INSIDE: COULD ETHANOL FUEL NEXT-GENERATION LOCOMOTIVES?

Ethanol

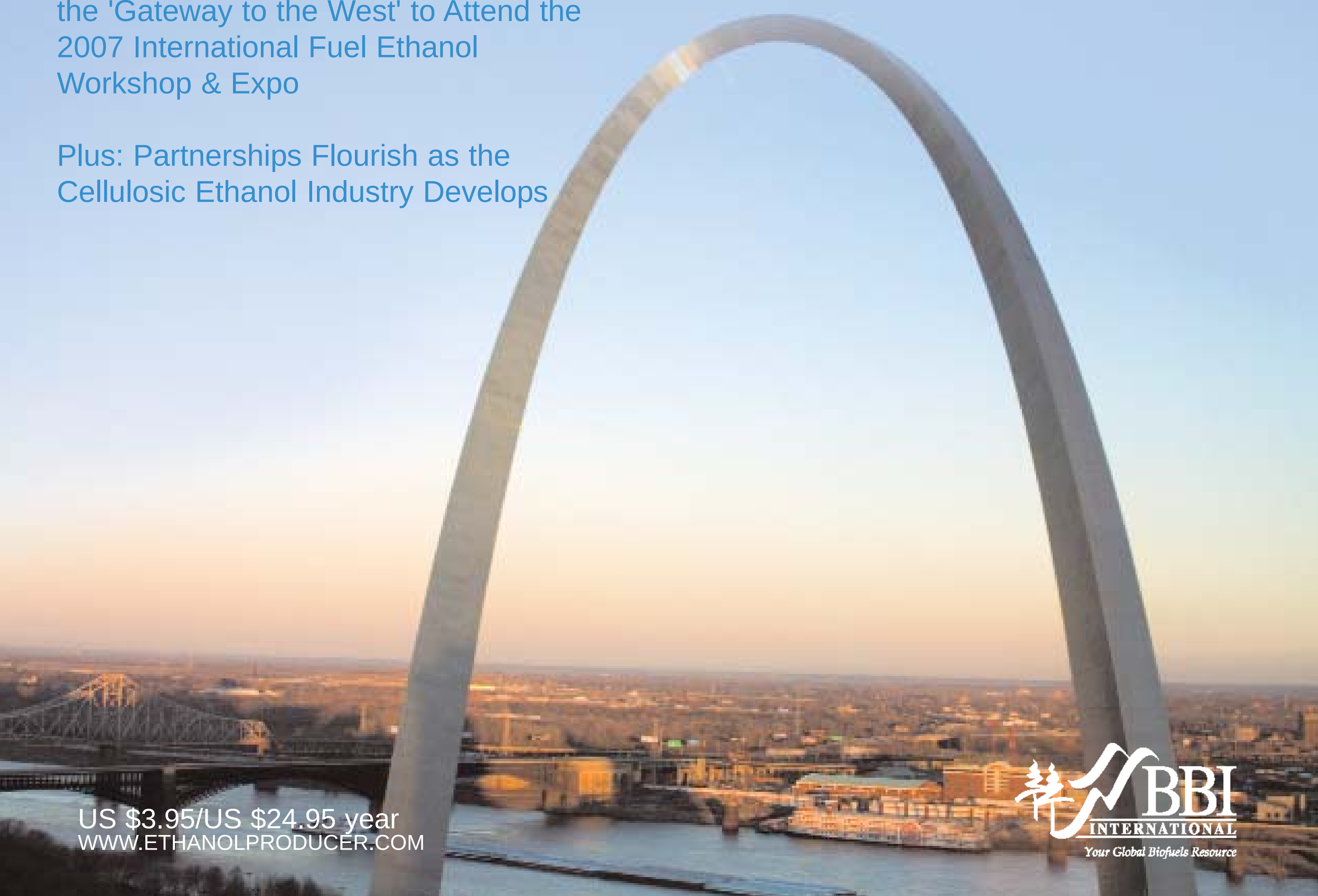
PRODUCER MAGAZINE

Meet Me in

St. Louis

Nearly 5,000 People Will Convene in the 'Gateway to the West' to Attend the 2007 International Fuel Ethanol Workshop & Expo

Plus: Partnerships Flourish as the Cellulosic Ethanol Industry Develops



US $3.95/US $24.95 year
WWW.ETHANOLPRODUCER.COM

BBI INTERNATIONAL
Your Global Biofuels Resource

The New Math: Ethanol Production with Steam from Nuclear Plants

By Samuel Rosenbloom, Charles W. Forsberg and Gregory W. Loest

Areas of technological expertise are logically concentrated in specific industries. The oil and gas industry, for example, is known for its ability to weld pipes efficiently. The water industry has a great deal of expertise in large-scale reverse osmosis. The nuclear industry knows a lot about making steam. Farmers know corn.

Recognizing these areas of expertise—these know-how niches—provides opportunities to meld technologies in synergistic ways. Therefore, it may be reasonable to assume that the nuclear energy industry might be intrigued by ethanol production. Likewise, it would be logical to assume that ethanol producers might be interested in affordable nuclear-plant-derived steam.

U.S. ethanol producers understand corn—and corn procurement—because the industry is so closely tied to the farmers who grow the feedstock. However, when it comes to the heat and steam needed for production, producers are in a less than ideal position. They don't have a lot of leverage when it comes to buying electricity and boiler fuel—typically natural gas, but sometimes coal and even biomass—and those energy costs represent the highest input expense an ethanol plant has outside of buying grain.

Interestingly, the electric utility industry has long been attracted to battery-powered cars. Does this mean the electric utilities care about charging car batteries? Not really. It simply means the electric utilities have been interested in using their commodity as motor fuel to power automobiles. With that in mind, it would be interesting to consider how a nuclear utility might try to take advantage of the growing need for domestically produced transportation fuels by providing the process heat and steam needed to make ethanol.

Whether it's nuclear or coal, what an electric utility company really sells is steam; it just converts it to a more useful form of energy before it delivers it. Thus, it's surprising that the util-

Coal Creek Station in Underwood N.D., is owned and operated by Great River Energy.

Blue Flint Ethanol, a 50 MMgy ethanol plant that recently started production in Underwood, N.D., is powered by electricity and process steam from the Coal Creek Station power plant.

ity industry hasn't taken note of the enormous thermal demand that the ethanol industry has created for steam.

If a nuclear utility was to get involved with ethanol production, it would probably start by locating an ethanol plant near its nuclear steam plant. Historically though, ethanol plants have been located close to the source of the corn feedstock to reduce transportation costs. However, the ethanol industry is growing rapidly, and there may be some evidence to support the notion of a paradigm shift in the process of deciding where to locate new plants. The process of choosing a location may already be experiencing the early signs of change from the geographical source of low-cost feedstock to low-cost energy. This is evidenced by an increasing number of ethanol plants locating next to large power plants to obtain lower-cost steam. For instance, the newest 50 MMgy ethanol producer Blue Flint Ethanol chose to locate next to the lignite-fired Coal Creek Station, a power plant in Underwood, N.D. Great River Energy owns Coal Creek Station and has less than controlling interest in Blue Flint Ethanol. Controlling interest in Blue Flint Ethanol is owned by Headwaters Inc. Two other new ethanol facilities, both 100 MMgy in size, are also being located next to either major power utilities or large steam generators.

Steam from Nuclear Plants

The question is, would it make economic sense, hypothetically speaking, for a nuclear utility to sell steam to a colocated ethanol plant at its boundary?

To start, how does one calculate the cost of the nuclear steam? The price of nuclear plant steam can be estimated from the price of electricity. A nuclear power plant produces steam that can be sold or used to produce electricity. The utility will demand at least the same revenue from the sale of steam as the sale of electricity. An example can clarify this logic: The price of electricity varies across the country, so it would be acceptable to use the recent average market price for wholesale electricity in Minnesota—$53.89 per megawatt hour of electricity (MWhr(e)). Minnesota serves as a good example because it is a major producer of ethanol and has nuclear reactors in the communities of Monticello and Prairie Island. The efficiency of nuclear power plants is approximately 33 percent. In other words, if one less Btu of electricity is produced, three Btus of steam become available. However, nuclear reactors produce high-temperature steam, and ethanol plants require only relatively low-temperature steam. In converting high-temperature steam to electricity, 40 percent of the electricity is obtained by the time the steam pressure is 150 pounds per square inch (suitable for

$53.89/MWhr(e) x 0.33 x 0.6 =
$10.67/MWhr(steam) =
$3.13 per million Btu

ethanol production) with the remaining 60 percent of the electricity produced in the low-pressure turbines. Using this information, a rough estimate can be made of the corresponding price of steam from a nuclear plant given the price of electricity.

This is less than half the price of natural gas. The price of electricity is lower at night than during the day. If some of the steam demand (such as for byproduct drying) can be shifted to the nighttime, steam costs may be one-half or one-third as much. This may be unrealistic because changing to a non-steady-state design could introduce inefficiencies greater than the potential energy savings. Nevertheless, the various design issues may be worth considering. The cost of energy is only in the range of 20 percent of the cost of corn, so it would be difficult to make up the increased cost of getting corn to the plant by lowering the energy costs. However, it does appear to be attainable, and that could be part of the reason for our paradigm shift. Many large ethanol plants coming on line will have transportation costs anyway, and in periods of peak natural gas prices, the breakeven point may have already been crossed.

Regional Production

Nuclear plants are large and produce from 1,500 to 3,500 megawatts (MW) of steam compared with the 120 MW requirements of a typical 100 MMgy dry-grind ethanol plant. The large size of a nuclear plant is intriguing, especially, in contrast to the past where we have seen mostly decentralized farmer-owned ethanol production.

Some ethanol facilities that are currently planned and under construction are more centralized with some feedstock being transported reasonably large distances. An interesting question is whether it might be economically feasible to build even more centralized or regional production facilities. Since 60 percent of the electrical output of a nuclear utility is produced by its low-pressure turbines, it would be interesting to see how a utility might operate if its entire low-pressure steam capacity was used for ethanol production. This represents enough thermal capacity to run up to 15 100 MMgy ethanol facilities—or one colossal 1.5 billion-gallon-per-year plant.

The logistics of this operation would imply a significant learning curve. The biggest hurdle would be the costs of transporting corn, and the shipment of massive amounts of distillers grains and ethanol to customers. Since there are no ethanol pipelines at this time, removal of the ethanol alone would require about 141 railcars per day. The distillers grains would require about 145 railcars per day. By current standards, the size would be enormous.

Assuming such a plant did exist, the nuclear utility serving it would continue to run a high-pressure turbine for a typical output of 400 MW of electricity. Since all the corn feedstock would be railed in, the corn-to-the-door price would be higher. Therefore, we would site this facility where the transportation costs are the lowest in the country: along the Mississippi River.

Could such a plant be economical? A bushel of corn produces about 2.7 gallons of anhydrous ethanol. Transportation costs from the Midwest to Louisiana are about 40 cents a bushel. Therefore, the transportation premium equals about 15 cents per gallon. Currently, it takes about 0.034 MMBtus of natural gas and about 0.75 kilowatt hours (KWhrs) of electricity to make a gallon of ethanol. To make up the 15 cents on thermal energy alone, we would have to lower the cost by $5 since:

0.030 MMBtu x $5 (savings)/MMBtu
= $ 0.15 savings

Therefore, if the price of an MMBtu of natural gas was $8.13, a nuclear utility could sell the same MMBtu at $3.13, and the costs would be break even. The utility could sell this steam at the same rate it currently receives without the concern for generating and transmitting electricity. This calculation is conservative for several reasons:

1. The U.S. DOE is developing its next generation of nuclear reactors. These reactors, called "high-temperature gas-cooled reactors" (HTGRs) operate at much higher temperatures than current nuclear facilities. The coolant temperatures are much higher, and for reasons of thermodynamics outside the scope of this article, the $3.13 would be closer to $2.13 for an advanced reactor of this type. The DOE plans to build one of these reactors at its Idaho laboratory with the budgeted mandate that it coproduce hydrogen for industrial uses (refining) and as a future transportation fuel. The reactor in Idaho is a demonstration with the purpose of making the technology available to the industry wherever needed. These are modular reactors that would be smaller in size than current reactors. This may simplify colocating future nuclear facilities with ethanol plants.
2. There are significant economies of scale associated with ethanol plants.
3. If some of the steam demand (such as for byproduct drying) can be shifted to off-peak periods, the steam costs may be lower.
4. An ethanol producer (or any industrial facility for that matter) that purchases over $200 million of a utility's output per year would be able to negotiate a better electricity rate. Remember, the highlighted calculation is based on breaking even on thermal energy alone.

Alternatively, there are various possible joint-ownership options.

5. The calculation assumes that we are trying to break even with a typical plant that has no transportation premium, and we know this is not the case. However, trying to estimate the transportation premium for ethanol plants currently being planned is probably more of a moving target. This point is illustrated by a recent article in the *Washington Post* which asserted that as early as 2008, Iowa would become a net corn importer to support its ethanol industry.
6. A low transportation cost to an ethanol plant also implies low transportation costs from the plant. Such plant siting would allow the low-cost transport of ethanol by barge to half the United States, and low-cost export of the expanding overseas market for distillers grains. Because the barge infrastructure (locks, navigation aids, etc.) is owned by the government, it is a highly competitive industry that minimizes transport costs.
7. Steam from a nuclear plant for ethanol production would lower the carbon dioxide emissions associated with each gallon because nuclear power doesn't involve combustion. The future potential for taxes on greenhouse gases or a cap-and-trade system indicates added economic incentives to use steam from a nuclear plant. Therefore, although speculative, it wouldn't be surprising to expect and receive a 15-cent-per-gallon tax credit for each gallon so cleanly produced.

According to one industry expert, as ethanol production facilities grow and a larger percentage of corn needs to be transported by rail, the transportation premium we have hypothesized may actually turn out to be a savings rather than a cost. In conclusion, nuclear energy with lower unit costs could provide the energy for a typical-size ethanol plant, or coupled with competitive barge transportation, it could provide a sound, economically advantageous basis for regional ethanol production. In the late 1700s, American farmers in Ohio and Western Pennsylvania converted their corn to whiskey and shipped it down the Mississippi River to the world. Three centuries haven't changed the fact that transportation is an important component for the sale of corn products.

Samuel Rosenbloom is a nuclear engineer with the U.S. DOE in Washington, D.C. He can be reached at samuel.rosenbloom@eh.doe.gov, (301) 903-5749. Charles W. Forsberg is a corporate fellow with Oak Ridge National Laboratory. Reach him at forsbergcw@ornl.gov or (865) 574-6783; or by fax at (865) 574-0382. Gregory W. Loest is director of technology integration at ICM Inc. in Colwich, Kan. Reach him at greg1@icminc.comor or (316) 977-6189.