

Solar Hydrogen Generation

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Toward a Renewable Energy Future

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Dedication

Krishnan Rajeshwar

To the three girls in my life, Rohini, Reena, and Rebecca: I could not have done this without your love and support

Robert McConnell

To my wife Suzie Star whose love and support made this possible. To my children and especially my grandson Tharyn. My hope for them is to live in a cleaner world powered by renewable energy and hydrogen.

Stuart Licht

To my children: Reeva, Gadi, Ariel, Jacob and Dov; I hope to open a path to a sustainable energy future for them. To my wife Bregt, this is here because you are here.

Preface

This book examines ways to generate hydrogen from sunlight and water. It largely arose out of a desire to bring all the disparate ways to accomplish this goal within the confines of a single edited volume. Thus we are aware of many books and reports discussing the pros and cons of a hydrogen economy but none, that we are aware of, that focus on the science and technology of generating hydrogen from sunlight and water. While renewable hydrogen currently remains an elusive goal, at least from a cost perspective, the *scientific* principles behind its generation are well understood. Thus over and above reviewing this substantial fundamental database, part of the incentive for creating this book was to hopefully inspire future generations of scientists and engineers to respond to the grand challenge of translating the impressive laboratory advances and prototype demonstrations to a practical renewable energy economy. Much of this daunting hurdle has to do with optimizing the efficiency and hence the cost-effectiveness of hydrogen producing solar energy systems.

History certainly is on our side in meeting this challenge. Many early civilizations used the sun, water, and the wind to meet basic needs. Even geothermal heat was used by North American Indians some 10,000 years ago for cooking. The ancient Greeks used hydro power to grind flour and the Persians used windmills to pump water in the first millennium. The human race is very good at solving technological problems and we can certainly wean ourselves from fossil fuels if we collectively put our minds to it. But cost is certainly going to be a driver and no amount of civic sense is going to render the hydrogen economy practically realizable if a gallon of gasoline continues to be substantially cheaper than a kilogram of hydrogen. Unfortunately however we can only give short shrift to the issue of economics in this book because of the rapidly shifting landscape of assumptions that an evolving technology brings with it. Nonetheless, the concluding chapter of this book examines investments, leveled hydrogen prices, and fuel cycle greenhouse gas emissions of a centralized electrolytic hydrogen production and distribution system powered by photovoltaic electricity.

Another important and related topic, not specifically addressed in this book, concerns the issue of how to store hydrogen, especially in a mobile transportation application. We felt that this topic was specialized and wide ranging enough to warrant a separate volume to be created by scientists and engineers far more qualified and knowledgeable than us. While fuel cells are briefly introduced in Chapter 1, how hydrogen is to be utilized to generate power is again left to many other excellent treatises in the literature; some of these are cited in what follows.

Every effort was made to remove redundancy and add homogeneity to the material in this multi-author volume. Indeed, the more authoritative level of discussion afforded by having specialists write each chapter will have hopefully overridden any “rough edges” that remain from chapter to chapter. Undoubtedly, many flaws remain for which we as editors are wholly responsible; we would welcome feedback on these.

A project of this magnitude could not have been completed without the collective contributions of many people, some of whom we wish to acknowledge at this juncture. First, Ken Howell deserves special thanks for his many useful suggestions. His patience as this book production went through countless delays is also much appreciated. Don Gwinner, Al Hicks and their production team at NREL managed to create quality illustrations from the drawings and graphs (many in primitive form) that were furnished to them. Maria Gamboa is thanked for very capably doing the pre-print lay-out of the various manuscripts. Finally we offer simple thanks to our families for their love and support and for putting up with the many weekends away spent in putting this volume together.

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