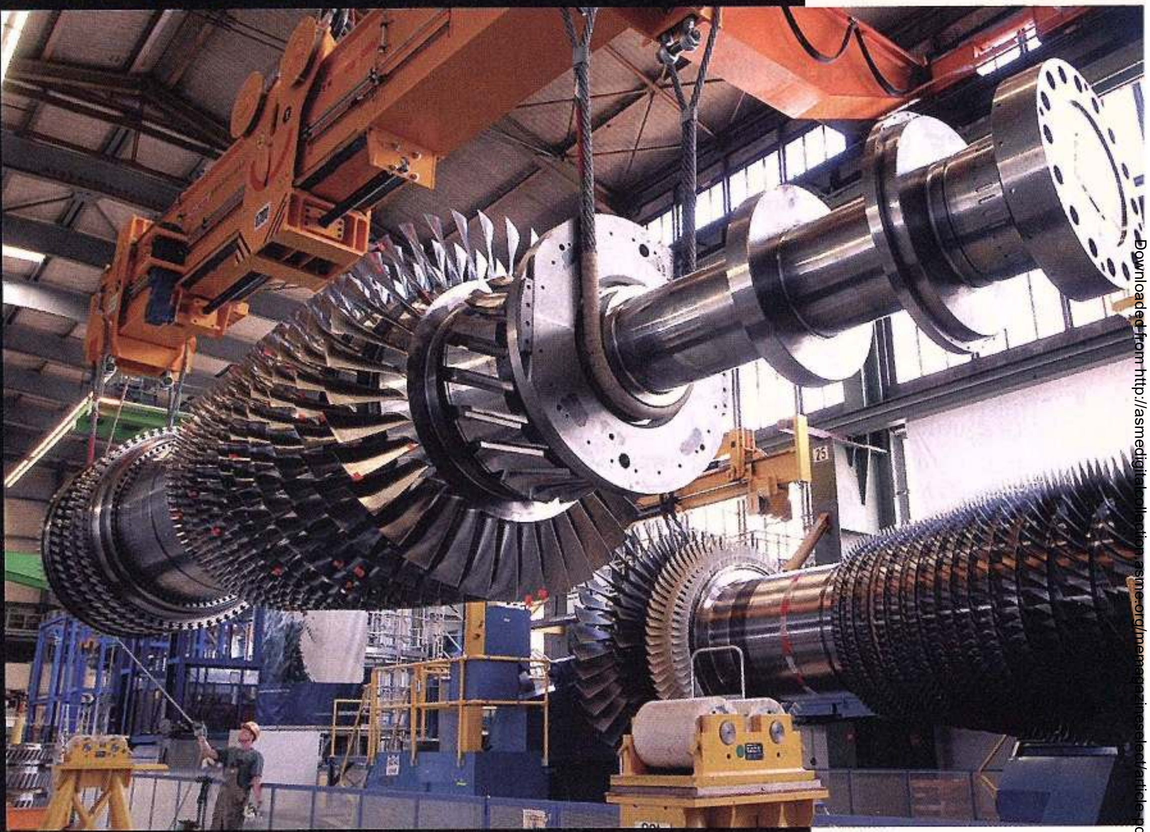
GAS TURBINE INDUSTRY OVERVIEW 2008



▲ Technicians prepare the Siemens Energy SGT5-8000H for delivery to a power plant in Irsching, Bavaria. The turbine weighs 440 metric tons.

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plowing new ground

As the gas turbine becomes steadily more advanced, the industry reaps the benefits. By Lee S. Langston

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CAN YOU BE TOO EFFICIENT? There has been, over the years, a tendency on the part of some companies and government research funding agencies to declare that gas turbine performance has reached a plateau. I remember listening to an engineering manager at a major gas turbine manufacturer pontificate that the jet engine was a mature device and the industry was entering "harvest time." The whole declaration was used to justify major reductions in the company's gas turbine R&D, following management's assessment that "sometimes it is too costly to be number one."

This was in the late 1970s. And needless to say, it didn't take long to fulfill management's desire to move out of the top spot in the market. Competitors continued to aggressively pursue and fund gas turbine R&D for more efficient and cost effective machines.

Indeed, to this day companies have furiously continued to devote resources to improving the gas turbine, and the result is an industry seeing steady growth. Technical refinement and commercial appeal are linked. Advanced gas turbines are able to perform better than ever, whether producing more pounds of thrust or operating at greater efficiency, and because of this, manufacturers are able to sell into more markets and provide better return on investment for their customers than ever before.

That's borne out both in the sales figures for the industry this year and the advances announced by individual companies. We well may be reaping the harvest of previous research, but that's only because the field has been subject to careful and continual tending rather than a rapacious extraction of wealth.

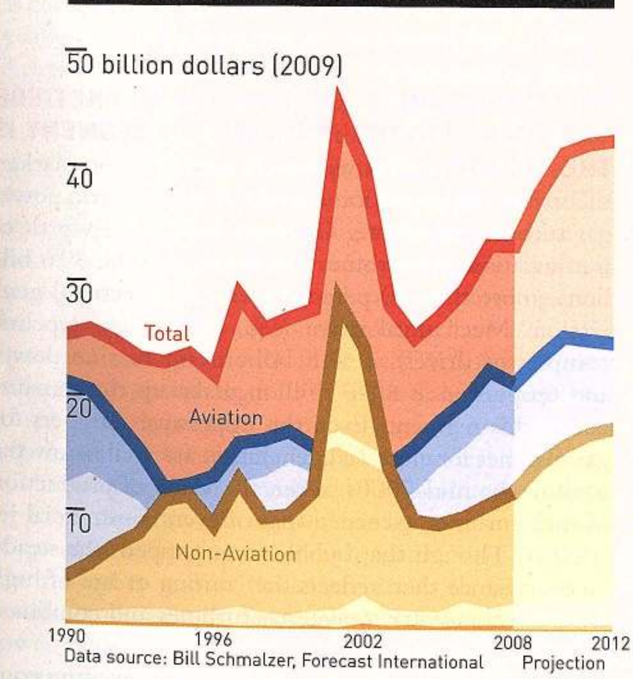
THE ANNUAL VALUE OF PRODUCTION PROVIDES THE VITAL SIGNS FOR THE INDUSTRY. Forecast International in Newtown, Conn., uses its computer models and extensive data base to monitor value of production (considered more accurate than sales figures) for both the aviation and the non-aviation gas turbine market. FI's value of production data allows us to view the entire gas turbine industry, while trade journals usually report separately on each of the two market segments. Analyst Bill Schmalzer provided me this data stretching back to 1990, as well as FI's projections to 2012.

For 2008, the total worldwide value of production for both markets was $33.3 billion, about the same as the year before. By 2012, however, the industry is expected to show strong growth in all gas turbine markets; the projection is for more than $42 billion in production by that date, an increase of more than 25 percent.

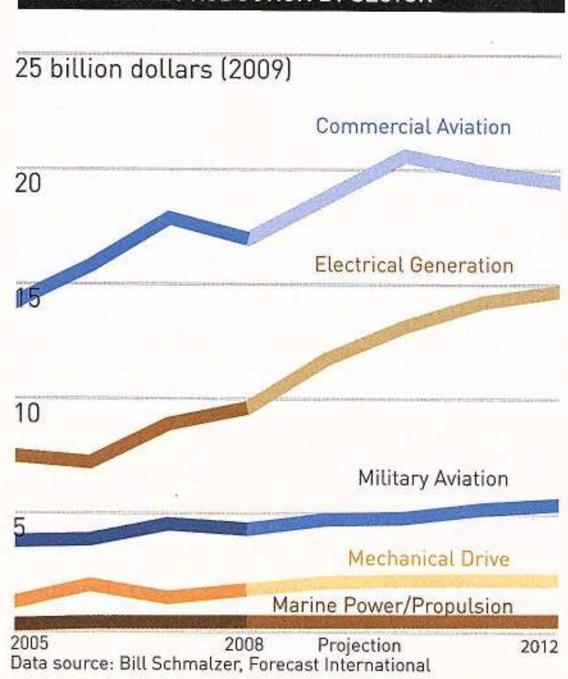
The largest segment in the industry is aviation—jet engines and turboprop engines for commercial and military manned aircraft—with $21.4 billion in production last year. And the lion's share of that was for the commercial aircraft market, accounting for almost $17 billion. That means that more than half of the value of gas turbines production last year was destined for commercial aircraft. Gas turbines for military aircraft amounted to another $4.4 billion.

Though subordinate to commercial engines in terms of production value, the technology developed in military jet engines can bear fruit in commercial jet engine and non-aviation gas turbine development. Perhaps the most ambitious military jet engine program is that for the Joint Strike Fighter, now being developed by Lockheed Martin. The Joint Strike Fighter Lighting II jet engine, designated the F135, is one of the most advanced jet engines ever produced and is now undergoing testing (See "Fahrenheit 3,600," April 2007, for more on the F135). During 2008, a JSF aircraft completed its first supersonic flight, and the first F-35B short-take-off-and-vertical-landing (STOVL) flight took place.

WORLDWIDE GAS TURBINE PRODUCTION



GAS TURBINE PRODUCTION BY SECTOR



But for all the technical virtuosity of military jet engines, it's the commercial market where, if one can produce a dominant product, sales can carry other not-so-profitable jet engines in the manufacturer's engine fleet. An early example of such a "golden engine" is Pratt & Whitney's JT8D: Introduced in the 1960s, it was the first engine used on Boeing's popular 737 and to date over 14,000 engines have been delivered.

A current golden engine for CFM International, a joint company of General Electric of the U.S. and Snecma of France, is the CFM56, which now powers most of Boeing's newer 737 models, all of the four-engine Airbus A340s and many twin-engine A320s.

▲ First built in the 1970s, the CFM56 is a workhorse of the commercial aviation fleet, powering the Boeing 737 and Airbus A340.

International Aero Engines, a consortium of Pratt & Whitney, Rolls-Royce, Japanese Aero Engines, and MTU Aero Engines, has its own contender, the V2500. It currently is one of Rolls-Royce's most profitable engines.

With more than 18,000 units in service, the market share of the CFM56 dwarfs that of the V2500, which has had only 3,100 units delivered, but CFM is clearly hearing footsteps. To keep pace, in 2008, CFM announced its launch of the LEAP-X engine to replace the CFM56.

One of the characteristics of a golden engine is the thrust range. The CFM56 has a thrust range of 19,000 to 34,000 pounds thrust, and the V2500 ranges between 22,000 and 33,000 pounds thrust. Since the 1990s, Pratt & Whitney has been aiming for a product in this thrust range in its development of a new geared turbofan, or GTF, engine. (See "Changing the Game," May 2008, for more on the GTF).

The GTF significantly reduces jet engine noise and will cut fuel consumption by more than 12 percent. Designated as the PW1000G, it is currently being flight tested on an Airbus A340. The GTF will be launched on the new Mitsubishi MRJ regional jet and the Bombardier C Series narrowbody jet, but will be scaled up to thrust levels for the next generation of 737s and A320s.

WHILE AVIATION IS THE LARGEST MARKET FOR GAS TURBINES, THE NON-AVIATION SEGMENT IS THE BROADEST. But within the non-aviation market, the values of production data show that electric power gas turbines dominate. Of the $11.4 billion worth of non-aviation gas turbines produced in 2008, $9.6 billion—more than 80 percent—were for electrical generation. Mechanical drive (e.g., natural gas pipeline compressor drives) at $1.8 billion and marine power and propulsion at $440 million make up the remainder of this segment. Even the impressive numbers for gas turbines for electrical generation are well below the peak in the mid-2000s, when the value of production of such turbines exceeded that of even commercial jet engines. Though that bubble soon popped, the steady recovery since then reflects the coming of age of high temperature electric power gas turbines and combined cycle plants.

This past fall, ASME was a sponsor of an exciting conference on nuclear energy, the Fourth International

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◀ Three Mitsubishi combined cycle plants, far left, generate 1,500 MW at an efficiency of 59 percent and occupy one-third of the land needed by the 40-year-old, 1,050 MW steam plant they replace. One of the new plants is shown in the center photo. The three exhaust through a single stack.

Topical Meeting on High Temperature Reactor Technology, held in Washington, D.C. The meeting, with 500 attendees, was a forum on new gas-cooled nuclear reactors designed to provide energy to heat helium gas to drive closed-cycle electric power gas turbines. Companies involved in the design and development of HTR power plants include Pebble Bed Modular Reactor (Pty.) Ltd. (PBMR) of South Africa, General Atomics of the United States, and Areva of France. South Africa's PBMR remains the clear leader to complete the first nuclear-powered gas turbine power plant; the company is scheduled to have a 165 MW pilot plant in operation and test at Koeburg, near Cape Town, in 2013. (See "Pebbles Make Waves," February 2008, for a history and description of the PBMR power plant).

Even now, gas turbines are beginning to make a huge impact in the electrical generating market. If we assume all natural gas used for electrical generation in recent years has been burned in gas turbine plants, the latest U.S. Energy Information Administration data shows that in 2007, 22 percent of U.S. electric power was gas turbine generated. In New England the value is a staggering 40 percent for 2007. The EIA also projects that of the estimated 255 gigawatts of additional electric generating capacity to be added in the U.S. by 2030, some 55 percent of that will be in the form of natural gas-fueled gas turbines.

Some of this additional capacity will come in small packages as part of combined heat and power plants. Here at the University of Connecticut we have a 25 MW combined-cycle plant with three 7 MW Solar gas turbines, burning natural gas (with fuel oil as a backup) and providing high pressure steam to run a 4 MW single-stage steam turbine (detailed in "Campus Heat and Power," December 2006). Combined heat and power plants can be exceedingly efficient and can be considered about as "green" a technology as you can find.

At the other end of the spectrum, both GE Power Systems and Siemens Energy have combined-cycle H power plants, H class being the very largest electric power gas turbines. After the success of the installation of a GE 9H gas turbine at Baglan Bay, Wales, which is producing 520 MW, three GE 9H gas turbines are being installed in Japan, at TEPCO, near the entrance of Tokyo Bay. In the U.S., two GE 7H gas turbines will power combined-cycle plants—each with an output of 400MW—in Romoland in southern California. The GE H machines are unique, in that the first turbine stage is steam-cooled, thereby superheating some steam for the Rankine cycle, adding to the overall cycle efficiency.

Siemens has been developing its first H class gas turbine

▼ The first stage turbine stator blade ring in Mitsubishi's combined cycle M701G2 334 MW gas turbine is steam cooled to control blade tip clearances under varying load conditions.

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for nine years. The SGT5-8000H is rated at 340 MW, making it the world's largest, and is undergoing testing and producing power for Germany's grid at Irsching, Bavaria. The air-cooled turbine is slated to be part of a combined cycle plant output of 530 MW and Siemens is predicting a plant efficiency greater than 60 percent.

Natural gas isn't the only fuel for gas turbines. Integrated gasification combined-cycle plants convert coal into a low calorie value gas called syngas, which is used as fuel

▲ Now installed, this 340 MW Siemens SGT5-8000H is destined to be the heart of a combined cycle plant running at 60 percent efficiency.

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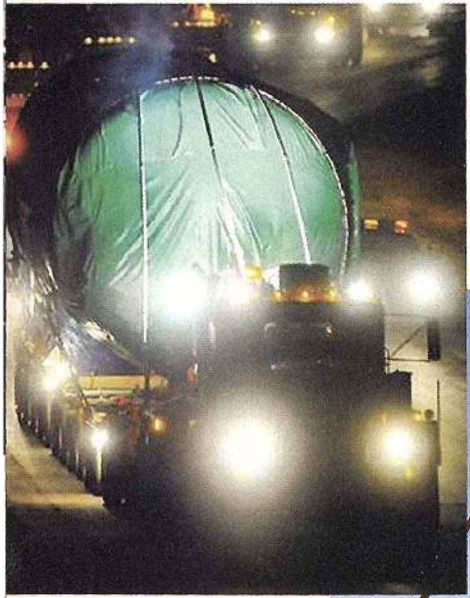
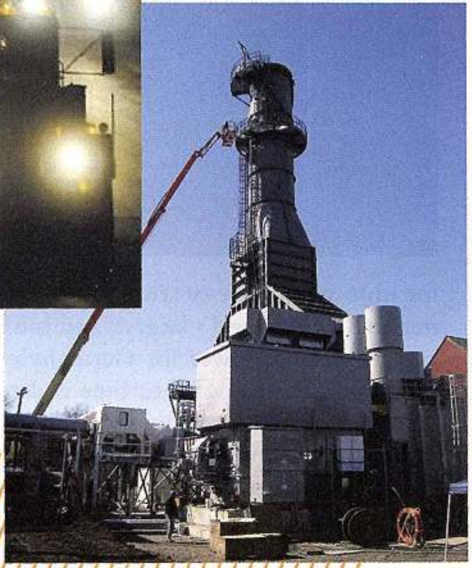
input to the gas turbines in the combined cycle plant. This year GE Energy announced it will be providing IGCC equipment for power plants in Edwardsport, Ind., and in Hatfield, South Yorkshire, in the U.K.



▼ The 100-metric ton intercooler for an LMS100 made a slow journey to a site in Waterbury, Conn. It is now installed as part of a plant that will produce 100 MW.



WATERBURY GENERATION, LLC

HOW FAR ARE GAS TURBINES FROM BEING A STAID TECHNOLOGY TO BE HARVESTED FOR PROFITS?

General Electric's new LMS100 gas turbine is one example firmly on the cutting edge. Introduced in 2005 and rated at 100 MW, the LMS100 is the first modern production electric power gas turbine to have an intercooler. The intercooler—a water-cooled shell-and-tube heat exchanger—cools gas path flow between the LMS100's high and low compressors, reducing the need for compressor work and providing colder turbine cooling air. The result boosts machine output and increases efficiency to 45 percent, a new record for simple-cycle gas turbines.

The LMS100 is aimed at the mid-merit and daily cycling segments of the electrical market—the difficult-to-predict, must-be-ready-to-start electrical peak and intermediary power providers. As of the start of 2009, GE had sold 37 units and unit 14 is currently being installed and readied for operation in Waterbury, Conn.

At 100 MW the Waterbury power plant is not large, but the unique intercooler is. Shipped from its manufacturing site in Korea, the intercooler was barged up the Connecticut River. Then the 225,000-pound cylindrical heat exchanger was transported overland to Waterbury at 6 mph on a 96-wheel tractor trailer truck.

It is one thing to see an intercooler as a simple entry in a textbook, but to witness the actual hardware as it crawled down the road was awe-inspiring. It's a testament to enduring ability of gas turbine engineers to seek out ever-greater efficiency—and a massive monument to the lengths they go to achieve it. ■