

# Alternative Energy

*Edited by*

*A.K.M. Mohiuddin*

*Asif Hoda*



IIUM Press

Published by:  
IIUM Press  
International Islamic University Malaysia

First Edition, 2011  
©IIUM Press, IIUM

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without any prior written permission of the publisher.

Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

A.K.M. Mohiuddin and Asif Hoda  
Alternative Energy  
A.K.M. Mohiuddin and Asif Hoda  
Include index  
Bibliography: p.

ISBN 978-967-418-158-1

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM  
(Malaysian Scholarly Publishing Council)

Printed by :  
**IIUM PRINTING SDN. BHD.**  
No. 1, Jalan Industri Batu Caves 1/3  
Taman Perindustrian Batu Caves  
Batu Caves Centre Point  
68100 Batu Caves  
Selangor Darul Ehsan

## Table of Contents

Table of Contents .....	v
Preface .....	viii
Chapter 1	
The Impact of energy utilization on environment.....	1
<b>M.N.A. Hawlader</b>	
Chapter 2	
Desalination of Seawater to provide fresh water .....	9
<b>M.N.A. Hawlader</b>	
Chapter 3	
A solar assisted desalination system using heat pump.....	16
<b>M.N.A. Hawlader, Leong Chiing Yang</b>	
Chapter 4	
An experimental study of a phase change storage system.....	23
<b>M.N.A. Hawlader and Smita Panga</b>	
Chapter 5	
Moisture migration in a grain column subjected to drying .....	30
<b>M.N.A. Hawlader and Md. Shafique J. Chowdhury</b>	
Chapter 6	
Solar Drying of Guavas, Papayas and Apples .....	38
<b>M.N.A. Hawlader and Lee Hwee Peng</b>	
Chapter 7	
Drying under inert environment: the quality of Mango and Rockmelon.....	47
<b>M.N.A. Hawlader and Pan Jiahe</b>	
Chapter 8	
A low temperature flat plate solar collector .....	53
<b>M.N.A. Hawlader, M. Zakir Ullah and Maung Than Htut</b>	
Chapter 9	
Optimization of an integrated solar heat-pump system.....	60
<b>M N A Hawlader and Ye Shaochun</b>	
Chapter 10	
Comparative study of performance characteristics using <i>Jatropha</i> Oil Methyl Esters Biodiesel and Diesel.....	69
<b>A.K.M. Mohiuddin and Azan Mohd</b>	
Chapter 11	
Comparative Study of Emission Characteristics using <i>Jatropha</i> Oil Methyl Esters Biodiesel and Diesel .....	74
<b>A.K.M. Mohiuddin and Azan Mohd</b>	
Chapter 12	
Waste Cooking Oil Utilization for Biodiesel Production.....	79
<b>A.K.M. Mohiuddin and Nabeel Adeyemi</b>	
Chapter 13	
Flow Characteristic of Mixing Impeller for Liquid-Liquid Mixing .....	85
<b>A.K.M. Mohiuddin and Nabeel Adeyemi</b>	
Chapter 14	
Solar Energy Management for Poverty Alleviation and Income Generating Activities.....	91
<b>A.K.M. Mohiuddin</b>	

Chapter 15	
	Turbulence model for axial mixing impeller in unbaffled vessel..... 97
	<b>A.K.M. Mohiuddin, Nabeel Adeyemi and Muhamad Husaini</b>
Chapter 16	
	Optimization and economic analysis of a solar assisted heat pump drying system..... 103
	<b>M.N.A. Hawlader, S. M. A. Rahman and K.A. Jahangeer</b>
Chapter 17	
	A solar heat pump water heater for rural hospitals ..... 117
	<b>M.N.A. Hawlader and M. Zakir Ullah</b>
Chapter 18	
	A solar heat-pump system for air-conditioning, water heating and drying ..... 126
	<b>M N A Hawlader, K A Jahangeer, Ye Shaochun and Choy Tack Hoon</b>
Chapter 19	
	Engineering design – An approach to the development of creativity ..... 132
	<b>M.N.A. Hawlader</b>
Chapter 20	
	Analysis of Engine Performance with NGV ..... 140
	<b>Sany Izan Ihsan, Nabila Sulaiman, AKM Mohiuddin and Maizirwan Mel</b>
Chapter 21	
	Analysis of Engine Performance with Enhanced Fuel..... 147
	<b>Sany Izan Ihsan, Khairussani Farid, Maizirwan Mel, and AKM Mohiuddin</b>
Chapter 22	
	CFD analysis of an evacuated solar still..... 156
	<b>Ahmad F. Ismail, Mirghani I. Ahmed, Yousif A. Abakr</b>
Chapter 23	
	Developments on Solar Operated Water Desalination..... 163
	<b>Mirghani I. Ahmed, Yousif A. Abakr and Ahmad F. Ismail</b>
Chapter 24	
	Theoretical and experimental evaluation of LPG as refrigerant for domestic refrigerators and freezers ..... 169
	<b>M.M. El-Awad, M.I. Ahmed</b>
Chapter 25	
	Preliminary investigation of biodiesel reactor optimization using combine CFD-Taguchi method ..... 179
	<b>A.K.M. Mohiuddin and Nabeel A Adeyemi</b>
Chapter 26	
	Alternative mixing strategy for biodiesel production: mixed flow impeller characterization ..... 188
	<b>A.K.M. Mohiuddin and Nabeel Adeyemi</b>
Chapter 27	
	Experimental Investigation of a Multistage Evacuated Solar Still ..... 197
	<b>Yousif. A. Abakr, Ahmad F. Ismail and Mirghani I. Ahmed</b>
Chapter 28	
	Modelling of electronics heat sink – Influence of the wake function generation on the accuracy of CFD analysis ..... 203
	<b>M. I. Ahmed, A. F. Ismail, Y. A. Abakr</b>
Chapter 29	
	The effect of the operating conditions on the apparent viscosity of crude palm oil during separation..... 213

**Sulaiman Al-Zuhair, Yousif A. Abakr and Mirghani I. Ahmed**

Chapter 30

Thermal analysis of a micro device used for detection of colorectal cancer..... 220

**Mirghani I. Ahmed, Meftah Hrairi**

Chapter 31

Performance of different photovoltaic cells operating under the meteorological conditions of Singapore..... 229

**M.N.A Hawlader, Lee Poh Seng and Chua Kok Kiang**

Chapter 32

Analyses of motion and drag coefficient of water droplets in a natural draught cooling tower..... 240

**Liu Baomin and M. N. A. Hawlader**

Chapter 33

A solar assisted heat pump system for desalination..... 252

**Zakaria Mohd. Amin, M N A Hawlader and Azharul Karim**

Chapter 34

Comparative study of combustion characteristics using Jatropha oil methyl esters biodiesel and diesel..... 261

**A.K.M. Mohiuddin and Azan Mohd**

Chapter 35

Performance of evaporator collector and air collector in a solar assisted heat pump dryer.  
..... 269

**S. M. A. Rahman and M. N. A. Hawlader**

## Chapter 16

### **Optimization and economic analysis of a solar assisted heat pump drying system.**

**M.N.A. Hawlader, S. M. A. Rahman\* and K.A.Jahangeer\***

Department of Mechanical Engineering, International Islamic University Malaysia

\*Department of Mechanical Engineering, National University of Singapore

#### **ABSTRACT**

A solar assisted heat pump drying system has been designed, fabricated and tested. The performance of the system has been investigated under the meteorological conditions of Singapore. This paper presents an economic optimization of a solar assisted heat pump drying system. Economic viability of solar energy heating systems is usually made by comparing the cost flows recurring throughout the lifetime of the solar and conventional alternative systems. Therefore, the optimum variables by using simulation program and pay back period of the system are presented in this paper. Effect of load and different economic variables on pay back period is also investigated. From optimization, it was found that the optimum combination of air collector area, evaporator collector area, drying temperature, and air mass flow rate are about 1.25 m<sup>2</sup>, 2 m<sup>2</sup>, 500C and 0.036 kg/sec, respectively, which provides around 90 % of the total load. Economic analysis shows that system has a sufficient amount of savings during the life cycle with a minimum payback period of about 4.37 year.

#### **INTRODUCTION**

Growing concern about the depletion of conventional energy resources has provided impetus for considerable research and development in the area of alternative energy sources. A solar assisted heat pump dryer found to be one of the solutions while exploring for alternative energy sources. The heat pump system is used for drying and water heating applications with the major share of the energy derived from the sun and the ambient. A solar assisted heat pump dryer has been designed, fabricated and tested. The performance of the system has been investigated under the meteorological conditions of Singapore. The conversion of solar energy for useful applications requires considerable initial investment compared to the conventional system. In the majority of solar processes, a source of auxiliary energy is required so that the system includes both solar and conventional equipment to meet the desired load. Solar systems are, normally, characterized by a higher initial investment followed by lower operating costs. It is, therefore, necessary to determine whether such an investment is economically viable. A number of