BY SHERRY STOKES

The Energy-Environment Connection

"I would argue that over the last 25 to 30 years, the major driving force in issues related to energy technology has been concerns about the environmental impacts of energy production and use," states Edward Rubin, a leading figure in energy and environmental research at Carnegie Mellon."As we look ahead, the connection between energy use and global climate change is arguably the biggest challenge facing us."

Americans today hear a lot about energy issues: fuel-efficient cars, alternative fuels, and the rise and fall of oil prices — all are fodder for the evening news. Yet as Rubin explains, until about 30 years ago, "the word 'energy' didn't grab people's attention." Prior to the '70s, energy was cheap and plentiful, and people assumed it would stay that way. What made energy an attention-getter was the 1973 Arab Oil embargo, when OPEC, for political reasons, restricted its oil exports to the U.S. The result was shortages and long lines at the gas pumps. "Suddenly energy became a major issue," says Rubin, explaining, "energy became synonymous with oil, specifically with gasoline and transportation fuels." By the mid-1980s, world oil prices had fallen and supplies were again plentiful. In the 1990s, Americans went on an oil binge buying gas-guzzling SUVs. "Now the circle has come full turn," Rubin says, "because today the security of our energy supplies is again a prominent issue." Today there are renewed concerns about oil supply disruptions in the Mid East due to the war in Iraq; however, Rubin says that another new factor is growing demand for oil in emerging economies like China and India. All these factors affect the price of energy and the math is easy: when the supply is tight and the demand is great, the price goes up.

The tug on our purse strings also has broader financial implications. "We are importing more oil now than we were 30 years ago, which means more U.S. dollars are leaving the country to pay for that oil," says Rubin. "This hurts our balance of payments since we're pumping more dollars out than we're taking in. If we want to break our addiction to oil we need to use energy more efficiently and develop new domestic sources like biofuels."

The use of energy is intertwined not only with economics and national security, but with the environment as well. Securing our economy is necessary for our well-being, but so is protecting our health and the vitality of our environment. "In the 1970s, with passage of the Clean Air Act, air pollution and the environment became a front-burner national issue," says Rubin. Power plants, factories and cars were emitting pollutants, such as sulfur dioxide, particulate matter, and nitrogen oxides, and thus, the environmental issues that gained prominence were directly related to humankind's use of energy. Not only oil was the culprit, but also the burning of coal, which is used to generate more than half the country's electricity. Eventually new environmental laws led to sustained efforts to use energy more cleanly, particularly for power generation and transportation. In addition, because energy had become more expensive, conserving energy and using it more efficiently became a research thrust. Rubin says, "If you went to sleep in 1970 and woke up today you'd see radical changes in new technologies for transportation and electric power generation. There have been major innovations to control not just air pollutants, but also water pollutants and solid wastes. But the 800-pound gorilla remaining today is carbon dioxide emissions — the major greenhouse gas linked to global warming. This is our next and biggest hurdle since most of the world's energy comes from fuels that emit CO_2."

"Another characteristic of how energy and environmental issues have evolved is that they have become geographically more encompassing," says Rubin. Unlike air pollution concerns of the '70s which mainly affected health at a city-wide scale, the problems of smog and acid rain in the '80s affected much larger regions, predominantly the Eastern United States. Now, climate change is a truly a global problem, and how we will tackle this problem remains to be seen. Rubin, however, remains optimistic. "We already have a lot of the technology and know-how to address this problem," he states, "and with sustained research and development the cost of controlling greenhouse gas emissions will continue to decline. What's needed now is the will to move ahead."

You Can't Have Ethanol Without Infrastructure

If you want to talk to Scott Matthews about alternative fuels, then you better be ready to discuss infrastructure. Matthews, a professor in CivE and EPP, says, "While these sound like two different problems, they are one and the same."

"For a long time, people have suggested a litany of alternative fuels and solutions — ethanol, hydrogen, hybrid cars," states Matthews, "but what the essential issue becomes is that it is very hard to do an engineering assessment of an alternative fuel and compare it to existing petroleum-based fuels for vehicles, and have the alternatives look better." Here's why. For more than 100 years, we in the United States have been developing infrastructure to collect, refine and distribute petroleum. "Everything has become optimized to be cheap and effective," states Matthews, "It's hard for new emerging alternative fuels to compete."

Yet, the young professor is compelled to drill out a plan that would give alternative fuels, ethanol to be specific, a foothold. "We are dependent on foreign oil sources, which leads to social and economic problems. Then there is climate change and CO_2 issues. We are continually bombarded with reasons why we should break the oil habit," explains Matthews. He, along with Chris Hendrickson and Jeremy Michalek from CIT, Lester Lave from EPP/Tepper and Michael Griffin from Tepper, received $1.5 million dollars from the National Science Foundation to systematically research the economic, environmental and social issues associated with alternative fuels. As Matthews explains they are not just studying the fuels but "the infrastructure we'd need to get the fuels to us."

So What About Ethanol?

Emerging fuels, like technologies, have their problems — some are environmental, others are infrastructure problems, and ethanol is no exception. When we look at ethanol, it has been used as a gas blend for a long time, and is present in almost all gas sold in the States. "Most of the ethanol we use is from corn, which the last time I checked was a food. We are growing corn not to eat but to make fuel, and that's not an efficient way to make fuel. If you want to make ethanol, there are better ways to do it, and switchgrass is one of those ways," says Matthews.

"Switchgrass is a perennial grass. It's a tall, single stalk — it's just a big thick piece of grass. You harvest it and process it much like hay. That's it," says Matthews, adding, "We could easily replace 15% of our gasoline consumption with switchgrass-based ethanol. The problem is that we don't have good ways of getting the ethanol around as of yet."

Ethanol can't be shipped in existing pipelines because "petroleum is dirty, and it leaves water on the bottom of pipelines dirty. The ethanol would soak up the dirty water in the pipes. When the ethanol got to the other end, it would be dirty, and you'd have to clean it and that would be expensive," says Matthews. Another means for transporting ethanol would be by rail or truck, but to deliver enough ethanol to fuel America's cars, we'd have to add 5% to 10% more trucks to our highways. That would be inefficient, too. Of course, the ethanol industry could build new pipelines, but that would be expensive and time-intensive, and what would we do with all of the empty petroleum pipelines? Producing ethanol is easy, but distributing it is an entirely different matter. "We need to look for a solution that optimizes the use of current infrastructure, minimizes the investment in new infrastructure and doesn't lock the country into a single technology path," says Matthews.

ENERGY RESEARCH AT CIT

In this issue of ENGINEERING we set out to provide a comprehensive look at the energy research going on within the College. When we started talking to the faculty and reading their articles and proposals, we realized nearly every department in the College is involved in energy-related research. Our professors and students are working on everything from bio fuels and fuel cells to CO_2 sequestration and wind-generated electricity. In short, there is far more energy work occurring in CIT than we can possibly cover in one issue of our magazine. However, considering that attaining reliable energy while protecting our environment and economic well-being is one of our society's most pressing challenges, in future issues of ENGINEERING and on our Web site (**www.cit.cmu.edu**) we will keep you apprised on the energy-focused innovations that we're working on.

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Just Enough Ethanol to Be Dangerous

Transporting ethanol nationwide isn't feasible, but it is possible to provide a specific region, say Iowa and portions of neighboring states with ethanol. Switchgrass could be grown, processed into ethanol, and transported locally. Flexible-fueled cars that run on gas or ethanol would be available, too. (According to Matthews, the major U.S. automakers sell a limited number of flexible-fueled cars here in the United States, however, they have been selling them in large quantities in Brazil for many years.) "People could get ethanol cheaper than we could get gas. But here's the point: When people talk about how sensitive gas prices are, they are talking about a couple of percentage points. If we could actually conserve 1% or 2% of our gasoline use, this would make a big difference at the pump. That's all you need to do to control gas prices," says Matthews adding, "You do just enough ethanol to be dangerous. And you get rid of all those infrastructure problems."

So, where are we with regional ethanol production and use? According to Matthews, the upper Midwest, Minnesota in particular, is leading the charge. There, companies are producing their own ethanol and blending 10% of it into their gasoline, which regular cars can burn. "It's once you get higher blends, 20%-85% that you need other [flex-fueled] cars or relatively cheap modifications to current cars," says Matthews.

If region-specific ethanol use is to become viable, Matthews believes that the states must jump in, like Minnesota. "It's a win-win, because you in a small way help manage petroleum demand in your state, and offset it with state production of biomass and ethanol," says Matthews. He explains that once states make ethanol 10% of the fuel they sell, they could then produce a compelling argument to car manufacturers to sell more flex-fueled cars in their state.

What we have right now "is a bit of the chicken and egg problem," says Matthews. At present, less than 1% of the gas stations in the U.S. sell E85 (a blend of 15% gasoline and 85% ethanol). "Putting more FFVs [flexible-fueled cars] on the road will only help if you sell them in areas where you can actually buy E85," he says, adding that the present situation is this: "Our efforts to date in expanding ethanol haven't kept up with our overall demand." We can make ethanol, develop new distribution networks and modify cars to run on it, but it will take public demand and the concerted efforts of regional policy makers for ethanol usage to become common in the United States.