Preface

This book was inspired by my need for a textbook to teach the Renewable Energy Technology class that I developed at the Illinois Institute of Technology (IIT) and I am now teaching at the University of Illinois at Chicago (UIC). Most textbooks that cover the subjects of renewable energy and hydrogen systems focus on the supply side with little or no mention of the considerations one must make to balance of the system in the areas of energy storage, system control, and optimization. This book is an attempt to cover that gap by providing a textbook to present basic knowledge of the various components of hybrid renewable hydrogen systems as well as a methodology and overview for systems design, control, and optimization.

This book is intended for an audience of senior undergraduate and graduate engineering students as well as other graduate students from colleges of Architecture, Business, Law or Policy. This book is also intended to discuss the various aspects of the much celebrated "Hydrogen Economy" and to cover the basics of renewable energy sources and their technical and economical limitations or barriers. In addition, this book provides an overview of energy storage and conversion technologies such as hydrogen storage, batteries and fuel cells. Finally, case studies on hybrid hydrogen systems for clean energy and clean water applications are presented.

The first chapter provides an overview of worldwide energy consumption, the state of renewable energy, and the potential role renewable energy can play in a sustainable energy future.

Chapter 2 presents an overview of first principles in solar and wind energy. The chapter discusses fundamentals of operation as well technical and economical constraints.

Chapter 3 provides an overview of hydrogen production methods and discusses various alternatives for hydrogen storage. In addition the chapter provides a good summary for the various types of fuel cells and their operating principles.

Chapter 4 describes the operation of the Renewable Hybrid Energy System (RHES) and explains why hybrid generation and storage make economic sense under certain conditions. The chapter also discusses the dynamic behavior of a fuel

cell and battery hybrid system and the design of an active controller for such a system.

Chapter 5 provides an overview of hybrid energy systems, such as the PEM (Polymer Electrolyte Membrane) fuel cell/battery hybrid system, as well as guidelines for control of these systems. The controller logic developed is able to respond to three different load scenarios. The controller is also tuned to buffer the fuel cell from load transients. The work in this chapter is based on previous work from the inter-professional project "Solar Hydrogen Project" at IIT, sponsored by the Illinois Department of Commerce, ComEd, BP, and Proton Energy Systems.

Chapter 6 presents a case study that describes the design and implementation of a hybrid system for the elimination of engine idle in airport ground support vehicles. A PEM (Polymer Electrolyte Membrane) fuel cell/lithium-ion battery system is shown to be the most suitable design for this project. Details of the proposed design are discussed as well results and a summary of the successes and limitations of the project along with proposed future work. The project was sponsored by the Chicago Department of Fleet Management (CDFM) with major technical contributions and insights by Mathew Stewart at CDFM and Mohammed Khader from AllCell Technologies.

Chapter 7 discusses the key decisions that factor into the design of a hybrid fuel cell/desalination (HFCD) system to supply a developing region with adequate electrical power and water. The focus of this case study is Caye Caulker, a Caribbean island located off the coast of Belize. Caye Caulker has limited fresh water sources and currently uses diesel generators as its sole source of power. The goal of this case study is to replace these diesel generators with an HCFD system that can also provide Caye Caulker with potable water. The work in this case study was part of a project sponsored by the Middle East Desalination center in Oman. Major contributions were made to the chapter material by Greg Albright.

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