MODELLING OF RENEWABLE ENERGY BASED EMBEDDED GENERATION IN LONG TERM PLANNING

A SRI LANKA CASE STUDY

A dissertation submitted to the
Department of Electrical Engineering, University of Moratuwa
in partial fulfilment of the requirements for the
degree of Master of Science

by

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Declaration

The work submitted in this dissertation is the result of my own investigation, except where otherwise stated.

It has not already been accepted for any degree, and it also not being concurrently submitted for any other degree.

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Date: 03/02/2011

We/I endorse the declaration by the candidate.

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Abstract

The share of Non-Conventional Renewable Energy (NCRE) penetration in Sri Lanka has been increased to a significant level in the recent past. As at 31st of August 2010, around 215 MW of NCRE based power plants were connected to the Sri Lanka national grid. This accounts to 6% of total energy and 7.8% percent of total capacity of the system. According to the Energy Policy – 2006, the government's endeavour is to reach 10% of total energy in the national grid from NCRE by 2015. As a result, modelling and studying of NCRE is vital especially in generation planning. Though the present practice of using lumped NCRE thermal equivalent model is simple, it can cause a lot of inaccuracies owing to the volatile nature of wind and hydro sectors.

The issue of non-availability of suitable NCRE models was addressed by this research and separate NCRE models were prepared for each of the three major types of NCRE technologies; mini hydro, wind and biomass power plants, in Sri Lanka. Each NCRE technology was separately treated and modelled considering the seasonal variation of energy availability. Models were tested in generation planning software, Wien Automatic System Planning (WASP) to ascertain the accurate functioning of models. The mini hydro model prepared has five stage probabilistic distributions on a monthly basis. Past generation data of about 74 existing plants were used to validate the model. Predictability and adaptability of the model with WASP were tested and accurate dispatch of mini hydro power plants by the model was confirmed. Due to unavailability of reliable and continuous long term historic generation data, the wind model was prepared on measured wind speed data. After refinement of data, two modelling approaches were initially considered namely, a Run-of-River (ROR) type hydro equivalent wind model and the Modified Load Duration Curve method. Based on the results of error vs commitment analysis, a five-stage probabilistic ROR type hydro equivalent wind model was selected as the best fitted model for the study. Biomass power plants were modelled as a conventional thermal equivalent plant.

NCRE models prepared were then used for three scenario studies to examine their adaptability in both committed and least cost basis. Various methods to interpret results of scenarios were conducted to verify that there is no curtailment of results due to the new NCRE models. The breakeven cost and avoided cost of generation of each NCRE technology were also calculated.

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Abbreviations

ADCF	Air Density Correction Factor
CEB	Ceylon Electricity Board
ENS	Energy Not Served
FOR	Forced Outage Rate
GIS	Geographical Information System
GP & D	Generation Planning & Design
IPP	Individual Power Producers
IAEA	International Atomic Energy Authority
LTGEP	Long Term Generation Expansion Plan
LTL	Lanka Transformers Limited
LDC	Load Duration Curve
LOI	Letter of Intent
LOLP	Loss of Load Probability
MLDC	Modified Load Duration Curve
NCRE	Non Conventional Renewable Energy
NEP	National Energy Policy
NCRP	Non Conventional Renewable Projects
NREL	National Renewable Energy Laboratory
PPI	Private Power Investments
PU	Per Unit
ROR	Run of River
SPPA	Standardised Power Purchase Agreement
SEA	Sustainable Energy Authority
SPP	Small Power Producer
WASP	Wein Automatic System Planning (Package)