LESSONS FROM ELECTRIC UTILITY MODELING

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Summary

This article describes how system dynamics practitioners put their knowledge to work in the electric utility industry. Electric power is a massive industry with major impacts on the environment. It is also a capital intensive industry with a rich tradition of long range planning. System dynamics has been applied extensively on utility issues, and there is an impressive record of implementation. This article interprets the large body of work to reveal how practitioners contributed a unique perspective on the utility industry. Their contribution stems from an ability to "see the feedback" in the system.

1. Background on Electric Power in the United States

Figure 1 shows a historical time line starting with the birth of the industry in 1882 and concluding with the growing interest in deregulation in the 1990s. This article provides a short review culminating with the shift to small scale in the 1980s.

The power industry was "born" with great publicity at 3 p.m. on September 4, 1882. This is the moment when the "jumbo generator" at the Pearl St. Station in New York City began to spin. The electricity was transmitted to the Wall Street office of JP Morgan and the editorial room of the *New York Times*. Within the decade, the industry was embroiled in a debate over electric transmission. The debate is sometimes called the AC/DC debate. In technical terms it was a debate over AC (alternating current) transmission versus DC (direct current) transmission. In personal terms, it was a debate between the giants of the industry. George Westinghouse favored AC; Thomas Edison favored DC. And in organizational terms, it was a debate over the fundamental shape of the industry. DC transmission relied on low voltage power lines running short distances from the generating station to the consumer. AC transmission required transformers to “step up” the voltage for transmission over longer distance lines. The DC proponents envisioned an industry with many, small power generators which could be mass-produced and sold at a substantial profit to factories and office buildings. The AC proponents saw an industry with larger, more efficient power plants interconnected with a large number of customers. Bigger power stations could be designed to convert fuel into electricity in a more efficient manner, especially if they served a larger number of customers (with diversity in their hour-by-hour demands for power). The vision of larger power stations won out, and Edison’s role in the power industry began to fade.

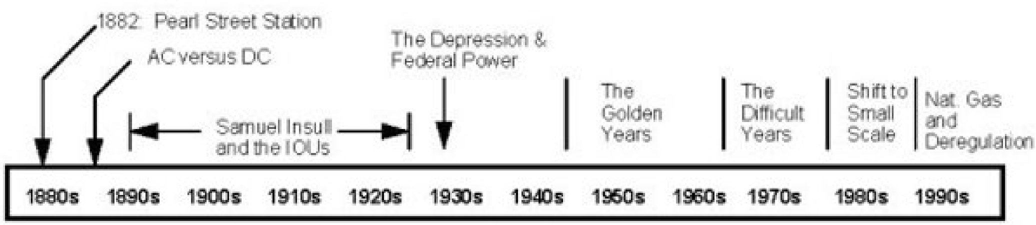

Figure 1. History of electric power in the USA.

The most important individual to shape the American power industry was Samuel Insull, an Englishmen who immigrated to America in 1881 to serve as Edison’s personal secretary. Insull struck out on his own in 1892. He took the controls of the Chicago Electric Company convinced that the path to large profits was through the sale of electricity (not necessarily the sale of electrical equipment). By 1907, Insull was a millionaire and the ruler of Chicago’s electricity monopoly. By 1911, his engineers had created the world’s largest power station; and by 1912, his “empire” encompassed 400 communities throughout 13 states.

One threat to Insull’s expansion was public power. Some towns and cities believed that electric power is a basic, public service. They took over the electric power facilities and financed their subsequent expansion through the sale of public bonds. Fearing the encroachment of public power, Insull devised a plan to give the public limited control over private power. Each state would form a public utility commission to be staffed by professionals with knowledge of the industry. He argued that privately owned utility companies should continue to enjoy monopoly privilege in their service territories so that the company engineers could pursue economies of scale. Abuses of monopoly privilege would be controlled by the state commissions. Electricity prices were to be fixed by the state commissions to allow the power company to recover its costs and to earn a reasonable profit. Utilities, for their part, would commit themselves to building the power stations needed to serve the customers within their service territory.

1.1. The Golden Years

Insull’s plan allowed privately owned power companies to grow and flourish. The private companies became known as IOUs or investor-owned utilities. By the 1990s, the IOUs accounted for roughly 80% of electric power in the United States, a business with close to $1 trillion in assets. Their biggest challenge was to build the new power plants needed in a rapidly growing industry. The demand for electric energy grew at around 7%/year, doubling the need for electricity every decade. To keep pace, the IOUs turned to larger and larger power stations. Company engineers were successful in designing bigger and better power stations during the "golden years" of the 1940s, 1950s and 1960s. Each new wave of power stations allowed the retirement of older, less efficient power stations. Regulatory commissions found themselves in an enviable position because electric rates were always sufficient. That is, the current rates, multiplied by current electricity sales, always generated the necessary revenues to pay this year's bills and finance next year's construction. Electric rates remained relatively constant (in nominal dollars) over many decades as company engineers succeeded with bigger and better power plants. By the end of the golden years, power plants were coming on line at the immense size of 3,000 MW shown in Figure 2.

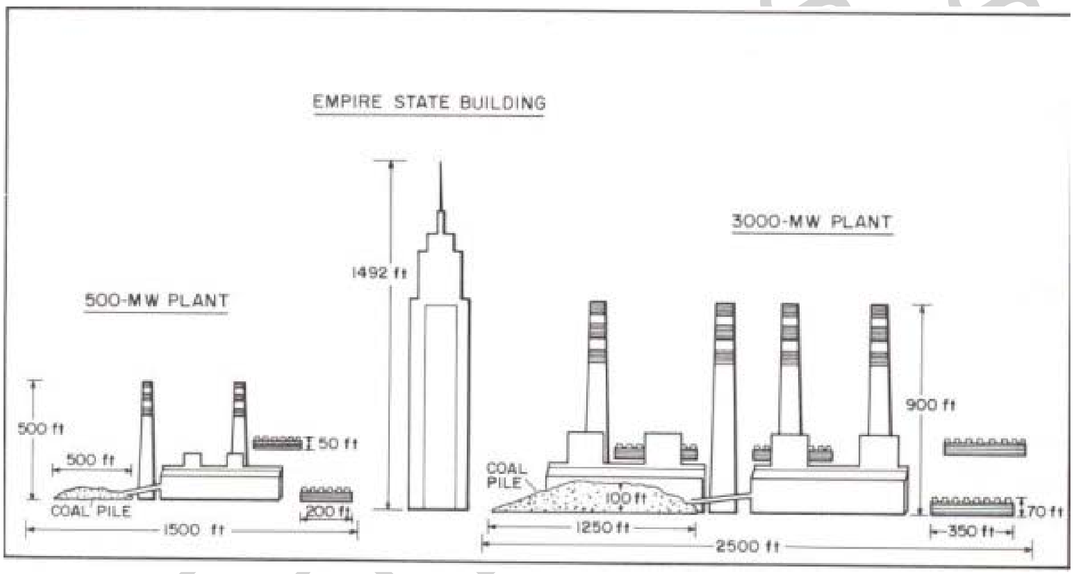

Figure 2. Drawing of large and small power plants.

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Biographical Sketch

Andrew Ford was born in 1944 in Lone Pine, California. His research deals with energy and environmental problems in the western United States. He is especially interested in the use of simulation modeling for policy analysis in the electric power industry. Dr. Ford completed his doctoral studies in the Program on Public Policy and Technology at Dartmouth College in 1975. He worked in the Energy Policy Group at the Los Alamos National Laboratory and in the Systems Management Department at the University of Southern California. His research on electric power and conservation was honored with the 1996 Jay W. Forrester Award.

Dr. Ford is Professor of Environmental Science at Washington State University where he teaches system dynamics for students interested in systems and the environment. His text on Modeling the Environment was published by Island Press in 1999.