Appendix 8B: Development and Utilization of Gas Turbines

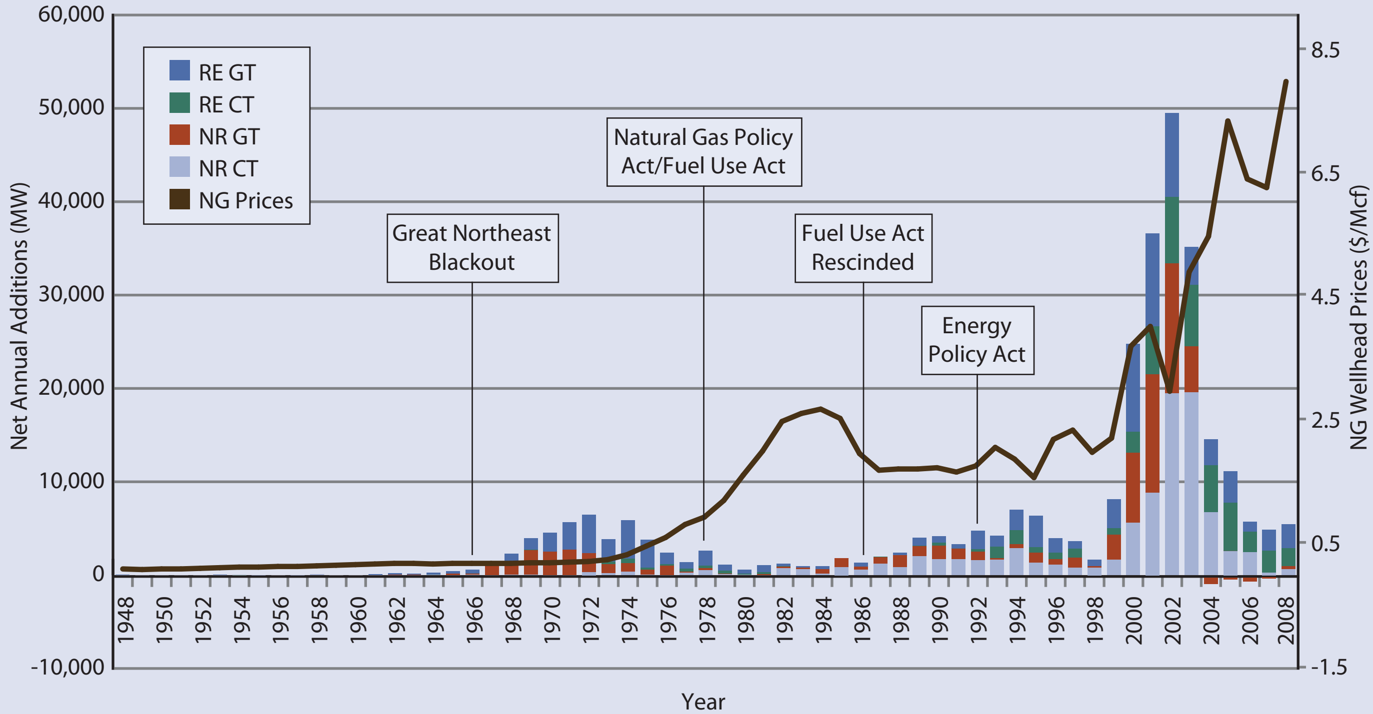
Development of unconventional natural gas supply and the application of gas turbines for electricity generation are arguably the two most significant natural gas-related energy technology developments of the last many decades. However, unlike unconventional natural gas, the federal RD&D role in the development and deployment of gas turbines for electricity generation has had limited impact. Rather, the widespread adoption and utilization of gas turbines can be mainly attributed to the interplay of the following four factors: 1) the incremental technological advancements that were a result of military and industry RD&D efforts, 2) natural gas availability, 3) environmental concerns and 4) the restructuring of the electricity sector.

Figure 8B.1 shows the introduction of gas turbines into the U.S. power generation sector. Clearly, government policy had a major impact on deployment of natural gas combined cycle (NGCC) technology. Repeal of the Fuel Use Act and restructuring of the electricity generation sector stimulated by the 1992 Energy Policy Act, together with relatively low natural gas prices in the 1980s and 1990s, eventually led to a major deployment — until natural gas prices began a major climb about a decade ago. In particular, the electricity deregulation policy environment combined with low gas prices, Clean Air Act restrictions on SOx and particulate emissions, high efficiency, low capital cost and short construction times made NGCC units the overwhelmingly favored option for Independent Power Producers (IPPs). Annual deployment of gas turbines reached nearly 50,000 MW early in the last decade. Many of these investments were stranded when natural gas prices rose dramatically. A legacy of this is the underutilized NGCC fleet that was discussed in Chapter 4.

Technology Development

As highlighted by Unger and Herzog[1], early technological advancements in gas turbines can be traced to government spending on defense programs that began during World War II and focused on developing and enhancing turbojets. The U.S. government spent upwards of $13 billion between 1940 and 1999 on jet engine development and continues to spend millions per year on RD&D efforts through companies such as GE and Pratt & Whitney.[2] The military RD&D program led to the development of highly efficient gas turbines mainly through advancements in heat-resistant blade materials and cooling technologies. The technological advancements achieved by the military program created a "supermarket of technology" that allowed the adoption of these technologies into industrial turbines.[3]

Figure 8B.1 Annual Gas Turbine Net Additions and U.S. Natural Gas Prices. RE: regulated utility; NR: Not-regulated utility; GT: standalone combustion turbines (peaker unit); CT: the combustion turbine component of combined cycle units (topping cycle).



Source: EIA Capacity Databases

United States government efforts directed specifically at gas turbines for power generation were limited to the small DOE High Temperature Turbine Technology (HTTT) program in the late 1970s, focused on coal-derived fuels, and the more recent Advanced Turbine Systems (ATS) program, launched in 1992. The ATS program was a DOE-industry cost-shared partnership aimed at higher efficiency. The program goal was to significantly increase turbine firing temperatures, enabling combined cycle efficiencies of 60% or more, and simultaneously lowering NOx emission levels. The goals were achieved in less than a decade through development of a suite of innovative materials, coatings, closed loop cooling and other technologies. Firing temperatures of 2,600° F and NOx emissions less than 10 parts per million were achieved without post-combustion cleanup. The results of the ATS program have been incorporated in the commercial offerings of the industry partners: the GE H-System Turbine and the Siemens Westinghouse Advanced W501G Turbine. The total cost of the program was approximately $470 million (1999 dollars) with the government accounting for approximately two-thirds.[4]

NOTES

[1]D. Unger and H. Herzog, Comparative Study on Energy R&D Performance: Gas Turbine Case Study. MIT Energy Laboratory report EL 98-003 (1998).

[2]Ibid., p.19.

[3]Ibid., p. 19.

[4]Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000. National Academy Press (2001), ISBN 0-309-07448-7.