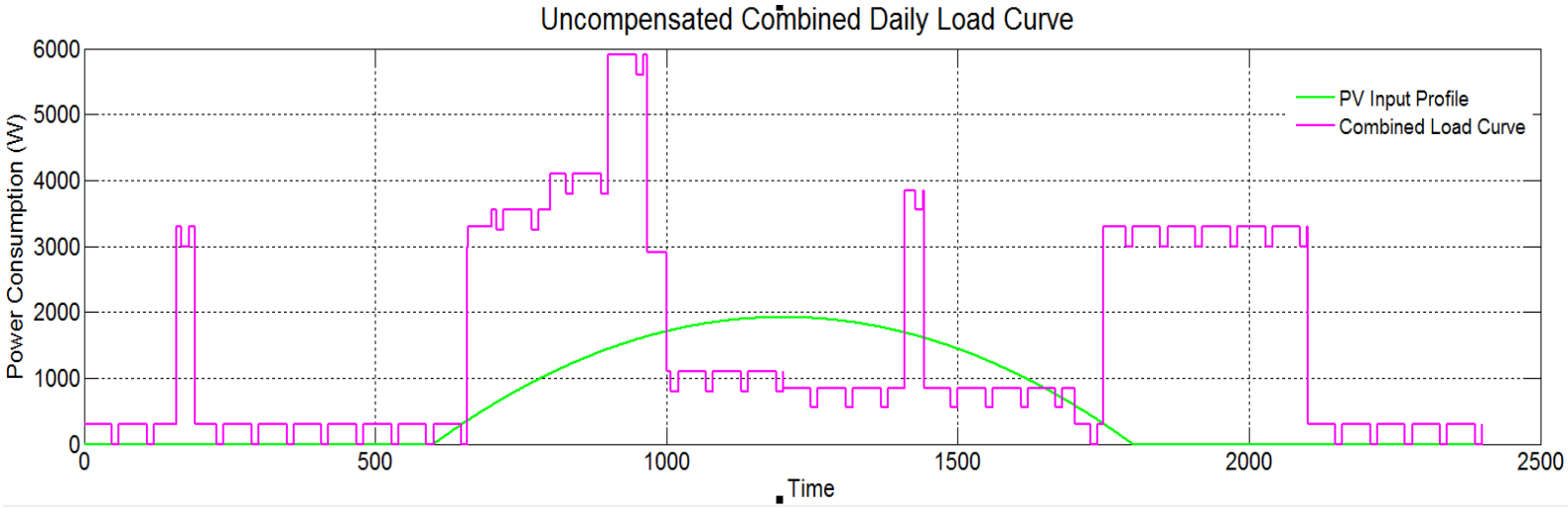


EMS Simulation Graphs





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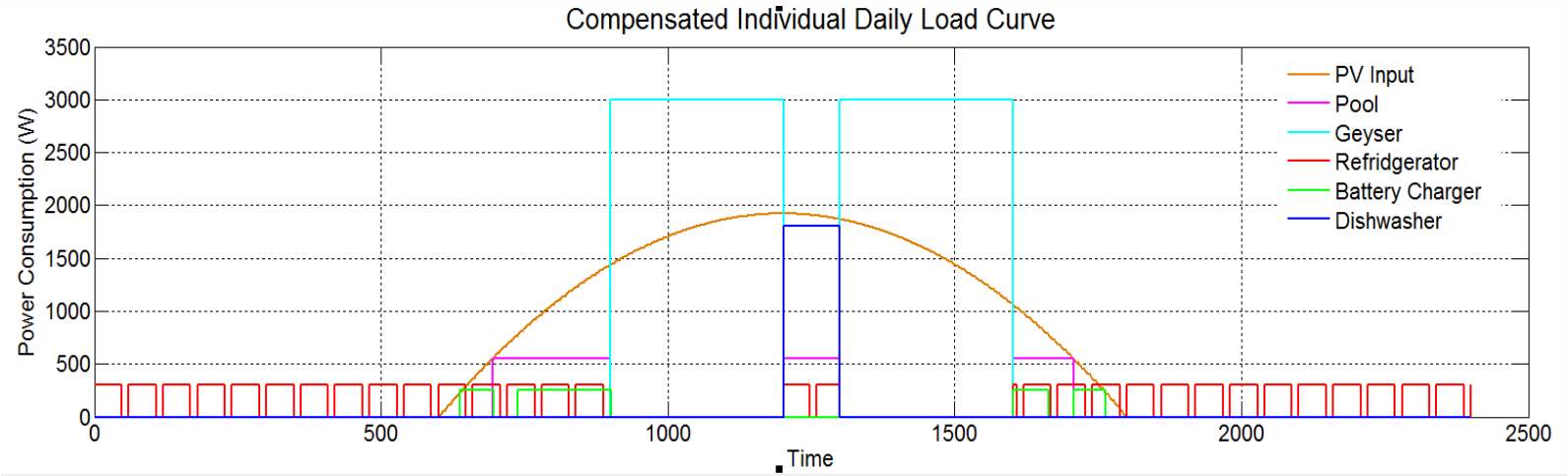

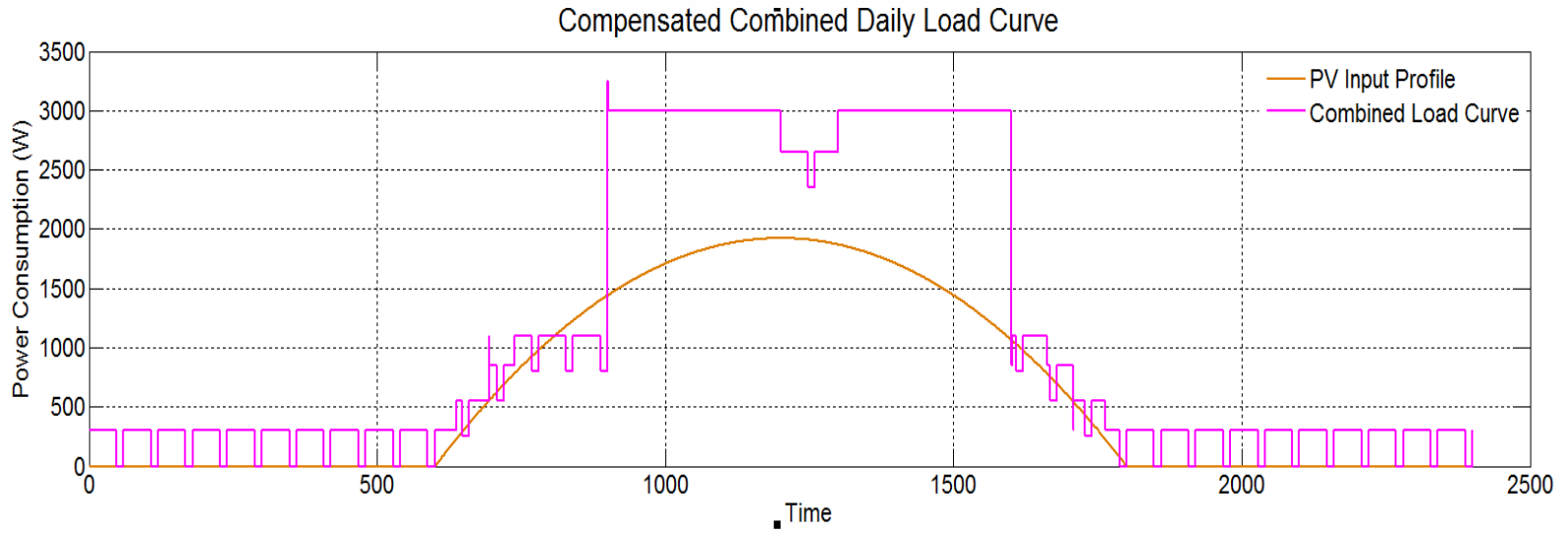

EMS Simulation Results

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SIMULATION RESULTS				
CHARACTERISTIC	SIMULATION 1 (UNCOMPENSATED)	SIMULATION 1 (COMPENSATED)	SIMULATION 2 (UNCOMPENSATED)	SIMULATION 2 (COMPENSATED)
PV Energy Input (kWh)	15.37 kWh	15.37 kWh	12.58 kWh	12.58 kWh
PV Energy Lost (kWh)	4.94 kWh	0.35 kWh	3.07 kWh	0.14 kWh
PV Energy Consumed (%)	67.7 %	97.7 %	75.6 %	98.9 %
Total Load Requirement (kWh)	35.63 kWh	27.26 kWh	35.63 kWh	26.89 kWh
Utility Supplied (%)	70.7 %	44.9 %	73.3 %	53.7 %
PV System Supplied (%)	29.3 %	55.1 %	27.7 %	46.3 %

Discussion

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- The total electricity consumption has been reduced from 35.63 to 27.26 kWh which is a reduction of 23.4 %.
- More importantly, of the 27.26 kWh, 55.1 % thereof is supplied by the PV and only 44.9 % is supplied by the centralized grid.
- This translates to a daily cost of R 18.11 (R 1.48 per kWh) per day for the electricity consumed from the centralized grid. Comparing the system with no EMS installed, a cost reduction of R19.17 or 51.4 % is possible.
- Of the total PV generated electricity, only 0.35 kWh or 2.3 % was lost to the centralized grid. This equates to a total of R 0.52 per day.

Thank You

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Microgrid Formal Definition (IEC)

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- A **microgrid** is a group of **interconnected loads** and **distributed energy resources** within clearly **defined** electrical boundaries that acts as a single controllable entity with respect to the grid and that connects and disconnects from such a grid to enable it to operate in **either/both** grid-connected or “island” mode.

Project Photos

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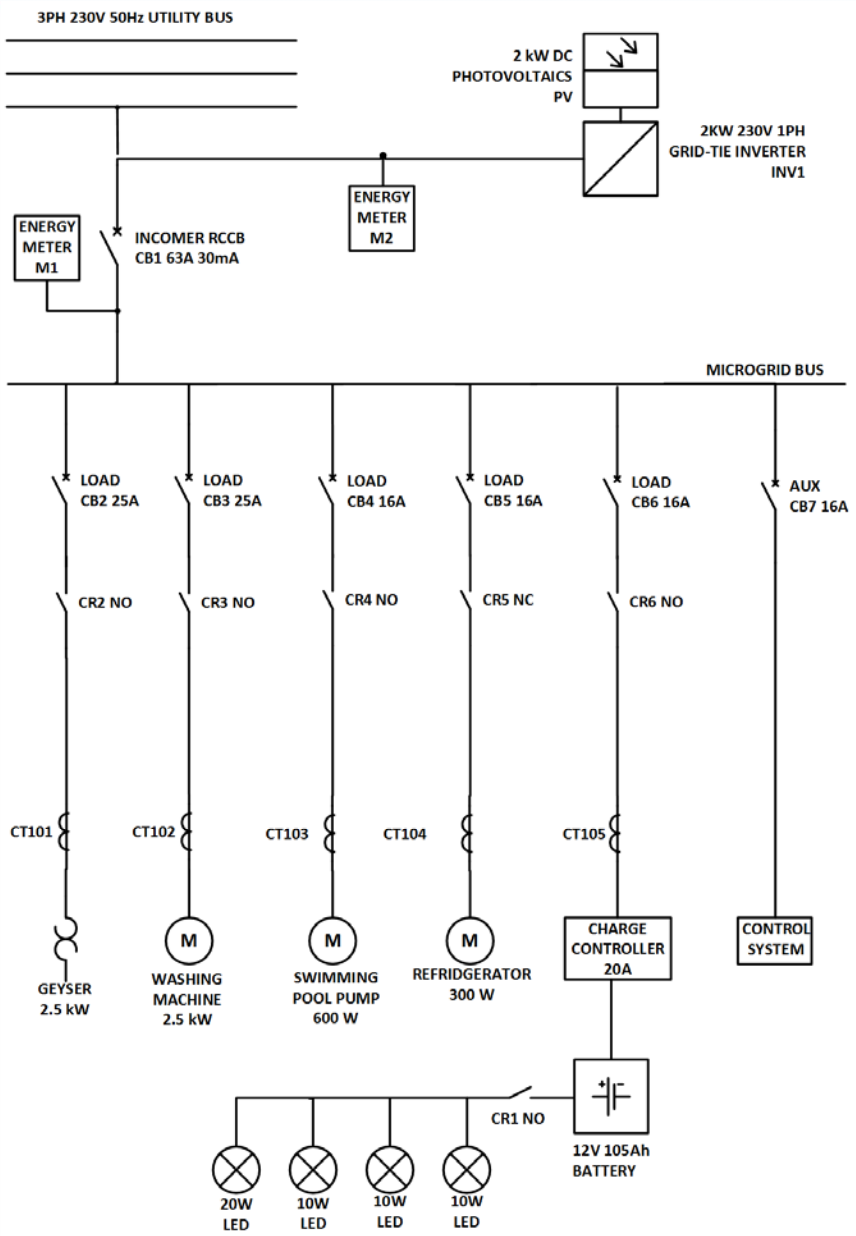
Drawings


3PH 230V 50Hz UTILITY BUS
2 kW DC
PHOTOVOLTAICS
PV
2KW 230V 1PH
GRID-TIE INVERTER
INV1
ENERGY
METER
M2
ENERGY
METER
M1
INCOMER RCCB
CB1 63A 30mA
MICROGRID BUS
LOAD
CB2 25A
LOAD
CB3 25A
LOAD
CB4 16A
LOAD
CB5 16A
LOAD
CB6 16A
AUX
CB7 16A
CR2 NO
CR3 NO
CR4 NO
CR5 NC
CR6 NO
CT101
CT102
CT103
CT104
CT105
M
M
M
GEYSER
2.5 kW
WASHING
MACHINE
2.5 kW
SWIMMING
POOL PUMP
600 W
REFRIDGERATOR
300 W
CHARGE
CONTROLLER
20A
CONTROL
SYSTEM
CR1 NO
12V 105Ah
BATTERY
20W
LED
10W
LED
10W
LED
10W
LED

Project Design

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