

PEAK ENERGY

MYTH OR REALITY?

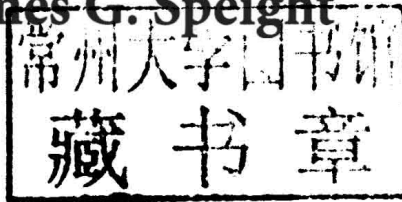
JAMES G. SPEIGHT
M. R. ISLAM

 Scrivener
Publishing

WILEY

Peak Energy: Myth or Reality?

M. R. Islam
and
James G. Speight



WILEY

Copyright © 2016 by Scrivener Publishing LLC. All rights reserved.

Co-published by John Wiley & Sons, Inc. Hoboken, New Jersey, and Scrivener Publishing LLC, Salem, Massachusetts.

Published simultaneously in Canada.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750-4470, or on the web at www.copyright.com. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at <http://www.wiley.com/go/permission>.

Limit of Liability/Disclaimer of Warranty: While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

For general information on our other products and services or for technical support, please contact our Customer Care Department within the United States at (800) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic formats. For more information about Wiley products, visit our web site at www.wiley.com.

For more information about Scrivener products please visit www.scrivenerpublishing.com.

Cover design by Kris Hackerott

Library of Congress Cataloging-in-Publication Data:

ISBN 978-1-118-54942-1

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

Peak Energy: Myth or Reality?

Scrivener Publishing

100 Cummings Center, Suite 541J
Beverly, MA 01915-6106

Publishers at Scrivener

Martin Scrivener (martin@scrivenerpublishing.com)
Phillip Carmical (pcarmical@scrivenerpublishing.com)

Preface

Crude oil, natural gas, and coal are the major sources of fuel used to supply energy for various needs. Users of crude oil, natural gas, and coal must take into account that these energy sources are, without doubt, non-renewable depleting resources, and the cost of extraction depends not only on the current rate of production but also on the amount of cumulative production. In fact, while coal is projected to last for another two hundred years or so at current rates of use, after which crude oil and natural gas will no longer be in ready supply.

This phenomenon has given rise to the *peak oil theory* – peak oil is the point in time when the maximum rate of petroleum recovery from the reservoir is reached, after which the rate of petroleum production enters terminal decline. From this concept has emerged the wider concept of the *peak energy theory* which, as it is related to the availability of all fossil fuels, is also subject to decline with fossil fuel use. At this time it is worthy of note that the term *peak oil* is often used synonymously and interchangeably with the term *peak energy* – crude oil being the most abundant form of energy – and the terms are used interchangeably throughout this book.

The issues related to crude oil and natural gas supply and energy generation arose from the concept that both crude oil and natural gas, like any finite natural resource, have a limited lifetime that is dependent upon use (energy demand). From that, the term peak oil arose, which refers to the maximum rate of oil production, after which the rate of production enters terminal decline. Peak oil production usually occurs after approximately half of the recoverable oil in an oil reserve has been produced (i.e., extracted). The theory also espouses that the rate of world oil production cannot increase and that oil production will inevitably and irreversibly thereafter decrease with time, even if the demand for oil remains the same or increases. Following from this, the term peak energy is the point in time after which energy production declines and the production of energy from various energy sources is in decline. However, what the peak oil theory ignores is that in many oil-producing nations production declines have been offset by discoveries and production growth elsewhere in the world.

Petroleum might be in the position as voiced by the immortal saying of Mark Twain – the rumors of my death have been greatly exaggerated!

It is not the purpose of this book to deny that the rate of depletion of any finite natural resource increases with time – assuming that the total natural resource is known and acknowledged. However, this book responds to the notions that predict the immediate death of crude oil as well as natural gas and, hence, energy production, and explores the reality of crude oil stocks and the availability of other resources to continue the necessary production of all forms of energy. In fact, the concern over crude oil supplies and other energy supplies lies mostly in the misuse of data that supposedly indicate that the world is approaching an energy precipice in which fossil fuels will no longer be available for use as energy sources – the date the energy precipice is reached is wildly speculative and, in many cases, totally unrealistic.

Fossil fuel energy sources (defined as “recoverable” in today’s term) will undoubtedly reach a depletion point in the future when these energy sources are no longer available, but not at the moment or even within the next 50 years; the reality of reserve/production ratios dispels the notion of the short lifetime of energy-producing resources. At the same time, the evolution of technologies that continue to lift the lid of “recoverability” will help recover supposedly unrecoverable oil from depleted reservoirs, and new gas-fired generating units use highly efficient technologies and are supported by abundant gas supplies. Added to that are the continual discoveries of new reserves and the moving of the boundary of conventional oil and gas. These issues are not always taken into account by the *precipice theorists*.

The issue of crude oil reserves and natural gas reserves – as well as the future of the petroleum refinery – and the reserves of other energy sources are discussed in the context of peak energy and the manner in which energy production scenarios can be prolonged well into the future.

Dr. James G. Speight
Laramie, Wyoming,
USA

Dr. Rafiq Islam
Halifax, Nova Scotia
Canada

About the Authors

Dr. James G. Speight

Dr. James G. Speight, who has doctorate degrees in Chemistry, Geological Sciences, and Petroleum Engineering, is the author of more than 60 books in petroleum science, petroleum engineering, and environmental sciences. He has served as Adjunct Professor in the Department of Chemical and Fuels Engineering at the University of Utah and in the Departments of Chemistry and Chemical and Petroleum Engineering at the University of Wyoming. In addition he has been a Visiting Professor in Chemical Engineering at the following universities: the University of Missouri-Columbia, the Technical University of Denmark, and the University of Trinidad and Tobago.



As a result of his work, Dr. Speight has been honored as the recipient of the following awards:

- Diploma of Honor, United States National Petroleum Engineering Society. *For Outstanding Contributions to the Petroleum Industry*, 1995.
- Gold Medal of the Russian Academy of Sciences. *For Outstanding Work in the Area of Petroleum Science*. 1996.
- Einstein Medal of the Russian Academy of Sciences. *In recognition of Outstanding Contributions and Service in the field of Geologic Sciences*. 2001.
- Gold Medal – Scientists without Frontiers, Russian Academy of Sciences. *In recognition of His Continuous Encouragement of Scientists to Work Together across International Borders*. 2005.

- Methanex Distinguished Professor, University of Trinidad and Tobago. *In Recognition of Excellence in Research*. 2006.
- Gold Medal – Giants of Science and Engineering, Russian Academy of Sciences. *In recognition of Continued Excellence in Science and Engineering*. 2006.

Dr. M. Rafiqul Islam

Professor M. R. Islam is a worldwide consultant on environment and energy-related issues. He is currently director of Oil and Gas at Trans Canada Training. Dr. Islam is known as the most published engineer in the world. He is credited with the coining of terms such as “green petroleum” and “sustainable petroleum development” at a time when “sustainable petroleum” was considered to be an oxymoron. His groundbreaking approach in research, training, and education is summarized in his book *Reconstituting the Curriculum* (Wiley-Scrivener, 2013). His work has created a paradigm shift in a wide range of applications, spanning various disciplines.



Dr. Islam's most notable contribution is in the areas of sustainability, environmental integrity, and knowledge modeling, on which topics he has written dozens of books and over 700 research papers. His latest works are captured in his book: *Unconventional Gas Reservoirs* (Elsevier, 2014) and *Greening of Pharmaceutical Engineering* (Scrivener-Wiley). During the 30 years of his professional career, Professor Islam has held faculty positions with seven different universities and supervised over 150 research students and post-doctoral fellows. He received \$30 million in research funding from various government and industrial entities. His research spun off a number of technology transfer projects that led to the development of three companies. One of them has now become one of the most innovative oil spill remediation technology development companies.

From 2000 through 2005, Dr. Islam held the Killam Research Chair Professor in Oil and Gas, which was the only Petroleum Engineering Research Chair in Canada. Prior to this, Dr. Islam was the first NRCan (Natural Resources Canada) professor of engineering at the University of Regina, where he was the program leader of petroleum engineering. He was instrumental in establishing the Petroleum Technology Research Center

(PTRC) and the Greenhouse GasTechnology Center (GTC) in Regina. Dr. Islam has written over 700 research articles on various modeling, management, energy, environmental, and communication-related topics.

During the same period, he received more than \$20 million in institutional and over \$10 million in individual research grants, and employed over 150 post-doctoral fellows, and graduate and undergraduate research students. In recognition of his research and teaching excellence, he has received a number of international awards, including the Einstein Gold Medal of Honor, and the Crown and Eagle Gold Medal, for both of which Dr. Islam is the first recipient in Canada. He has taught 30 different academic courses and some dozen industry professional development workshops around the world. He has also given numerous invited and guest speeches in many countries.

Contents

Preface	xi
About the Authors	xiii
1 History and Terminology of Energy Sources	1
1.1 Introduction	1
1.2 Fossil Fuel Resources	10
1.2.1 Petroleum	11
1.2.2 High-Acid Crude Oils and Opportunity Crudes	14
1.2.3 Oil from Tight Formations and from Shale Formations	16
1.2.4 Natural Gas	17
1.2.5 Heavy Oil	19
1.2.6 Tar Sand Bitumen	20
1.2.7 Coal	23
1.2.7.1 Lignite	24
1.2.7.2 Subbituminous Coal	25
1.2.7.3 Bituminous Coal	25
1.2.7.4 Anthracite	27
1.2.8 Oil Shale	27
1.2.9 Gas Hydrates	30
1.3 Non-Fossil Fuel Resources	32
1.3.1 Biomass	32
1.3.2 Wind Energy	37
1.3.3 Solar Energy	37
1.3.4 Geothermal Energy	38
1.3.5 Ocean Energy	39
1.3.6 Nuclear Energy	40
1.3.7 Hydrogen Energy	41
1.3.8 Hydropower	42
References	43

2	Energy Sources and Supply	49
2.1	Introduction	49
2.2	Fossil Fuel Sources	56
2.2.1	Petroleum, Heavy Oil, and Tar Sand Bitumen	57
2.2.2	Natural Gas	65
2.2.3	Coal	67
2.3	Oil Shale	68
2.4	Gas Hydrates	71
2.5	Non-Fossil Fuel Energy Sources	72
2.5.1	Biomass	73
2.5.2	The Wind	75
2.5.3	The Sun	75
2.5.4	Geothermal Sources	76
2.5.5	The Tides	76
2.6	Nuclear Energy	77
2.7	Hydrogen Energy	77
2.8	Energy Supply	78
2.8.1	Physical Factors	78
2.8.2	Technological Factors	80
2.9	Economic and Geopolitical Factors	82
2.10	Peak Oil	83
2.10.1	Peak Oil Theory	83
2.10.2	Effects and Consequences	87
2.11	Energy Independence	87
2.12	Energy Security	92
	References	96
3	Future Energy from Fossil Fuels	103
3.1	Introduction	103
3.2	The Role of Enhanced Oil and Gas Recovery	106
3.3	Heavy Oil, Extra Heavy Oil, and Tar Sand Bitumen	123
3.4	Natural Gas and Gas Hydrates	125
3.5	Tight Oil and Gas	127
3.5.1	Tight Oil	128
3.5.2	Tight Gas	129
3.6	Undiscovered Oil	129
3.7	Oil Shale	132
3.8	Synthetic Fuels	133
3.9	The Future Refinery	135
3.9.1	The Refinery and Peak Oil Theory	137

3.9.2	Refinery Configurations	138
3.9.2.1	Petroleum Refinery	138
3.9.2.2	Biorefinery	141
3.9.2.3	Coal Liquids Refinery	143
3.9.2.4	Shale Oil Refinery	144
3.9.2.5	Gasification Refinery	146
3.9.3	The Integrated Refinery	147
References		151
4	Future Energy from Unconventional Sources	157
4.1	Introduction	157
4.2	Unconventional Oil and Gas	159
4.3	Tar Sand Bitumen	162
4.3.1	Mining and Bitumen Conversion	164
4.3.2	Other Processes Related to Mining	167
4.3.3	Non-Mining Methods	169
4.3.3.1	Steam-Based Processes	170
4.3.3.2	Combustion Processes	171
4.3.3.3	Other Processes	172
4.4	Coal	173
4.4.1	Coal Liquefaction	174
4.4.2	Gasification	175
4.4.3	Gaseous Fuels from Coal	178
4.4.3.1	Low Heat-Content (Low-Btu) Gas	178
4.4.3.2	Medium Heat-Content (Medium-Btu) Gas	179
4.4.3.3	High Heat-Content (High-Btu) Gas	180
4.4.4	Liquid Fuels	180
4.4.5	Solid Fuels	181
4.5	Oil Shale	182
4.5.1	Production of Shale Oil	184
4.5.2	Refining Shale Oil	185
4.6	Gas Hydrates	188
4.7	Synthetic Fuels	192
4.8	Other Energy Sources	196
4.8.1	Geothermal Energy	197
4.8.2	Hydrogen Energy	199
4.8.3	Nuclear Energy	201
4.8.4	Wind Energy	203
References		205

5	Future Energy from Biomass	209
5.1	Introduction	209
5.2	Biomass Feedstocks	212
5.2.1	Energy from Crops	215
5.2.2	Energy from Wood	216
5.2.3	Energy from Waste	217
5.3	The Chemistry of Biomass	217
5.4	A Biorefinery	218
5.5	Biofuels	220
5.5.1	Ethanol	220
5.5.2	Biodiesel	221
5.5.3	Bio-oil	222
5.5.4	Biofuels from Synthesis Gas	223
5.6	Biofuels: A Replacement for Petroleum and Natural Gas	226
5.6.1	Gaseous Fuels	226
5.6.1.1	Fermentation	227
5.6.1.2	Gasification	227
5.6.1.3	Biophotolysis	228
5.6.2	Liquid Fuels	229
5.6.3	Solid Fuels	230
5.7	Processes	231
	References	232
6	Peak Energy	237
6.1	Introduction	237
6.2	History of the Peak Oil Theory	240
6.2.1	Relation to Population and Lifestyle	241
6.2.2	Evidence in Favor of the Peak Oil Theory	245
6.2.3	Social Theories and the Peak Oil Theory	249
6.3	Petroleum in the Big Picture	250
6.4	World Petroleum Reserves	252
6.5	Unconventional Oil and Gas	259
6.5.1	Petroleum and Natural Gas	260
6.5.2	Shale Gas	262
6.5.3	Coalbed Methane	263
6.5.4	Tight Gas Reserves	264
	References	267
7	The Reality of the Peak Oil Theory	271
7.1	Introduction	271
7.2	The Petroleum Industry	272
7.2.1	Background	272

7.2.2	Jevons Paradox	275
7.2.3	Equity Shoulder Debt	286
7.2.4	The Finite-Infinite Conundrum	288
7.2.5	Renewable and Non-Renewable: Energy without Boundaries	288
7.3	Scientific Characterization of Energy Resources	292
7.3.1	Solar Energy	294
7.3.2	Hydropower	297
7.3.3	Ocean Thermal, Wave, and Tidal Energy	298
7.3.4	Bioenergy	299
	7.3.4.1 Fuelwood	300
	7.3.4.2 Bioethanol	302
	7.3.4.3 Biodiesel	303
7.3.5	Nuclear Power	304
7.3.6	Geothermal Energy	307
7.3.7	Hydrogen Energy	308
7.4	Conclusions	310
	References	310
8	Global Climate Change	315
8.1	Introduction	315
8.2	Interglacial Periods	320
8.3	The Role of Human Activity	322
8.4	Climate Change	324
8.5	Conclusions	325
	References	327
9	Energy Sustainability	331
9.1	Introduction	331
9.2	Sustainable Energy	333
9.3	Real Reserve Potential	336
9.4	Biomass Sustainability	341
9.5	Conclusions	343
	References	344
	Common Conversion Factors	345
	Glossary	349
	Index	371

