Bayer MaterialScience LLC and Calpine Case Study: Emissions Reductions and Combined Heat and Power

1.0 Background & Summary
The State of Texas faces a significant environmental challenge along the Texas Gulf Coast, specifically in the Houston/Galveston area, a designated non-attainment area under the Clean Air Act. The State Implementation Plan (SIP) adopted in 2002 for the Houston/Galveston area requires reductions in emissions of nitrogen oxides of 80% from a baseline value by 2007.

NOx and CO2 are produced during the combustion of fossil fuels. This case study focuses on how a project to change how energy is produced at one industrial site led to decreased NOx emissions and cost savings.

2.0 Plant Description
The Baytown Industrial Park is the flagship site for Bayer MaterialScience LLC in the NAFTA region. Bayer MaterialScience is the chemical manufacturing arm of Bayer AG. The Park sits on 1500 acres in Chambers County near Baytown and is 35% developed. The site is home to five Bayer sub-groups: polycarbonate, coatings and colorants, polyurethane, organics, and inorganics.

The site has grown more than 10-fold since 1971, when the first polyurethanes unit started up. Today, the site is a thriving industrial park site anchored by Bayer MaterialScience LLC and Bayer Technology Services. The site also hosts LANXESS Corporation, Borden Chemical, El Dorado Nitrogen, First Chemical Texas, Texas Brine, and the Calpine Baytown Energy Center.

3.0 Energy, Environmental and Economic Benefits

Background
The project began in the late 90’s, when Bayer started considering how to address a variety of utility and emission reduction needs at its Baytown Industrial Park site. At the time, it was unclear what would happen with the Houston/Galveston area State
Implementation Plan for ozone, in terms of timing of implementation requirements or the percent reduction to be met. There were many unknowns, both in the regulatory context and future energy prices. Both of these would affect project economics.

Bayer’s team defined the situation as follows:

- The Baytown Industrial Park’s steam and electricity costs were significant and rising.
- The site had four aging boilers, which were a reliability issue and a maintenance cost sink.
- Steam quality was an issue.
- At least two of the boilers were grandfathered under permits that were facing sunset. In addition, Bayer knew that it was likely that there would be stringent emission reduction requirements on NOx sources in the region.
- The company’s business model called for eliminating non-core competencies.

A number of solutions were examined, including a Combined, Heat and Power (CHP) plant, sale of the existing utility infrastructure to a third party, or expansion of the existing utility infrastructure by Bayer.

Bayer approached the problem by soliciting bids from companies that included independent power producers, utility companies, and existing fence line chemical companies. These companies competitively proposed a solution to meet Bayer’s needs through a bidding process. A CHP facility met Bayer’s criteria and had the best economics. Calpine Corporation was selected as the winning bidder.

Key pieces of the economic justification included:

- Pricing agreements on steam and electricity;
- Avoidance of capital costs;
- Avoidance of extensive emission control technology; and
- Elimination of NOx compliance costs.

The Solution

With the shut down of the five steam boilers, the site-wide NOx emissions fell below the level needed to meet the SIP requirements for the Bayer site. In fact, Bayer was able to use the NOx reductions to comply with the SIP, hold some credits in reserve and provide Calpine with some of the credits needed to permit the new facility. The Calpine site began operating in June 2002.

Figure 1 shows Bayer’s allowable emissions under the SIP and the site’s actual emissions. The actual emissions are for Bayer MaterialScience only.
As of 2003, Bayer was in compliance with the site’s 2008 emission limits (based on current SIP requirements).

Lessons Learned

Bayer looked at applying this solution to other sites, but found the economics are site specific. Although exact cost savings are confidential, Bayer reports that this site constituted its largest energy user of its US sites. In 2000, Bayer spent over $200 million on energy in the US. Bayer is seeing cost savings from that 2000 level for energy expenditures.

Bayer defines the critical success factors for the project to be:

- **Successful integration of the host/guest facilities.** A number of site-wide services had to be integrated. Advance planning and defining these relationships made it work.
- **Many detailed contracts.** Engineers from both companies confirmed specific performance requirements and how they could be met. This covered everything from construction, infrastructure, services, and pricing schedules to demolition.
• **Strong leadership.** Due to the scale of the project, you need to have one leader throughout the project that can get senior management to make the big decisions.

• **A comprehensive transition plan.** Startups and shut-downs can be complex. It was necessary to transition from the old to the new without a loss of service. Training also had to be addressed within that timeframe.

*The Technology*

Calpine’s Baytown Energy Center, which serves the Bayer’s Baytown Industrial Park began operations in June 2002. This combined-cycle cogeneration facility has a base capacity of up to 700 MW throughout the year plus an additional 130 MW of “peaking” power during the summer months. The Calpine facility provides Bayer Material Sciences with all of its electrical and steam needs under a long-term contract.

The Calpine facility uses three natural gas-fired combustion turbines and then recovers thermal energy from the hot combustion exhaust to create steam. The steam is used to generate additional electricity in a steam turbine. This combined-cycle operation enables the Calpine facility to produce electricity with 30% less fuel than the average fossil fuel-fired plant in Texas.

To make more complete use of the excess steam available, Calpine routes a portion of the steam to the Bayer plant to satisfy the latter’s steam requirements. Calpine thus generates and uses both power and thermal energy from a single fuel source. This approach, known as cogeneration or CHP, improves the Calpine’s efficiency by another 10%.

Together the combined-cycle operation and the cogeneration of electricity and steam produce a net heat rate of approximately 6,200 Btu per kWh, which is about 40% lower than the average fossil fuel-fired plant in Texas.

To reduce NOx emissions, Calpine uses a combination of low-NOx combustion systems and selective catalytic (SCR) technology. Theses technologies enable Calpine to produce electricity with 90% fewer NOx emissions and 45% fewer CO2 emissions than the average fossil fuel-fired generation facility in Texas. Extending this comparison to annual performance, the Calpine plant represents potential emissions reductions of 7,000 tons of NOx, 13,000 tons of SO2, and 2.9 million tons of CO2. These figures do not include the NOx emission reductions from shut-down of the aging boilers at the Bayer site.

For a detailed explanation of the technologies used at the Calpine site, you are referred to the Tour Guide Book, Baytown Energy Center, prepared by the US DOE for the Texas Technology Showcase 2003 and available on the web at [http://TexasIOF.ces.utexas.edu](http://TexasIOF.ces.utexas.edu)

4.0 **Summary**
This case study highlights an opportunity faced by sites in ozone non-attainment areas that have onsite boilers. Sites will face large costs for compliance with NOx reduction requirements, especially if they must retrofit the boilers with SCR, a control technology which reduces NOx emissions. However, careful selection of a Combined Heat and Power (CHP) project can result in a number of benefits for the host site, including cost reduction, compliance with regulations, and increased reliability.

**Benefits:**

**To Bayer**
- Decreased energy costs
- No capital investment in NOx compliance while achieving a NOx reduction of 300 tons per year, and going beyond compliance
- Improved reliability of steam services
- Improved core business focus

**To the Region**
- Early NOx Reductions, improving air quality in the region
- Cleaner electric capacity brought online (40% less fuel used per kWh)
- Potential reductions of up to 7,000 tons/yr of NOx (compared to average fossil-fuel fired plant in Texas)

**Acknowledgements**

The data for this case study was extracted from two sources. The first was a presentation by Jeffrey Kovacs, Bayer Material Sciences, presented at the “Industrial NOx Source Reduction Technologies and Strategies” conference, held on August 24, 2004. The second source is a DOE case study on the Calpine unit developed for the Texas Technology Showcase 2003.

Both of these original sources can be found on the Texas Industries of the Future (IOF) website at [http://TexasIOF.ces.utexas.edu](http://TexasIOF.ces.utexas.edu)

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