FEASIBILITY ANALYSIS OF HARVESTING DYNAMIC BRAKE ENERGY IN DIESEL-ELECTRIC MULTIPLE UNITS FOR SUSTAINABLE OPERATION IN THE SRI LANKAN CONTEXT

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Thesis/Dissertation submitted in partial fulfilment of the requirements for the degree Master of Engineering in Manufacturing Systems Engineering

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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. I retain the right to use this content in whole or part in future works (such as articles or books).

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Name of Supervisor: Dr. Lihil Uthpala Subasinghe

Signature of the Supervisor: Date:

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ABSTRACT

Dynamic braking helps regulate train speed and avoids it from becoming too high, especially when they are going downhill. Sri Lanka's non-electrified railway system loses energy because Diesel-Electric Multiple Units (DEMUs) turn braking energy into heat. However, electrified railways recover and reuse braking energy. This study's goal is to perform feasibility study on the use of this wasted energy, which will make things more sustainable, lower costs, and lower carbon emissions.

The first step of this study is to figure out how much energy is lost by S14 DEMUs running on Sri Lanka's upcountry railway line. Study looked at data from onboard loggers, circuit diagrams, operation manuals, and previous tests of the brakes. The results show that a 20-hour round trip from Badulla to Colombo dissipates about 3.5 MWh of energy. Additionally, dynamic braking intervals and patterns were identified to study on feasibility analysis.

Feasibility analysis continued on sustainable energy recovery system to store and reuse a portion of this wasted energy for auxiliary power in the S14 DEMU without altering its existing structure. A Lithium Iron Phosphate (LFP) battery storage system was chosen because of its use in the past and in the railway and automotive industries. A 1 MWh battery pack was added to utilize 1.7 MWh where charging was best during the first 6.5 hours from Badulla to Gampola, where the brakes work best.

The system is expected to save more than 105 million LKR and cut diesel use by 550,800 liters over a period of 10 years. This will lower emissions and support sustainability. These results point to a feasibility study that is cost-effective and will help make non-electrified railway networks more energy-efficient and environmentally friendly.

Keywords: Dynamic braking, Diesel electric multiple units, Energy recovery, Battery storage, Sustainable system

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LIST OF ABBREVIATIONS

Abbreviation	Description
AI	Artificial Intelligence
APTA	American Public Transportation Association
BEDEL	Battery-Hybrid Diesel-Electric Locomotive
BEL	Battery Electric Locomotive
BESS	Battery Energy Storage System
BMB	Battery Management Board
BMS	Battery Management System
CAD	Computer Aided Design
CATL	Contemporary Amperex Technology Co., Limited
CFD	Computational Fluid Dynamics
CTC	Cell-to-Chassis
CTP	Cell-to-Pack
DEMU	Diesel-Electric Multiple Units
DfD	Designing for Disassembly
DRL	Deep Reinforcement Learning
EPA	Environmental Protection Agency
EV	Electric Vehicles
GHG	Green House Gas
HVAC	Heating, Ventilation, and Air Conditioning
IBIS	Integrated Battery Interface System
LFP	Lithium Iron Phosphate
MBD	Model-Based Design
ML	Machine Learning
MPC	Model Predictive Control
MTU	Motoren- und Turbinen-Union
NCA	Nickel-Cobalt-Aluminum
NS	Norfolk Southern
RDM	Robust Design Methodology

SAC	Soft Actor-Critic
SLR	Sri Lanka Railway
SOC	State of Charge
TIM	Thermal Interface Material
TIM	Thermal Interface Materials
UK	United Kingdom
USA	United States of America
WESU	Wayside Energy Storage Unit
ZEBL	Zero-Emission Boost Locomotive