ELECTRIC POWER INDUSTRY

IN NONTECHNICAL LANGUAGE
2ND EDITION

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Contents

Preface

To look at the electric utility industry as a static estate is undeniably a mistake. The many developments going on inside the industry foretell the story of an ever-changing, ever-evolving industry. From what is taking place within individual electric utilities to what is transpiring on state and federal levels, we can learn a lot about where the electric power industry is heading.

What is going on is a plethora of activity germane to how electric utilities operate and will be required to operate—probably far more than what can be covered in this book. The activity swarms around governance on a vast array of issues, such as environmental protection, technology issues and advances, reliability and security enhancements, and generally on the processes of generation and transmission.

As was the case with the 1st edition of this book, *Electric Power Industry in Nontechnical Language,* this 2nd edition will seek to present timely, and oftentimes thought-provoking information about the state of the industry. This book is, simply put, the layman's handbook. The text you are about to read is specifically written for all those non-technical individuals who are wanting to learn the fundamentals of one of the largest and most fascinating industries in the world.

My goal with this book was to provide a somewhat different "read" than the first edition. In the pages of the 2nd edition, readers will be able to get a clearer picture of where the electric utility industry is headed in the future. Thus, the primary focus of this book is more one of how electric utilities are functioning and are expected to function within the current air of restructuring activities. My hope is that readers will enjoy the look back at the early years of the industry and its colorful beginning and evolvement, but will, like me, be most attuned to how electric utilities are going to handle their businesses in the future.

In the following pages, readers will learn everything from the very early beginnings of the electric utility industry to the more complicated realities surrounding the industry today. With you in mind, I have developed the following three parts that may be read consecutively, or if preferred, read out of the order in which they are presented, since each "section" is a concept within itself.

Part I explains the core technical competencies of the electric utility industry. This section touches on generation, efficiencies, fuel, and new technologies affecting such. The reader will also learn about transmission and distribution and, most importantly, how they work together with generation to produce and deliver power to consumers.

Part II examines both the formation and reformation of the electric utility industry. From early regulation to the ongoing movement of industry reregulation, this part will help get readers up to speed on how regulatory strictures began in the formative years of the electric utility industry, how regulation has evolved, and currently how the industry is practically reinventing itself amidst a climate of restructuring.

Part III discusses emerging issues and trends. Readers will find this section to be a wealth of information on learning about where the electric utility industry is headed in the next few years. Of great importance is the passage of the Energy Policy Act of 2005. Here, readers will find a concise overview of one of the most comprehensive pieces of legislation enacted since 1992. Also covered for general understanding are the issues of transmission, technology, and how they tie into reliability of the nation's power grid. Readers will also be offered a bird's eye view on the status of security and system stability and the increasing role of broadband over power lines. In addition, readers will get an overview of environmental standards and issues facing electric utilities and how mergers and acquisitions are affecting the industry as a business enterprise.

For those wanting additional resources, a glossary, acronyms, and an industry contacts directory appear at the end of this book as an appendices.

As will be learned through reading this book, there is much change stirring in the electric utility industry. Many of the brewing changes in the industry are either being postulated or enacted to help strengthen the industry for the future, both in terms of infrastructure for reliability and security sake, as well as in terms of consumer protections for an affordable, stable flow of electricity.

It is my hope that readers can, through the concise and easy-to-read format of this book, learn more about the ever-changing powerful electric utility industry. I hope you enjoy reading through the pages of this book as much as I did creating it for you.

Denise Warkentin-Glenn

1 Power Generation

The electric power industry is comprised of many functions. From the generation of electricity flows the transmission and hence the distribution of power to homes, businesses, and other end users. It is, therefore, important to begin at the beginning—generation—particularly because this process happens to be one of the most capital-intensive functions of electric power producers.

To understand the generation of power, it is important to look at the process, the measurement, and the resources required. In general terms, ***generation*** has a two-fold meaning. First, it may be defined as the process of producing electric energy by transforming other forms of energy. Second, generation can also refer to the amount of electric energy produced for end-user consumption. Expressed in ***kilowatt-hours*** (kWh), or the electric energy produced in 1 hour (hr) by 1 ***kilowatt*** (kW) of electric capacity, generation is the amount individual consumers see on their electric bills.

Electricity may be defined as a class of physical phenomena that results from the existence of charge and from the interaction of charges. When a charge is stationary, it produces forces on objects in regions where it is present, and when it is in motion, the charge produces magnetic effects. ***Electric and magnetic fields*** (EMFs) are caused by the relative position and movement of positively and negatively charged particles of matter. Particles associated with electrical effects are classed as neutral, positive, or negative. However, electricity is concerned with the positively charged particles, such as ***protons***, that repel one another. Also of concern are the negatively charged particles, such as ***electrons***, which also repel one another. Later in this chapter, the generation process and its magnetic properties, among other aspects of generation, are discussed in detail. However, in summary of this brief discussion, it will suffice to simply state that like charges repel and unlike charges attract.

The principle behind how gas turbines work is similar to a jet engine. Gas turbine generation is often used for peak, emergency, and reserve power production because of their quick start-up time. The downside is that gas turbines tend to be less efficient than their steam turbine counterparts. Generally, gas turbines are 100 MW or less. However, some are more, and they may be installed in a wide range of locations.

Gas turbines generally require smaller capital investments than coal or nuclear and can be designed to generate small or large amounts of power. The main advantage of gas turbines is the ability to be turned on and off within minutes, supplying power during peak demand. Large turbines may produce hundreds of megawatts.

Gas turbines may be described thermodynamically by the Brayton cycle (see fig. 1–6). Air is compressed isentropically, combustion occurs at constant pressure, and expansion over the turbine occurs isentropically back to the starting pressure.

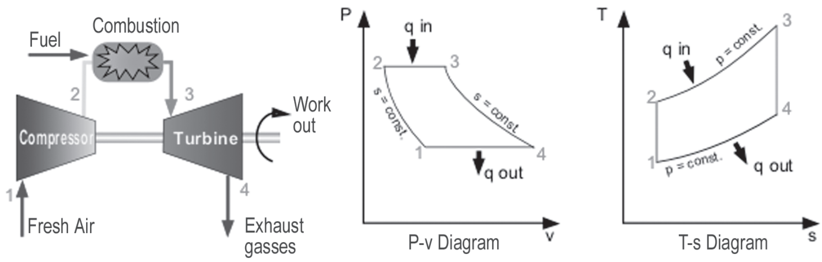

Fig. 1–6. Brayton cycle

As with all cyclic heat engines, higher combustion temperature means greater efficiency. The limiting factor is the ability of the steel, ceramic, or other materials that make up the engine to withstand heat and pressure. Considerable engineering goes into keeping the turbine parts cool.

Most turbines also try to recover exhaust heat to the compressed air, prior to combustion. Combined-cycle designs pass waste heat to steam turbine systems. Combined heat and power or cogeneration uses waste heat for hot water production. Both combined cycle and cogeneration are discussed later in this chapter.

Opponents claim the lack of a containment building is one of the biggest drawbacks of the PBMR design. Not having a containment building does save money; however, some in the industry contend this makes the technology unsafe. Proponents claim the containment building is not in the PBMR design plan because it would hinder the design's passive cooling feature of the reactor core through natural convection.

Other possible design features, which may increase health and safety risks, include the lack of an emergency core cooling system, and a reduced one-half mile emergency planning zone. In comparison, the light water reactor design has a 10-mile emergency planning zone. The Nuclear Information and Resource Service estimates that a single 110-MW PBMR would produce 2.5 million irradiated fuel elements during a 40-year operational cycle. Naysayers of the PBMR technology say this fact, as well as other issues, would make radioactive contamination uncertainties surrounding the technology persist long after a PBMR has closed.

Clean coal technologies

Clean coal technologies (CCT) are the products of research and development conducted over the past 20 years. The results are more than 20 new, lower-cost, more efficient, and environmentally compatible technologies for electric utilities, steel mills, cement plants, and other industries. Several of these technologies are detailed a little later in this chapter.

According to the Coalition for Affordable and Reliable Energy (CARE), CCT helped make it possible for U.S. utilities to meet more stringent Clean Air Act (CAA) requirements, while continuing to utilize America's most plentiful domestic energy resource.

Originally, the CCT program focused on commercializing processes to help reduce sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions. Begun in 1986, the original program was aimed at demonstrating more efficient and environmentally friendly alternatives to traditional pulverized coal boilers.

Newer programs in CCT are essential for building on the progress of the original CCT program, according to CARE. New programs are also vital in the process of finding solutions for reducing trace emissions of mercury, reducing or eliminating carbon dioxide (CO_2) emissions, and increasing fuel efficiencies. One such program is the Clean Coal Power Initiative (CCPI), an industry/government partnership to implement the president's National Energy Policy recommendations to increase CCT investment.

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Power quality is clearly a major issue electric power utilities face when dealing with their customers. Thus the next several pages of this book will be devoted to types of transmission lines, distribution system facilities, and the link that ties them all together.

Transmission and Distribution Components

Transmission lines carry electric energy from one point to another in an electric power system. They can, as briefly discussed earlier, carry AC or direct current (DC), or a combination of both. In addition, electric current may be carried by either overhead or underground lines. Figure 2–3 shows overhead power transmission lines crossing the San Fernando Valley, while figure 2–4 illustrates underground power lines.

Fig. 2–3. Transmission lines crossing the San Fernando Valley

consumed, regardless of the time in which it was used. Real-time pricing, by its operational definition, means passing fluctuations in the true cost of electricity on to customers, so they have the pricing information they will need to adjust their electricity usage.

In addition, this resource will mean new communication and control technologies must be employed. Electricity system operators would require more precise information about demand fluctuations. Operational control systems that can respond to load reductions on par with power generation will need to be given high priority should electrical load become a reliability resource.

And, finally, some electrical equipment, such as induction motors and various other power electronics devices, may create some challenges for reliable grid operation. These types of equipment have tremendous impact on the grid. For price- or emergency-responsive loads, this equipment may need to be redesigned or operated in such a way to reduce its effects on the grid.

The challenge ahead

According to the Electric Power Research Institute (EPRI), the energy industry continues in its pattern of globalizaion, disaggregation, deregulation, and restructuring. As it does so, traditional and emerging transmission and distribution companies are faced with critical decisions that will impact their survival.

Open access markets, the saturation of the exisiting transmission grid, and the emergence of distributed resource technologies are forcing power delivery entitites to deal with significant and often unpredictable complexity. The greatest challenge facing transmission and distribution companies, EPRI contends, centers on enhancing system reliability and performance while maximizing the utilization of power delivery system assets.

Providing the major backbones of the energy industry, transmission companies are subject to the same uncertainties and opportunities as the industry at large. At the federal level, for instance, the three major interconnected grids in the United States have been deregulated to provide open and competitive access. The traditional and emerging owners and operators of these networks are being confronted with power flows, patterns, and magnitudes not contemplated in the original planning, design, and construction of transmission facilities.

What Steinmetz Knew and Charged for It

The following is an anecdote, as told by Charles M. Vest, President of the Massachusetts Institute of Technology, during commencement on June 4, 1999:

In the early years of this century, Steinmetz was brought to General Electric's facilities in Schenectady, New York. GE had encountered a performance problem with one of their huge electrical generators and had been absolutely unable to correct it. Steinmetz, a genius in his understanding of electromagnetic phenomena, was brought in as a consultant—not a very common occurrence in those days, as it would be now. Steinmetz also found the problem difficult to diagnose, but for some days he closeted himself with the generator, its engineering drawings, paper and pencil. At the end of this period, he emerged, confident that he knew how to correct the problem. After he departed, GE's engineers found a large 'X' marked with chalk on the side of the generator casing. There also was a note instructing them to cut the casing open at that location and remove so many turns of wire from the stator. The generator would then function properly. And indeed it did. Steinmetz was asked what his fee would be. Having no idea in the world what was appropriate, he replied with the absolutely unheard of answer that his fee was $1,000. Stunned, the GE bureaucracy then required him to submit a formally itemized invoice. They soon received it. It included two items: 1. Marking chalk 'X' on the side of generator: $1, and 2. Knowing where to mark chalk 'X': $999."

In 1889, Steinmetz established a small laboratory at a factory in Yonkers, New York, under the tutelage of his employer, Rudolph Eickemeyer. Eickemeyer had invented hat-making machinery and wanted to expand into electrical motors and generators, a brand new field at that time.

Steinmetz' experiments on power losses in the magnetic materials used in electrical machinery led to his first important work, the law of hysteresis. This law deals with the power loss that occurs in all electrical devices when magnetic action is converted to unusable heat. Until that time, the power losses in motors, generators, transformers, and other electrically powered machines could be known only after they were built.