American Energy Innovation Council

CASE STUDIES ON THE GOVERNMENT'S ROLE IN ENERGY TECHNOLOGY INNOVATION

Aeroderivative Gas Turbines

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EXECUTIVE SUMMARY

For more than a half-century, gas turbine engines pioneered for military jet fighters have hung under the wings of commercial airliners. For nearly as long, these aircraft engines have been adapted to drive electricity generators, pump oil and gas, and power ships. These aeroderivative gas turbines are a part of the larger industrial gas turbine market, valued at $15.6 billion worldwide in 2010. Gas turbines provide over 20% of electricity generation in the U.S., are essential for oil and gas production, and power navy ships around the world; aeroderivative turbines in particular are increasingly utilized for electric grid stability. Meanwhile, aircraft engines from which these turbines derive are responsible for the commercial and defense aviation engine market in the U.S., valued at over $26 billion.

The development of aeroderivative gas turbines is inseparable from the development of aircraft engines, which was led by the military and bolstered by the rise of commercial aviation. Industry-government partnerships to advance aircraft engine technology drove the evolution of aeroderivative gas turbines through several mechanisms: competitive military procurement, military R&D management, technology testing and validation, and public-private partnerships.

EXECUTIVE SUMMARY (Continued)

Competitive military procurement: In the 1940s and 1950s, competition was fierce and the military bought tens of thousands of gas turbine engines. Vigorous military demand allowed firms to explore a variety of initial designs, and development accelerated. Key innovations freed engineers to create and refine the high-pressure compressors needed for aircraft engines, which distinguish aeroderivative gas turbines from most other industrial gas turbines. The efforts of the 1940s and 1950s resulted in innovative engines defining the overall design still used today.

Military RD&D management: Gas turbine engines posed a complicated engineering challenge, and procurement efforts alone were not able to sustain the innovation needed to meet increasing military demands. In the 1960s, the U.S. Air Force led research and demonstration efforts focused on improving the core components of gas turbine engines. These efforts significantly assisted the launch of commercial aircraft engine lines that would become the parent engines for the most widely used aeroderivative gas turbines. NASA also worked with the Air Force to advance the engineering science used to design compressor blades and cooling regimes for turbine blades.

Technology testing and validation: The U.S. Navy helped to ruggedize aeroderivative gas turbines through materials engineering research and testing. Although some operating conditions, like high salinity, are unique to marine applications, the materials engineering knowledge cultivated through these efforts was valuable more generally for further adapting aircraft engines for industrial service in harsh environments. As a result, aeroderivative turbines were proven for service using non-aviation fuels, further demonstrating their reliability in various industrial applications like oil and gas production and electricity generation.

Public-private partnerships: Beginning in 1991, the GUIde consortium helped overcome certain damaging vibration issues afflicting military aircraft engines and threatening industrial gas turbines. The GUIde consortium succeeded because it addressed an industry-wide problem that individual firms otherwise lacked the means to resolve. University researchers received from industry the data and guidance needed to develop practical models for mitigating vibration phenomena earlier in the engine design process. The government had a key role in organizing a cooperative framework and facilitating the codification and diffusion of technical knowledge.

With the rise of commercial aviation and millions of flight hours thus accumulated, engine builders learned to improve manufacturing and maintenance procedures that further strengthened aeroderivative gas turbine performance. By the late 1980s, a confluence of factors had lowered natural gas prices, and aeroderivative gas turbines were being used year round in cogeneration configurations, providing simultaneously electricity and building heat at airports and other large facilities. Today, the rapid start-up and load-following capability of aeroderivative gas turbines provides a viable way to integrate variable renewable power sources into the grid.

The development of aeroderivative gas turbines occurred in a unique context of military innovation during the exceptional circumstances created by World War II, the Korean War, and the Cold War. Military imperatives drove technological development and involved massive expenditures of public funds unlikely to be reproduced today, absent a clearly articulated and broadly supported public good. Moreover, not all technologies are suited to the kinds of multidisciplinary partnerships and incremental gains evident in aeroderivative gas turbine technology. Nevertheless, this case provides a central lesson that aligning research with customer priorities and user needs is not a downstream or translational activity, but rather central to a successful energy R&D process.

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