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Understanding Complex Systems

Founding Editor: S. Kelso

Future scientific and technological developments in many fields will necessarily depend upon coming to grips with complex systems. Such systems are complex in both their composition – typically many different kinds of components interacting simultaneously and nonlinearly with each other and their environments on multiple levels – and in the rich diversity of behavior of which they are capable.

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Climate Change and Energy Dynamics in the Middle East

Modeling and Simulation-Based Solutions

 Springer

Editors

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To My Grandfather

Raja Munawwar Khan (late)

—Hassan Qudrat-Ullah

To My Parents, Wife, and Children

—Aymen A. Kayal

Preface

Global climate change and global warming has the potential to severely impact both the production and consumption of energy across the globe. The Middle East region with even slightly warmer weather can result in an increased demand of energy (e.g., for more air conditioning use and energy-intensive methods for water supply), lower labor productivity (e.g., relatively few hours are available during the day), and less supply of energy (e.g., hydro generation can suffer due to none or less availability of water due to rising temperature). The potential imbalance of energy demand and supply can often lead to rising electricity costs and power outages which, in turn, can have severe impact on the socioeconomic welfare of the population of these countries. Although more sunny days can help in harnessing solar power, the predominant use of fossil-based electricity generation by this region and the resulting environmental emissions are major concerns to be addressed. Consequently, for the decision-makers, to better understand the sustainable production and consumption of energy and the related socioeconomic dynamics requires a systematic and integrated approach. Modelling and simulation in general and system dynamics and optimization modelling in particular have the capabilities to deal with the complexity of climate change and energy dynamics. Therefore, the primary aim of this book is to present, in the context of the Middle East region, the latest decision-making tools, techniques, and insightful and innovative solutions that the decision-makers can utilize to overcome the challenges that their energy systems face. Furthermore, we hope to encourage further theoretical and empirical research that perhaps may be interwoven by the works presented herein and in advancing new methodological perspectives to include multilevel and cross-level analysis to better understand the dynamics of sustainability-focused supply chains.

Unified by the common goal of making better decisions in the sustainable production and consumption of energy, we invited potential authors to submit and showcase their work related to the major theme of this book, *Climate Change and Energy Dynamics in the Middle East*. In addition to relevance of their work to the Middle East, we sought both theoretical (only state-of-the-art reviews) and empirical chapters with a focus on system dynamics, econometric, optimization, and conceptual modelling. It is our hope that this book will stimulate a new way of

thinking as a proclamation of a new era of resource constraints and renewed focus on “integrative” solutions for the challenges in climate change and energy policy-making.

Content Overview

The integrating theme of this book is modelling-based solutions to deal with dynamics of climate change and energy domains. The book contains five parts. Part I presents the introduction and preview of Climate Change and Energy Dynamics in the Middle East. Part II of this book, “Dynamic Modelling in Service of Climate Change and Energy Decisions,” examines the dynamic modelling-based approaches to better understand the dynamics of climate change and energy-related issues in the Middle East. Five state-of-the-art applications of dynamic modelling include Socioeconomic and Environmental Implications of Renewable Energy Integrity in Oman: Scenario Modelling Using System Dynamics Approach, Energy and Emissions Modelling for Climate Change Mitigation from Road Transportation in the Middle East: A Case Study from Lebanon, Climate Change and Energy Decision Aid Systems for the Case of Egypt, Control Strategy and Impact of Meshed DC Micro-Grid in the Middle East, and The Energy-Water-Health Nexus Under Climate Change in the United Arab Emirates – Impacts and Implications. Part III of this book, “Understanding the Dynamics of Climate Change and Energy Using Optimization and Econometric Modelling,” showcases four unique contributions addressing the challenges of climate change and energy dynamics utilizing optimizing and econometric modelling approaches: (i) Leapfrogging to Sustainability: Utility-Scale Renewable Energy and Battery Storage Integration – Exposing the Opportunities Through the Lebanese Power System, (ii) Climate Change and Energy Dynamics in the Middle East: Challenges and Solutions, (iii) Greenhouse Gases Emissions and Alternative Energy in the Middle East, and (iv) Quantitative Analysis Methods Used in Modelling Power Systems and Climate Change for Saudi Arabia. Part IV of this book highlights the role of conceptual modelling in a better understanding of climate change and the energy dynamics of the Middle East. In this category, we have two chapters: (i) Transformation Toward Clean Energy in the Middle East: A Multi-Level Perspective and (ii) Global CO₂ Capture and Storage Methods and the New Approach to Reduce Emission for Geothermal Power Plants with High CO₂ Emission: Turkey Case Study.

Finally, Part V of this book overviews the key insights and learning points as well as the future research avenues contained in this book.

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Dhahran, Saudi Arabia
December, 2018

Hassan Qudrat-Ullah
Aymen A. Kayal

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