Educating Engineers To Make Technological Contributions In the New Competitive Electrical Power Market

Fred Haag
New York State Department of Public Service

The free-market economic system is generally recognized as a powerful means to improve human conditions. This system, which is based on having fair competition, provides the incentives to produce more goods and services for consumers. In addition, the need for a stable and transparent legal framework to support fair competition has the added benefit of aiding the development of democratic institutions.

An understanding of the free market system requires an understanding of some basic economic principles. There is, however, a disconnect between economics as it is taught to engineers, commonly called "engineering economics," and the principles from mainstream economics that are relevant to the mechanisms that make free markets work. This paper illustrates the modifications that are needed by using electric energy conversion and conservation as an example.

After a century of regulation as a monopoly, the nation's electric power supply systems are undergoing quantum-leap changes. The generation and other contestable functions are being transformed, as were the airlines and long-distant communications before, to enter the modern era of competitive-driven market-oriented enterprises. The potential benefits are enormous: lower electric bills, greater choice of supplier, and the promise of innovation. This paper discusses where engineering education should refocus in order to prepare energy conversion and conservation engineers for the opportunities that will be created by the new paradigm.

Selected aspects of the current treatment of engineering economics will require different emphasis to prepare engineers for work in the field of energy conversion and conservation. For example, a market-focused engineer should become familiar with some basic supply and demand concepts from micro economics, have an appreciation for the issues associated with market power, and possess a customer-oriented focus. In addition, work in the competitive electrical power market will require at least an acquaintance with the total variety of energy conversion and conservation alternatives that are, and will become available, for example, small self-generation units and novel conservation techniques. Learning outcomes are described that will be particularly important components in the skill-set of educated energy conversion and conservation engineers.

Background

Over the last 20 years, the airline, bus, trucking, railroad, bus, natural gas and communications industries have been undergoing varying degrees of economic deregulation and restructuring. Now, the last remaining large regulated monopoly industry - the electricity industry - is entering the world of consumer-driven market forces. The United States Department of Energy, in U.S. DOE News dated April 15, 1999, estimated potential annual savings to consumers of $20 billion.

Over 23 states, comprising over one-half the nation's population are proceeding with electric deregulation efforts. Also, there are at least six different proposals pending in the U.S. Congress to restructure and deregulate the electric industry. Because of the coming changes, future engineers entering the fields of energy conversion and conservation will enter a changed commercial environment.

Energy Conversion and Conservation Engineering

The laws of thermodynamics and electron flow, of course, remain the same under both regulation and deregulation. The technological applications, however, have expanded considerably from the traditional Rankine-based power cycles used in central power stations. They will include fuel cells, micro-turbines, wind machines, solar cells, co-generation, distributed generation, smart buildings, interruptible loads, load management - and who knows what novel idea some clever engineer will create tomorrow?

There are good reasons why the electric industry is the last to be deregulated. Under airline deregulation, for example, less profitable routes were simply abandoned. The regulation of electric utilities and the issuing of an exclusive franchises, however, has been based on an obligation of the incumbent utility to supply all customers who asked to receive service. An additional complexity for the electric industry is that all market participants are connected to the same grid on which power flows according to complex physical laws

For many people, especially those on medical life-support systems, having electric service is a matter of life or death. Electrical and mechanical engineers will be called upon to ensure the continued reliability of the electric grid, in short, to make sure that the lights go on after a flip of the switch. Maintaining reliability will be a challenge. Portions of the system, like generation, will be unregulated and other portions, such as wires and poles, will still be regulated. Under restructuring and deregulation, the control of power flow and system security will rely on power system engineers who will have to balance the needs of commercial profit-seeking interests and the needs of customers for a reliable system.

Traditional Engineering Economics

The earliest book on engineering economics is attributed to Wellington.[1] Wellington, while working for the Mexican National Railway, was concerned with cost-based comparisons of alternative routes for new railway rights-of-way. Subsequent engineering economics books continued his emphasis on comparing two or more alternatives with the objective of selecting the one with the discounted least-cost.

Today, basic engineering economics texts typically begin by presenting the fundamental discounting formulas involving present and future worth, annual cash flows, rate-of-return, and interest rates. These relationships are then applied to choosing from among two or more alternatives. Specific topics then illustrate extensions such as: comparison by benefit/cost, manipulation of depreciation formulas, effects of income tax, incremental rate-of-return, effects of inflation, and an introduction to risk and probabilistic analysis. Many of these topics will require, to some degree, a different emphasis for application to a market economy.

Depreciation and Taxes

Engineering economics courses typically describe a menagerie of depreciation formulas that the federal government is, or was, allowing to be used for tax calculation purposes. For example, straight-line, sum-of-years digits, and declining-balance methods are applied to determine after-tax rates of return.

Attempting to present the numerous and latest Internal Revenue Service algorithms for depreciation should be de-emphasized. Under market conditions, economic depreciation is as important as the depreciation method that is allowed by tax laws. Economic depreciation is based on the difference in market values at two different times, and is strongly influence by innovation..

The greatest benefits expected from deregulation will likely come from unforeseen innovations. The surprises will be pleasant for society at large, but upsetting to those who lack flexibility. Schumpeter called this process "Creative Destruction," and stated that it is the essential fact about capitalism.[2] Engineering is a major force that drives Schumpeter's Creative Destruction and engineers should at least be aware of the different aspects of depreciation..

Market Power

Market power is the ability of a firm to set prices above those that would exist under pure competition. Free markets are compromised when a firm has market power - there are unjustified profits - and equally important innovation is stifled. Market power comes in two basic varieties, vertical and horizontal. Vertical market power, for an electric utility, is when the utility controls different steps in the production and delivery process for electricity and is able to use its ability at one step to gain an advantage over its competition at a different step of the process.. The traditional regulated electric utilities owned generating stations, long-distance transmission lines, local distribution lines and poles, and direct customer functions such as meter-reading and billing. Through the control of the ownership of the transmission and distribution system, a utility could favor its own generation assets and economic regulation was required to prevent undesirable monopolistic outcomes.

Horizontal market power, for example, is when one or a few owners control a high percentage of the electric generating capability and are able to use that control to raise prices above competitive levels. System engineers will be needed to assess the degree of market power that can be exerted by a utility. The Federal Energy Regulatory Commission (FERC) uses a simple screening tool for horizontal market power called the Hirschmann-Hierfandahl Index, or

HHI. The HHI is based on market shares of all the sellers in a given market. It is equal to the sum of the squares of the percentages of the market shares of each of the sellers. For example, if 5 sellers each have a 20 percent share, the HHI is the sum of 5 times 20 squared, or 2,000. And if 100 sellers each have a one percent share, HHI = 100. That is, a high HHI indicates a high potential for market power. This is a very crude screening method. By use of computer simulations, system engineers can improve considerably on heuristic rule of thumb techniques such as the HHI.

Contestable Markets

A contestable market is when new entry by potential competitors is relatively easy and inexpensive. Even when a contestable market is dominated by only a few firms, if those firms become inefficient, or start to earn above market profits, new entrants will be a threat. Consequently, to prevent new entrants, incumbent firms in a contestable market are forced to act as though they are in a purely competitive market.

The process of sorting out those portions of the total electric supply functions to make them contestable is called "unbundling." Unbundling the contestable components of the total bill, such as the metering and billing functions, from those in currently bundled bills requires an understanding of cost causation for which cost engineers are needed. The concepts that are involved are: marginal cost, or the cost of the last unit produced; and embedded cost, or the average cost. Related concepts are short-run marginal costs and long-run marginal costs, where long run implies the inclusion of significant capital cost expenditures.

Self-Generation Decisions

There are two major schools of thought on the future nature of electric generation. Some believe that because of the economy of scale, the future will remain dominated by large central generation stations, such as large gas-fired, combined-cycle units. Others believe that small distributed generation, such as fuel cells, roof-mounted solar panels and micro turbines will begin to supplant the central station.

Attributes that will determine future developments are: the importance of the economy of scale; the required degree of reliability; the need for, and cost of redundancy; the interconnection costs; and the cost of back-up power. This is the classic defender/replacement analysis and engineers will have a large role in evaluating the alternatives and arriving at appropriate solutions.

Conclusion

The topics now taught as engineering economics should be modified by introducing concepts from mainstream economics so that engineers are better prepared to work in free market commercial environments.

Acknowledgment and Disclaimer

The author owes a large debt to numerous colleagues at the New York State Department of Public Service who helped him learn the concepts discussed in this paper; however, the opinions expressed are those of the author alone and do not necessarily reflect the views of either the New York State Public Service Commission or the New York State Department of Public Service.

Bibliography

[1] Wellington, A. M., *The Economic Theory of Railway Location*, 2nd Edition, John Wiley & Sons, 1887, an abbreviated 1st Edition was published in 1877.
[2] Schumpeter, Joseph A., *Capitalism, Socialism and Democracy*, Harper Torchbooks, 3rd Edition, 1950, page 83.

FRED HAAG
Fred Haag is an engineer in the New York State Department of Public Service.