Chapter 1

Introductory Chapter: Trends in Research on Energy Harvesting Technology

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Additional information is available at the end of the chapter

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1. Introduction

This introductory chapter gives a general view of global energy state, demand, and some of the historical events which have led to the current global energy situation. A brief review of the trends in energy research, the motivation, and direction are then presented.

2. Global energy status and research trends

The world demand for energy is projected to continue due to increased population and associated economic activities in addition to technological developments and changes. Environmental concerns related to traditional energy sources such as fossil fuels and recognition, that this is a diminishing resources globally, has given impetus in the development and search for a number of alternative energy sources. To date, new methods and techniques that allow energy to be harvested mechanically, electronically, magnetically, thermally, biochemically, or through some other means for different purposes and applications have been developed. However, some of the methods and techniques still require refinement and perfection in order to realize their full potentials. For example, despite solar cell technology having matured over the years, its full utilization of photovoltaic (PV) systems has been hampered by high costs related to processing technologies of silicon as well as limited conversion efficiency. In this respect, new materials are being tested to solve the high-cost problem.

Prior to the development of coal in the mid-nineteenth century, nearly all energy used was renewable. Energy that can be collected and naturally replenished on human timescale such as sunlight, wind, rain, tides, waves, and geothermal heat are termed renewable energy [1]. Four important areas—electricity generation, air and water heating/cooling, transportation, and rural (off-grid) energy—are the areas in which renewable energy provides services [2]. There

is no doubt that traditional biomass used for fuel fires is one of the oldest forms of renewable energy. The use of biomass has been traced back to about 790,000 years ago. According to much literature, biomass for fire did not become commonplace until many hundreds of thousands of years later, sometime between 200,000 and 400,000 years ago. Many authors put the second oldest usage of renewable energy as harnessing the wind in order to drive ships over water. The practice can be traced to ships in the Persian Gulf and on the Nile some 7000 years ago. However, historical records show that the primary sources of traditional renewable energy were human labor, animal power, water power, wind, in grain crushing windmills, and firewood, a traditional biomass.

Fears that civilization would run out of fossil fuels started to emerge in the 1860s and 1870s and the need was felt for a better source of energy.

The start of a major global energy crisis of the twentieth century began to unfold as petroleum production in the United States and some other parts of the world peaked in the late 1960s and early 1970s. World oil production in different oil producing countries began a long-term decline after 1979. The problems brought about by these events created a crisis which came to be known as the 1970s energy crisis. Major industrial countries of the world, particularly the United States, Canada, Western Europe, Japan, Australia, and New Zealand, faced substantial petroleum shortages, real and perceived, as well as elevated prices. The year 1973 saw the first worst oil crisis period. This was followed by another energy crisis in 1979, when the Yom Kippur War and the Iranian Revolution triggered interruptions in Middle Eastern oil exports [3–6]. The major industrial centers of the world were forced to contend with escalating issues related to petroleum supply. Western countries started creating reliance on the resources of potentially unfriendly countries in the Middle East and other parts of the world.

What followed after the 1970 oil crisis led to stagnant economic growth in many countries as oil prices rose sharply. Although there were genuine concerns with supply, part of the run-up in prices resulted from the perception of a crisis. The combination of stagnant growth and price inflation during this era led to the coinage of the term *stagflation*.

Both the recessions of the 1970s and adjustments in local economies saw many nations and countries finding ways to use petroleum in a more efficient manner. Strategies were developed and put in place which saw the petroleum prices worldwide return to more sustainable levels in the 1980s [7].

The 1970 oil crisis period was not uniformly negative for all economies. Petroleum-rich countries in the Middle East benefited from increased prices and the slowing production in other areas of the world. Some other countries, such as Norway, Mexico, and Venezuela, benefited as well. Major economic booms were experienced in the United States in places such as Texas and Alaska and some other oil-producing areas due to high oil prices even though most of the rest of the country struggled with poor and stagnant economy. Many of the economic gains, however, did not continue as oil prices stabilized and dropped in the 1980s [8–10].

While all these events were taking place, researchers worldwide intensified their efforts toward the search and development of energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and

geothermal heat for industrial and domestic uses. The sources called renewable energy sources often provide energy in four important areas: electricity generation, air and water heating/cooling, transportation, and rural (off-grid) energy services.

With the emergence of new technologies employing semiconductors requiring low current and the realization that fossil fuels cause climate change and global warming coupled with high oil prices, the search for new and renewable energy and energy sources intensified. There has been increasing different world government support in terms of driving renewable energy legislation, incentives, and commercialization. New government spending, regulations, and policies that were implemented helped the energy industry weather the global financial crisis better than many other sectors. In a report of 2011 by the International Energy Agency, it is projected that solar power generators may produce most of the world's electricity within 50 years, reducing the emissions of greenhouse gases that harm the environment [11]. These sentiments have been echoed by the United Nations Secretary Ban Ki-moon.

As of 2011, small solar PV systems provided electricity to a few million households, and micro-hydro configured into mini-grids served many more. Though rural folks in least developed countries have no electricity, many households now rely on renewable energy such as biogas made in household-scale digesters for lighting and/or cooking. Others rely on new generations of more efficient biomass cook stoves. These efforts are, however, doing very little to address the bigger problem of global warming. On the other hand, the United Nations is highly in support of the renewable energy initiatives and believes that renewable energy has the ability to lift the poorest nations to new levels of prosperity [12].

Apart from the mainstream technologies using large amounts of energy, new gadgets in many households globally presently rely on continuous supply of small amounts of energy. Different forms of renewable energy sources are now in abundant supply for their operations. Mobile phones, portable Compact Disc players, and sport lights have evolved so much that most of them use rechargeable batteries. Though some of these gadgets are working quite well, researchers are still pushing the limits to perfect their energy supplies.

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