Turbine inlet cooling: First step on the pathway to net zero emissions

Adding TIC to a combined cycle will eliminate the need to boost output with an aero peaker and its less-friendly emissions profile to meet grid demand

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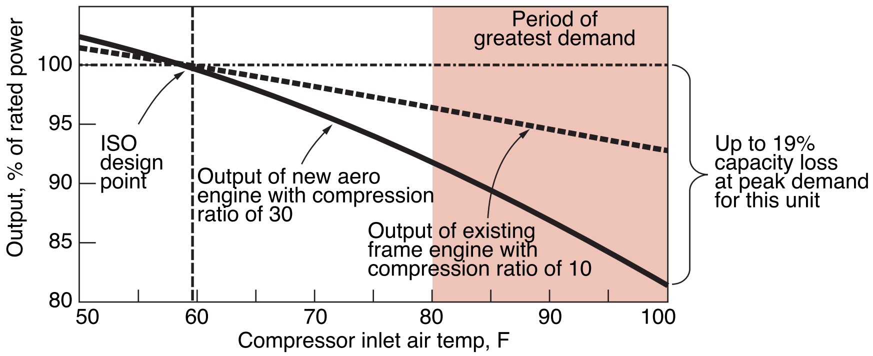
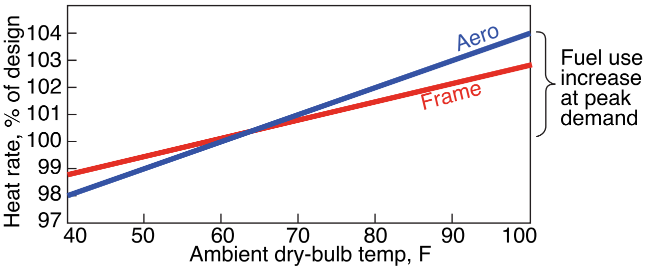
Gas turbine systems produce over one-third of US electric energy requirements. They provide reliable baseload power, in addition to that required to support the intermittent production of electricity from renewable sources. According to a *Washington Post* article, "Turns Out Wind and Solar have a Secret Friend: Natural Gas," every 0.88% of capacity from renewables needs 1% capacity back-up from a fast-reacting fossil-fuel system.

Thus, gas turbines, a cornerstone energy conversion technology for the efficient production of electricity and heat today, are destined to play an important role in the emerging global quest for zero carbon emissions.

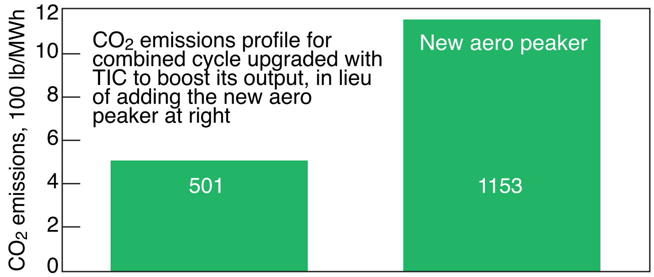


1. Power production decreases as compressor inlet air temperature increases

The operating capacity and energy efficiency of gas turbines is impacted by ambient temperature and humidity. These machines are rated at a standard set of ambient conditions, defined by the International Standards Organization (ISO) as 59F and 60% relative humidity. Increases in



2. Fuel consumption increases as air temperature increases. Heat rate is directly proportional to fuel consumption per kilowatt-hour and inversely proportional to energy efficiency



3. CO_2 emissions from the capacity gained by adding turbine inlet cooling to a nominal 500-MW combined cycle (left) are less than half those from the 50-MW simple-cycle peaker eliminated by it (right). The peaker in this example is an LM6000PC Sprint with hot SCR and TIC

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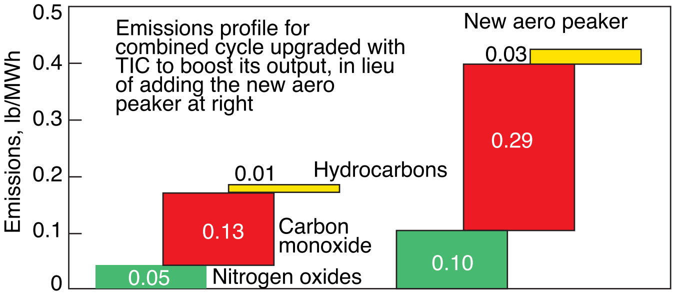
ambient temperature and humidity adversely affect output and energy efficiency of all gas turbines. Figs 1 and 2 present examples for the two major types of gas turbines: aeroderivative and industrial frame.

Since high ambient temperature reduces the performance of gas turbines, the logical solution for preventing this adverse effect is to cool the inlet air before it enters the compressor. Several technologies have been used successfully for this purpose.

The Turbine Inlet Cooling Assn's (TICA) website at https://turbineinletcooling.org is an excellent source of information on these solutions. The table lists them and includes QR codes that link directly to information of value in decision-making. The website also includes an inlet-cooling performance calculator, database of installations, and library of publications and presentations on all technologies.

Bear in mind that each technology has its pros and cons. No one technology is best suited for all applications. Selection of the optimum technology for your plant depends on many factors—including gas-turbine design, weather data for the plant location, value of additional electrical energy produced, and the value of unitized fuel saving.



4. Regulated emissions from the capacity gained by adding turbine inlet cooling to a nominal 500-MW combined cycle (left) are significantly less than those from the 50-MW simple-cycle peaker eliminated by it (right). The peaker in this example is an LM6000PC Sprint with hot SCR and TIC

The following summarizes the benefits attributed to cooling of gas-turbine inlet air:

- Increased power output.
- Increased energy efficiency.
- Reduced emissions per unit of electric energy produced (higher efficiency).
- Reduced grid-wide emissions (reduced need to operate less-efficient systems for meeting grid demand).
- Increased thermal energy in exhaust gases, which benefits combined-cycle and cogeneration systems.
- Lower capital cost compared to the addition of a peaking unit to increase capacity.

Because combined cycles are the most efficient fuel-fired option for producing electricity, upgrading with inlet cooling eliminates the need to operate a less-desirable alternative—such as running a simple-cycle peaking turbine with a rated capacity equal to the combined-cycle output gained by adding inlet cooling.

Examples of the quantitative benefits of using TIC on a 500-MW combined-cycle system for reducing emissions of carbon dioxide and regulated pollutants, are compared in Figs 3 and 4 to the emissions from a simple-cycle peaking turbine whose need was eliminated.

Similarly, installing inlet cooling on simple-cycle turbines eliminates the need to operate less-efficient systems.

According to an estimate by TICA, the use of inlet cooling on all combined-cycle systems in the top 20 states can reduce carbon emissions by more than 22 million tons annually. CCJ