MICRO POWER OPTIMIZATION FOR WATER DESALINATION FOR OCCUPANTS IN REMOTE ISLANDS

Kasun Chamendra Dhanapala

(178247 P)

Thesis submitted in partial fulfilment of the requirements for the degree

Master of Engineering in Mechanical Engineering

Department of Mechanical Engineering

University of Moratuwa
Sri Lanka

February 2023

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 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.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date: 09 Feb 2023

K.C Dhanapala

The above candidate has carried out research for the Master's Thesis under my supervision.

Signature: .... Date: 09 Feb 2023

Dr (Mrs). M.M.I.D Manthilake,

Senior Lecturer,

University of Moratuwa.

ABSTRACT

The seawater desalination is a good method to produce portable water, particularly in rural and coastal areas where access to surface and ground water is limited. However sea water desalination consumes more energy, and practical difficulties faces while introducing this system for places like isolated islands where utility grid is absence. Hence, integrating renewable energy offers a feasible approach to desalinating water.

This study discusses on various desalination methods and identified Reverse Osmosis technology as a most suitable desalination method for an island based on the factors such as cost, energy, geography and environment, technology and social impact. The methodology describes the selection procedure of a RO plant according to the water requirement and hybrid power system architecture for the selected RO plant. In this study two scenarios were analyzed, without water storage tank and with water storage tank.

The Baththalanginduwa island in Sri Lanka was selected to simulate the methodology which requires $75m^3$ of water per day. The RO plant's Specific Energy Consumption calculated as 9.27 Kwh/m^3. The optimum configuration in the first scenario gives NPC (Rs 281 Mn) and $Rs\,1.23/l$ as water production cost. In this configuration HOMER suggested 02 Wind Turbines, 64 batteries, 50 kW Diesel generator and 86 solar panels which gives highest renewable factor (76%) among other configurations. The optimum configuration in the second scenario gives NP (Rs 154 Mn) and $Rs\,1.39/l$ as water production cost. In this configuration it was calculated the optimum configuration should requires 02 Nos of RO plants (83 m^3), a single wind turbine , 100 NOs solar panels , 50 kW Diesel generator and water storage tank ($55m^3$).

Keywords: Desalination, HOMER, hybrid energy, optimization, RO

ACKNOWLEDGEMENT

It gives me great pleasure to thank all of the lecturers at the Mechanical Engineering Department of University of Moratuwa's for their advice, direction, and assistance. Second, I would like to thank my supervisor, Dr. M.M.I.D. Manthilake, from the bottom of my heart for her guidance, persistence, and dedication in getting the research done. I would like to express my sincere appreciation to our course coordinator, non-academic staff and all the students of the MEng/PGDip in Energy Technology program, those who rendered the fullest support in my studies.

I would like to give special thanks to my wife Mrs. Eranjika Rathnayaka who gave her continues supports and sacrificed her time and relived me from domestic matters. I respectfully acknowledge my parents who supported me in every possible ways.

Finally, I wish to convey my gratitude to everyone who actually contributes to successfully complete the studies related to this academic program.

K.C Dhanapala

Thank You,

Department of Mechanical Engineering,

University of Moratuwa.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AC	- Alternating Current
ADB	- Asian Development Bank
BCM	- Billion Cubic Meters
CAPEX	- Capital Expenditures
CEA	- Central Environmental Authority
CKDu	- Chronic Kidney Disease Of Unknown Etiology
COE	- Cost Of Energy
CPV	- Concentrating Pv
DC	- Direct Current
DNI	- Direct Normal Irradiance
EDR	- Electro Dialysis Desalination
EIA	- Environmental Impact Assessment
EMP	- Environmental Monitoring Plans
FAO	- Food And Agriculture Organization
FD	- Freeze Desalination
FO	- Forward Osmosis
G.hyd	- Gas Hydrate Desalination
GDP	- Gross Domestic Product
GHG	- Green House Gas
GHI	- Global Horizontal Irradiance
GOR	- Gain Output Ratio
HDH	- Humidification And Dehumidification
HOMER	- Hybrid Optimisation Model For Electric Renewable
HRES	- Hybrid Renewable Energy Systems
I.Ex	- Ion Exchange Desalination
IDA	- International Desalination Association
IPS	- Institute Of Policy Studies Of Sri Lanka
IWMI	- International Water Management Institute
MASL	- Mahaweli Authority Sri Lanka
MED	- Multiple Effect Distillation
MENA	- Middle East And North Africa
MSF	- Multi-Stage Flash Distillation
MVC	- Mechanical Vapour Compression
NARA	- National Aquatic Resources Agency
NASA	- National Aeronautics And Space Administration
NBRO	- National Building Research Organisation
NF	- Nanofiltration
NPC	- Net Present Cost
NWS & DB	- National Water Supply And Drainage Board
OPEX	- Operating And Maintenance Expenses (O&M)
PR	- Performance Ratio

PV	- Photo Voltaic
RO	- Reverse Osmosis
SEE	- Single Effect Evaporation
SLSI	- Sri Lanka Standard Institution
SWRO	- Sea Water Reverse Osmosis
TDS	- Total Dissolves Solids
VCD	- Vapour Compression Distillation