Energy Studies

Volume 16 Number 3
January/February 1991

Newsletter of the Center for Energy Studies of The University of Texas at Austin

Energy Studies reports on activities of the Center for Energy Studies and other energy-related news from The University of Texas at Austin. Subscription is free upon request (six issues a year). ISSN: 0743-829X.

The Center for Energy Studies is a multidisciplinary research center, the central liaison for energy research, education, and public service at The University of Texas at Austin. Dr. John R. Howell is director.

Editor: Jennifer Evans

Center to develop models of utilities for Texas PUC

The Public Utility Commission of Texas (PUC) and the UT Center for Energy Studies have started a joint venture aimed at enhancing the quality of electric utility regulation in Texas.

In the project, center researchers will adapt computer models for the commission staff to use in electric utility cases and will provide related technical support.


Steven P. Nichols (left) and Jay Zarnikau

According to James L. Crouch, executive director of the PUC, the collaboration will allow the PUC to tap the expertise of The University of Texas at Austin. "We hope to get some very, very qualified people. . . . The PUC's mission is to regulate the utilities because competition doesn't. [Electric utilities are monopolies.] . . . We need all the help we can get."

The PUC Electric Division currently lacks many of the computer modeling capabilities of the utilities that it regulates.

"The Texas PUC has an extremely dedicated and talented staff, yet the Electric Division's computer resources are currently inadequate," said Jay Zarnikau, the agency's former director of electric utility regulation.

"Computer models are needed to analyze the utilities' requests to change rates, build new plants, and build new transmission lines. The lack of state-of-the-art computer models often places the PUC's engineers and economists at a disadvantage relative to the state's utilities." Dr. Zarnikau left the PUC in February to join the center as manager of the new project.

The job of regulating electric utilities is a big one in the Lone Star State. Texas produces and consumes more electricity than any other state. The PUC, assisted by an Electric Division staff of 55, currently regulates 107 electric utilities.

Dr. Zarnikau said the number of electric utility cases and their complexity are both increasing dramatically. The chief activity of the Electric Division is to prepare written testimonies for PUC hearings. The number of testimonies has doubled in the past two years to more than 200.

"Public service is an important part of the center's mission," said Steven P. Nichols, principal investigator on the project and deputy director of the

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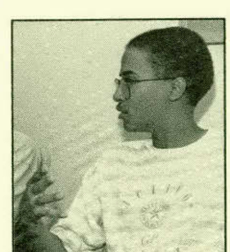

Undergraduates talk about energy research—
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Jason Garel

center. "One of our goals is to do more to support state agencies like the PUC." He said he hopes that faculty and staff from other universities can become involved in future PUC research, including UT Arlington, Texas A&M University, UT El Paso, University of Houston, Texas Tech University, and Baylor University.

Research may also be carried out for PUCs in other states and for other state and federal agencies. Dr. Nichols said the effort has the potential to stimulate academic interest, research, and course offerings in regulation and utility modeling.

In the first year of the program, four IBM PC models, generally based on existing models, will be developed.

- *Resource planning* models will be implemented to explore the need for additional generating capacity; the type and timing of capacity required; and whether conservation, load management, cogeneration, or purchased power might displace the need for new plants
- *Existing production costing* models will be analyzed to assist the PUC in selecting a model that can efficiently model a utility's operations and costs, given the PUC's time and resource constraints
- *Transmission load flow* software will be provided and adapted to help determine the need for new transmission lines in Texas
- *Building energy performance* software will be implemented that will permit the PUC staff to better analyze utility-sponsored conservation programs

The researchers will train PUC staff to use the models and provide technical and analytical support.■

Spot-pricing of electricity

Sending truer price signals to consumers

The following article on a new electricity rate system, spot pricing, is adapted from an article to appear in the winter 1990 issue of Forum for Applied Research on Public Policy. *The authors are Jay Zarnikau, former director of electric utility regulation at the Public Utility Commission (PUC) of Texas; Martin L. Baughman, professor of electrical and computer engineering at UT Austin and head of the Energy Systems Program; and George Mentrup, assistant manager of rate design at the PUC.*

In an electric utility, costs change continuously as different generating units are placed on line and operated at different levels, and as nonutility cogeneration resources are made available. The costs of meeting an extra increment of demand may vary geographically within the service region as well.

While marginal costs change almost continuously, electricity prices change infrequently. Most electricity consumers face prices that remain constant for months or even years, regardless of how the utility's costs fluctuate.

At least 13 US utilities and several European suppliers have demonstrated that hourly pricing of electricity is feasible. Bulk power brokerage systems and cogeneration buy-back rates also have successfully based hourly prices on hourly marginal cost estimates.

One new rate-making proposal, spot-market pricing (also know as real-time or flexible pricing), has utilities posting electricity prices that change regularly to reflect both marginal operating costs and the costs of constraints on generation or transmission capacity. The features that make spot pricing attractive are that it provides price signals

- to consumers to encourage consumption consistent with the short-run costs of providing that electricity at the time, and
- to producers to expand or contract their production with the value that consumers place on the product at the time

These powerful properties are not present in any traditional pricing systems.

Electricity prices established according to spot-market principles assure a short-run market equilibrium, i.e., a price and level of consumption that satisfy the conditions of a competitive market equilibrium. The prices will reflect the marginal operating cost of producing electricity and include, when appropriate, a curtailment premium and/or transmission congestion charge. Price signals can alert regulators, managers, and engineers as to when, where, and what type of system expansion is most valuable to consumers.

If spot prices are the basis for payments to third-party generators of electricity, such as industrial cogenerators and independent power producers, these producers have incentive to adjust their output levels according to their cost patterns and profit motives. This arrangement assures the most economical generation is used to supply electricity, regardless of ownership.

Spot prices will promote electricity consumption, but only at times when it is economical to consume more. Many utilities currently own excess production capacity. Short-run spot prices will encourage the most efficient consumption responses to existing capacity.

From the utility's perspective, real-time pricing encourages consumers to conserve more during peak periods, when utility costs are higher, and shift consumption to lower cost, "valley" periods of demand. Reductions or slower growth in peak demand might permit the utility to defer new plant construction. The need for conservation or marketing programs could be reduced, and, at least in theory, the utility's overall costs could be lowered.

Real-time pricing will allow some consumers to lower their utility bills, particularly if they can be flexible in their consumption patterns. For example, an industrial plant could review price quotes and schedule production for the next day to minimize costs. A cogenerator could purchase electricity when the price was lower than the costs of operating its own generating equipment. A residential customer might run the dishwasher at low-demand times. (Continued)

Spot prices need to be electronically transmitted, decoded, and displayed for consumers. Cable television, telephone lines, power transmission lines, and radio signals have all been tested or suggested. Decoders, readouts, fax machines, or "smart homes" technology might accompany some of these media.

Logic devices could be installed to read the quote and automatically turn off certain appliances when the price is above a selected level. Storage devices could be installed to take advantage of the low-cost electricity in off-peak hours. Many new opportunities to reduce electricity costs would become available.

Much of the existing metering equipment also will need to be upgraded to track consumption on at least an hourly basis. Widespread installation of such communications and metering hardware could involve considerable cost.

Electricity suppliers are regulated monopolies. Thus the revenue earned under spot prices must be reconciled with the constraints placed on a utility's overall prices. With spot prices, one would not expect the overall revenue earned to automatically equal what would have been earned under conventional cost-of-service pricing. Raising or lowering the overall level of spot prices may be necessary to avoid rates of return that are too low or too high.

The amount of the curtailment or congestion premium must take into account how customers and customer classes vary in their responsiveness to price changes. More detailed and accurate information is needed about consumer price responsiveness.

Critics of spot-market pricing claim that spot pricing will undermine utilities' obligation to serve and shortages of electricity will be inevitable. This argument is without basis. The result of spot pricing in times of tight supply will be higher electricity prices, resulting in an optimal distribution of the tight supply.

There remain several practical considerations that must be successfully addressed for spot pricing to succeed. Considerable opportunities exist, however, for a more efficient electric power industry through spot pricing.■

CES Update

Office of Director

Two textbooks by John R. Howell, center director, will soon be out in new editions. *Thermal Radiation Heat Transfer*, one of the most widely used graduate texts on radiative heat transfer, will be released in summer 1991 in its third edition by Hemisphere Publishing (coauthor Robert Seigel). *Fundamentals of Engineering Thermodynamics* appears later in 1991 in its second edition, from McGraw-Hill (coauthor Richard Buckius).

Building Energy Systems

In the cold climate of Minneapolis, winter heat loss through windows can be substantial. Summer heat gain through windows, though not as large, is significant as well because it increases air-conditioning loads. Many indoor and outdoor shading devices are sold to reduce these energy costs.

In a study of fourteen shading devices on typical Minneapolis buildings, researchers led by Bruce D. Hunn, head of the Building Energy Systems Program, found that in Minnesota's climate, high-

(Continued)

Window shading devices: How much do they save in Minnesota?

Home	*$/yr saved*	*%*
1. High-performance glazing	58	5.3
2. Roller shade	40-54	3.5–4.2
3. Solar screen (summer only)	37–45	2.4–4.0
4. Awning (summer only)	30–41	2.5–3.6
5. Drape/curtain	34	3.0
6. Blinds	31	2.8
7. Low-emissivity glazing	31	2.8
8. Low emissivity glazing with reflective coating	27	2.4
9. Reflective film	14	1.3
10. Overhang	4–6	0.3–0.5
11. Solar screen (year-round)	2	0.1
12. Awning (year-round)	-10	-1.0

Small office	*$/yr saved*	*%*
1. High-performance glazing with reflective coating	1,349–2,589	5.3–9.8
2. Solar screen (summer only)	1,262–1,376	4.9–5.2
3. Solar screen (year-round)	874	3.4
4. Reflective glass	807–822	3.1–3.2
5. Reflective film	773	3.0
6. Blinds	543–601	2.1–2.3
7. Drape/curtain	510	2.0
8. Low-emissivity glazing	405	1.6
9. Overhang with side fins	379–395	1.5
10. Tinted glass	318	1.2

High-rise office	*$/yr saved*	*%*
1. High-performance glazing with reflective coating	9,967–13,455	4.6–6.8
2. Solar screen (year-round)	7,563–11,505	3.5–5.8
3. Reflective glass	5,208–9,160	2.4–4.6
4. Reflective film	5,046	2.3
5. Low-emissivity glazing	3,828	1.8
6. Overhang with side fins	3,524–5,405	1.6–2.7
7. Blinds	2,869–3,495	1.3–1.8
8. 2-ft overhang	2,665	1.2
9. Drape/curtain	2,274	1.1

performance glazing is generally the most effective window device for saving energy (see table). High-performance glazing is a type of glass that acts as a "heat mirror" and traps heat inside, acting more as an insulating than a shading device.

A window combining high-performance glazing with a reflective coating can significantly reduce energy costs and peak electric demand in commercial buildings, the study found.

The researchers performed detailed hourly computer simulations over a one-year climate cycle. Cost savings were calculated by simulating a prototypical building with standard double-glazed windows and comparing its energy performance with and without each shading device. The buildings studied were three homes, a school, a small office building, and a ten-story office building. Not all devices were simulated for all buildings. The savings were found to be generally higher for older buildings than newer ones.

The outside overhangs and awnings, if left in place year-round, actually increased rather than decreased the Minneapolis homes' energy bills.

For the prototypical school building, no window shading device was found that lowered energy costs significantly.

Dr. Hunn said that shading devices are best at lowering energy costs in the summer and can reduce a Minneapolis home's summer cooling load by 30 percent. When the entire year's energy costs are considered, however, that savings drops to only about 4 percent of the annual bill.

The study did not examine the costs of installing and operating the shading devices nor the effectiveness of two or more devices in combination. The cost of a shading device is a major factor in the investment decision. Esthetics and comfort affect the choice also.

In homes, the solar screens and awnings each reduced the summer peak demand for electricity by up to 20 percent. The solar screen reduced the summer peak by as much as 12 percent in small offices and 9 percent in high-rise offices. None of the devices had much effect on the winter peak.

In the nonresidential buildings, generally 2–3 percent more savings than shown in the table can be achieved when the heating and air-conditioning system can be downsized slightly to take advantage of the reduced demand. Downsizing is appropriate for a building in the design stage, but is not practical for an existing building being retrofitted.

The study was sponsored by Northern States Power Company. Other participants in the study are Jerold W. Jones, mechanical engineering professor; Maureen M. Grasso, associate professor of human ecology; James D. Hitzfelder, research engineering associate; and student Jo Jo Wong.

■

A set of IBM PC algorithms for the design of **ice-on-coil ice storage** systems has been developed by Building Energy Systems researchers and is available for $18.

Ice storage is a method of cooling a building during the day by use of ice accumulated off-peak during the night when electricity is less expensive. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) funded the study that developed a mainframe version of the software, called CBS/ICE.

With the PC version, the user is required to assemble the component algorithms into a system and to supply weather and load profile data. A more user-friendly design program for the PC, called ICICLE, is expected to be available in spring 1992. ICICLE will feature economic optimization routines, component libraries of design and cost data, input menus, output reports and graphs, and sizing routines.

The mainframe version is part of the building energy analysis program, DOE 2.1D, of the US Department of Energy.

Those who developed CBS/ICE are Jerold W. Jones, mechanical engineering professor; Martin L. Baughman, electrical and computer engineering professor; Bruce D. Hunn, head of the Building Energy Systems Program; researcher James Hitzfelder; former researcher Scott Silver; and engineering graduate students Leszek M. Kasprowicz and Abraham Jacob. Mr. Kasprowicz is the primary developer of the ICICLE program.

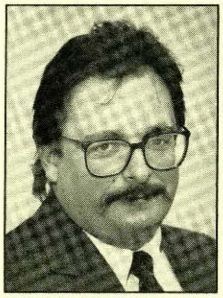
To order a copy of the CBS/ICE software for the PC and its user's guide, contact Alice Wilson (512/471-7792), Center for Energy Studies, 10100 Burnet Road, Austin, Texas 78758.

Process Energetics

Philip S. Schmidt, head of the Process Energetics Program, has been appointed to the Donald J. Douglass Centennial Professorship in Engineering.

Separations

José Luis Bravo, manager of the Separations Research Program, will leave the center January 15 to pursue a career in industry.



José Luis Bravo

"He has done a terrific job," said James R. Fair, head of the program. "He's been a key person in organizing the Balcones experimental program, and he's been active in recruitment of new member companies, as well as a focal point of contact for sponsors."

Mr. Bravo said, "It's been a great seven years." He will remain associated with the Separations Research Program, he said, and will serve as one of the instructors in the UT short course on separations led by Dr. Fair February 4–8.

Dr. Fair said he is actively considering replacement candidates.

■

Imagine a 1-ft pipe with perforated covers on each end. Imagine pushing a fistful of straight, hollow spaghetti noodles through the perforations in the covers, making a tight seal. What this device will allow you to do is flow one liquid through the hollow spaghetti and another liquid in the opposite direction within the pipe between and around the spaghetti. And if your spaghetti strands are 240 microns across—smaller than a human hair—with even smaller pores,
(Continued on page 8)

Six of the center's undergraduate research assistants discuss the pitfalls and rewards of research.

Undergraduates in the lab

Does energy research experience turn young students' minds toward graduate school?

Undergraduate students are a growing part of the workforce of the Center for Energy Studies. Twenty worked on center research in 1989–90.

One reason to increase undergraduates' exposure to research is to increase their chances of going on to graduate school, according to John R. Howell, director of the center. National Science Board statistics show that the enrollment of US students in graduate engineering programs has been declining since 1986. Bringing young students onto the research teams led by faculty members is one strategy to interest them in graduate study and reverse that trend.

Six of the center's undergraduate research assistants discussed with Dr. Howell and Energy Studies *editor Jennifer Evans their experiences and impressions of research. Without exception the students said they had become more interested in graduate school (one had already applied) because of their exposure to research—even despite the fact that fellow students graduating with bachelor's degrees "were going out to $40,000-a-year jobs."*

EVANS: How has research been different from what you expected?

SANDHU: What I found out was that it takes a lot of time to do research. We have projects that go on and on endlessly. Graduate school looks a lot easier than undergraduate [other students laugh] because you don't have to meet so many deadlines.

EVANS: What do you like about participating in research?

HO: I like being able to actually apply what I learned in class. This semester I had to work with thermocouples and know their time response and the different types. It was really neat to say, "Oh, wow, I just learned this in class." It was neat to see how the things in books can actually apply in real situations.

GAREL: Most of the stuff I'm doing now, I haven't even learned about in class, so I have a little bit of a jump on people.

GONZALEZ: I like the idea that you get to work on what *you* like. You get to learn more about what you're really interested in. Ideas aren't being pushed on you. Being involved in research is more independent than taking undergraduate courses.

EVANS: You went into combustion, something very interesting to you.

GONZALEZ: Right. Especially the project that I was working on, the experimental engine.

SANDHU: When you start out as an undergraduate research assistant, you don't in most cases deal directly with the professor. You might get put under a graduate student.

EVANS: Is that true for you all? [All but one say they are working directly with a professor.] But it can happen.

SANDHU: Once in a while you can get, in a way, abused. The graduate students extract a lot of work that they are supposed to do.

EVANS: You're sometimes doing the work that the graduate student does not want to do?

SANDHU: Right. This is usually the case when you start off. Later on the professor feels more comfortable with you and gives you better projects to do and more independence.

(Continued)

The students

Carl Faulkner, electrical engineering senior from Little Rock, Arkansas. Research area: industrial heating and drying

Jason Garel, mechanical engineering sophomore from Houston, Texas. Research area: combustion

Oscar Gonzalez, mechanical engineering senior from Cotulla, Texas. Research area: combustion

Gloria Ho, mechanical engineering senior from Orange, Texas. Research area: heat transfer in porous ceramics

K.D. Sandhu, chemical engineering junior from India. Research area: acid gas treatment

Darrell Seibert, civil engineering junior from Houston, Texas. Research area: Desulfurization of flue gas

When I started out as a sophomore, I did feel I was someone there just to do the odd job.

FAULKNER: You're cheap labor. Where I used to work, when they needed to load a truck, the undergraduates got herded up.

EVANS: Driving over here, I heard you say that this job [as an undergraduate research assistant] is more appealing to you than a job totally unrelated to engineering.

FAULKNER: Definitely. The only thing that's been really frustrating to me is when I've had deadlines in research *and* in class.

EVANS: Does working in research interfere with getting your academic work done?

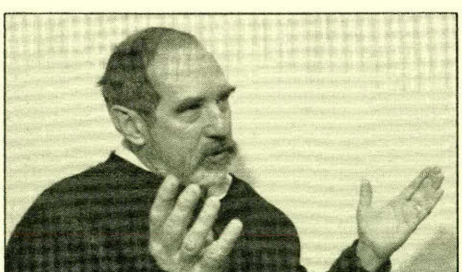
SANDHU: It is certainly a disadvantage, to a certain extent, as compared to your classmates. You cannot devote as much time as they can. No matter how related your research is to the classwork you're doing, it doesn't do your homework for you [laughter].

HOWELL: But is that any worse than putting the same amount of time in at McDonald's, for example?

SANDHU: It's much better.

FAULKNER: In undergraduate research, you get an idea of how to start out on your own. I know that will help me as a graduate student. I know that has helped in Senior Lab.

SEIBERT: The best part right now is



John R. Howell

that I can come in and say, "I have a test today. I can't come in this afternoon, but can I come in tomorrow?" So far there haven't been many deadlines. I need a little bit of guidance before I get started, but then the graduate student totally leaves me alone, and I get a lot of confidence when I can do something and bring back the results and say, "Is this what you were looking for?" and get the smile from seeing a perfect line, a perfect correlation. It really boosts my ego.

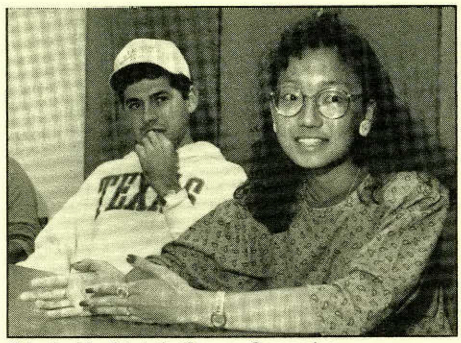
EVANS: Oscar, you've been a coop student working for large companies, doing engineering rather than R&D.

GONZALEZ: Right, doing number-crunching, routine calculations.

HO: I found it to be tedious work. I summer-interned and saw the jobs people do every single day. When I look at my research work, I think, "Oh, this is a lot better." You can think on your own.

EVANS: It's more diverse.

HO: Right. And you can choose what you want to do. I found it more satisfying than a regular job with a big company.



Gloria Ho (right), Oscar Gonzalez

EVANS: Do you ever feel the research you're asked to do is beyond your limits?

FAULKNER: When I first started, I did. It was after my freshman year, and the person I worked for just assumed I had graduate knowledge in all of the courses necessary. The first day I showed up, he sent me to the machine shop, and I had never worked in one before.

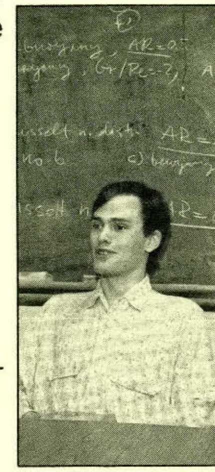
HOWELL: You're not sure what the new students' capabilities are, so you just give them a project and see what happens. Everybody has different backgrounds and experiences. Has the research experience made the option of graduate school more attractive? [All students agree it has.]

FAULKNER: I'm starting in January.

SANDHU: You get to see the graduate side of school beforehand. It's not like undergraduate—so rigorous and so *painful* [laughter]. Here I am taking so many courses, and here you see a graduate taking just two or three courses, and a lot of those are the dummy classes like thesis writing and the research class.

EVANS: Who feels the research experience has really changed your mind about going into graduate school?

GAREL: I wasn't really sure if I wanted to go ahead after undergraduate school. For one, I didn't have the money, and for two, I was thinking I'd go work and think about coming back later. It seems a whole lot more interesting to do research than general engineering work. I like to explore.



Carl Faulkner

HOWELL: I've got to say that that's the whole reason we hire undergraduates. It's not really the cheap labor [laughter]. We'd really like to get more people thinking about graduate school because there are a lot of people who are qualified, and there's a real need for people in graduate school, not only to do research in industry but also to teach. The federal government needs people all around. We just can't meet the demand. The salaries are there. The trouble is, people get finished with the undergraduate degree, and the salaries are there, too. They say, "I don't want to go another two or three years."

FAULKNER: I have friends that are going out to $40,000-a-year jobs.

HOWELL: If you look at the economic value of an engineering PhD, it certainly pays out. Even with the extra two or three or four years' delay before you enter the workforce, the increase in salary is enough to make it pay. It's not so clear that the master's degree ever pays for itself, but I think it does give you a shot at better job opportunities.

EVANS: I heard that MIT now requires every undergraduate in engineering to take one course where they're involved in real research, not class research. Do you think that would be a good idea at UT?

FAULKNER: It's a good idea as far as a learning experience. You learn a lot more in actual research than in some of your classes. But there are so many students.

HOWELL: 1,300 in mechanical engineering alone, and about 50 faculty.

FAULKNER: That would be as impersonal as a 50-person class.

HOWELL: We are trying to give all

the honors students the opportunity to do this, trying to get enough research projects that have enough money in them that we can pay five hours a week for a semester. If the student does well and wants to keep going, they can, if it's mutually agreed. At least make that opportunity available for all the students who would qualify for graduate school.

EVANS: If your brother or sister were trying to decide whether to become an undergraduate research assistant, what would you tell them?

GAREL: It's painstaking work. If it can't hold their attention, well maybe research in engineering is not what they want to do. I'd tell them to get some hands-on experience to see if they'd be totally bored running a sieve test all day long, or by being meticulous about doing procedures.

EVANS: What other skills do you need to do research?

GAREL: Determination. If you're not determined, you're going to just give up. You can't be lazy and do this stuff. First of all, you get attacked by the graduate students—not *attacked*—[laughter].

EVANS: Criticized?

GAREL: Yes.

FAULKNER: You have to be motivated to do the work on your own. Otherwise you're going to see the work and feel completely lost.


Darrell Seibert (left), Jason Garel

HOWELL: Another skill is knowing how to find the tools you need. We share equipment all over the lab.

FAULKNER: I think researchers are still on the barter system.

SEIBERT: It develops good people skills: "I'll do this for you if you'll do this for me."

HOWELL: You have to learn how to order stuff. Most people don't know how difficult that whole system is.

HO: Building things the cheapest way . . . being able to manage your time.

SANDHU: You've got to be sharp. When you come in, and there's an apparatus you'll be working on, you're told once—just *once*—how to work the whole thing [laughter]. You never get a second chance.

GONZALEZ: Not being afraid to take on projects that are over your head is important. If you want to be able to do something that's fun, beyond routine tests, you have to say, "Well, I think I can handle that."

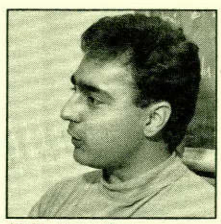
HOWELL: Does the open-ended kind of problem-solving you use in the lab help your ingenuity and problem-solving skills in the classroom?

SANDHU: It certainly is true, if you're lucky enough to get that kind of project.

HOWELL: Do you have a different appreciation of what graduate school is like? Most undergraduates I find have no idea what a graduate student does.

HO: It gives me more opportunity to talk to graduate students. You can talk to them about how they do their research. They always say they take classes that they want to take rather than that they have to take.

HOWELL: All of you are paid through the Center for Energy Studies, I think. Are all of you working in labs on campus or out at the Balcones Research Center?


K.D. Sandhu

FAULKNER: I work at Balcones [The rest say they work on campus].

EVANS: Does doing research as an undergraduate give you an advantage for graduate school?

SANDHU: A good recommendation from your professor, and a more personalized recommendation than he could give a student in his class, goes to your favor.

HO: It's a different way of thinking when you do research compared with classwork. You have to think of all the different things that could affect your results.

FAULKNER: With classwork, you can go straight to the equations or tables in the book and you know that you can get the answer from it.

GONZALEZ: In contrast, the design classes kind of prepare you to do research. There's no one solution. It's the same in research.

HOWELL: One of the things under continuing discussion about undergraduate education is that we don't stick enough open-ended problems into the way we teach. The design courses are one place that we do that, but we'd like to push it all the way back into every course so that instead of having a fixed answer to a problem, you'd consider alternatives.

FAULKNER: In research you also learn that if you take a circuit out of a book, it's not going to work just perfectly. A lot of the classes focus on the ideal. When you try it in actual practice, you find out the limitations.

HOWELL: Is there anything that we ought to do differently with undergraduate research?

SANDHU: Pay scale?

FAULKNER: I've heard some people say that they've been stuck taking data all day long.

HO: But someone has to do that work anyway. I would rather do that than work at McDonald's.

HOWELL: Those professors who have involved undergraduates have been very pleased with the results they get. There's a lot of work on research contracts that the undergraduates can do as well as or maybe better than graduates. Undergraduates have gotten more and more involved, and I think more and more will do that. Other professors haven't gotten into the mode of working with undergraduates.

A faculty member gets about 1/6 of one teaching load credit for an undergraduate researcher, while a master's student counts as 1 hour and a doctoral student counts for 3 hours. That's the state formula and it's set up to put a premium on working with graduate students.

FAULKNER: Maybe something needs to be changed at the legislative level.

EVANS: Is writing and publishing a research paper something that you'd seek out? [Nearly all say yes.]

FAULKNER: That would certainly help getting into grad school. And it lets you know that what you did actually amounted to something.

SANDHU: I know a large number of undergraduates who would like to work in undergraduate research, but the openings are not available.

HOWELL: Yes, we have a lot more students than we have money to support. I would guess 5 or 10 percent of undergraduates have this opportunity.

FAULKNER: I think it would really be nice if they could bring the research into the classes as a whole. It really motivates the students to see what they can do with the stuff.■

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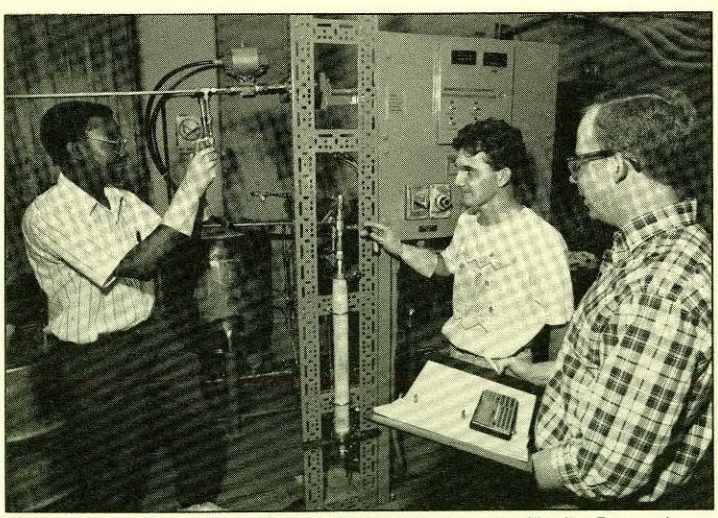
the surface of contact between the two liquids inside the pores will be roughly 1,000 square feet for every cubic foot of your bundle.

This idea is the basis for a young technology called *membrane extraction*. Separations researchers led by A. Frank Seibert are studying membrane extraction in an experimental system donated by Hoechst Celanese. Other participants are James R. Fair, head of the Separations Research Program, visiting researcher Xavier Py, and graduate student Msafiri Mshewa.



Separations researchers (from left) Msafiri Mshewa, Xavier Py, and Frank Seibert test modules used in membrane extraction.

The technology of membrane extraction is about four years old and so far is used mainly in the pharmaceuticals industry. Dr. Seibert, a chemical engineer and center research associate, said membrane extraction is a way of removing one liquid from a mixture of liquids by use of chemical affinity.

For example, to extract phenol from water, another liquid that has a chemical attraction for phenol must be used, such as MIBK (methylisobutyl ketone). When these liquids are put into the membrane module and meet in the microscopic pores, the phenol is strongly attracted out of the water and into the MIBK. The MIBK and water, on the other hand, have comparatively little attraction between them. Thus the water becomes purified.

The group has tested two types of membrane extraction modules and various liquids, pressures, and interfacial tensions (the surface tension at the boundary between the two liquids). Dr. Seibert said that, as they expected, changes in interfacial tension do not have an significant effect on the performance of the system.

The researchers learned that a gap between the bundle of membrane fibers and the surrounding module wall may be reducing performance. Dr. Seibert said liquid seems to flow along the gap instead of penetrating into the fiber bundle because the gap offers a path of less resistance.

■

The US Environmental Protection Agency has awarded $100,000 to UT civil engineering professor Earnest F. Gloyna for research on the **destruction of toxic wastes by supercritical water oxidation.** Contributions from the industry-sponsored Separations Research Program and other UT sources bring the total to $231,000.

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The EPA awarded $75,000 to James R. Fair, head of the Separations Research Program, for an investigation of **adsorptive purification of contaminated vent gases.**

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A ceramic membranes researcher from the German university RWTH Aachen, Egbert Jakobs, will be working with chemical engineering professor William J. Koros in the Separations Research Program during a six-month stay. ■