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DEVELOPMENT OF A GRID CONNECTED SOLAR PHOTOVOLTIC SYSTEM

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Degree of Master of Science

University of Moratuwa

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Department of Electrical Engineering

University of Moratuwa

Sri Lanka

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Dissertation submitted in partial fulfillment of the requirements for the degree

Master of Science

Department of Electrical Engineering

University of Moratuwa

Sri Lanka

October 2011

DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the Masters Dissertation under my supervision.

UOM Verified Signature

Signature of the supervisor: Date 31/10/2011

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Abstract

This study and development are focused about an integration of a solar photovoltaic (PV) system to an existing power plant located in Colombo Sri Lanka.
The combined cycle power plant related to the project consists of many easily identifiable resources for the development of a solar project.
Survey to find out available resources, ways of integrating the selected resources to optimize the project outcome, best way to utilize the solar energy and finding out the feasibility of implementing the project are the objective behind the project development.

The project identifies a grid connected solar PV system with a single axis tracking as the best way to integrate solar PV energy to an existing power plant.
The areas of study and design are related to solar panels and the structural frame work, sun tracking system, tracker drive mechanism, power conversion and power evacuation system.

The project components selection criteria developed in this project are based on the preliminary studies and surveys. Comparison made for deferent types of solar cells based on their reliability, cost & efficiency.

Also surveys were done about gains, regulations, quality checks, safety and environmental aspects related to project components.

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Upon finalizing the basic project configuration, sizing of the systems carried out in a logical criterion prior to the detailed design stages.

Comprehensive design carried out for the control module and drive mechanism of solar tracker which demonstrates the flexibility of existing plant control system. Design of structural framework is used to find cost components relevant to the balance of system and to find out the impact of loading the building roof with solar PV components.

Cost benefit analysis carried out against three different options of energy dispatch to meet the conclusions.

As an outcome following conclusions have been met,

- By effective utilization of existing resources available at a power plant simple pay back (SPB) period of a solar PV system of 106 kW capacity could be brought down to 9-10 years .
- A single axis tracking system could further reduce the SPB period of a solar PV system.
- It is more beneficial to export solar PV energy separately to the grid during the cases where thermal energy production cost is cheaper than Rs.20/= to further bring down SPB period. This is possible by introducing a switching signal from DCS for smooth change over between separate power feeding and station power feeding based on online energy unit cost comparison.

- Design, construction and commissioning of Solar PV system with a thermal power plant at initial stages in parallel with main project could avoid wastages of resources.

The concepts and design criteria used at different phases of this project development could be useful for direct application or with appropriate modifications to incorporate with solar PV project developments.

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List of Abbreviations and Units

Abbreviation	Description
AC	Alternating current
A/D	Analog to Digital
a-Si	(Hydrogenated) amorphous silicon
ASTM	American Society for Testing and Materials
BOS	Balance of system
CDM	Clean Development Mechanism
CEB	Ceylon Electricity Board
CIS	Copper indium Di-Selenide
CIGS	Copper indium Gallium Di-Selenide
DC	Direct Current
DSSC	Dye sensitised solar cell
EHS	Environment, Health and Safety
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers (USA)
ISO	International Standards Organization
ITO	Indium-tin oxide
LV	Low voltage
MPPT	Maximum power point tracker
NREL	National Renewable Energy Laboratory (USA)
O & M	Operations and Maintenance
PV	Photovoltaic, photovoltaics
RH	Relative Humidity
STC	Standard Test Conditions
UL	Underwriters Laboratory (USA)
X-Si	Crystalline Silicon

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Unit Abbreviation	Description
watt (W)	SI unit of power. Symbol is W. power under standard test conditions (STC).
W_p (peak watt)	peak power at STC (standard test conditions).
W m^{-2}	watts per square meter. Used to measure solar short-wave radiation
G	global short-wave radiation flux, i.e. radiant energy flow per unit time, is known as the irradiance. The integral of irradiance flux over any period is called the irradiation. Typical integration periods are the hour, which yields the hourly global irradiation, G_h.(units MJ m^{-2} h^{-2} or Wh m^{-2} h^{-2}). the day G_d (units MJ m^{-2} d^{-1} or Wh m^{-2} d^{-1})and the month G_m (units MJ m^{-2} per month or Wh m^{-2} per month).

Term	Definition
Controller	*Directs field processes; the Harmony area controller is an example.*
Control logic document	A grouping of sheets containing control logic (usually with a similar purpose). A controller configuration frequently contains multiple control logic documents.
Control logic template	Preconfigured configuration documents used to simplify the creation of a new control logic document. A control logic template, when dragged into a controller, becomes a control logic document that is identical to the template.
Control network	Data communication highway.
Exchange	Project-wide repository of system and user-defined reusable components (symbols, shapes, macros, and documents). These components are organized into folders.
Function code	An algorithm that manipulates specific functions. These functions are linked together to form the control strategy.
Harmony control unit	A control network node that contains controllers.
Human systems interface	Combined hardware and software entity (sometimes just a software application) used by operators to monitor and control the process control system.
Project	The largest grouping of configuration information (displays, control logic documents, etc.) for a process.
Sheet	The actual pages of a control logic document on which control logic is inserted.

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