LIFE CYCLE GREENHOUSE GAS EMISSIONS OF SOLAR PANEL INSTALLATION

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Degree of Master of Science in Environmental Management

Department of Civil Engineering

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Thesis/Dissertation submitted in partial fulfilment of the requirements for the degree Master of Science in Environmental Management

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DECLARATION

Declaration of the candidate:

I declare that this is my own work, and this thesis/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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The above candidate has carried out research for the Masters dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

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Abstract

This study presents a comprehensive life cycle assessment (LCA) of greenhouse gas (GHG) emissions for a 1 kW_p multi-crystalline silicon photovoltaic (PV) module installed in Sri Lanka. The analysis encompasses the entire life cycle of the PV module, including material acquisition, production, distribution, use, and end-of-life stages. The findings indicate that the life cycle GHG emissions total 2,569.35 $kgCO_2e/kW_p$, with the production stage in China being the primary contributor due to high energy and material demands. Significant emission sources include the extraction and processing of silicon, electricity consumption during manufacturing, and the distribution of modules from China to Sri Lanka. However, the PV modules' operational phase yields substantial emission reductions, with an annual GHG reduction of 637.1 $kgCO_2e/kW_p$, resulting in a payback period of approximately 4.03 years.

Furthermore, the study emphasises the impact of module design and production location on GHG emissions, noting that sourcing modules from regions with cleaner energy mixes can significantly lower emissions. It also highlights the importance of adopting efficient solar technologies and implementing recycling programs to further reduce environmental impacts. Comparisons with global studies show that the emissions associated with Sri Lanka's PV modules are within an acceptable range, reinforcing the viability of solar power as a sustainable energy source for the country. The research underscores the critical role of up-to-date inventories and accurate electricity yield calculations in promoting sustainable solar module designs and reducing the carbon footprint of solar energy installations.

Keywords: Life Cycle Assessment, Greenhouse gas emissions, multi-crystalline silicon photovoltaic (PV) module

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LIST OF EQUATIONS

LIST OF ABBREVIATIONS

Abbreviation	Description
ADB	Asian Development Bank
CdTe	Cadmium Telluride
CIGS	Copper Indium Gallium Selenide
CO_2	Carbon dioxide
CH_4	Methane
DEFRA	Department for Environment, Food & Rural Affairs
DESNZ	Department for Energy Security and Net Zero
EVA	Ethylene Vinyl Acetate
GDP	Gross Domestic Product
GHG	Greenhouse gas
GHI	Global Horizontal Irradiance
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Assessment
MSc	Master of Science
NDC	Nationally Determined Contributions
N_2O	Nitrous oxide
OPV	Organic Photovoltaics
PRC	People's Republic of China
PV	Photovoltaic
RE	Renewable Energy
SLSEA	Sri Lanka Sustainable Energy Authority
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute

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