Preface

The industrial *revolution* in the eighteenth and nineteenth century has had a profound impact on every aspect of human activity. This technology revolution catalyzed a transition from a manual and animal labor based economy towards an energy driven manufacturing economy. This revolution started with the mechanization of the textile industries, the development of iron-making techniques and the increased use of coal for steam engines and furnaces. It has evolved to include the generation of large quantities of electric power, derived primarily from the combustion of coal and other fossil fuels, construction and operation of energy intensive buildings and the construction and utilization of energy-intensive transportation systems on the land, in the sea and in the air. A key impact of this revolution has been dramatically enhanced per capita income, with an associated sixfold growth in population to the current 6.8 billion. Unfortunately, a by-product of this revolution has been the massive generation of greenhouse gases, most importantly, Carbon Dioxide (CO_2). There has been a consistent increase of anthropogenic CO_2 emissions since the beginning of the industrial revolution. Over the period of 2000–2008, there has been an acceleration of CO_2 emissions associated with strong economic growth in China and other Asian countries yielding increased demand for coal-based electricity and petroleum based cars and trucks. In 2008, humanity emitted almost 30 billion tons of CO_2. Emissions of such a magnitude are unsustainable, and if not dramatically reduced, can yield potentially catastrophic climate change. The goal of this book is to consider the challenges for another technology-based *revolution*, this one based on the development and wide scale utilization of low carbon technology.

The scope of the book evolved from papers and presentations by Frank Princiotta, the book editor, who attempted to cover the subject of the climate change mitigation challenge and the availability of key technologies for all the key sectors. It became apparent to him that the subject was too broad and complex, to be adequately covered in a single publication by a single author. When Springer Publications suggested that a book might be the appropriate venue for this important and complex subject, and his agency, the Environmental Protection Agency[1]

[1]Please note: The views expressed in this book are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency. Mention of trade names or commercial products does not constitute Agency endorsement or recommendation for use.

agreed, the book project was initiated. This effort would not have been possible without the enthusiastic & diligent participation by the talented chapter authors from the private, academic & public sectors, willing to devote their valuable time to this project. Note that Chapter 5, Renewable Energy: Status and Prospects, was graciously contributed by the International Energy Agency, from Energy Technology Perspectives (2006). Also, special recognition should be given to Gloria Fuller, USEPA, whose administrative contributions were invaluable during all stages of the book's development.

Chapter 1 examines the greenhouse gas mitigation challenge and summarizes the status of key technologies in all the key energy sectors. It quantifies the reductions in emissions that will be necessary to avoid unacceptable climate change, and the technologies that have the potential to play an important role in mitigating CO_2 emissions. It concludes, that in order to avoid the potentially catastrophic impacts of global warming, the recent 3% CO_2 annual global emission growth rate must be transformed to a 2–3% declining annual rate, as soon as possible. This will require a rapid and radical *revolutionary* transformation of the world's energy production and end use systems. It concludes that the current generation of energy technologies, are not capable of achieving the level of mitigation required. Next generations of renewable, low carbon generation and end use technologies will be needed. Their status and prospects are summarized for each key sector, e.g., power generation.

Subsequent chapters dig in more deeply in describing technological challenges for each of the key energy sectors. They consider the status of key technologies needed to protect the planet from serious climate change impacts. Current and emerging technologies are characterized for their mitigation potential, status of development and potential environmental impacts. The status of technologies relevant to *Power generation, mobile sources, industrial and building sectors are evaluated in detail.* The importance and unique challenges for rapidly developing countries, such as China, India and Mexico are discussed in a separate chapter. Current global research and development efforts for key technologies are discussed. It is concluded that it will be necessary to substantially upgrade and accelerate the current worldwide RDD&D effort on both emerging energy technologies and those enabling technologies needed to improve mitigation effectiveness and economics. A chapter examining the potential environmental characteristics of evolving energy technologies, concludes that It will also be necessary to carefully evaluate the potential environmental characteristics of next generation technologies to avoid unacceptable health and ecological impacts.

Finally, given the monumental technological challenge associated with transforming the world's energy system, geoengineering options, i.e., intentional anthropogenic modifications of the earth's thermal balance, are evaluated, since *if* deemed feasible and successfully deployed, they have the potential to allow more time for the necessary energy system transformation.

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