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PARAMETRIC ADAPTIVE MODEL FOR OPTIMUM ELECTRICAL SYSTEM CONFIGURATION IN TELECOMMUNICATION BASE STATIONS CONSISTING OF DIESEL GENERATORS, LI-ION BATTERY BANKS AND SOLAR PHOTOVOLTAIC

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DECLARATION

I declare that this is my own work and this Thesis 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. I retain the right to use this content in whole or part in future works (such as articles or books).

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The supervisor should certify the Thesis with the following declaration.

The above candidate has carried out research for the Master of Science by Research Thesis under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Prof. D.P. Chandima

Signature of the Supervisor: Date: 15/06/2025

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ABSTRACT

With the rapid development of next generation telecommunication devices and applications, demand for reliable, wider coverage and speed telecommunication networks has been a fundamental infrastructure prerequisite around the globe. For a highly reliable and wider coverage, the electrical system of the telecommunication base station should have the capacity to effectively maintain an uninterrupted power supply for smooth operations of radio and cooling equipment of the telecommunication base station. Development and operations of electrical systems for a network operator typically cost in the range of 20% to 30% of the total cost of ownership of a telecommunication network. Therefore, a significant impact on the bottom-line targets of the network operator can be achieved by evaluating the impact of optimization of power infrastructure deployed in telecommunication base stations.

In this research, a parametric approach has been discussed to quantify multi dimensional characteristics affected when determining the optimum electrical system configuration for telecommunication base stations. Results of the proposed model have highlighted that when functional constraints become strict, the optimization model changes its proposed configuration with higher Levelized Cost of Energy (LCOE) with a change ranging from 5.7% to 15.3% which indicated the adaptive behaviour of the model. Further from the results, it is evident that the increase in expected network availability leads to an exponential increase in LCOE in the proposed electrical system which indicates the importance of correct benchmarking of the expected network availability of considered base station. When it comes to the behaviour of LCOE within the optimization model, even when 100% network availability is considered and when grid availability is dropped to 89.5%, LCOE of proposed optimum electrical system configuration maintained under 0.1 $/kWh, compared to the industry average of between 0.15 $/kWh to 0.3 $/kWh for a typical hybrid electrical system consisting of diesel generator, li-ion battery bank and solar Photovoltaic.

Keywords: Telecommunication Base Station, Genetic Algorithm Optimization, Hybrid Energy System, Adaptive Optimum Sizing, Network Availability

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LIST OF ABBREVIATIONS

Abbreviation	Description
AC	Alternating Current
BMS	Battery Management System
BOS	Balance of System
BSS	Battery Storage System
Capex	Capital Expenditure
DC	Direct Current
DG	Diesel Generator
EMU	Energy Management Unit
ITU	International Telecommunication Union
LCOE	Levelized Cost of Energy
LOLP	Loss of Load Probability
LPSP	Loss of Power Supply Probability
MPPT	Maximum Power Point Tracking
Opex	Operational Expenditure
PV	Photovoltaic
ROI	Return on Investment
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index