Preface

The United States is a rich country when it comes to energy supply. It has an abundance of coal, oil, and natural gas, along with exceptional wind, solar, and hydropower resources. Recently, new technology has driven innovation in nuclear power. We have also seen an increasing focus on local air quality and global climate change.

Today's world is at a turning point. Resources are running low, pollution is increasing, and the climate is changing. Fossil fuels are depleting quickly, and it is necessary to find substitutes that will guarantee wealth and growth. Modern technology is already providing us with alternatives like wind turbines, photovoltaic cells, biomass plants, and more. But these technologies have flaws. Compared to traditional power plants, they produce much smaller amounts of electricity. Even more problematic is the inconsistency of energy production. The global demand for electricity is huge, and growing by approximately 3.6% annually; however, the sun isn't always shining nor is the wind always blowing. For technical reasons, the amount of electricity fed into the power grid must remain on the same level as demanded to prevent blackouts and damage to the grid. This leads to situations where the production is higher than the consumption or vice versa. This is where storage technologies come into play—they are the key element to balance out these flaws.

With the growing importance of renewable energy sources, scientists and engineers are anxious to enhance efficiencies and lower the costs of these technologies. Yet, there seems to be only a handful of technologies available that are efficient and economical. Storing energy isn't an easy task, as most of us know. Our smartphone battery only lasts for about a day, and laptops last only a few hours. The range for electric cars is limited to little more than a hundred kilometers. These are only examples for comparatively small devices. Now imagine the problem of storing energy at the level of hundreds to thousands of wind turbines and photovoltaic cells is much more complex.

Many new products and services that reduce emissions for new and existing power plants have been created. One of our most exciting products is the combined-cycle gas turbine power plant, which uses jet engine technology combined with steam turbine technology to rotate generators to produce electricity. A similar innovative technological approach has been suggested by many scientists and engineers in the field of nuclear energy, using the new generation of nuclear power plant (NPP) that is known as Generation IV. These innovative approaches allow the combination of turbines in single or multiple shaft installation to provide the most cost-effective way to generate electricity from either natural gas or nuclear energy. The turbines used in this manner will provide fuel efficiency of greater than 63% and produce approximately 65% less carbon dioxide than the coal-fired power plants that they replace.

The Conergy hybrid energy storage system (CHESS) provides the key to transitioning large-scale sites to integrated solar energy supply and solar energy storage. CHESS is designed to provide on-demand, stable power supply for on-grid, fringe-of-grid, and remote off-grid sites. CHESS is a practical, renewable energy solution, engineered to lower operating costs and insulate businesses against future volatility in energy and fuel prices.

It is a modular and expandable technology that allows for flexibility and growth demand with full remote control and monitoring functionality. The technology is not only durable but easily transportable, making it ideal for remote locations.

The energy storage system (ESS) in a conventional, stand-alone Renewable Energy Power System (REPS) usually has a short lifespan due to irregular output of renewable energy sources. In certain systems, the ESS is oversized to reduce the stress level and to meet the intermittent peak power demand. A hybrid energy storage system (HESS) is a better solution in terms of durability, practicality, and cost-effectiveness for the overall system implementation. The structure and common issues of stand-alone REPS with ESS are discussed in this paper. This paper presents different structures of stand-alone REPS with HESS such as passive, semi-active, and active HESS. As there are a variety of energy storage technologies available in the market, decision matrixes are introduced in this paper to evaluate the technical and economic characteristics of the energy storage technologies. A detailed review of the state-of-the-art control strategies such as classical control strategies and intelligent control strategies for REPS with HESS is highlighted. The future trends for REPS with HESS combination and control strategies are also discussed.

This book also describes, energy storage at various levels. Energy storage technology has great potential to improve electric power grids, enable growth in renewable electricity generation, and provide alternatives to oil-derived fuels in the nation's transportation sector. In the electric power system, the promise of this technology lies in its potential to increase grid efficiency and reliability—optimizing power flows and supporting variable power supplies from wind and solar generation. In transportation, vehicles powered by batteries or other electric technologies have the potential to displace vehicles burning gasoline and diesel fuel, reducing associated emissions and demand for oil.

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