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Siting Gas-fired Power Plants

It is important to consider a range of issues when selecting and developing a site for a new natural gas-fired power plant.

By Conrad Anderson, Director of Engineering, Enventure Partners

By now, most individuals in the power industry are well aware of the new "natural gas boom" that has been predicted over the last couple of years. Even the general public is becoming familiar with the new gas extraction technology called "hydraulic fracturing" that will be used, together with horizontal drilling technology, to tap vast reserves of natural gas currently locked in shale rock in the U.S. and throughout the world. Adding current estimates of shale gas reserves to conventional gas reserves leads to current estimated total U.S. reserves of approximately 2,500 trillion cubic feet, which is over 100 years of gas usage at today's gas consumption rates.

As one might expect, the dramatic increase in estimated gas reserves has reduced and stabilized natural gas pricing for the foreseeable future, which effectively eliminates the "Achilles' Heel" of generating power with natural gas, namely, highly fluctuating prices. Historically, natural gas prices varied from a low of $2 to $4/million Btu throughout most of the 1990's to as high as $13.50/million Btu in late 2005 and again in late 2008. Assuming the gas industry and U.S. and state government regulators implement best practices and regulations to prevent the reoccurrence of a few well publicized stories of gas wells polluting local water wells, then relatively low-cost, long-term stable natural gas pricing, coupled with the environmental benefits of generating electricity with natural gas rather than coal, is expected to drive the new "gas boom" for years to come.

It is important to carefully evaluate a range of issues before selecting and developing a site for a new natural gas-fired power plant. This article will provide a checklist of those issues that has been compiled based on power plant site selection and development activities the principals at Enventure Partners have carried out since the late 1970's.

Key Project Parameters

Prior to initiating site development activities for a given project, critical project parameters that will impact site selection should be established, such as:

- The type of natural gas-fired power plant to be installed, for example, simple cycle gas turbine or reciprocating engine plants (typically used for utility peaking service); gas turbine or reciprocating engine-based combined cycle plants with or without supplemental firing (typically used for utility load-following service); or cogeneration plants with or without export power capability (typically used by industrial or commercial facilities to meet their in-house power, heating and cooling demand);
- Initial plant capacity and the future phased installation of additional capacity;
- Power purchaser's dispatching requirements, for example, quick-start and load-following capability and other ancillary services, as required;
- Natural gas supplier's guaranteed quality, delivered pressure, reliability of supply and the commercial terms associated with each guarantee;
- The quality, delivered cost, and reliability of supply for all potential sources of water, including grey water, if applicable;
- Annual variations in site ambient conditions, site elevation, site soil conditions, site preparation requirements and seismic zone;
- Type and extent of emissions control equipment and offsets needed to comply with site-specific permitting requirements;
- Plant performance based on heat and water balances at all anticipated operating modes.

Existing vs. Greenfield Sites

Developing a natural gas-fired power plant at an existing site can simplify the site development activities considerably and reduce both site development costs and schedules. Candidates for existing plant expansion include the many old coal-fired power plants that are scheduled for retirement in the next few years due to the more stringent emissions limits specified in the new regulations recently finalized and issued by the U.S. Environmental Protection Agency (EPA).

Potential advantages of existing sites compared to greenfield sites include:

- Eliminates the time and cost to identify greenfield sites and to negotiate site acquisition or leasing terms for one of them.
- Utilizes existing site infrastructure such as roads and off-site interconnection facilities for power, natural gas, water and waste water to reduce project development costs and to eliminate right-of-way issues that can slow down or even stop project development of a greenfield site.
- Utilizes existing power plant equipment such as the substation and the steam turbine island for use in a combined cycle configuration.

These advantages can reduce total plant engineering, procurement and construction (EPC) costs by as much as 20 percent and reduce the time to develop the project by 12 months or more. The discussion that follows will be applicable for developing both greenfield and existing sites.

Natural Gas Supply

One of the major advantages of using natural gas to generate power in the U.S. is the country's extensive underground natural gas pipeline and storage system. It allows underground delivery of a high quality fuel to virtually all urban and industrial areas throughout the country as well as to many remote areas, which is conducive to placing power generation closer to load centers rather than being constrained to use the fuel where it is available and transporting the power via overhead transmission lines. However, a few critical natural gas supply issues that can impact site selection need to be addressed:

Gas Pressure: If the expected minimum gas pressure delivered to the power plant fence is less than approximately 100 pounds per square inch absolute (psia) above the required gas pressure at the gas turbine combustor, an on-site gas compressor booster station will be required. Today's gas turbine pressure ratios can be as high as 42:1 requiring a gas pressure at the inlet of the flow control valve of over 700 psia. Natural gas-fired engines, on the other hand, typically only need the delivered pressure to be less than 100 psia, thus calling for an on-site pressure reducing station for high pressure gas delivery.

Gas Quality: If the expected gas quality falls outside the allowable range specified by the gas turbine or engine manufacturer, gas treatment will be required to prevent subpar performance or damage to plant equipment.

Gas Supply: If the expected gas supply will be interruptible, an alternative back-up source of natural gas or on-site storage of a back-up fuel, such as diesel fuel, may be required depending on the project's contractual economic incentives to maximize plant availability. That is, the cost and complications of adding on-site storage or an alternative source of back-up fuel must be weighed against the penalty in the power sales agreement for interruptions in power supply.

Gas Delivery: The cost and right-of-way acquisition for the gas supply pipeline (usually buried) running from the main gas distribution pipeline to the project site can also be a critical site selection issue.

Power Interconnection

In today's "not-in-my-backyard" world, the only guaranteed way to avoid local opposition to an overhead power line extending from the project fence to the applicable grid interconnection point is to avoid the power interconnection line altogether. That can be accomplished by either burying the power line or locating the power plant at an existing power plant site or adjacent to an existing substation, preferably one with congestion issues which could be relieved by installing power generation capacity nearby. This approach not only eliminates the cost and easement issues associated with the power interconnection line. It also may allow burying the project's gas interconnection pipeline to the nearest natural gas distribution grid in the power transmission corridor thereby avoiding right-of-way issues with both the project's power and gas interconnections altogether.

In the U.S., the project will need to execute an interconnection agreement with the applicable independent system operator (ISO), a process that, in many parts of the country, defines the critical path to financial closing. There are two reasons it takes so long.

First, the time it takes to conduct the studies to determine the extent and cost of adding interconnection equipment as needed to maintain stable and reliable operation of the electric grid can be significant. Second, there may be as many as several dozen projects in the queue in front of your project that are still waiting to begin the studies.

For example, PJM Interconnection is currently estimating up to two years to execute an interconnection agreement from the date a project's application to interconnect is executed.

Water-related Issues

Water use by natural gas-fired reciprocating engines, operating in the simple cycle mode with radiator (air) cooling are limited to potable and sanitary water use, water storage on site for fire protection and intermittent miscellaneous washing. Gas turbines operating in a simple cycle mode may require additional water for inlet air cooling, water

injection for power augmentation and/or NO_x control, and intermittent on-line and off-line water washing to restore gas turbine performance.

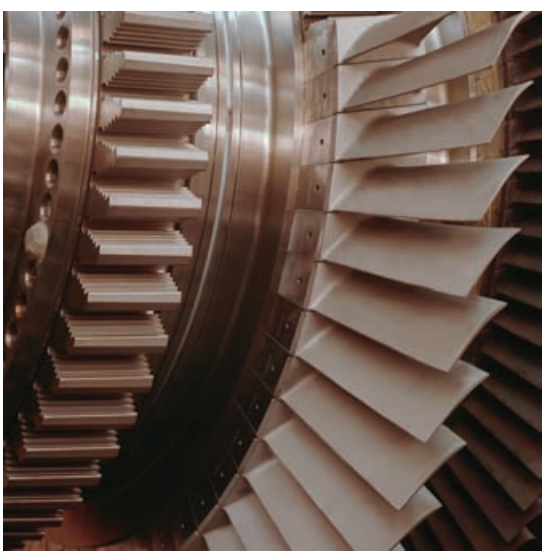
Adding a steam turbine (Rankine) cycle to capture waste heat in the exhaust gas for combined cycle operation can add significant water use, particularly with regard to steam condensation, cooling tower blowdown and boiler blowdown. Typically, if there are no water supply constraints, conventional evaporative (wet) cooling towers are the most cost-effective way to condense steam exiting the steam turbine. However, many plant sites in the western U.S. and a growing number throughout the U.S. have chosen air-cooled (dry) condensers or some combination of wet/dry condensing to reduce or eliminate cooling water consumption. In addition, local governments, particularly in the northern part of the country, are requiring enough dry cooling capacity installed to avoid plumes and dangerous icing during winter months on nearby heavily traveled roadways and airports. Converting from 100 percent wet cooling to 100 percent dry cooling will typically increase total plant installed cost and reduce plant capacity to the extent that power production costs increase on the order of 5 to 10 percent.

Another trend to lower power plant water consumption is to use gray water from a local sewage treatment or industrial facility, which typically increases the sophistication and subsequent cost of the water treatment system. Likewise, as local governments push for lower water consumption, they are also looking to reduce or eliminate wastewater discharges from power plants to local waterways. For those power plant sites that have sufficient space to install evaporation ponds and more sophisticated wastewater treatment equipment, project developers are using zero liquid discharge (ZLD) facilities to eliminate wastewater discharge altogether so that the only waste generated by the power plant is the solid waste residue produced by the ZLD facility itself.

The detention pond and site preparation needed to accommodate storm water runoff can also impact site selection and development. For sites with sandy soil that absorbs rainfall well, a typical rule of thumb is to size the detention pond to accommodate roughly 0.3 to 0.4 acre-ft. of water per acre of site covered by roadways, buildings or ground cover that does not allow rainfall to readily absorb into the ground. For compacted clay soils, this figure can increase considerably.

Emissions Control Equipment and Offsets

In today's highly regulated environment, a preliminary permitting analysis is recommended to determine the extent of on-site pollution control needed to satisfy both USEPA and state-mandated requirements. This analysis is particularly important for power plant sites located in non-attainment or environmentally sensitive areas where enhanced pollution control is required. While natural gas-fired power plants do not emit significant amounts of particulate, sulfur-based oxides, or mercury like coal-fired power plants do, they do emit NO_x, CO and unburned hydrocarbons that may need to be controlled with equipment and processes that can be expensive and use up valuable on-site space. In addition, offsets may be required that can be expensive and therefore can impact the site selection process.



New fossil-fired generating capacity is likely to favor natural gas for the foreseeable future.

A selective catalytic reduction (SCR) catalyst is oftentimes used on natural gas-fired combined cycle plants to control NO_x emissions that require ammonia injection and therefore, ammonia storage and handling facilities on site. In addition, as of July 2011, any facility that emits more than 100,000 tons/year of greenhouse gases must be considered a "Major Source" as defined by the EPA, that can trigger enhanced criteria pollutant control equipment depending on whether the site is in a non-attainment area or not. Thus, this new federal EPA greenhouse gas mandate could require new natural gas-fired peaking power plants to install SCR catalysts, with large dilution air systems needed to meet SCR catalyst temperature limits, which will significantly impact on-site space requirements and costs. Of course an alternative to installing SCR would be to restrict the annual hours of plant operation via the Air Permit

Artist Rendering

Before taking the project to the local town government for approval, an artist rendering based on the preliminary plant design and site equipment layout is typically required. The artist rendering will need to show the community what the plant will look like installed on the site next to adjacent properties, particularly from ground level.

The artist rendering should include all major plant equipment, as well as buildings and tanks, the detention pond, recommended landscaping, (including trees and berms), parking, on-site buildings; all interconnects to off-site facilities for power, natural gas, water and wastewater discharge; and all major surrounding properties such as transmission line(s), the substation, roads and miscellaneous buildings.

Local Government Approvals

The first step in the process of obtaining local government approvals should be to identify exactly what local approvals will be needed and from which government entity, that is, from village, town, city, rural township and/or county government. The quickest way to understand the local approval process is to retain a local attorney with experience in obtaining local approvals for similar projects in the area. Probably the most common reason why local governments deny approval of a power project proposal is if the site requires rezoning, which usually means the proposed power plant is not consistent with the local government's development plan, a plan that typically takes a lot of time and resources to develop and therefore should not be taken lightly by the project developer.

Typically, the most significant site-related expenses to be incurred over the life of a natural gas-fired power project are the payments to local governments in the form of property taxes, other local taxes and payments in addition to taxes. Such payments are typically designed to cover project-related costs the local government will incur and/or any inconvenience the community might endure for hosting the project. It is crucial for the site developer to keep in mind that most communities expect to be compensated

for hosting the project since natural gas-fired power projects do not generate many jobs—typically less than 100 short-term construction jobs and somewhere between five to 20 long-term jobs on the plant's operations and maintenance staff, depending on the type of natural gas-fired plant.

Project payments to local governments vary considerably since the method used to calculate property taxes varies so much, since payments in addition to taxes are negotiable and since the local community's appetite for hosting a natural gas-fired power plant is unpredictable. Thus, it is important to have a good idea of just how high all up-front and annual recurring payments to the local government will be for each alternative site under consideration before finalizing site selection.

Neighbors closest to the project site deserve special attention. Personal visits with an explanation of exactly what is proposed and an honest assessment of how it will affect the neighbor's property value (if at all) is highly recommended prior to the project being made public.

A draft non-technical, comprehensive description of the project is usually presented to the town or county board before presenting it to the general public. Comments and questions from the board are then incorporated into the presentation for the general public, which typically includes the following general topics:

- **Aesthetics:** What will it look like from the public's vantage point
- **Safety:** To what risks will the general public be exposed
- **Noise:** Obtain a noise map from the turbine or engine manufacturer and compare noise levels at the site boundary with and without a building and compare to noise levels of familiar sounds
- **Traffic:** Determine the impact of the project on local traffic, which is usually not an issue with natural gas-fired power plants
- **Pollution:** Compare "stack versus tailpipe" emissions, that is, controlled pollution from the power plant stack versus an equivalent number of cars or trucks
- **Water Consumption:** Present the annual maximum and average seasonal variations in water consumption for an assumed plant capacity factor. For on-site wells, power plants should attempt to avoid drawing from the same aquifer the host local government uses for its water supply.

Whether or not to include a building to cover major plant equipment will depend, to some extent, on the community's objectives. If a low profile plant that is hidden behind a berm and trees is preferred, then a building may not be advisable since it can raise the profile of the plant by at least a factor of two. However, if the community is particularly concerned about noise, safety and/or aesthetics, a building may be required. Generally the cost of the building will not have a significant impact on project economics.

Site Control

Prior to committing significant resources to a specific site, project developers will oftentimes control a site by executing a two-to-three-year option to purchase or lease the site from the site owner. Such control gives the developer time to make progress with site development prior to actually purchasing the site or committing to long-term lease payments. Consequently, site option agreements commonly require periodic option payments made to compensate the owner for taking the property off the market throughout the option period. Occasionally, site owners may have an interest in sharing project development risk by forgoing option payments or payment for the site altogether in exchange for a portion of the project development fee, usually paid at financial closing and/or a carried interest in the project equity once the project begins commercial operation.

During the negotiating processes with the local government and the site owner, it is prudent for the developer to retain the option of considering one or more alternative sites so that he can walk away from the site if either the local government or the site owner becomes unreasonable.

Additional Site-Related Studies

Site-related studies that could impact site selection and development that are not discussed above are included here for reference.

- An environmental site assessment to determine the need for site remediation due to soil contamination
- A geotechnical analysis to define foundation requirements
- An infrastructure analysis to assess the need for on-site and off-site improvements
- A flood risk analysis to establish site elevation, fill and grading requirements
- Water supply studies to confirm water quality and quantity and the impact of project drawdown from the aquifer, as required
- Wastewater discharge analyses to evaluate ZLD options and compare them to treating and discharging wastewater to an approved local waterway
- Storm water runoff analysis to determine location and size of on-site detention pond
- Wetlands analysis
- Archeological investigations
- Endangered species study
- Utility wheeling charges
- The need for on-site housing for permanent O&M staff and incentives to attract staff to remote sites

Experience will be required to know when each of these studies will need to be completed during the site development process which will depend, to a large extent, on the unique characteristics of each site. pe

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