# MAINSTREAMING RENEWABLE ENERGY DEVELOPMENTS INTO TRADITIONAL PLANNING

J.H.K. Kanchana Chathuranga

109204C



Degree of Master of Science in Electrical Engineering

Department of Electrical Engineering

University of Moratuwa

Sri Lanka

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## 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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Signature of the author Date:
J.H.K.K. Chathuranga

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



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## ABSTRACT

Electricity is one of the key driving forces of the economy of a country and generation of electricity in an optimal way to meet the increasing demand has become a national priority in the recent years. Due to serious concerns with regard to energy security, global warming, rising costs and depleting reserves of fossil fuels, many countries are now actively seeking to mainstream NCRE power generation in to their generation portfolios as a future energy solution. Since generation planning plays a major role in a country's efforts to mainstream NCRE developments, the Sri Lankan generation planning practices were examined and several methodological changes and models were proposed to successfully integrate and evaluate NCRE resources in the present planning approaches.

The CEB generation planning process was reviewed and associated issues concerning NCRE planning were identified. These issues were first addressed conceptually and the proposed solutions were subsequently applied to the Sri Lankan system to assess their applicability. This thesis provides a new insight into the capacity contribution of NCRE plants and also discusses the constraints to mainstream adoption of NCRE technologies in Sri Lanka along with the present policy and regulatory interventions relating to NCRE developments. The use of peak period capacity factor method was suggested to calculate the capacity credit of NCRE generation and since the associated risks are not explicitly evaluated in the present approaches, the Mean Variance Portfolio Theory is proposed to assess the risks of generation portfolios. Two models were developed to calculate the wind power output from wind measurement data and to evaluate the portfolio risks of generation mixes which can be readily used in the present practices. In addition, methodologies were presented to model a wind power plant in WASP IV and to evaluate the benefits of modeled NCRE plants.





Keywords:
Non-Conventional Renewable Energy
Long Term Generation Planning
Wien Automatic System Planning Package
Capacity Credit
Mean Variance Portfolio Theory

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J.H.K. Kanchana Chathuranga
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| | |
|---|---|
| AIC | Average Incremental Cost |
| BOI | Board of Investments |
| CCGT | Combined Cycle Gas Turbine |
| CEB | Ceylon Electricity Board |
| EF | Efficient Frontier |
| EGEAS | Electric Generation Expansion Analysis System |
| ELCC | Effective Load Carrying Capability |
| EMCAS | Electricity Market Complex Adaptive System |
| ENS | Energy-Not-Served |
| EPRI | Electric Power Research Institute |
| EU | European Union |
| FOR | Forced Outage Rate |
| IEA | International Energy Agency |
| LNG | Liquefied Natural Gas |
| LOI | Letter of Intent |
| LOLE | Loss of Load Expectation |
| LOLP | Loss of Load Probability |
| MIT | Massachusetts Institute of Technology |
| MVPT | Mean Variance Portfolio Theory |
| NCRE | Non-Conventional Renewable Energy |
| NREL | National Renewable Energy Laboratory |
| O&M | Operation and Maintenance |
| OECD | Organization for Economic Cooperation and Development |
| ORNL | Oak Ridge National Laboratory |
| PUCSL | Public Utilities Commission of Sri Lanka |
| PV | Present Value |
| ROR | Run-of-River |
| RPS | Renewable Portfolio Standard |
| SLSEA | Sri Lanka Sustainable Energy Authority |
| SPPA | Standardized Power Purchase Agreements |
| SYSIM | System SIMulation |
| TVA | Tennessee Valley Authority |
| WASP | Wien Automatic System Planning |

## LIST OF APPENDICES