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During hot weather, a turbine produces up to twenty percent less power than in winter.

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El Paso Energy's Chaco Plant Harnesses Fog to Gather 18 Percent More Gas During Hot Days

At the Chaco Cryogenic Processing Plant

With the demand for cleaner-burning natural gas steadily rising in the West and prices following suit, El Paso Energy has been pumping every possible cubic foot through its western pipeline network. As a result, the volume has built from 1.8 billion cubic feet per day (Bcf/d) in 1997 to around 2.2 Bcf/d today, much of it from the San Juan Gathering System in Northwest New Mexico. Central to this rise in production has been the output of the Chaco Cryogenic Processing Plant.

Situated in Bloomfield, 20 miles south of Farmington, New Mexico, this facility has successfully harnessed a fog-based evaporative cooling to gather as much as 18 percent more gas during the hot summer days. This gas is then processed and routed to the El Paso gas pipeline system to be shipped to Western States and Northern Mexico.

In this article, we discuss the changing market forces which drove the adoption of fog, how El Paso Energy harnesses the technology and the results obtained.

Market Forces

El Paso Energy has been able to take advantage of the shifts in supply and demand taking place as a result of industry deregulation across America. The increased need for natural gas-fired power generation in the United States—driven primarily by stricter emission standards and new higher-efficiency gas turbine technology—has resulted in increased demand for natural gas in many regions of the country. With North American gas flow trends favoring the movement of Canadian gas supplies to Midwestern and Eastern markets, El Paso Natural Gas has been transporting increasing gas volumes from southwestern U.S. producing basins into California (See Figure 1, El Paso Field Services Network).

The San Juan Basin, in particular, has been heavily involved in the dramatic surge in gas volume to California. El Paso Energy runs a 5,000-mile gathering system in the basin for approximately 1.2 Bcf/d of conventional natural gas supplies. This system delivers to El Paso Field Services' Chaco and Conoco Blanco processing plants for redelivery to El Paso Natural Gas. The San Juan Gathering System connects 9,400 wells, owned primarily by Burlington Resources Inc., Amoco Production Company and Conoco Inc.

To keep up with growing demand, El Paso Energy opened the Chaco Cryogenic Processing Plant in 1996. The processing facility contains three refrigeration/de-ethanizer compressors and has a processing capacity of over 500 MMcf/d with natural gas liquid production of 50,000 Bbls/d. It recovers 100 percent of propane and heavier components and 93 percent of the ethane from the gas stream. After processing, the gas is delivered to El Paso Natural Gas Company and transported to the West.

Stepping on the Gas

In 1998, El Paso Field Services executed a compression project to reduce field delivery pressures and increase production by an estimated 130 MMcf/d. This $50 million project included the installation of approximately 36,000 horsepower of new field compression and construction of an additional 56 miles of pipeline system. 10 new compressor units were added at five separate locations on its 5,500-mile system. These additional units lowered average wellhead pressures to about 150 pounds per square inch gauge (psig) on 70 percent of its high pressure gathering system, affecting approximately 3,000 wells. The majority of this increased volume went straight to the Chaco plant.

Even with this surge in capacity, however, Field Services still had a major problem. While Chaco had recorded a gathering average of 472 MMcf/d over the course of one quarter, this number dropped dramatically during the summer. According to plant floor staff, less than 400 MMcf/d would come when the temperature soared. This situation severely curtailed the output of the Chaco plant.

Chaco engineers looked into the situation to determine the cause. They discovered that during hot weather, its combustion turbines (CT) produce up to twenty percent less power than in winter (See Figure 2, Turbine Performance Chart). This is due to the fact that the power output of a turbine depends on the flow of mass through it. That's why on hot days, when air is less dense, power output falls off. As the pumps that pushed the gas into Chaco were powered gas turbines, the facility was not receiving the volume needed to satisfy demand.

In response, El Paso augmented the power of its two of its GE Frame 5 CT's by installing a high-pressure fog system manufactured by Mee Industries of Monrovia, CA. Fog systems use high-pressure water pumps to pressurize RO water that flows through a network of stainless steel tubes to fog nozzle manifolds that are installed in the air stream inside the inlet duct. These nozzles atomize the water into micro-fine fog droplets which evaporate quickly and cool the air. By feeding cooler air into the CT, mass flow is increased, resulting in higher output. At Chaco, that translates to an extra 72 MMcf/d, depending on ambient conditions.

This translates into savings in the range of $10,000-plus per day. Assuming a daily average increase in pumped gas at 9 percent (on hot days this figure rises to 16 to 18 percent according to plant staff). 9 percent in a 400 MMcfd comes to 36 MMcfd. At a rate of $300 per MMcfd, this increases revenue at the Chaco plant by $10,800 per day. In comparison, the cost of operation of the fog system works out at $603 per day for 24 hours continuous operation: 720 gallons of RO water at $0.05/ga = $360/day; power to fog skid per day = $75/day; maintenance cost estimate of $2/hr = $48/day; amortization of capital at $3/hr = $72/day.

Due to the climate of New Mexico, however, fogging at the cryogenic plant is a seasonal activity. Between October and April the system isn't needed much as temperatures remain low. In the other five months of the year, Chaco runs the fog system at maximum capacity to ensure that turbine power output remains high. Almost all of the USA, in fact, can harness fog for power augmentation. Natural gas producers in Canada and Alaska may only gain four months of use out of the system, whereas those in California, Texas and Florida can use it for much of the year

Fog System Components

The fog system in use at the Chaco plant consists of a series of high-pressure (2000 psi) pumps (4 pumps total, one 3 hp pump, three 5 hp pumps, mounted on a skid, an Allen Bradley PLC control system and an array of fog nozzle manifolds (224 nozzles total). Each pump is connected to a fixed number of fog nozzles, representing one discrete stage of fog cooling (there are 7 stages in total). The pumps are turned on sequentially to control the amount of cooling. With seven stages, a 21°F drop in temperature is managed in 3°F increments.

El Paso Field Services monitors the Chaco fog system via a built-in PLC. This regulates the flow and pressure of water to ensure proper function of the skid components. Weather sensors are connected to the PLC to monitor ambient temperature and humidity. Proprietary control software by Mee Industries automatically turns on or off each of seven stages of fog cooling depending on the capacity of the inlet air to absorb water vapor.

The nozzle manifolds are made of stainless steel, as are the specially designed fog nozzles. In order to make droplets small enough to create a fog, impaction-pin nozzles are utilized (See Figure 3, Impaction Pin Nozzle). The Chaco plant requires 224 nozzles in each turbine. These nozzles have orifice diameters of 6 thousandths of an inch and produce fog droplets in the 10 micron range, ideal for inlet air cooling and small enough to reduce the possibility of compressor damage that could be caused by bigger water droplets. With the mean droplet size kept around 10 microns, cooling efficiency is high and water wastage minimal. At Chaco, this translates into as much as 35°F of cooling according to the plant's controls technician.

Operations staff also noticed a difference in the condition of the turbine compressor. The Chaco plant utilizes a fogging technique known as intercooling or over-spray. By purposefully injecting more fog into the inlet air stream than can be evaporated, turbine operators produce larger power boosts than would normally be associated with ambient conditions.

How does it work? First, enough high-pressure fog is injected to exceed 100 percent relative humidity. Unevaporated fog droplets are then carried by the air stream into the first stages of the turbine compressor section, where the air is hot due to the work of compression. Higher temperatures increase the moisture-holding capacity of air, so the fog droplets that would not evaporate in the inlet air duct, do so in the compressor. Once the fog evaporates in the compressor, it cools and makes the air more dense. This results in a reduction of compressor outlet temperature and increases turbine efficiency, allowing fuel flow to be increased, thus generating more power.

When applied at Chaco, this additional surge of power was accomplished without any problems with blade coating or compressor fouling. In fact, the fog system controls technician at the plant noted that the compressor blades were far cleaner than before.

Environmental Bonus

The Chaco Cryogenic Plant in Bloomfield prides itself in its environmental record since its opening five years ago. El Paso Energy has received the EPA Regional Administrator's Air Compliance Environmental Excellence Award for the State of New Mexico. The award was granted for state air compliance above and beyond requirements at Chaco.

While not the reason for the initial installation, Chaco's fog system has also resulted in a reduction in emissions. By increasing the power output of the turbine, most people would expect that the level of NOx emissions would increase correspondingly. However, the opposite is true.

Gas turbine NOx comes from the oxidization of atmospheric nitrogen (i.e. it is not a product of fuel, it comes from the air). NOx formation is a strong function of combustion temperature. The presence of water vapor in the combustion air reduces hotspots, which are the primary source of NOx. Thus it is the quenching effect of fog that makes the difference. Result: increased power achieved while lowering NOx emissions levels.