Student-devised process would prep Chinese shale gas for sale

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A team of Rice University students accepted a challenge to turn shale gas produced in China into a range of useful, profitable and environmentally friendly products and did so in a cost-effective manner.

The CHBE Pandas (CHBE stands for chemical and biomolecular engineering) designed a process by which shale gas extracted in the rich Sichuan Basin could be turned into methanol, hydrogen and carbon disulfide, all valuable products in the booming Chinese economy. The Rice team was one of seven groups of students presented similar challenges for locations outside of the United States as their capstone design projects, required of most graduates of Rice's George R. Brown School of Engineering.

For their efforts, the Pandas – Apoorv Bhargava, Prachi Bhawalkar, Valicia Miller, Shelby Reinhardt, Kavita Venkateswar and Erte Xi – were grand prize winners at the Engineering Design Showcase, part of Rice's UnConvention earlier this month.

"We literally got the last one in the hat," Bhargava said of the assignment handed out for their final semester at Rice. "All of the chemical engineering projects were the same, just in different locations, and how we approached the solution depended on the location."

The team had to deal not only with processing what's known as "sour gas" straight out of the wellhead, but also had to come up with a solid budget for the construction and profitable operation of the plant as well as a strategy to protect the environment.

"We think it's a viable project because of what we're transforming the natural gas into," Venkateswar said. The process they designed would take in the raw shale gas produced in the controversial extraction process known as hydraulic fracturing, or fracking. The primary product would be methanol, of which China is the largest user in the world. China blends methanol into gasoline and is developing cars that would run on pure methanol.

The second product, hydrogen, would be a feedstock for ammonia in fertilizer production, which has great value in the Sichuan Basin, the largest agricultural area in China. The third would be carbon disulfide, widely used in the Sichuan textile industry. The team said 99 percent of the recovered fracturing fluid would be purified into water and fed into methanol production. A small amount of crystallized sludge from fracturing chemicals would be sent to a landfill.

Team advisers Kenneth Cox and Richard Strait were inspired to issue the assignment by a Department of Energy-funded 2011 study on shale gas and U.S. national security by Rice's Baker Institute for Public Policy. The report details the rapid development over the last decade of technology to extract natural gas from shale, an increasingly rich resource in the United States, and the resulting shift in the world's energy economy.

"The world of shale gas presents a real interesting situation," said Strait, an adjunct professor of chemical and biomolecular engineering at Rice and former director of coal monetization and CO2 management at KBR. "We're in boom times – if you want to produce gas at what are now historically low prices. You make no profit." He said energy producers are considering ways to turn raw shale gas into products that will better serve the market's needs.

"We tried to give the students problems for which there's no current solution," said Cox, a Rice professor in the practice of chemical and biomolecular engineering. "Major companies are looking at ways to upgrade shale gas, but no one's built a plant to do that yet."

Also, Cox said, "There are a lot of issues associated with the public perception of fracking, and part of the assignment was to help change that perception by offering something that was environmentally friendly, gave benefit to the community, helped clean up the water and was still able to pull a profit at the end of the day."

He said the Pandas' solution was "very imaginative" for their handling of the high concentration of highly toxic hydrogen sulfide found in Sichuan shale gas. "It's 8.38 percent of the incoming feed," said Venkateswar. "Usually natural gas feeds have it on the order of several hundred parts per million."

"The ability to make carbon disulfide provides us a solution to the high hydrogen sulfide content," Xi said.

Building the Pandas' plant with the team's innovative assembly of known technologies would cost the Chinese government $5 billion, Bhargava said. "Chemical engineering design in the real world, the way we understand it, works in three phases," he said. "You start off with a preliminary design analysis, as we did. Then we move into another stage where the chemical engineers meet up with the mechanical engineers and start designing it in more detail: 'What pipes do we need to go from here to there?'

"And then we meet with the architects for the final design stage: 'OK, what is this going to look like when we build it? Is it going to look terrible in someone's backyard?'"

Bhargava said the Pandas designed a process that would generally take as many as 15 engineers six or seven months to accomplish. The team spent long hours using simulation software at Rice's Oshman Engineering Design Kitchen, where the students aligned components and tested for the desired chemical reactions. "But a computer can tell you only so much," Bhargava said. "A chemical engineer has to make the decisions. Our design is very, very close to what a real chemical engineer does in his or her job. We were working in a very realistic setting."

Provided by Rice University

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