Shell Center for Sustainability • Rice University

KEESHAN & BOST CASE STUDY

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Executive Summary

Matt Hotze and Christine Robichaud, students in the Professional Master's Environmental Analysis and Decision-Making Program, embarked on a Shell Center for Sustainability Student Case Study in the fall 2003 to examine the Houston-based Keeshan and Bost Chemical Company, owned and operated by Rice alumni Dr. Andrew and wife Sue Schwartz. Since the late 1970's, this North Brazoria Co. area business has focused on taking co-product streams from other chemical processors and converting them from what would have been wastes into marketable materials. The Schwartz's granted a series of interviews and tours allowing the Rice students open access to information regarding their operations and business objectives, in this way offering insight into real-world applications of sustainable development innovations.

The case study explored the history, philosophy and technologies behind this company's innovations in sustainability. Specifically, three innovations implemented at the Keeshan and Bost Chemical Company plant are the focus of the study:

1. Design and use of stationary elevated pipes attached to distillation towers in the manner of a ship's sail for cooling product with natural gulf winds rather than water.
2. Use of compressors and engines that capture byproduct off-gases, both minimizing waste gas release and generating electricity (30% of that used by the facility).
3. Design and use of unique water treatment system with completely closed waste-water treatment tanks and non-waste-generating on-site sludge system

The company's owners humbly insist that many businesses, when faced with the economic, regulatory, and mechanical obstacles felt throughout the chemical industry, respond with innovations that fall in the creative and sustainable categories much as the Schwartz's have. The design of the novel "sail" made of cooling pipes, for example, was born of necessity after a devastating tornado destroyed part of a cooling tower, serving both as a testament to the realities of small business ownership and the cleverness of the Schwartz family.

This case study has offered a hopeful look into the world of sustainable development; the same spirit of innovation that serves to reduce negative environmental impact is also the quality that drives economic advantage and social responsibility.

Company History

The Houston Ship Channel, lined with refineries and chemical manufacturing plants, has been called the "aorta" of the U.S. chemical industry. It is the largest petrochemical complex in the Americas; it represents half of the nation's basic petrochemical manufacturing capacity and is the largest port in the nation for foreign trade of petrochemical products[1]. As such, this monolithic development on the Texas Gulf Coast generates immense waste streams along with its impressive volume of saleable products. The ship channel is responsible for over 200,000 jobs in the Houston area, but also presents serious environmental challenges and concerns for the region. These characteristics make the area a perfect subject for a case study on ways to achieve sustainability, or how to operate while balancing the protection of economic, environmental and social interests.

Andrew and Sue Schwartz purchased the Houston Ship Channel area Keeshan and Bost Chemical Company in 1982, and since that time have sought this sustainable balance in their core business decisions and in their daily operational activities. The Schwartz's have grown the operation in size, production throughput, and technological complexity. Their facilities have tripled in size as their throughput increased tenfold. The physical infrastructure has become more dense while growing from a 3 acre plot to take up a full 7 acres today. Input volumes to the plant's processes have increased from 3 to 4 million pounds per year to the current rate of 40 million pounds per year. Simultaneously, these co-products (wastes if not purchased) that the plant uses as inputs have become more complex to break down and resell. As other companies catch on to the simpler methods of chemically recycling their waste products, the Keeshan and Bost plant sees byproducts further and further removed from the simple first derivative products. This company has risen to the challenges presented through technical ingenuity, conscientious stewardship of the local environment, and a fundamental commitment to sustainable practices. The Shell Center for Sustainability Student

[1] http://www.sts-aiche.org/Houstonshipchanneltrip/Houstonshipchanneltrip.htm

Case Study focuses on three specific innovations that embody the Schwartz's success.

Water Cooling Pipes "Sails"

The cooling fins were added to the plant for two reasons. Primarily, the original cooling tower was partially destroyed by a tornado. Putting up the sails was a more price sensitive alternative to replacing the tower. Secondarily, Keeshan and Bost routinely experienced power outages. Sails provided a reliable source of cooling when water cooling was limitedly effective on backup generators.

At any one time, Keeshan and Bost has a need for cooling boiling liquid that is held in a container about the equivalent volume of a typical rail tanker. When power is shut down liquid will continue to boil even if the boiler is off. Fin tubes present a novel and efficient way to handle this problem. (See Picture) Taking advantage of the Texas Gulf Coast breezes, the fins are mounted 12-15 feet off the ground and drain via gravity, effectively providing condensers for separating hydrocarbons and alcohols from other parts of the process.

These fins work very well for condensing liquids, which is the main energy demand in the system (this energy requirement is called Heat of Vaporization). In terms of total energy demand of cooling, this energy lost to the fans represents about 90 percent for alcohols and 70 percent for hydrocarbons. Due to the gravity collection method, sails alone cannot effectively cool the product to its final temperature, so some water-cooling is necessary. However, while electricity consumption has increased significantly since the implementation of the cooling fins, electricity costs at the plant have remained steady. Thus the increased consumption has been entirely satisfied by this method of producing electricity on-site to meet the growing plant's needs.

To maintain efficiency, precautions must be taken. Tubes must be protected from damage and from exterior buildup. Weather events bring frequent rains to the Gulf

Coast area; these events clean the tubes but bring with them damaging aspects, such as hail and hurricanes. Therefore, the tubes must be attached firmly enough so they don't blow away, and loosely enough so they can expand/contract without causing structural issues.

Cooling fins take advantage of the natural environment in a sustainable manner. Electricity and water consumption has decreased because water-cooling pumps and fans do not have to be used as frequently now that they merely supplement the fins' cooling process. Less electricity, thus fewer resulting emissions, must be produced in order for Keeshan and Bost to run an effective business. Less thermal pollution of water is also a sustainable consequence of the cooling fins. For Keeshan and Bost, this all translates to lower electricity and utility bills, representing a boost to their bottom line.

Cogeneration fans

Internal combustion engines, salvaged from old oil fields and built for longevity with little or no maintenance, generate 30% of the electricity for the plant. Of this internally generated electricity, 1/3 comes from burning the plant's own off-gases and the rest is created by burning natural gas in the engines. The business of this company is refining alcohol, venting gases that contain light alcohols and ethers as principle components. As these chemical species tend to have high octane, the use of internal combustion engines is suggested; unlike a boiler or incinerator that runs the risk of flashback, the engine is designed to take in combustible gas mixtures and not catch on fire.

The off-gases originate as by-products from the chemical processes taking place in the plant's operating units. First the gases go through the liquid ring compressor, a rough analogy for which is a water piston. As the name suggests, the gas is compressed by passing through this gas conducting ring, through the ring's water-containing core, and back out through the other side of the ring. The use of water to compress these gases alleviates the combustibility problem. Now compressed, the gas is then passed into the combustion engines where the carbon is burned off and used as fuel to create 30% of the plant's electricity. The final step feeds the now mostly carbon-free gas mixture from the engines into fired waste heat boilers to burn off oxygen and dispose of carbon monoxide before releasing the nearly inert gas that remains.

Knowing how the process works is key to understanding the sustainable business practices, but an equally important part of the equation for innovation is the process by which the company came to implement such a method. Keeshan and Bost formed what they called the "Engine Committee", a group of people in the plant who had experience with combustion engines. The group decided that old slow speed oil field engines for running pump jacks were best because of their durability; they were designed to run unattended under harsh conditions with little maintenance. A market exists for retired integral engine gas compressors in various uses, from developing countries to creative companies like this one, so the engines fit the desired characteristics and were available at low prices.

Wastewater Treatment

Closed Treatment Tanks

From 1968 to 1982, the plant had a questionable reputation with its neighbors because of anaerobic smells emitted from the water treatment pond. These odors were caused by the byproducts and decay of anaerobic bacteria, which live in environments with no oxygen. The wastewater treatment pond emitted these odors because of what is called anaerobic turnover. Normally the anaerobes flourish at the bottom layer of the pond, since the top layer is exposed to oxygen; however, quick temperature changes or critical changes in the composition of the pond would cause a turnover event resulting in the anaerobes' sudden exposure to the surface. The Schwartz's learned how to prevent this by sprinkling the surface with a pump from the bottom of the pond; this controlled the temperature gradient so that it was not extreme enough to induce a flipping of the aerobic and anaerobic layers. The practice was to introduce all nutrients at the top layers of the pond, so that you starve the anaerobes on the bottom and feed the aerobes on top. Except in cases of a "blue northern" rapid temperature drop that could induce a sudden turnover, this was successful at keeping the anaerobic odors at bay. After seven years of controlling the odors, the company's odor complaints were reduced to 2 per year.

Then in the early 1990's, what Dr. Schwartz calls the "smell from hell" began emanating from the wastewater treatment system. This mildew dishrag odor was caused by Pseudomonas bacteria. A strict aerobe, the bacteria dominated the treatment ponds, and control of the odors caused thereby was difficult because most odor treatments on the market are for elimination of anaerobic odors. The bacteria can also infest municipal water filters, imparts an undesirable taste, and poses a problem because it is unaffected by chlorine. Makers of contact lens wetting solutions sometimes must deal with this because it can infect its contact solution, and it is commonly found in nuclear reactors. Rarely, the bacteria can even cause disease in the form of a localized infection called the blue puss.

Once it was determined that the smell was coming from the aerobe Pseudomonas, the treatment ponds were covered up until the bacteria were suffocated. After this they treated for anaerobic odors. The Schwartz's point out that though this solution sounds simple enough, it took over a year and came at great costs, as much of the production had to be slowed and even stopped while the wastewater treatment system was out of commission. For this reason, they knew the company could not afford another bout with Pseudomonas.

The risks of another infection were threefold: regulatory risks, profitability risks, and supplier relationship risks all faced Keeshan and Bost. Regulatory law prevents nuisance level odors that travel off-site. The profitability risk was due to the threat of a manufacturing shut-down necessitated by its water treatment process being out of commission for periods of time. Such a shutdown clearly puts the company's relationships at risks; its suppliers depend on them to take their waste streams as process inputs, and will continue to produce these waste streams regardless of Keeshan and Bost's ability to take it.

In answer to this problem, the company came up with the idea to carry out waste treatment in covered aerated lagoons, moving toward sustainability in two ways:

1. Aerated lagoons with activated sludge were put in to replace the previous tanks.
2. Trickling filters – developed technology to take all air from these and use as input to boilers. Every cubic foot of air that touches wastewater is directed to the intakes of the combustion engines that the plant already uses to generate energy and to burn off noxious odors. There were minor difficulties associated with foam accumulating in the boiler air intake. The foam enters the intake pipes, but then collapses leaving liquid, bacteria bodies and dead flies on the interior pipe walls. These remnants cause the condensing conditions in the boilers to be too corrosive for the pipes, so the foam waste must be cleaned out. The design of the system therefore includes drains and removable hatches on the boiler entry pipes, which can be taken off for cleaning out the deposits.

With these covered treatments, the Schwartz's have eliminated the risk of odors from either aerobic or anaerobic bacterial infection of their wastewater system.

Non-Waste Generating Sludge System

The next unique innovation with their wastewater treatment system is the Schwartz's method of running their sludge to extinction. The activated sludge in a wastewater treatment system is made of activated organisms that consume the waste products in the water. The sludge life in this facility is very long; none has been removed from the system for over ten years. Keeshan and Bost has a unique advantage in their ability to keep the sludge active for so long. Because all the wastewater entering the sludge tanks is essentially distilled water, it contains only alcohols and acetic acid, no dissolved solids which would diminish the longevity of the consuming organisms. Acetic acid is a classic bacteria culture mediate, readily biodegradable down to metabolic needs of 20ppm suspended solids maximum.

The decision to cease exporting sludge waste came from a commitment to approach a nearly closed loop system, making the plant more sustainable. The Schwartz's went to a number of experts for advice in setting up this closed loop system, but were only met with responses that it could not be done. They believe the experts primarily deal with treatment of municipal waste, and that these streams have too high a suspended solid rate to entertain the option of sustainable sludge. The company therefore had to look beyond the common wisdom in the wastewater treatment industry and find a solution that fit their specific situation.

The process now used by Keeshan and Bost is called the Kraus Process, developed by a German man of the same name and found by the Schwartz's through independent research of various methods. The details involve contacting all incoming wastewater with sludge in a countercurrent way in order to recover nutrients. This involves volatilization, which is the result of metabolization of chemicals in the presence of air; volatile gases then travel to the engines and are burned off there. The process prevents the biosorption that is involved in most treatment methods. Biosorption occurs when growing bacteria absorb nutrients and other compounds that may or may not be consumed but most likely stay absorbed until the sludge is removed from the system.

It is actually more expensive to operate a wastewater system this way, as well as more difficult. In total, the water treatment tank capacity has grown from 250,000 gallons to 400,000 gallons with the change in strategy. However, public relations considerations justify this choice. Keeshan and Bost has developed a brand and a corporate culture that is defined by sustainability: they take co-product chemicals as input and produce only treated wastewater, boiler flue gas, and outgoing product. There is no question for their suppliers as to whether their product has been disposed of in an environmentally friendly manner. Consumers also believe they are buying product from a company that espouses to as many sustainable practices as possible.

This method means the facility has a larger wastewater treatment system than their peers with similar plant throughput. Municipal sludge has beneficial end-uses such as fertilizer, and regulations are set to allow as much disposal of these beneficial end-uses as is desired. By contrast, industrial sludge is treated as hazardous based on its status as industrial, not based on its content. This inequality in the treatment of industrially-generated sludge helped guide the Schwartz's decision not to produce sludge at all so that they would not have to dispose of it.

Evaluation

The Schwartz's have grown their facility to three times its size since 1982, and have increased its production tenfold. Clearly, their efficiency improvements and commitment to sustainable practices have not only helped their neighborly reputation, but have added to their profitability and bolstered the robustness of the manufacturing process.

Small businesses are always under tremendous pressure to operate cost effectively, and the Schwartz's have responded to this need with innovations drawn from personal experimentation, from industry best practice, and at times from academic research. The Schwartz's creativity allows them to capture every kilowatt of energy out of their process, reusing their gases and leveraging their assets such as the boilers and cogeneration fans. Their recognition of the need to mitigate their risks, such as the bacterial infection of wastewaters, has inspired the design of systems that keep their neighbors safe from odors and helps allow the no-sludge-removal policy that adds to their brand of sustainability.

The principle lesson learned in this case study is that the tenets of sustainability are truly carried out in the guts of the operations process. Of course, a commitment to the philosophy of the triple bottom line, always working toward economic, environmental, and social success, is key. However, it is the Schwartz's intimate knowledge of and responsibility for all aspects of their chemical process that allows them to make constant improvements to the sustainability of their core business. Their attention to human capital allows them to maximize the use of their assets, their stakeholder relationships, and their profits.