# Technical Publication


# Power Plant Converts To Combined Cycle Operation With The Help Of Thermal Mass Air / Gas Flow Meter

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**During an upgrade project to install combined cycle gas turbine (CCGT) technology, the process engineers at an electric power plant in Western Europe also wanted to maximize the efficiency of their existing gas fuel turbines while maintaining the highest safety levels. By optimizing the performance of both the existing gas fuel turbines and adding the new steam turbines, they hoped to add significantly more generating capacity.**

CCGT power plants operate with both gas turbines and steam turbines working together, which can achieve power generation capability that's up to 50 percent higher than with gas turbines alone *(Figure 1)*. The additional generation capacity requires no additional natural gas fuel. To achieve these results, the excess heat from the natural gas powered turbines is collected with heat-recovery generators (HRGs).

The excess heat from the gas turbines then powers the boilers creating the steam necessary to drive their turbines. There are two important advantages to CCGT power plants. First, the cost per megawatt is reduced by avoiding the expense of additional natural gas fuel. Second, using less natural gas to create more generating capacity is environmentally green-friendly as well.

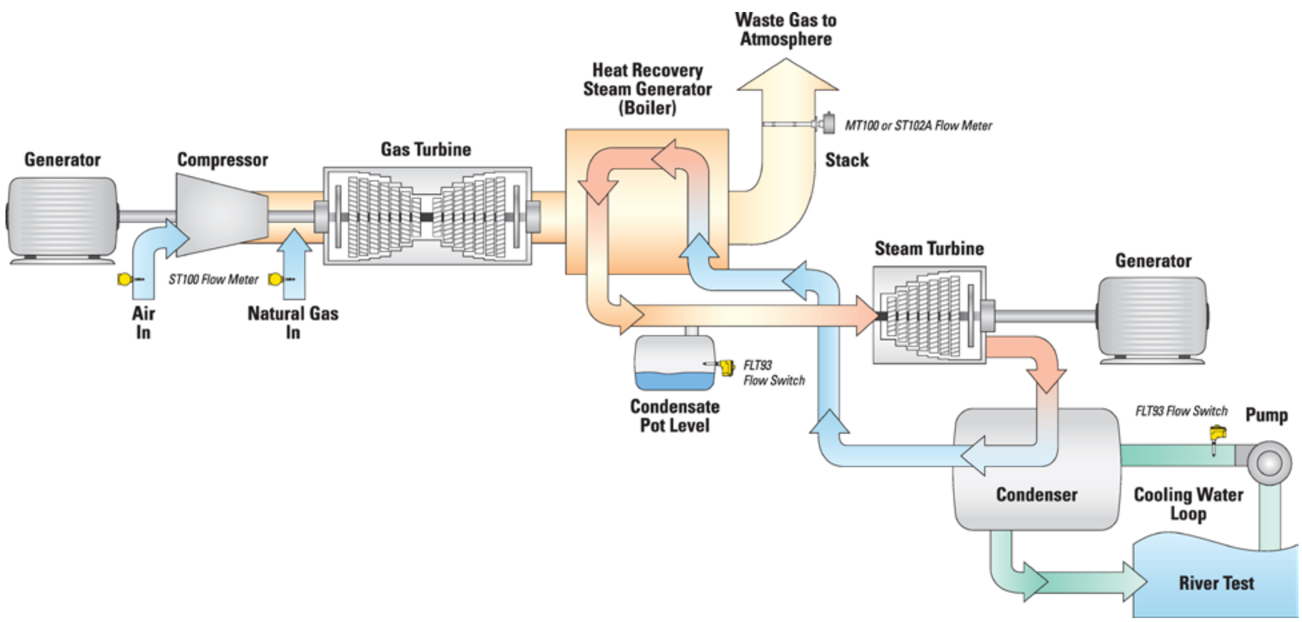
## The Problem

As part of their plant upgrade project, the process engineers recognized that they could increase the productivity of their existing gas turbines. To operate them more efficiently and safely, the gas turbine's combustion system needed a precisely controlled air-to-fuel ratio mixture. Such control is achieved by closely monitoring the ratio of the air (oxygen) and the fuel, which is typically natural gas. This ratio is also known as a stoichiometric mixture.

Both the rate of air feed flow and natural gas flow must be measured accurately, consistently and reliably. The flow meter chosen for this task also must operate over a wide turndown range for safe startups and restarts of the gas turbines that vary throughout the day and the seasons due to variable consumer demands on the electric power grid.

In this case, the existing flow meters at the plant were installed a number of years ago. They were designed with flow sensors that do not measure gas mass flow directly—they "infer" the flow rate. This meant that the flow measuring system also required temperature and pressure sensors and a flow computer to infer the mass flow rate properly. In addition these existing flow meters were unable to measure low flows (velocity had to

*Figure 1: Air-to-Fuel mixture flow measurement in combined cycle processes*



be above 10 ft/sec [3 m/sec] and had very limited range-ability, a maximum of 5:1. The result was less than optimum air flow measurement accuracy that was sometimes inconsistent too, which raised the cost of plant operations unnecessarily.

## The Solution

To solve the problem, the process engineers contacted Fluid Components International (FCI) for discussions about improving the accuracy and repeatability of the air/gas flow meters. FCI has helped dozens of CCGT power plants around the world to measure the mass flow rates of natural gas in line sizes varying from 0.5 inch [15 mm] to 24 inches [600 mm] and air feeds in pipes varying from 3 inches [80 mm] to 60 inches [1500 mm] or in ducts from 10 inch x 10 inch [250 mm x 250 mm] to 8 foot x 8 foot [2400 mm x 2400 mm].

FCI's thermal mass technology flow meters are applied not only on cold fresh air intakes, but also on preheated or combustion air feeds to the gas turbines. The direct mass flow measurement capability of thermal meters allows the operator to achieve a direct control ratio between the natural gas fuel and the air without any corrections for pressure, temperature or density, which requires extra components and possibly extra offsets and failures.

Thermal mass flow meters from FCI provide highly accurate and reliable direct mass flow data. Independent third party studies have been conducted that include the failure mode effects and diagnostic analysis (FMEDA) reports necessary for Safety Integrity Level (SIL) rating. With 2 out of 3 voting capability, they are available with a high SIL 1 rating.

For these reasons, FCI recommended its ST100 Series thermal mass flow meter *(Figure 2)*. It is ideal for the measurement of air, combustion air, oxygen, natural gas, synthesis gas, methane and many other process gases. The process engineers at the power plant agreed with FCI's recommendation for several reasons.

They appreciated the ST100 meter's fast response thermal dispersion direct mass flow sensors, making the meter ideal for close ratio control in CCGT applications. The standard turndown is 100:1 with an optional 1000:1 turndown available – again a perfect fit for CCGT operations.

The process engineers chose the insertion style meter because of its easy installation in any line size above 2.5 inches with optional retractable hot tap process connection to prevent any interference with plant operation even when thermal mass flow meters are removed from process for inspection or verifications.

The ST100 flow meter can sense flow rates from as low as 0.25 standard ft/sec [0.08 normal m/sec] up to a maximum of 1000 standard ft/sec [300 normal m/sec]. Range-ability is standard 100:1 with optional staggering 1000:1 turndown ratio

Developed for rugged industrial processes including power generation, the ST100 meter measures air/gas temperatures from -40 to 850°F (-40 to +454°C). Along with its SIL rating, the meter is certified for hazardous areas with comprehensive approvals that include FM, FMc, IECEx, ATEX, Inmetro, EAC, NEPSI, CPA and others.

The process engineers were pleased that whether their output requirements for this CCGT application were traditional 4-20 mA analog, frequency/pulse or advanced digital bus communications such as HART, Foundation Fieldbus™, PROFIBUS, or Modbus, the ST100 meter supported them all. Its bus communications have been certified by and are registered devices with HART and Foundation Fieldbus.

The meter is also available with an optional digital readout, which was selected by the plant's process engineers for easy technician access to data. The meter's handy local or remote display provides a best-in-class information suite, backlighted LCD and four optical touch buttons. The display and button functions can be rotated electronically, via the buttons, in 90-degree increments to optimize display viewing and button activations.


*Figure 2: FCI Model ST100 Series flow meter*

## Thermal Flow Sensing

All FCI meters are designed with the same thermal dispersion sensing technology that provides direct mass flow measurement. It places two thermowell protected platinum RTD temperature sensors in the process stream.

One RTD is heated from a constant current source while the other senses the actual process temperature. The temperature difference between these sensors generates a voltage output, which is proportional to the media cooling affect and can be used to measure the gas mass flow rate *(Figure 3)* without the need for additional pressure or temperature transmitters.

With this direct mass flow sensor technology, the FCI meter also includes built-in real-time temperature compensation. This capability ensures repeatable and reliable measurement even in applications where wide process temperature variations are present.

With no moving parts to plug or foul, the ST100 meter promises to deliver extensive future cost savings over higher maintenance alternative constant temperature thermal dispersion meters. This meter provides the accurate and repeatable gas flow measurement essential for safe and dependable electric power plant operations at the lowest life cycle costs.

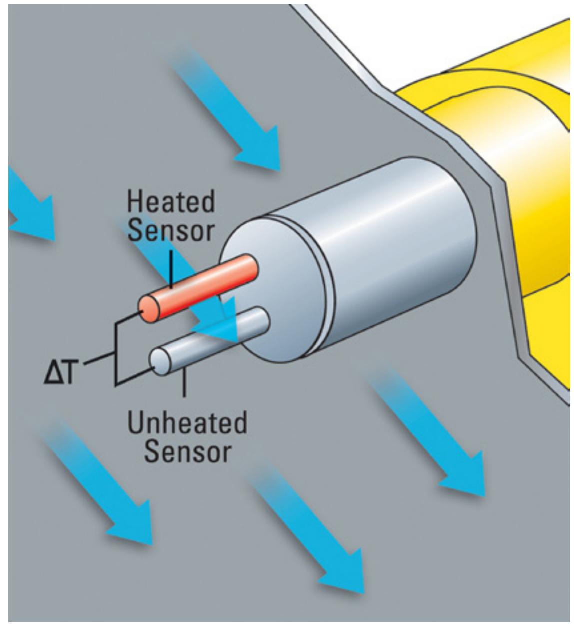



*Figure 3: Thermal dispersion technology principle of operation*

## Conclusions

The project was completed successfully with the new flow meters installed and commissioned without any issues. Their accuracy, repeatability and reliability has improved system flow measurement and helped support the process engineers' goal to optimize the operation of the facility's gas turbines. In the future, the process engineers plan to recommend the ST100 meters for use at other plants. ■