Zinc Whiskers

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Critical Cogeneration Power Plants Optimized for Total Cost of Ownership

Power purchase agreements and natural gas contracts make for profitable business

As we noted in the last issue, many data center owners and operators have concluded that both our power generation and transmission capacities in the U.S. are so overburdened that we need to consider alternative and renewable sources of energy in order to meet the exponential demand of our IT facilities. By using alternative energy resources, the data center community can positively affect the environment, reduce our dependence on foreign oil, and extend the life of our electrical grid. Apple and eBay are planning to power their data centers with natural gas fuel cells. And Microsoft recently announced plans to power its data centers with methane off-gases from landfills and wastewater treatment plants.

The Data Centers (TDC) is in the process of developing a first-of-its-kind facility that will help lead us to a more energy independent future while providing the requisite reliability required by our industry. The patent-pending design combines best-in-class data center energy efficiencies with the efficiencies of on-site cogeneration and tri-generation plants that can operate as an island without relying on the electrical grid as a backup. That means that critical power generation with gas turbines, steam turbines, and adsorption chillers back up one another to power and cool the data center while excess power can be supplied to the grid to support demand response requirements. The facility will secure long-term gas contracts to keep operating costs low and competitive. The concept provides for flexibility in site location, eases the strain on the local existing electrical grid infrastructure, and provides one of the most economical of alternative energy solutions Construction cost estimates for the facility are around $7.5 million per critical megawatt of IT power for a Tier III+ data center and a very efficient power plant.

TDC plans to continue to build similar facilities in the future and has selected a site on the University of Delaware STAR campus for its first project. From this Delaware location, the data center will serve technology communities in Philadelphia, Baltimore, New York City, and Washington, DC. This area appears to be gaining traction as a data center community because of its central location and because the zero sales tax in Delaware provides significant savings on IT equipment required by tenants. Adding to the colocation data centers currently operating in Newark and Wilmington, the Bank of America recently announced plans to build a large $300 million data center on its Delaware campus only seven miles away from the TDC site, and it is rumored that several departments of the federal government have also been looking in this community for new data center capacity as well.

THE POWER PLANT

The TDC power plant is designed to optimize total cost of ownership (TCO) while ensuring efficiency, economy, and flexibility during both build-out and operating phases. The plant consists of a proprietary configuration of natural gas turbines, steam turbines, and gas engines with two independent natural gas supply lines on site to provide the reliability required to deliver uninterrupted, fault tolerant power to the data center. The systems are designed to provide N+2+1 system-wide redundancy, allowing for the continuous operation of two redundant generators and the ongoing maintenance of a third.

TDC evaluated many configurations of combined heat and power (CHP) plants using sophisticated operations and financial models in order to determine the optimal design. Some of the configurations:

- Generation-only power plants with inexpensive and efficient gas engines as the prime movers
- Combined cycle power plants with gas turbines operating as the prime movers supported by heat recovery steam generator (HRSG) boilers and turbines to efficiently capture waste heat and generate additional electrical power,
- Cogeneration power plants with gas turbine prime movers with heat recovery systems to heat space and create steam for use in facilities operations,
- Tri-generation power plants using combined cycles to generate electricity through prime mover gas and steam turbines, as well as chilled water through the use of absorption chillers
- Mixed gas generator power plants using both gas engines and gas turbines as the prime movers, sup-

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ported by steam turbines.

TDC analyzed variations of each of the above configurations for operating condition cases that represent the entire potential range of operating conditions. For each configuration and operating condition, the analysis factored deployment costs and operating costs and income into a TCO analysis comparing operating efficiencies, reliability, construction costs, and the financial performance of each case. The most cost-beneficial configurations from each category of power plant were analyzed further and more thoroughly evaluated for a final comparison. Sensitivity analyses are also performed to account for significant variable costs such as gas and electricity prices.

The final concepts include configurations with primary power gas engines as well as several primary power gas turbines that will meet the data center load while capturing the benefits of cogeneration, including heat recovery in the form of steam turbines to generate additional electrical power and optional absorption chillers to provide for chilled water production. Redundant gas engines, steam turbines, and gas turbines will provide backup power and increase overall reliability. Additional efficiencies can be achieved through the installation of absorption chillers or through the export of low-pressure steam to an off-site consumer.

The gas turbine cogeneration plant provides stable power and high efficiency operations while the gas engines provide for efficient power gradients between turbine steps in the power ramp-up curve. This combination of generation provides a variety of benefits and flexibility to the operator. The power plant will provide continuous power to the data center even while experiencing variations in seasonal turbine performance resulting in differences of capacity of up to 30 percent between the summer and winter months. This results in excess power capacity during the winter months, which creates opportunities to export substantial power to the grid or to turn down equipment.

THE MICROGRID

The power plant electrical distribution system is arranged in a 2N configuration. This arrangement is made up of a proprietary multiple bus and power conditioning system that stabilizes the transfer of power from primary generators to back-up generators in case of a turbine failure, while providing for a seamless transition of power and allowing the facility to operate as an "independent" microgrid.

TDC defined, developed, and assessed special operating conditions for emergency operating conditions during a grid outage and single and multiple generator failure modes to demonstrate the ability to maintain and recover power under the most stringent of conditions. This flexibility is the key to providing reliable independent power to the data center without the need for traditional uninterruptible power supply (UPS) systems, power distribution units (PDUs), static transfer switches (STS), remote power panels (RPPs), or backup diesel generator (DG) systems.

Annualized power plant efficiencies of better than 50 percent can be achieved while utilizing outside air to cool the data center. Although other cogeneration configurations can achieve higher electrical and thermal efficiencies, this configuration provides amongst the best of TCO solutions considering the integrated operating efficiencies of the power plant and the data center together.

Some of the key elements of the design came from the M+W Group design team and are based upon their previous award-winning experience with the design, construction, and operation of a similar tri-generation power plant that supports semi-conductor fab critical facilities in Dresden, Germany. The operating history of that site gives TDC great confidence in the design concepts developed for this project.

THE PROJECT

TDC has signed a lease with the University of Delaware to occupy a site on the STAR Campus and has lined up over half of the construction funding with Investment Bankers. According to TDC CEO Gene Kern, the site will employ approximately 370 FTE and is expected to attract over 90 other workers from our tenants, vendors, consultants, and our tenants' tenants.

With its high reliability, high-density design, and its managed services capabilities, the data center will be an ideal location for high-performance computing and cloud computing operations. Three tenants, including the University of Delaware, have already agreed to occupy space when the site is operational in late 2014. Opportunities exist for additional tenants to reserve space in the first phase of the facility as well.

CRITICAL FACILITIES ROUNDTABLE

CFRT met on September 27th in Santa Clara to hear presentations by Bloom Energy, eBay, and PG&E about the merits and challenges of renewable energies for the data center and on-site generation utility incentives. CFRT is a non-profit organization based in the Silicon Valley that is dedicated to the open sharing of information and solutions amongst our members made up of critical facilities owners and operators. Please visit the website at www.cfroundtable.org or contact us at 415-748-0515 for more information. ■