RISK BASED OPTIMAL ELECTRICITY GENERATION PLANNING USING MODERN PORTFOLIO THEORY

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DECLARATION

I hereby certify that this dissertation does not incorporate without acknowledgement of any material previously submitted for a Degree or Diploma in any University, and to the best of my knowledge and belief it does not contain any material previously published or written by another person or myself except where due reference is made in the text.

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ABSTRACT

At present majority of electric power systems are carbon intensive, supply driven and highly centralised. A high percentage of countries still have regulated monopolised markets and utilization of fossil fuel fed power plants proliferated rapidly to bridge the supply and demand gap.

Least cost and merit order methods are widely used for generation expansion planning. These methods incorporates present value based least cost generating technologies and favoured by policy makers. Generally least cost method favours fossil fuel based technologies over the renewable technologies irrespective of many other benefits rendered by renewable technologies. Therefore, energy supply is susceptible to fuel price volatilities. From an energy security perspective, the economies rich with diverse natural resources such as coal, crude oil, hydro, wind and superior technologies such as nuclear transcend above others. But countries which import crude oil face severe hardships due to sudden price hikes. Presently the governments are increasingly pressurised to decarbonise their electricity generation to combat global climate change even though low carbon emitting generating technologies impend relatively high initial capital outlays, exposing the system with greater risk from generation shortfalls.

The objectives of this dissertation are to determine the most efficient portfolios that abate cost and risk and to establish a quantitative framework to determine the efficient generating portfolios from the societal perspective. It further evaluates the sensitivity of risk and expected cost when incorporating a new power generating technology to existing portfolio.

Portfolio based generation planning is used to explicate the portfolio performance not only by cost (return) basis but more importantly by risk basis. Markowitz's (1952) Portfolio theory is well established, proven and robust model used in finance to determine the optimal portfolios of assets. The analysis for electricity generating technologies based on modern portfolio theory lays out a consistent framework which provides much better view into the portfolio cost and risk.

Therefore, it could infer that efficient portfolios (minimum expected cost and risk) determined are in dissonance with extant generation expansion plan of Ceylon Electricity Board. Secondly, the environmental adders were incorporated to find the efficient portfolio having least societal risk. A sensitivity analysis gives the direction that the existing portfolio will move in terms of expected cost and risk when adding a new generating source to the system. It is possible to use standard deviation as a predictor as well as a variable that measures diversification of generating technologies.

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LIST OF ACRONYMS

CCY	Combine cycle power plant
CEB	Ceylon Electricity Board
CPC	Ceylon Petroleum Corporation
DSM	Demand Side Management
GHG	Green House Gases
GoSL	Government of Sri Lanka
GWh	Giga Watt Hour
IEA	International Energy Agency
IPP	Independent Power Producer
kWh	Kilo Watt Hour
LKR	Sri Lanka Rupees
LNG	Liquefied Natural Gas
LOLP	Loss of Load Probability
MPT	Modern Portfolio Theory
MW	Mega Watt
MWh	Mega Watt Hour
NCRE	Non Conventional Renewable Energy
PV	Present Value
US$	United States Dollar
USCents	United States Cents
WASP	Wein Automatic System Planning Package

LIST OF SYMBOLS

μ	Expected cost, mean
σ	Standard deviation
ω	Weights
Ω	Covariance matrix
EV_t	Previous value
BV_t	Current value
δ	Lagrange multipliers