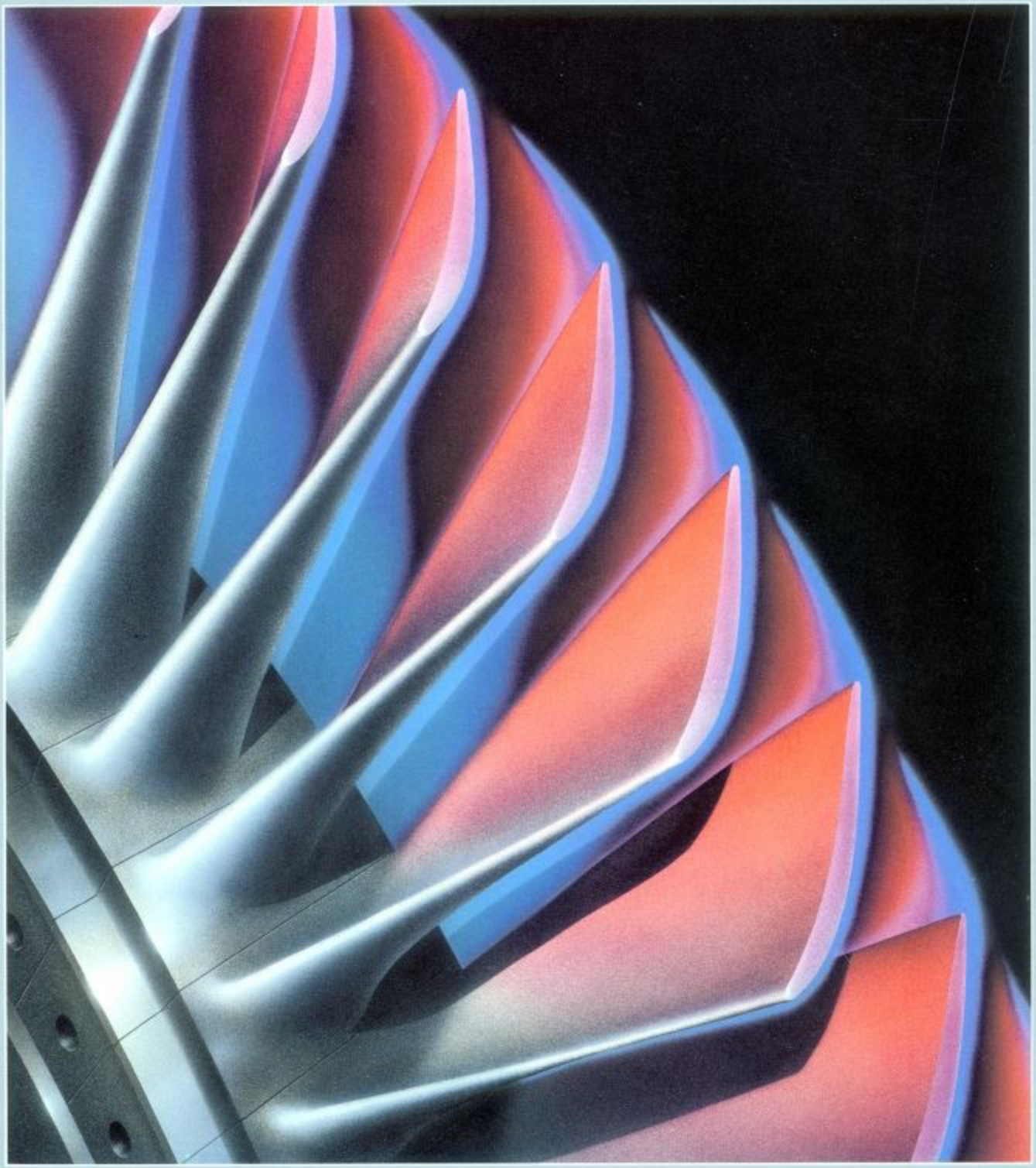
# Take a new look at **Westinghouse Combustion Turbines**



# WESTINGHOUSE COMBUSTION TURBINES: **VALUE PLUS**

***When Augie Scalzo went to work for Westinghouse, his first job was working on jet engines. That was in 1953, and he's been working on combustion turbines — an outgrowth of Westinghouse's jet engine involvement — ever since.***

***Today, he's technical director of Combustion Turbine Engine Design and Development in Orlando, Florida. And when you sit down and ask him about his product — large combustion turbines — he flashes with excitement. Speaking quickly, he heaps praise on the powerful engine and leaves his visitors with pounds of technical literature to back up every claim. He's proud of the Westinghouse product — and it shows.***

## The W-501D5 — An Industry Leader

The W-501D5, a familiar model throughout the industry, is currently the flagship of Westinghouse's 40-year old combustion turbine business. With combustion turbine technology emerging as an increasingly attractive power generation alternative for both electric utilities and industrial companies, Westinghouse is more committed than ever to this segment of its full-scope energy systems business.

At a net plant output of 104 MW, the W-501D5 combustion turbine is the largest 60 Hz engine in the world. And, according to Augie Scalzo, who directed its design, it's the best on the market today. "Our current heat rate is better than anyone else's in simple cycle. At 10,290 Btu/kilowatt-hour standard conditions gas fuel, we're better than anyone else in the world."

That's a lofty claim, but when challenged, Scalzo starts pulling out technical literature to elaborate. "It's a fact. Our most significant competitor has a heat rate of 10,660. It's an established, published fact." He makes his point.

The 100 MW class W-501 model currently in production is ideally-suited for peaking, intermediate, and baseload applications — in hostile or clean environments. Since 1960, when Westinghouse introduced its first large, direct-drive engine, each of its subsequent designs has shared three distinctive features:

**Cold end drive** — The generator attaches to the cold air inlet of the engine instead of the hot exhaust end, thereby allowing thermal expansion to occur toward the rear of the engine. This feature eliminates the need for a flexible generator coupling and enhances reliability and availability.

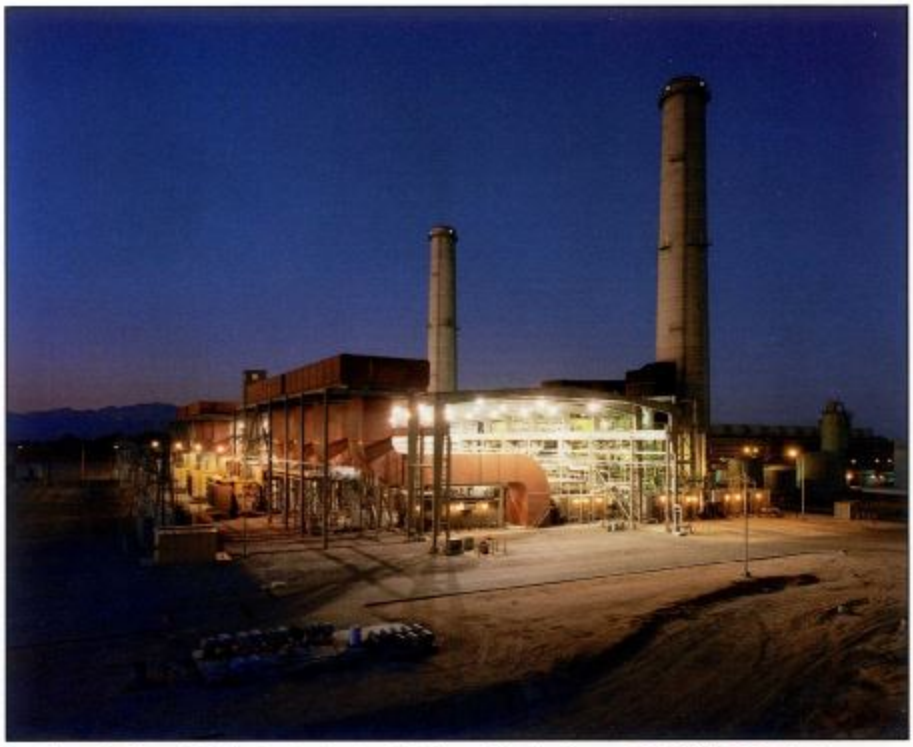
**Two-bearing construction** — This standard Westinghouse feature simplifies maintenance and reduces the potential for reliability and availability

*A W-501 unit ready for shipment*

problems that can occur with a center bearing located in the hot combustor area.

**Axial exhaust** — This design feature — made possible through the cold end drive design — enhances efficiency because it eliminates the turning losses produced by side exhaust. In addition, axial exhaust permits a more convenient, side-by-side arrangement of units, particularly in heat recovery applications.

According to Scalzo, the competition is playing catch-up. "Our major competitor has adapted its design to include these three features," he says. "It's funny, but in the sales brochures they boast that they're making these changes to match some European standards. But those aren't European standards — those are Westinghouse standards." It's a point he obviously enjoys making.

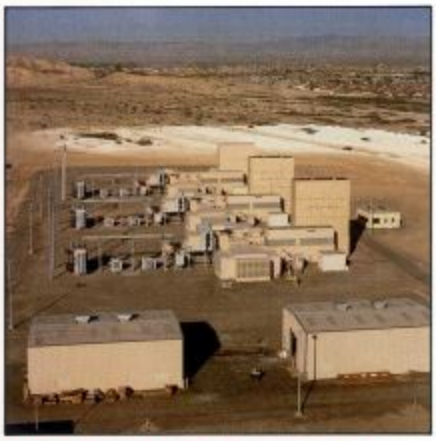


*Southern California Edison's Coolwater Station, a Westinghouse 520 MW PACE plant*

## Solving Problems And Creating Success Stories

That's not to say there haven't been problems. Several years ago, a few of Westinghouse's machines experienced turbine blade failures.

"Our blading problem was a number one concern for Westinghouse and we worked long and hard to solve it," says Scalzo. "Every new turbine has its problems; in Westinghouse's case, the problem was mass flow and load-related. But I'm happy to say it's been diagnosed and corrected. The replacement parts are in the field and have been running successfully for the past several years."



*Nevada Power's Clarke Station near Las Vegas, an installation containing multiple W-501B (83 MW) ECONOPACS*

Scalzo mentions Westinghouse's experience with Dow Chemical Company as a case in point. "Dow is recognized as the most experienced operator of gas turbine plants in the world," he says. "They have seven W-501D5s in operation. When we discovered the blading problem in one of the units, we took fast action, working in close cooperation with Dow in an intensive corrective action program involving a field telemetry rotating test [the first high temperature test ever conducted], a blade redesign, and a second field telemetry rotating test to confirm the new blade. The entire process was completed in fifteen months.

"All seven Dow units have been retrofitted with the new blades and some have been operating for over two years. In 1986, the units operated at an availability rate of over 97 percent!"

In addition, Dow Chemical has nine other large Westinghouse combustion turbines that are operating in baseload cogeneration applications at availability levels in the mid-90s. These units, predecessors of Dow's seven W-501D5s, were built between 1968 and 1972. Several have logged over 100,000 hours of operation.

Capitol Cogeneration is operating a Westinghouse combined cycle plant at better than 95 percent availability. This 375 MW plant contains three W-501D5 units.

In all, the 160 W-501-series units in operation throughout the world — 99 of which are owned by U.S. utilities — had an average year-to-date availability factor of 88 percent through December 1986. This figure is derived from operating data supplied to Westinghouse by users.

That's a track record that's hard to beat. But Westinghouse is going to try — with its advanced combustion turbine now in the design and development phase.

## The Advanced Combustion Turbine — The W-501F

The W-501F — an advanced unit in the 140 to 150 MW range — is the combustion turbine being jointly developed by Westinghouse and Mitsubishi Heavy Industries (MHI) of Japan. The two companies recently signed a five-part, ten-year agreement to jointly produce a broad line of combustion turbines and make them available to customers around the world.

Under the terms of the agreement, Westinghouse's long-established capabilities in combustion turbine technology, engineering, project management, and customer service will be merged with MHI's high quality manufacturing and product development capabilities. In the United States, Westinghouse will continue to market, install, and service the machines and will warehouse spare parts for quick response to customer needs. (Westinghouse will continue to manufacture its smaller frame units in Canada.)

The advanced model is scheduled for full load shop testing in early 1989, with commercial availability expected by early 1990. According to Tom Campbell, general manager of Westinghouse's Generation Technology Systems Division, this turbine is expected to be the best in the business with respect to dollars per kilowatt, fuel efficiency, and application flexibility.

"It will fire at 2,300 degrees Fahrenheit and feature enhanced emissions control," he says. "In addition, its critical hot section components will incorporate advanced, state-of-the-art materials and cooling technology. These and other features will produce the kind of efficiency and reliability that will outclass our competitors' products in every key performance category."

Adds Jarvis Cotton, director of Power Projects Development for Westinghouse, "The bottom-line is that the finished product will be competitively-priced equipment of the highest quality — a world-class product — enabling us to compete with any energy systems supplier in the world."

Scalzo elaborates on the engine's expected efficiency rating: "When applied in combined cycle plant applications, this engine will enable users to reach efficiencies of 50 percent or more! Even as a simple cycle unit, it will have an efficiency of 34 percent — an efficiency rating nearing that of a central station.

"This enhanced efficiency will be achieved by increasing the firing temperature — not the size — of the engine. Other performance enhancements will be derived from design changes in the compressor and the turbine areas. In physical appearance, however, the new engine will be the same basic size as the W-501D5."

*Managers representing Westinghouse and ENRON (a Westinghouse cogeneration customer) visit MHI's Takasago facility in Japan, where Westinghouse combustion turbines are being manufactured.*

## Perfect for Industrial Applications

The W-501F is expected to be of interest primarily to electric utilities that need big engines for both peaking and combined cycle installations. But, for industrial users, Westinghouse is also making available a series of smaller turbines — ranging in size class from 10 MW to 40 MW — that share the special features of the larger W-501 series:

**Standard Design** — Each of the units has a standard design which has been extensively tested. Therefore, customers can have, in advance, the system's engineering characteristics and operating data. This eases the process of obtaining necessary construction permits and licenses.

**Modular Construction** — By using a modular approach to combustion turbine plant construction, most wiring, piping, and component assembly is done at the factory to reduce on-site construction time and reduce capital costs.

**Ease in Siting** — Because of its relatively small size, the plants are easier to site than other types of power plants. In addition, the units are air-cooled and can be placed near the need for power, and not necessarily near a body of water.

**All Hardware Included** — A simple cycle combustion turbine order includes the complete plant — all the hardware necessary to produce power. The customer need only build the lines to get the fuel to the plant, and the power lines to get the electricity out. Given those features, a simple cycle combustion turbine plant can usually be put on line within approximately 18 months from receipt of the order.

**Ease of Startup and Operation** — With construction and check-out complete, startup is easy — often accomplished by pressing a single

*A Westinghouse W-501D5 rotor in final stages of engine assembly*

button. Automatic controls and systems monitoring allow minimal operator attendance.

**Easy Maintenance** — A number of specially designed features make Westinghouse combustion turbines the most maintainable in the industry. For instance, the unit is housed in a walk-in enclosure, facilitating inspection and maintenance in any kind of environment.

**Fuel Versatility** — Each unit is compatible with a variety of fuels, in addition to the usual natural gas or distillate oil. The heavy-duty turbines can even function with properly-treated crude and residual oils. Currently, Westinghouse and Dow Chemical Company are converting two of Dow's W-501D5 units to run on synthetic, medium Btu gas from coal. This is the largest combustion turbine conversion of this type to be performed anywhere in the world and will result in the largest integrated gasification combined cycle (IGCC) plant to date.

## Increased Efficiencies

Combined cycle applications are of special interest to both electric utility and industrial customers these days. In these applications, combustion turbines are combined with a steam turbine to achieve maximum levels of power generating efficiency.

In the early 1970s, Westinghouse introduced the concept of an economical, pre-engineered combined cycle plant — known as PACE (Power At Combined Efficiencies). The design matches two model W-501D5 combustion turbines, each exhausting into a heat recovery boiler. The steam produced by the boiler drives a 100 MW steam turbine.

Westinghouse has installed 11 PACE plants, with power ratings between 250 to 300 MW, for utilities in the U.S. and Mexico. These plants have efficiencies typically in the range of 42 to 44 percent. Today, based on the design of the W-501D5, 300 MW PACE plants with efficiencies of up to 48 percent are available. With the design of the W-501F, Westinghouse will be able to offer PACE plants with ratings of 400 MW and efficiencies of 50 percent or better.

## Orlando: A Mecca For Megawatts

Westinghouse's power generation headquarters in Orlando, Florida is the product of youthful rebellion. In 1980, Westinghouse management was looking for a new office site. A well established, quiet Eastern city seemed the sure choice. Then a small group of younger managers spoke up. They wanted a city with a future, a place that would add quality to daily living. They were given the task of searching the nation for a site. They chose booming Orlando.

There was another form of rebellion here, as well. By 1980, the market for new sources of power generation was approaching zero, and the future looked like what it has turned out to be — mega-tough. Traditional voices said, "Lie low." The voices of rebellion said, "Now is the time to move, to position ourselves for leadership in the 1990s." The bold voices were heard. At Orlando, Westinghouse built the world's most modern power generation headquarters. So it was when it opened in 1983. So it is now.

Today, Orlando employes are working through some hard times, still harnessed to a flat market, still determined to be the success story of the 1990s. It seems to look tougher all the time, but the momentum of that early ability to run into the face of the odds remains.

*Westinghouse's power generation headquarters in Orlando, Florida*

Power generation employes work in a building which was designed primarily as an electronic communications center. Its steel and stone are secondary to the 85 miles of coaxial cable which snake through its floors. Half of its 600 computer terminals can communicate with anyplace in the world — to exchange engineering information with plant personnel, to transmit the specifications for a component sourced from a vendor anywhere, to work with a customer. This building was erected on a concept: that a central cadre of power generation engineers, given computers and telecommunications, could create a power generation source anywhere. Orlando was born as a center of action.

Today, the building is crowded with capability. A significant portion of Westinghouse's Power Systems Business Unit is located here, including the Power Systems Operations Divisions and Generation Technology Systems Division, both of which are headquartered in Orlando. And, the facility is also home to groups representing major portions of the Power Generation Service Division, Service Technology Division, and Nuclear Services Integration Division.

Design it, manufacture it, or maintain it, the people of Orlando can do it all — for today's and tomorrow's customers.

In addition to the PACE option, Westinghouse also offers a number of approaches for converting existing plants to combined cycle units. In one approach, heat recovery boilers and steam turbines are added to an existing combustion turbine. In another option known as "repowering," combustion turbines and heat recovery boilers are added to an existing steam plant. Each of these approaches produces significant efficiency improvements for existing plants.

Upgrades and conversions like these are made possible through Westinghouse's full-scope service capabilities. From managing plant outages to refurbishing and supplying parts and components, Westinghouse offers flexible service approaches, including long-term service partnerships.

In 1986, Westinghouse completed a major modernization program for its longest-running PACE plant — Public Service of Oklahoma's 12-year old Comanche Station. Westinghouse provided all engineering and material on an accelerated schedule to allow the utility to accomplish all work during the off-peak season and have the plant back in service for the summer. After modernization, combustion turbine power output increased from 136 MW for both units to 160 MW. Replacement heat recovery steam generators produced 20 percent additional steam flow, which increased steam turbine power by 20 MW. Since returning to service in July 1986, the unit has met all performance milestones, and as of May 1987, had compiled an availability record approaching 100 percent.

## The Dynamic Organization Behind the Product

To keep on top of a changing and growing combustion turbine market, Westinghouse has strengthened its combustion turbine management team. Recently, the Combustion Turbine Operations segment of the Generation Technology Systems Division moved from its former Concordville, Pennsylvania facility to Westinghouse's power generation headquarters in Orlando, Florida [see opposite page]. From there, the group will continue its commitment: to offer customers responsive service for operating plants, and to keep Westinghouse power generation products at the leading edge of technology.

**Combustion Turbine Models Offered By Westinghouse**

| Model | Hz | Power Rating MW (ISO, Gas) |
|---|---|---|
| MF-111A,B | 50/60 | 12.6, 14.6 |
| CW-191 | 50/60 | 17.7 |
| CW-251B10 | 50/60 | 42 |
| W-501D5 | 60 | 104.1 |
| MW-701D | 50 | 126.9 |
| W-501F | 60 | 140 |

An important ingredient of this commitment involves project management, a service that Westinghouse will continue to offer its power generation customers.

Westinghouse has the broadest project management experience of any energy systems supplier in the world, covering everything from nuclear plants to waste-to-energy facilities. The company has provided hundreds of single- and multi-unit combustion turbine plants, as well as several large combined cycle plants — most on a total turnkey basis.

Says Jarvis Cotton, "We offer our combustion turbines as part of an engineered mini-plant package, known as ECONOPAC. The package incorporates the U.S.-made generator, controls, and other ancillary electrical and mechanical components.

"Heat recovery and combined cycle applications mean a more extensive scope; we can manage the construction, erection, and contractual arrangements for such projects — and we will do all of this on a firm-price basis. We'll also work in partnership with the utility and with architect-engineers, constructors, or third parties in whatever arrangement is desired by the customer."

Cotton believes that suppliers who are willing to provide that kind of flexibility are hard to find.

With the new MHI agreement, Westinghouse expects to strengthen its position in other areas, as well. "The production economies we will achieve through our new relationship with MHI will permit us to offer our products at an attractive price," Cotton says. "And, when price and performance are right, our customers will be satisfied."

*The 100 MW combined cycle Medicine Hat plant in Alberta, Canada, utilizes two CW-251B (35 MW) combustion turbines to repower 30 MW of existing plant capacity.*

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