



**AIN SHAMS UNIVERSITY**  
**FACULTY OF ENGINEERING**  
**Electrical Power and Machines Department**

## **Site Matching of Hybrid Generation Systems**

### **A Thesis**

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Submitted by

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## **Abstract**

Fossil fuel is rapidly declining worldwide besides it is not available in all areas, renewable energy sources such as wind, solar, hydro...etc. can be used whenever possible to generate all or part of the required electrical power especially for a remote area.

Egypt has a promising renewable energy resources that can be used to generate electricity, for example wind energy is so promising in both the Mediterranean Sea coast and the Red Sea coast, and Egypt is located in the global Sunbelt which is suitable for using solar energy to generate electricity.

For remote areas where there is a difficulty to connect with the electrical grid, hybrid power system generation with one or more renewable energy source will be more efficient.

The purpose of this thesis is to present such a hybrid power system generation for AL-Arish based on the site meteorological circumstances as wind speed and average insolation level to select the optimum system components (wind turbine & photovoltaic module) which best match this site in order to harvest the most possible amount of energy to supply a remote load of 11 Kw, a telecommunication site and a desalination unit.

Hybrid Optimization Modeling of Energy Renewable Software (HOMER) is used to find the optimum hybrid system combination both technically and economically.

Along with the hybrid system components hydrogen fuel cell is used as a storage and a back-up instead of diesel generator and batteries through hydrogen tank as it has no environmental impact and also renewable.

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## List of Symbols and Abbreviations

$V_r$	Wind Turbine Rated Speed
$V_c$	Wind Turbine Cut-in Speed
$V_f$	Wind Turbine Furling Speed
$f(V)$	Wind Speed Probability Density Function
$P_e$	Wind Turbine Output Electric Power
$P_{av}$	Wind Turbine Average Electric Power
$P_N$	Wind Turbine Normalized Electric Power
CF	Capacity Factor
TSI	Turbine Selection Index
$P_r$	Wind Turbine Rated Electric Power
K	Weibull Shape Parameter
C	Weibull Scale Parameter
$f(s)$	Insolation Level Probability Density Function
$V_{oc}$	Photovoltaic Module Open circuit Voltage
$V_{mp}$	Photovoltaic Module Max. Power Voltage
$I_{sc}$	Photovoltaic Module Short circuit current
$I_{mp}$	Photovoltaic Module Short circuit Max. Power current
PV	Photovoltaic Module
WT	Wind Turbine
FC	Fuel Cell
NPC	Net Present Cost
COE	Cost of Energy
RE	Renewable Energy
GHG	Greenhouse effect gas
CSP	Concentrating Solar Power
STEG	Solar Thermal Electric Generation
HOMER	Hybrid Optimization Modeling for Energy Renewable
MPPT	Maximum Power Point Tracking
PDF	Probability Density Function
K-S Test	Kolmogrov-Smimov Test
RO	Reverse Osmosis

## **Publications**

- Ahmed M Attala, A. T. M. Taha, Ahmed K. Ryad  
“Evaluation of Different Hybrid Energy Potential in AL-Arish”, International Journal of Computer Applications, Volume 88- No.17, February 2014, pp. 13-17.
- Ahmed M Attala, A. T. M. Taha, Ahmed K. Ryad “  
PV, Wind and Fuel Cell Hybrid Optimization Generation for AL-Arish Site” International Journal of Recent Development in Engineering and Technology, Volume 2, Issue 4, April 2014, pp. 1-4.
- Ahmed M Attala, A. T. M. Taha, Ahmed K. Ryad  
“Optimization of Hybrid Energy for a Telecommunication Unit and a Desalination Unit”, Engineering Research Journal, Faculty of Engineering SHOUBRA, July 2014.

## **Preface**

The aim of this thesis is to estimate a suitable hybrid generation system for a remote load matches the site metrological circumstances.

In Chapter 1 an overview of the renewable energy capabilities worldwide is presented besides Egypt renewable resources capabilities.

Chapter 2 presents the hybrid power systems technologies with its advantages and disadvantages with an overview on Egypt hybrid power system projects.

Chapter 3 presents HOMER Software, an application to model hybrid system on it? How it works to simulate various hybrid combinations to find the most optimum combination?

Chapter 4 deals with AL-Arish metrological data to estimate the optimum wind turbine model and the optimum PV module which best matches the site then HOMER software is used to determine the optimum combination to supply a remote load with a combination of wind turbine, PV module and Fuel Cell.

Chapter 5 examines various hybrid power system combinations to determine the most optimum hybrid power system technology.

Chapter 6 deals with both supplying electricity to a remote load besides providing fresh water through desalination process where both goals are achieved by a hybrid power system generation unit.

Chapter 7 summarizes the thesis results and suggests future work.

# Chapter 1

## Renewable Energy Sources

### 1.1 Introduction

Demand for energy to meet social and economic development and improve human welfare and health, is increasing. All societies require energy services to meet basic human needs (e.g., lighting, cooking, space comfort, mobility and communication) and to serve productive processes. Since approximately 1850, global use of fossil fuels (coal, oil and gas) has increased to dominate energy supply, leading to a rapid growth in carbon dioxide (CO<sub>2</sub>) emissions.

Fossil fuels as coal, oil, gas are all of limited amounts and can't be replaced. Nuclear fuels are of limited amounts of uranium for nuclear fission reactors but reprocessing of fuel is possible.

The greenhouse effect gas (GHG) emission resulting from the provision of energy services has contributed significantly to the historic increase in atmospheric GHG concentrations.

Renewable Energy (RE) as having a large potential to mitigate climate change, RE can provide wider benefits. RE may, if implemented properly, contribute to social and economic development, energy access, a secure energy supply, and reducing negative impacts on the environment and health [1].

Renewable energy provided an estimated 19% of global final energy consumption in 2012, and continued to grow in 2013. Of this total share in 2012, modern renewables accounted for approximately 10%, with the remainder coming from traditional biomass.

Heat energy from modern renewable sources accounted for an estimated 4.2% of total final energy use; hydropower made up about 3.8%, and an estimated 2% was provided by power from wind, solar, geothermal, and biomass, as well as by biofuels.