Rise SCADA and Electrical System

A report pertaining to the condition and serviceability of the electrical and SCADA systems of the former RISE facility

Chris Woodard

Supervisor: Assoc. Professor Graeme Cole

Associate Supervisor: Dr. Martina Calais
Abstract
The former Research Institute for Sustainable Energy (RISE) testing laboratory was originally a facility for measuring, monitoring and testing a variety of renewable energy systems. The RISE facility was independent of the School of Engineering and Energy, but has recently been taken over by the School as the Engineering and Energy Laboratory.

Many of the systems associated with the laboratory have not been operated for a number of years and the condition of these systems, and the equipment that is associated with them, is not known. Personnel involved with the former RISE facility have since left Murdoch taking with them their knowledge of the facility.

This project was primarily concerned with re-commissioning these systems and developing an operational knowledge of the SCADA based control system. Areas to be covered in particular were:

- connections to the grid from PV arrays and wind turbines
- PLC system and software
- inverters, solar array simulator, environmental chamber and other peripheral equipment
- power supplies such as the diesel generator, motor generator set and battery banks
- 3 phase permanently connected power monitors
- AC and DC electrical systems

Initial inspections of the electrical systems showed that two key components of the facility were found to be defective and would need to be rectified if the facility was to function properly. These components were the diesel generator which provided electricity totally independent of the grid for testing purposes, and a fault on the PLC which was affecting the operation of the electrical systems. Also several main pieces of equipment had since been removed from the facility; most notably of these being the battery banks, main test inverter and the DC supply from the wind turbines located in what is now known as the Renewable Energy Outdoor Test Area (ROTA). Several pieces of equipment required for the operation of the diesel generator would also require attention such as the fuel tank and starting battery.

Approval was granted for the alternator to be repaired and placed back into service. Approval was also granted for the purchase of a replacement analogue input card to rectify the fault with the PLC.

In addition to this another requirement of the project was to develop a system so that the laboratory could be used as a training facility for future students. A procedure was developed so that an electrical system consisting of actual real components; a source, a transmission and distribution system and a load could be simulated. Software was also developed using National Instruments LabVIEW software to monitor and record various power parameters from the system. The system is referred to as the “Small Electrical Distribution System”.

As an aside to this a program has been developed that monitors and records voltage, current and power that is being produced by the Real PV Array located on the roof of the Energy and Engineering Laboratory building.
For someone who is unfamiliar with the setup of the electrical systems that make up the Energy and Engineering Laboratory a simplified block diagram of the Main AC switchboard has been produced. Schedules have been included of all socket inlets and outlets, main AC and communications cables and the Main AC Switchboard nomenclature.

The diesel generator is nearly ready to be re-commissioned after approximately 5 years of non use. Procedures have been developed so that a user can configure the Main AC switchboard so that the “Small Electrical Distribution System” can be operated safely and measurements obtained and analysed.

The main goal of the project was to get the diesel generator operating; therefore this report is focused on the equipment associated with the diesel generator. The equipment focused on was the diesel generator itself, the Main AC Switchboard, the Load Bank and the PLC system. Systems such as the Main DC switchboard and Solar Array Simulator were not covered in as much detail as they are not required for the “Small Electrical Distribution System”.

Figure 1 View of the Engineering and Energy Lab
Disclaimer
I declare that the following to be my own work as defined by Murdoch Universities policy on plagiarism.

Acknowledgments
I would like to give thanks to Associate Professor Graeme Cole and Doctor Martina Calais for there support and encouragement for the duration of this project. Their wisdom, expertise and advice have helped make this past four months an enjoyable and fulfilling experience.

Thanks are also extended to Mr John Boulton for his assistance in the removal of the defective alternator, transporting myself and various pieces equipment around Perth and his assistance in getting the Energy and Engineering Lab operating again.

Mr Will Stirling for his efforts in recommissioning the PC’s that monitor and control the equipment in the Energy and Engineering Lab and for his assistance updating the software.

And thanks also to Mr Jeff Laava for his technical support and the Kat and June in the office for their administrative assistance.
## Contents

Abstract ........................................................................................................................................... 2  
Disclaimer ....................................................................................................................................... 4  
Acknowledgments .......................................................................................................................... 4  
List of figures ................................................................................................................................... 8  
Chapter 1 ......................................................................................................................................... 9  
Introduction ..................................................................................................................................... 9  
Chapter 2 ....................................................................................................................................... 11  
Main components .......................................................................................................................... 11  
  Large (Main) System ..................................................................................................................... 11  
    Main AC Switchboard ................................................................................................................ 11  
    Main DC Switchboard ................................................................................................................ 13  
    Cabling ..................................................................................................................................... 13  
  Small System ................................................................................................................................. 14  
    Small AC Switchboard ............................................................................................................... 14  
    Small DC Switchboard ............................................................................................................... 14  
  Diesel Generator Set .................................................................................................................... 15  
  Socket Inlets/Outlets .................................................................................................................... 15  
  Load Bank ..................................................................................................................................... 15  
  Environmental Chamber ............................................................................................................... 16  
  Solar Array Simulator ................................................................................................................... 17  
  Motor Generator Set ..................................................................................................................... 17  
  Main Inverter ................................................................................................................................. 18  
  Battery Banks ............................................................................................................................... 18  
  Solar Array Connection ................................................................................................................ 18  
  Control System .............................................................................................................................. 18  
    Powermonitor .......................................................................................................................... 19  
    Setting up the PLC to operate the Real PV Array ................................................................. 20  
Chapter 3 ....................................................................................................................................... 25  
Major works conducted ................................................................................................................... 25  
  Diesel Generator ......................................................................................................................... 25  
  Fuel tank .................................................................................................................................... 26
What did I achieve from this project ................................................................. 50

References ........................................................................................................ 52

Bibliography ...................................................................................................... 52

Drawings ........................................................................................................... 52

Websites ........................................................................................................... 52

Appendices ...................................................................................................... 53

Appendix A. Main AC Switchboard Label Schedule ....................................... 53
Appendix B. Main AC Cable Schedule ............................................................. 54
Appendix C. Schedule of Socket Inlets/Outlets ............................................... 55
Appendix D. Communications Cable Schedule ............................................... 56
Appendix E. Alternator insulation tests ......................................................... 57
  Windings to earth .......................................................................................... 57
  Between windings ......................................................................................... 57
  Continuity ..................................................................................................... 58
Appendix F. Load Bank co-ordination for single phase resistive loads .......... 59
Appendix G. Block diagram of MACSB .......................................................... 60
Appendix H. Block diagram of Real PV array connections ........................... 61
Appendix I. Block diagram of communications systems .............................. 62
Appendix J. Graph of Power Exported ............................................................ 63
List of figures
Figure 1 View of the Engineering and Energy Lab ............................................................. 3
Figure 2 Main AC Switchboard.......................................................................................... 11
Figure 3 Block diagram of the MACSB ............................................................................ 12
Figure 4 Main DC Switchboard....................................................................................... 13
Figure 5 Load Bank........................................................................................................... 16
Figure 6 Environmental Chamber control panel.............................................................. 17
Figure 7 Motor Generator Set........................................................................................... 18
Figure 8 Allen-Bradley Powermonitor. The Real PV Array is providing 1 amp on L1 ........ 19
Figure 9 Ensure PLC is online ........................................................................................ 21
Figure 10 Open the Force Files folder ............................................................................ 21
Figure 11 OUTPUT forces window .................................................................................. 22
Figure 12 Note how O:1/190 correlates to O:1.11/14 ..................................................... 22
Figure 13 Select Force On - O:1/190 .............................................................................. 23
Figure 14 Selecting Yes will enable the force ................................................................ 23
Figure 15 If Forces Enabled is displayed then outputs are forced ................................. 24
Figure 16 Diesel Generator with rewound alternator installed ........................................ 26
Figure 17 Power flow for the Small Electrical Distribution System ............................... 29
Figure 18 Front Panel of the Small Distribution System ................................................. 31
Figure 19 Voltage block diagram showing the integer and exponent ............................. 32
Figure 20 A full list of files is available under Address/Symbol ...................................... 34
Figure 21 All Data Files are found in the Data File folder .............................................. 34
Figure 22 Data File N200. Highlighted are the integer and exponent for current L1. It is showing 10.18 amps .................................................................................................................. 35
Figure 23 Data File N100 correlates with Data File N200 ............................................. 35
Figure 24 N100 is one of the 10 files to be read ............................................................ 36
Figure 25 Ladder rung 0006 Command & Status Blockmove Sequencer. Data File N101 is currently being read .................................................................................................................. 37
Figure 26 Main block transfer sequencer ...................................................................... 37
Figure 27 Voltage/current bit transfer read. When source A equals 100 data from N100 is transferred to M0 .................................................................................................................. 38
Figure 28 Front Panel Simplified Small Distribution System .......................................... 39
Figure 29 Front Panel Real PV array. Note the affect of a cloudy day ............................ 41
Figure 30 Emergency Stop ............................................................................................ 44
Figure 31 Drawing 0023E5-3 showing spare cable cores and inputs/outputs ............... 47