

Hydrogen and Syngas Production and Purification Technologies

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A Joint Publication of the Center for Chemical Process Safety of the American Institute of Chemical Engineers and John Wiley & Sons, Inc.

Published by John Wiley & Sons, Inc., Hoboken, New Jersey
Published simultaneously in Canada

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Library of Congress Cataloging-in-Publication Data:

Hydrogen and syngas production and purification technologies / edited by Ke Liu, Chunshan Song, Velu Subramani.

p. cm.

Includes index.

ISBN 978-0-471-71975-5 (cloth)

1. Hydrogen as fuel. 2. Synthesis gas. 3. Coal gasification. I. Liu, Ke, 1964– II. Song, Chunshan. III. Subramani, Velu, 1965–
TP359.H8H8434 2010
665.8'1–dc22

2009022465

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

Hydrogen and Syngas Production and Purification Technologies

Preface

Hydrogen and synthesis gas (syngas) are indispensable in chemical, oil, and energy industries. They are important building blocks and serve as feedstocks for the production of chemicals such as ammonia and methanol. Hydrogen is used in petroleum refineries to produce clean transportation fuels, and its consumption is expected to increase dramatically in the near future as refiners need to process increasingly heavier and sour crudes. In the energy field, the developments made recently in IGCC (Integrated Gasification Combined Cycle) and fuel cell technologies have generated a need to convert the conventional fuels such as coal or natural gas to either pure hydrogen or syngas for efficient power generation in the future. In addition, the dwindling supply of crude oil and rising demand for clean transportation fuels in recent years led to intensive research and development worldwide for alternative sources of fuels through various conversion technologies, including gas-to-liquid (GTL), coal-to-liquid (CTL) and biomass-to-liquid (BTL), which involve both hydrogen and syngas as key components.

The purpose of this multi-authored book is to provide a comprehensive source of knowledge on the recent advances in science and technology for the production and purification of hydrogen and syngas. The book comprises chapters on advances in catalysis, chemistry and process for steam reforming and catalytic partial oxidation of gaseous and liquid fuels, and gasification of solid fuels for efficient production of hydrogen and syngas and their separation and purification methods, including water-gas-shift, pressure swing adsorption, membrane separations, and desulfurization technologies. Furthermore, the book covers the integration of hydrogen and syngas production with future energy systems, as well as advances in coal-to-liquids and syngas-to-liquids (Fischer-Tropsch) processes. All the chapters have been contributed by active and leading researchers in the field from industry, academia, and national laboratories. We hope that this book will be useful to both newcomers and experienced professionals, and will facilitate further research and advances in the science and technology for hydrogen and syngas production and utilization toward clean and sustainable energy in the future.

We sincerely thank all the authors who spent their precious time in preparing various chapters for this book. We would like to express our sincere gratitude to our family members and colleagues for their constant support and patience while we completed the task of preparing and editing this book. We are also grateful to all

the staff members at John Wiley & Sons for their great and sincere efforts in editing and publishing this book.

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Chapter 1

Introduction to Hydrogen and Syngas Production and Purification Technologies

CHUNSHAN SONG

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1.1 IMPORTANCE OF HYDROGEN AND SYNGAS PRODUCTION

Clean energy and alternative energy have become major areas of research worldwide for sustainable energy development. Among the important research and development areas are hydrogen and synthesis gas (syngas) production and purification as well as fuel processing for fuel cells. Research and technology development on hydrogen and syngas production and purification and on fuel processing for fuel cells have great potential in addressing three major challenges in energy area: (a) to supply more clean fuels to meet the increasing demands for liquid and gaseous fuels and electricity, (b) to increase the efficiency of energy utilization for fuels and electricity production, and (c) to eliminate the pollutants and decouple the link between energy utilization and greenhouse gas emissions in end-use systems.¹

The above three challenges can be highlighted by reviewing the current status of energy supply and demand and energy efficiency. Figure 1.1 shows the energy supply and demand (in quadrillion BTU) in the U.S. in 2007.² The existing energy system in the U.S. and in the world today is largely based on combustion of fossil fuels—petroleum, natural gas, and coal—in stationary systems and transportation vehicles. It is clear from Figure 1.1 that petroleum, natural gas, and coal are the three largest sources of primary energy consumption in the U.S. Renewable energies

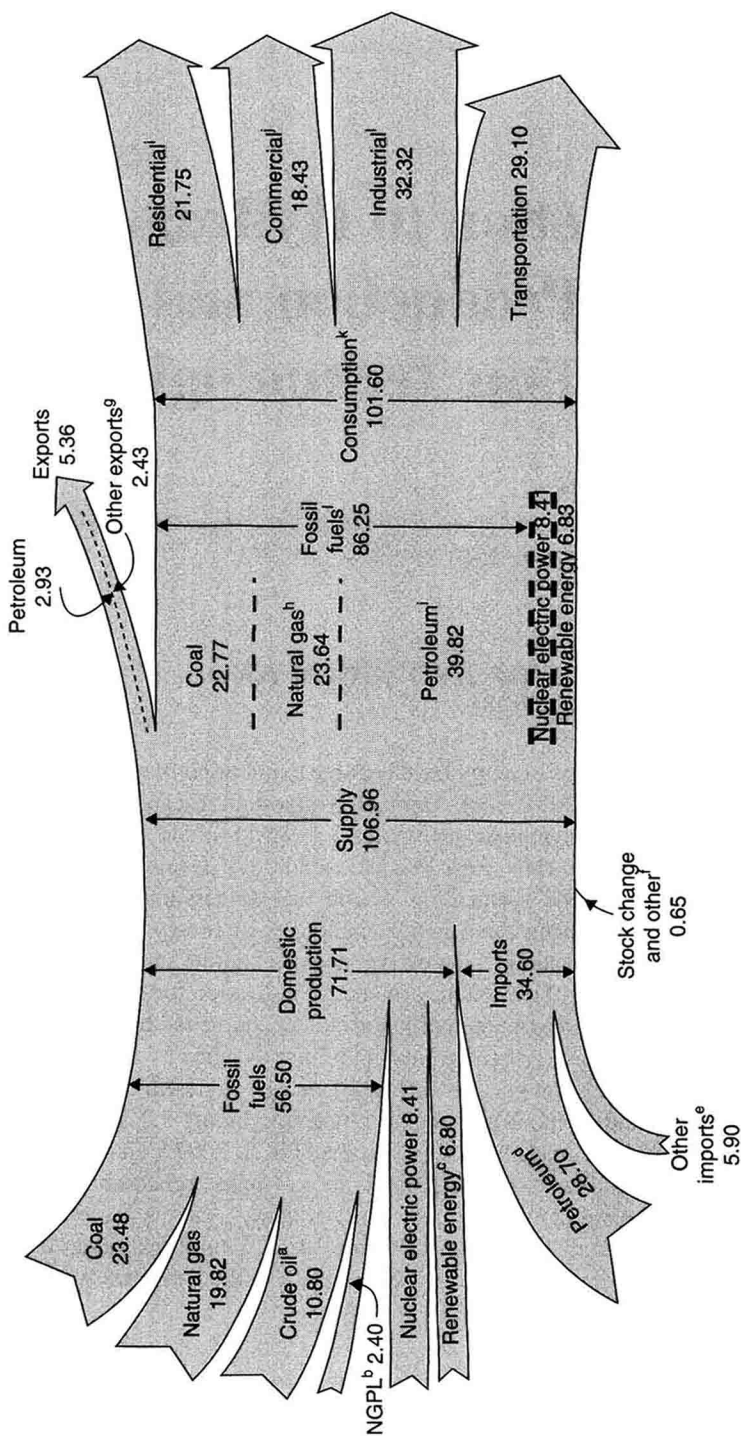


Figure 1.1. Energy supply by sources and demand by sectors in the U.S. in 2007 (in quadrillion BTU).²