Renewable Energy Education Programme

The Engineering and Economics of Solar Photovoltaic Energy Systems

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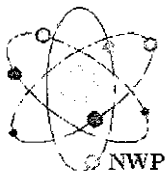

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This work is dedicated to my parents and all parents

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Preface

Each year solar electric generating systems offer people more solutions to their energy problems. The first practical solar cell was developed at Bell Laboratories in 1954. Since the 1960s photovoltaic (PV) cells have been the exclusive power source for satellite
es. Since the 1970s photovoltaic systems have been used for remote stand-alone systems throughout the world. In the 1980s, commercial and consumer product manufacturers began incorporating photovoltaics into every product. In the 1990s, many utilities found photovoltaics to be the best choice for thousands of small power needs.

During the current decade, a large part of the world's population will be introduced to electricity produced by photovoltaic systems. These photovoltaic systems will make the traditional requirements of building large, expensive power plants and distribution systems unnecessary. As the cost of photovoltaics continues to decline and as photovoltaic technology continues to improve, several potentially huge markets for photovoltaics will open up. For example, building materials that incorporate photovoltaic cells will be designed into new high rise buildings and homes, helping to ventilate and light the buildings. Consumer products ranging from battery-powered hand tools to automobiles will take advantage of electricity-producing components containing photovoltaic materials. Meanwhile, electric utilities will find more and more ways to use photovoltaics to supply the needs of their customers.

This book is written for people who have an interest in the engineering and the economics of solar photovoltaic systems. As this book aims to familiarise its readers with basic design principles and components of PV systems as well as the requirements of load analysis, cost analysis and system sizing, therefore it is recommended to be used as text book for courses dealing with engineering and economics of solar photovoltaic energy systems.

INTRODUCTION

Solar cells convert sunlight directly into electricity, our most versatile form of energy. Today solar generated electricity serves people living in the most isolated areas on the earth. First used in the space program, PV systems are now generating electricity to pump water, light up the night, activate switches, charge batteries, supply the electric utility grid, and more.

Solar electric systems are simple to operate and have no moving parts. PV cells operate on the physical principle that electric current will flow between two semiconductors with different electrical properties when they are put in contact with each other and exposed to light. A collection of these PV cells constitutes a PV panel, or module.

PV modules produce direct current (DC) rather than alternating current (AC), because of their electrical properties. Many simple devices, such as those that run on batteries, use direct current. Alternating current, in contrast, is electric current that reverses its direction at regular intervals. In the simplest systems, DC current produced by PV modules is used directly. In the applications where AC current is necessary, an inverter can be added to the system to convert the DC power to AC power.

PV systems produce power in all types of weather. On partly cloudy days they can produce up to 80% of their potential energy delivery; on humid days, about 50%; and on extremely cloudy days, they still produce up to 30%.

PV research and development worldwide has improved the performance and substantially reduced the cost of photovoltaic electricity. Researchers continue to experiment with various combinations of materials to increase the amount of electricity generated by solar cells and to reduce the cost of manufacturing the solar modules.