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THE DOLLARS AND SENSE OF CONSERVATION

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THE DOLLARS AND SENSE OF CONSERVATION*

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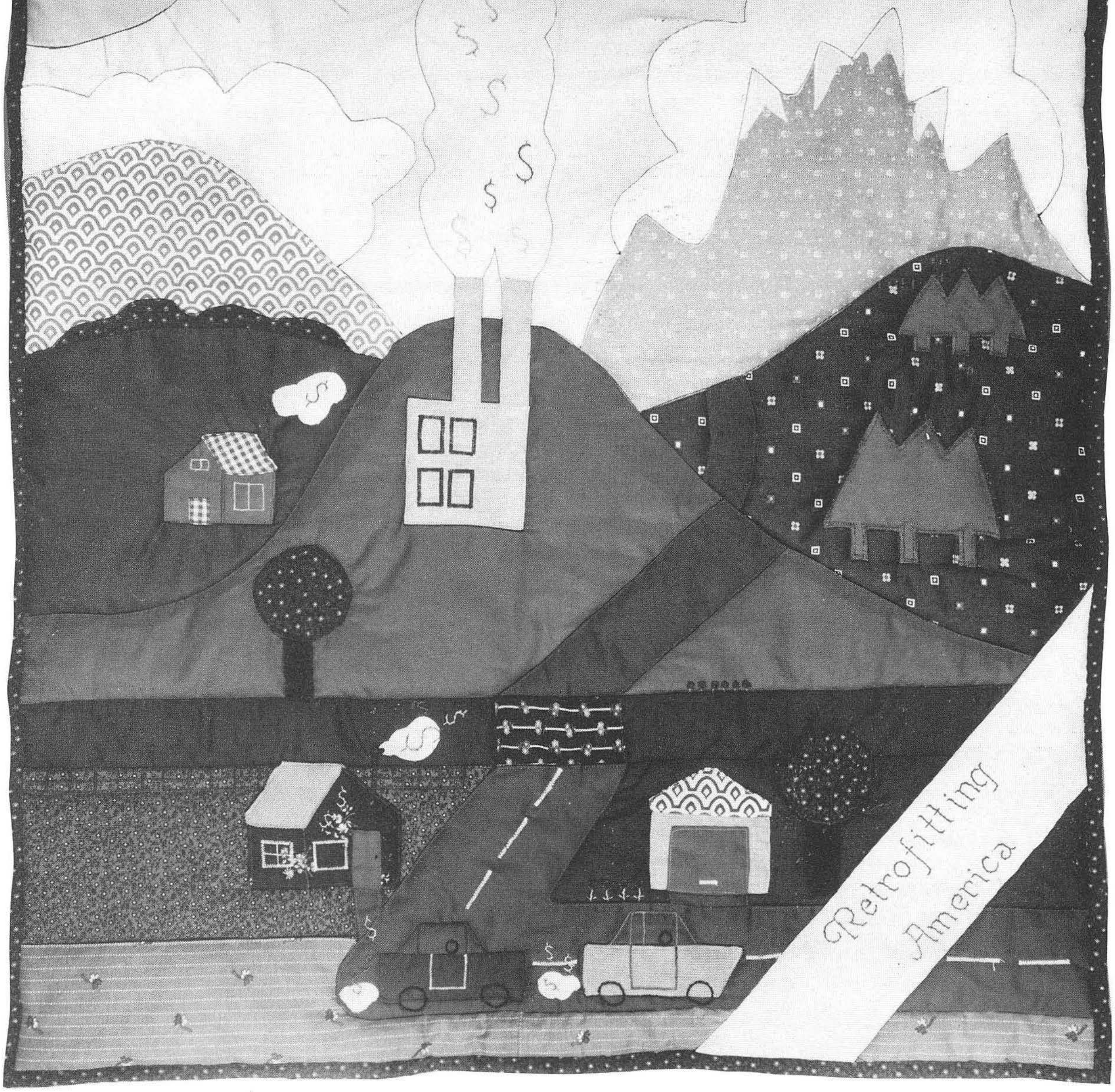


Quilt by Stephanie Quinn

The Dollars and Sense Of Conservation

Art Rosenfeld would like to save you and me about three hundred billion dollars over the next twenty years.

How's that again? Well, Rosenfeld, who is head of LBL's Energy Efficient Buildings program, explains that of the 1982 U.S. energy bill of $400 billion, about $120 billion went to pay the utility bills in the buildings sector of the economy.

This money was used to heat, cool, and light buildings, to run equipment and appliances like pumps, fans, refrigerators, washers, dryers, and water heaters.

"About half of this $120 billion, or $60 billion, is wasted," insists Rosenfeld. "That is, it could be saved, with no change in our lifestyle, if we made the optimum investments in lighting and daylighting, heating and cooling systems, controlling infiltration or supply of outside air, insulating, buying the most efficient appliances as our old ones wear out, reducing hot water waste, and so on.

"Most of this $60 billion saving will eventually be achieved by market forces, but the lag is probably twenty years. If we can reduce market lag from twenty years to ten years, we'll save $300 billion over the next twenty years.

"The investment in new and existing building required to do this will also be several hundred billion dollars, but that investment will be made anyway—we are just proposing to advance it. So the $300 billion stands as a net savings.

"In addition, the conservation investment would permit us to defer the constructon of two hundred standard 1000-megawatt powe plants, costing $1.5 billion each, which pay for the entire conservation investment all b itself."

Money Talks: Rosenfeld loves to talk abou money. As far as he's concerned, it's th topic most neglected by conservationists, wh sometimes come across as dreamers wh would like us to give up things that are fu and comfortable for the sake of a higher good But Rosenfeld doesn't see conservation lik that. He sees it in terms of dollars and cent

To drive his points home, Rosenfeld never without a chart, a graph, a slew statistics, and maybe even a prop or two lik a light bulb or a strip of plastic.

Whether he's talking to a TV reporter, Congressional committee, a scientific sen ar, or a group of high school kids, Rosenfeld ›mes across as one of the most effective ›okesmen for conservation that this country ıs. He has been featured on a network TV ›ecial on conservation, contributed to an ınswer book" for Shell Oil that was disibuted free to their customers all over the ›untry, and appears frequently before public ıd governmental agencies deliberating on ır energy future.

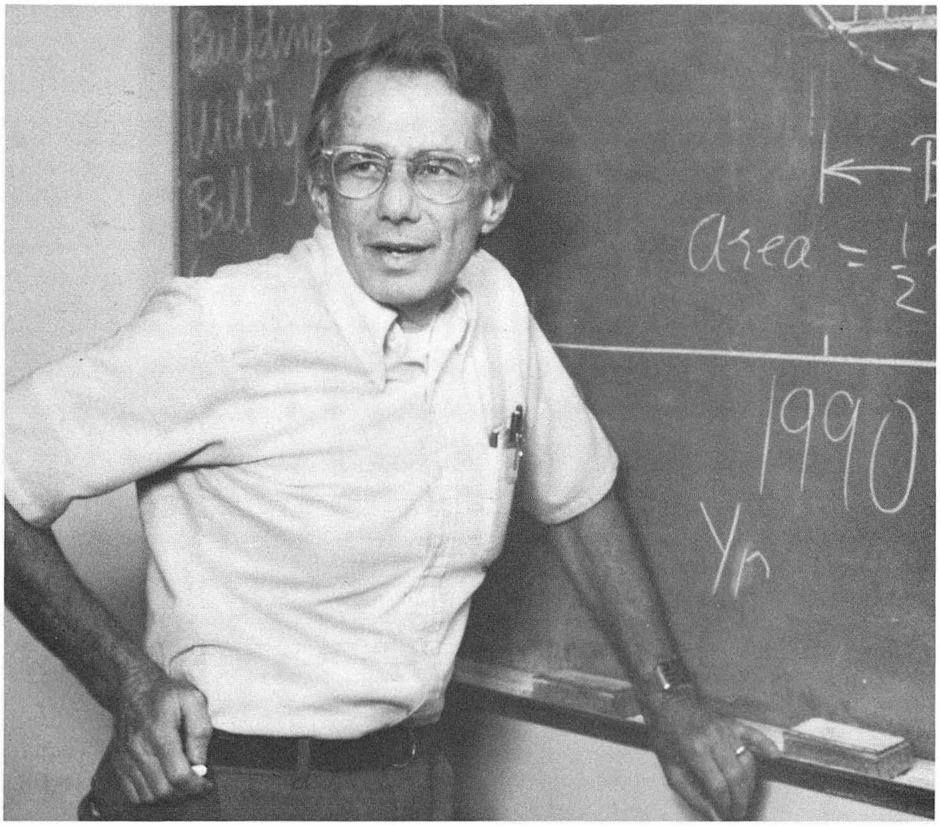
Rosenfeld is everywhere. Just back from trip to China (which he calls "even more ıergy-wasteful than the U.S."), he found a ee hour to talk to a NEWSMAGAZINE ·porter about trends, forecasts, conservation, ght bulbs, pollutants, windows, holes in ›uses, and, of course, his favorite topic, oney.

"When you talk about conservation," says osenfeld, "you've got to get specific. You ave to talk about dollars and cents. There's ılimited energy out there, but we're running ıt of cheap energy. It's all a matter of money. ı new office buildings, for example, by using ›nservation measures that are already ıown, we can make efficiency gains of an ·der of five. That means, instead of paying ility bills of $4 per square foot per year r a 1970's-style gas and electricity guzzler, e'd pay 80¢. Or, if you want to put it in rms of people, instead of $400 per person ·r year, $80."

'Avoided Gallons': Though his profesonal involvement is in the science of buildgs, Rosenfeld likes to illustrate his points ›out conservation by talking about cars, beıuse he believes that that's what American ›nsumers understand best. He points out ıat by upgrading the efficiency of our newır fleet from fourteen miles per gallon in ›75 to twenty-eight miles per gallon by 1985, ıe car owner is paying only 33¢ per "avoided allon of gasoline" instead of actually purıasing the fuel for $1 to $2 per gallon during ıe ten-year life of the car from 1985 to 1995.

"A crude way to calculate the cost of an voided gallon' is as follows," explains Roenfeld. "Over its 100,000 mile life, a 1975 uzzler would have used 7000 gallons of gas. he 1985 car can drive the same 100,000 iles on half the fuel—3500 gallons—thus ving 3500 gallons. But the 1985 car will ›st about $1000 more (in 1982 dollars) for catalytic converter, more gears, electronic nition, lighter materials, etc. So we invest 1000 to reduce smog and save 3500 gallons. his would seem to say that we can avoid ıying gasoline for an investment of $1000 vided by 3500 gallons, or for 29¢ per gallon ved—about $1 cheaper than the price of ıe purchased gasoline.

"The slight catch in this analysis is that e put up the $1000 when we buy the car, ıt the savings, averaged over the ten-year fe of the car, are deferred on the average ur to five years. If we use standard bankan type economics and discount future gas vings just as we discount future income, e find that 3500 gallons, saved over a tenear period, are only worth about 3000 gallons



E & E's Rosenfeld: Learning how to save $60 billion a year in home and office

today, and so the cost of avoided gasoline rises to 33¢ a gallon. That's still a very good buy." Rosenfeld loves this calculation because it's so typical of most investments in improved efficiency: avoided energy can generally be had for about one quarter the cost of purchased energy, and the environment can generally be improved at the same time—as in the case of the catalytic converter.

A New Career: For those who have known Art Rosenfeld since his early days as an experimental physicist and a participant in some of the most important high-energy physics discoveries of the era between 1955 and 1975, it always comes as a surprise to learn that he has now been devoting himself to conservation research for almost a decade. With Jack Hollander and Andy Sessler, Rosenfeld was one of the first to argue for the establishment of an Energy and Environment Division at LBL in the early seventies, and has been active in it ever since. The Energy Efficient Buildings Group which he heads was established in 1975.

"Now that we've been in business for eight years," Rosenfeld says, "it seems like a good idea to take a look at what we've accomplished so far." Since he likes to put everything in terms of dollars and cents, he thumbs through some of his recent Congressional testimony and adds up the annual savings that will come from implementation of the group's research and development achievements to date.

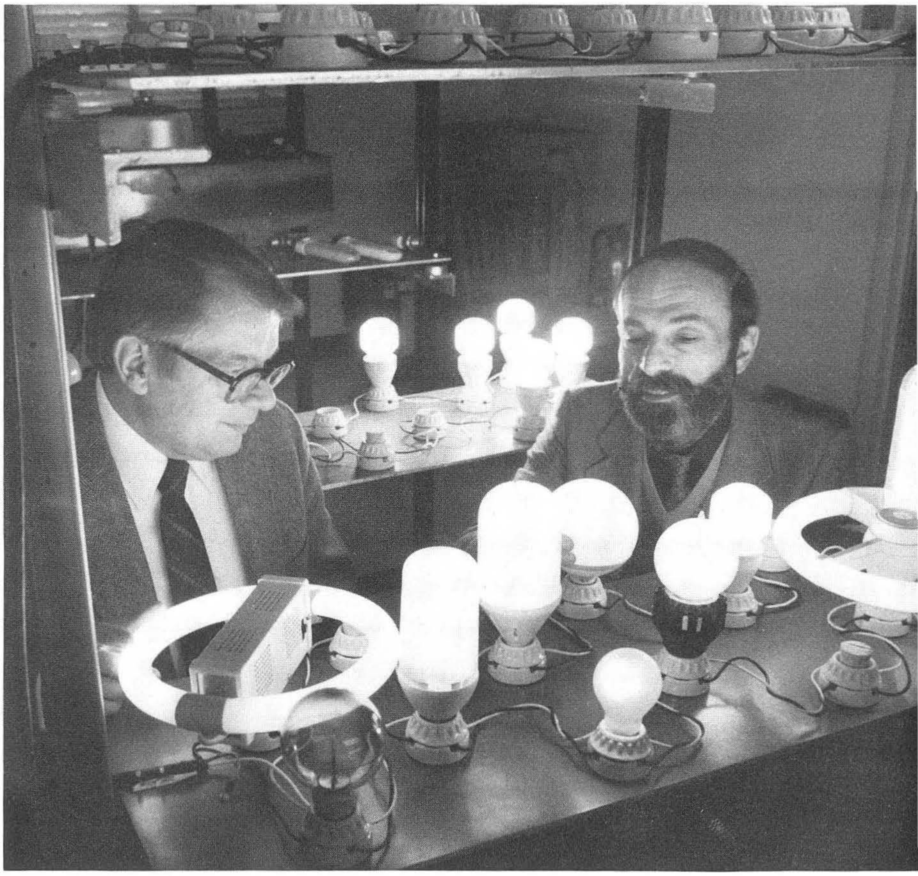
"It adds up to a yearly total of $20 billion," announces Rosenfeld after doing a quick calculation: "$5 billion for fluorescent lighting (including use of daylight), $5 billion for incandescent lighting, $5 billion for control of infiltration, and $5 billion for 'heat mirrors' on windows.

"Of course, most of these savings would occur eventually even if we weren't around, through the wavering invisible hand of the marketplace, but we estimate that we've advanced them five years. Some of the ideas might take a very long time to reach the marketplace without federal support. Thus it's easy to say that when infiltration of air into buildings is reduced, we'll save one-third of our heating bill. But you can't decide how much to reduce infiltration without understanding the possible problems involving indoor air quality, so there are complex issues involved.

"Another point to bear in mind is that the $20 billion I cited is only the tip of the iceberg—the result of successful research and development in our group to date. We can't estimate the eventual savings through improved knowledge, computer programs, and data bases. Consider just the impact of the fact that we can now predict the utility bill of a home or office to within plus or minus ten percent. The buildings industry can now adopt energy use labels. Lenders are beginning to loan more (and charge less interest) on low-energy houses. Such institutional change will eventually add to my claim of $20 billion a year, but it's hard to estimate exactly how much."

Fluorescent Lights: Getting down to specifics, Rosenfeld points to advances in electric lighting. "In this area, we've made three distinct contributions. First, there's the high-frequency electronic ballast for fluorescent lights, which is just now becoming available after about six years of development and testing in a tight collaboration between several small companies and LBL.

"Physicist Sam Berman, leader of our lighting group, got interested in this idea back around 1976, and spent many frustrating months trying to interest big manufacturers in the idea. The high-frequency ballast didn't have to be 'invented'; it's been known for some time that fluorescent lamps could be made at least fifteen percent more efficent if they were powered at high frequency—about thirty kilohertz. But back in 1975, none of the Big Four U.S. manufacturers of ballasts wanted to spend the money and effort necessary to develop the idea. Finally Sam got the Department of Energy to put up $200,000 to get a number of small companies to bid on developing prototypes. Within a year he had prototypes. Then Sam and Rudy Verderber and their colleagues spent several years directing further development and testing of prototypes at the P.G & E. headquarters on Beale Street in San Francisco. Now, after testing and debugging, the ballasts are on the market. They're already available at Sears, and are being manufactured by at least four different companies. What's more, it turns out that four different features of the electronic ballasts can add up to a typical savings of not fifteen but forty percent."



Seeing the light: Energy-saving light bulbs developed under the sponsorship of LBL lighting group are displayed by Rudy Verderber (l.) and Sam Berman

"The potential savings in this area are enormous," continues Rosenfeld. "In the U.S. last year we used 210 billion kilowatt hours of fluorescent lighting, at a cost of $15 billion a year, or one-tenth of the entire U.S. electric bill. So if the new energy-efficient ballasts are universally adopted, there will be savings of about $5 billion a year. Since the entire federal R & D program to develop the ballasts cost less than $5 million from start to finish, you can see that the payback to society is very large. In fact, Sam Berman likes to say that the payback time to consumers for the DOE investment in this project is nine hours.

Consumer Savings: "The benefits to the purchaser are also significant. Normal ballasts last seven to ten years, then they start to hum and misbehave. A normal electromagnetic ballast costs about $10, the new ones cost $20 to $25, perhaps $30. With further circuit developments that we know are possible, and with increases in sales volume, this price should drop fifty percent, to $15. Over ten years the new ballasts save forty percent of a $200 electric bill, or $80. Just as we calculated that the cost of conserving a gallon of gas by the 1985 car was 33¢, we can calculate that the new ballasts (at $15) conserve electricity for 1.7¢ 'per kilowatt hour avoided,' or one quarter the 1982 average price of 7¢ per kilowatt hour.

"Now, you might say that all this would have happened anyhow, without LBL's help. After all, we didn't invent the high-frequency ballast, and surely American industry would have gotten around to producing it sooner or later, given the economic realities of the eighties and the competition from Japanese and European manufacturers. But I think that we can claim with justice that we made the whole thing happen several years sooner than it would have otherwise. Since the savings are $5 billion *every year*, an advance of a few years is no trivial matter. And maybe if we waited it would not have been American industry that came up with the efficient ballast, but rather a foreign competitor. By working with the U.S. lighting industry in introducing innovations, we are helping it maintain its viability in a very competitive international market," concludes Rosenfeld.

Incandescent Lamps: "Our second target in the lighting area was the incandescent lamp, which nationally uses almost as much energy as the fluorescent does—about $10 billion a year. But the incandescent bulb is about three times less energy-efficient than any kind of fluorescent—even an old-fashioned one.

"Beginning around 1979, Sam Berman and his associates went out with grants to various small companies, and an amazing amount was accomplished in a short time. They can now show you prototypes of three concepts: first, a spherical version of the familiar filament lamp, coated with a film which is transparent to visible light but reflects invisible heat back on the filament, thus reducing energy loss through heat; second, a group of several compact fluorescents; and third, a fluorescent without an electrode.

"Stimulated by our work, the major lamp manufacturers have risen to the occasion. Now, working with LBL and others, they are on the way towards replacing the incandescent bulb with something better. One of these products is now on the market, manufactured by Phillips-Norelco. What Phillips did is to bend a fluorescent tube into a compact shape, use a high-frequency ballast of the kind I talked about earlier, and design it so that it screws into any standard light bulb fixture. Result: a lamp with the output of a 75-watt incandescent that uses only 1[illegible] watts. The Norelco now sells for $25, but will burn for 7500 hours (the same as te[illegible] incandescents). At $25, its main attraction is not only its dollar savings, but the fact that it will burn for a year in a stairwell without the labor cost that's involved with a normal incandescent that must be replaced every month. Norelco aims to reduce the price to $15 in 1984, and the cost of an avoided kilowatt hour will drop to 2.3¢, compared with today's price of 7¢. Then it will be ready for the residential market. Potential savings from the new generation of efficient light bulbs [illegible] $5 billion a year."

Daylighting: But Rosenfeld has even greater potential savings on his wish list. Turning away from the subject of artifici[al]

;ht, he's off and running on a related topic, e use and abuse of natural light—an area ıich is the special province of the energy-ïcient windows and daylighting group, aded by Steve Selkowitz.

"To make progress in the area of natural ;hting," says Rosenfeld, "we had to rethink me of the basic tenets that architects learn school, and then we had to convince them at our ideas were sound.

"To an architect, windows have historically nctioned with a combined purpose: light d view. But from an energy-efficient point view, that's not such a good idea. To make ogress, we had to separate the two func-ons.

"Daylight belongs high up, near the ceiling, ver under an overhang. But architects often it an overhang on a south-facing window cut off the hot high-summer sun, or use ghly reflecting glass to cut out eighty to nety percent of the light and heat. The lution is to have the overhang a foot *below* e top of the window, and painted white top, leaving a 'clear-story,' or clear light ndow, above.

"To replace the reflective glass, we are oking at selective coatings that have a high ansmittance to visible wavelengths, but are flective to the non-visible infrared energy sunlight.

Holographic Films: "The earliest day-ghting strategies we came up with to project ıylight deeper into buildings involved re-ective venetian blinds, and they're still what e recommend. But now Selkowitz's group examining the potential of advanced optical chnologies to replace mechanical devices. ong with Arlon Hunt of the solar program, ey are working on thin holographic films at can be applied to the window glass. oatings of this kind can reflect light pref-entially upwards onto a white ceiling. The oup is also studying a number of other proaches, including textured coatings on ass, microparticulate scatterers imbedded glass, and light pipes (borrowed from par-cle physics).

"For *view*, windows should be at eye level. ney can be as big as you want, but they ıve to be energy-efficient, which means ontrolling solar gain in summer to reduce r conditioning, while reducing heat loss—ıt letting the sun in—in winter. Some day e may replace our shades, blinds, and awn-gs with electrochromic or photochromic ɔatings like those used in sunglasses—coat-gs that switch from transparent to reflective ı a hot sunny day.

"To reduce heat loss, the conventional ethod uses double or triple glazing, with dead air space between each layer. But lkowitz and his co-workers are studying veral new approaches that promise reduced eat loss without a major reduction in solar in in winter.

Heat Mirrors: "The first new technology ey examined when they began this work 1976 was the use of 'heat mirror' coatings windows. These coatings are transparent to sunlight but highly reflective to the long wavelength infrared radiation which makes up sixty percent of the heat loss in a normal double glazed window. The coatings can be deposited directly on glass or on a thin plastic layer that is suspended in the air space between the two glass sheets. Depending upon coating properties and window design, double-glazed windows with these coatings will outperform triple glazing and even quadruple glazing in some cases. As a result of research at LBL, and support to several small private firms, these products were first introduced to the building market in 1982, and they're due to be followed by a flurry of competitors in 1983 and 1984. We have already built research prototypes of windows that are as well insulated as walls (R-12), using several layers of heat-mirror films and special gases in the window. But these are not cost-effective—at least at the moment.

"Selkowitz and Hunt are also studying a 'new' class of insulating materials, the aerogels. These materials are already familiar to particle physicists for their use in Cerenkov counters. Aerogels are reminiscent of styrofoam, in that they are mainly bubbles. In one aerogel we're studying for insulation purposes, the microbubbles are much smaller than the wavelength of light, so they don't scatter much light and you can't see them. By volume, the material is ninety-four percent air and six percent silica. Its thermal resistance is R-7.6 per inch, which means that a half-inch-thick slab beats a triple-glazed window, and a one-and-a-half-inch slab equals the conventional R-11 insulation in a four-inch stud wall."

Can aerogel windows be made cheaply enough to displace glass? "We don't know yet, but it's intriguing."

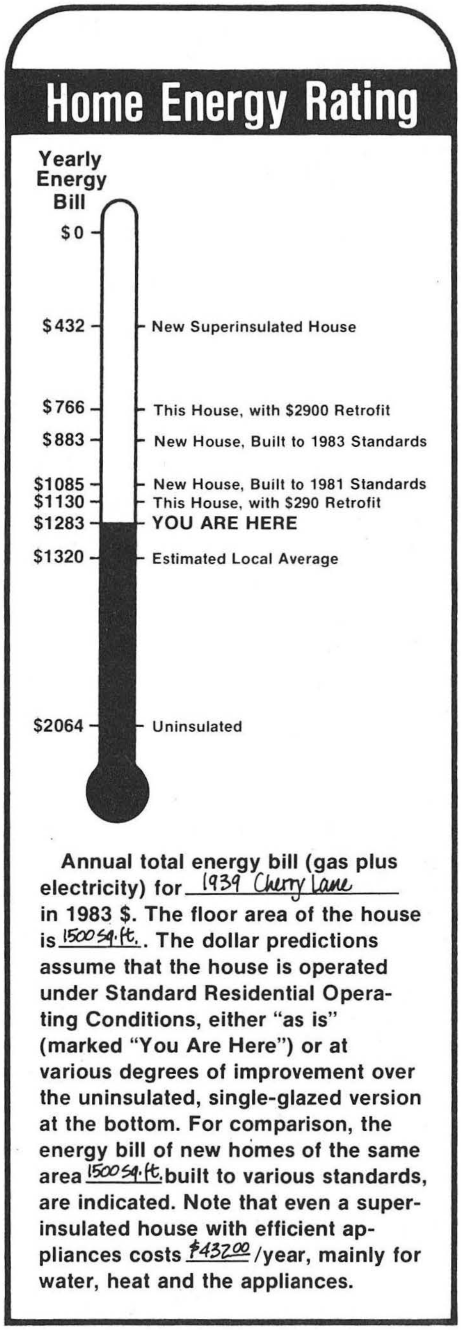
Potential annual savings from future windows—heat mirrors or something even better? Rosenfeld gets out his calculator again. "Residences, $3 to $4 billion; commercial buildings, $1 to $2 billion. Let's call it $5 billion per year."

A Change of Air: From windows, Rosenfeld turns to whole buildings, and the work of the energy performance of buildings group, headed by Robert Sonderegger.

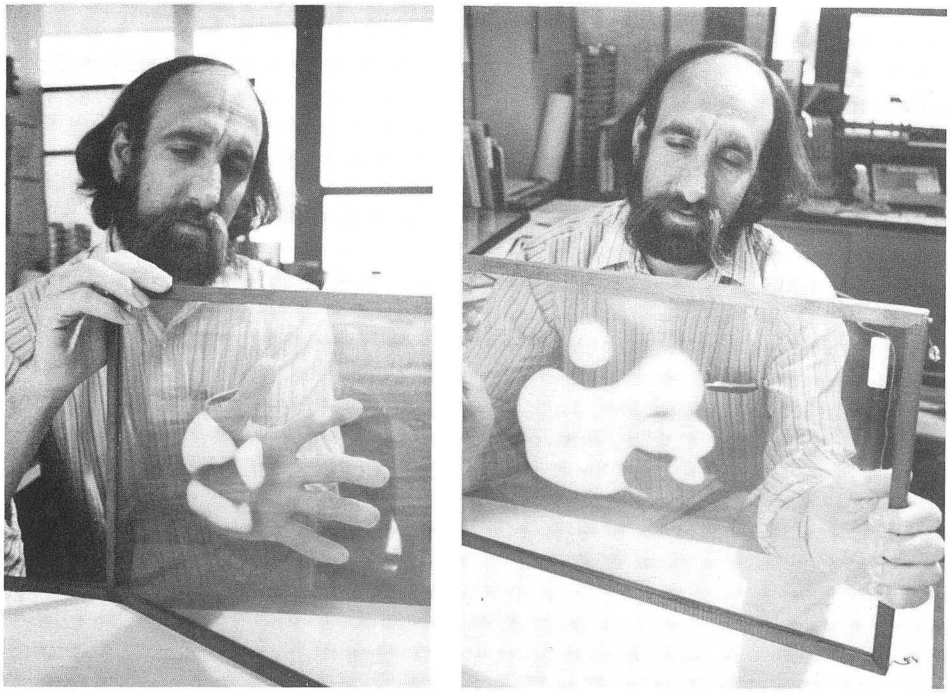
"In the normal American house, there's a complete change of air every hour or so," explains Rosenfeld. "Now you don't want to reduce that *too* much, or you'll start smelling last night's cooking—or, even worse, suffer the ill effects of what we call indoor air pollution. But it can safely be reduced considerably with just two simple measures, plugging the holes and using heat exchangers.

"The average American home is full of holes. In fact, the leaks add up to the equivalent of one square foot of hole. Think of it as half a square foot in the ceiling and the rest divided between the walls. When the wind blows, so do the drafts. Even without the wind, the light warm air floats out through the ceiling and is replaced with cold outside air seeping in lower down. Many of these holes come from the plumbing pipes and electric fixtures, which have usually been installed with big air spaces around them just because it was easier to do it that way and no one was thinking about energy efficiency.

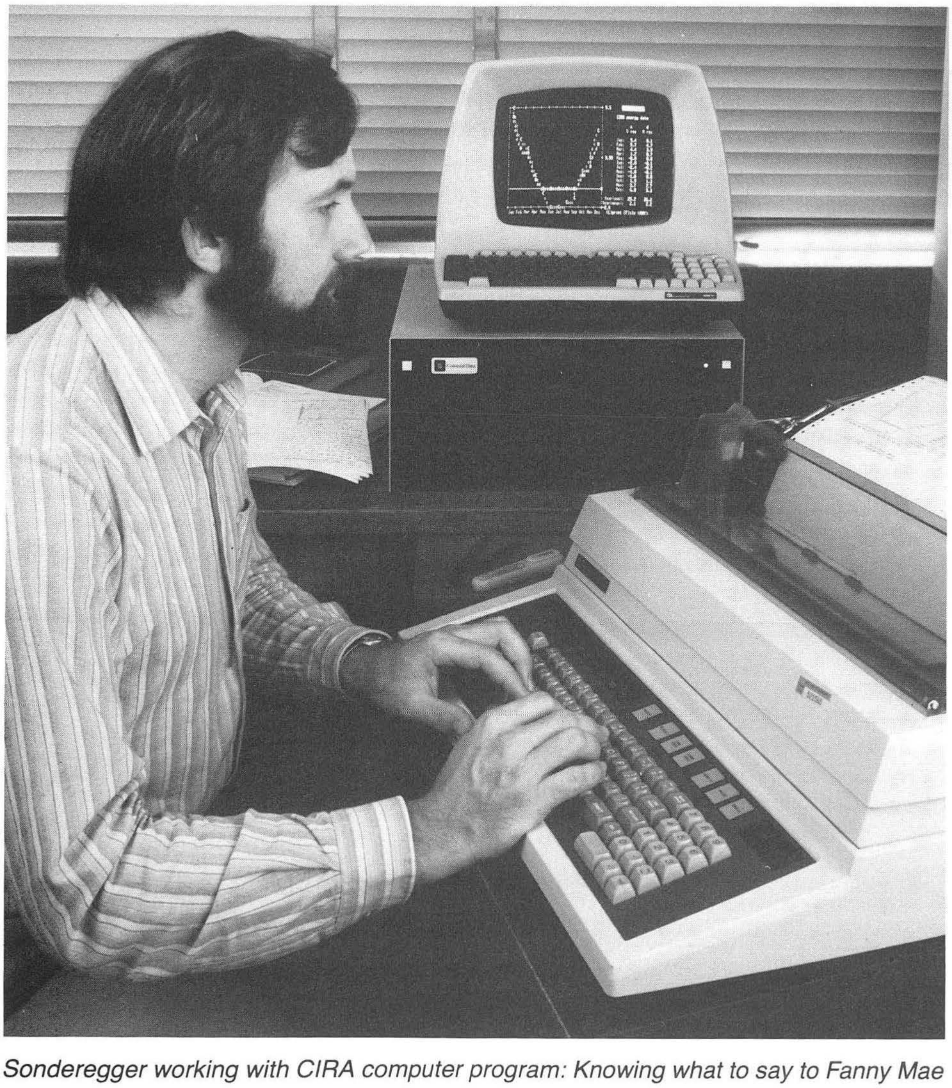
"If you want to plug the holes in houses, the first thing you have to do is find them. The infiltration model developed by physicist Max Sherman as a Ph.D. thesis for measuring the heat exchange in houses is now standard and accepted by ASHRAE—the American Society of Heating, Refrigeration, and Air Conditioning Engineers. Along with Princeton University and the National Bureau



Truth in labeling: Hot new idea in the building industry is an energy-efficiency label on every house sold. A proposed version of such a label, developed at LBL, is shown.



Steve Selkowitz demonstrates a window coating film which turns opaque as it heats up. Warmth from hand (left) leaves an opaque handprint on glass (right).



Sonderegger working with CIRA computer program: Knowing what to say to Fanny Mae

of Standards, we also improved the blowe door system that is used to pressurize a hous enabling you to find leaks with a small smol generator.

Energy Audit: "Most important, So deregger and his co-workers recently d veloped CIRA, a computer program designe to help home energy auditors to do their jo better. An energy auditor (like the ones P.(& E. sends to your home) can now actual bring along her little portable comput loaded with CIRA, punch in the releva numbers as she does her inspection, and te you in minutes exactly where the econom break-even point is for all kinds of improv ments like insulation or alternate kinds heat.

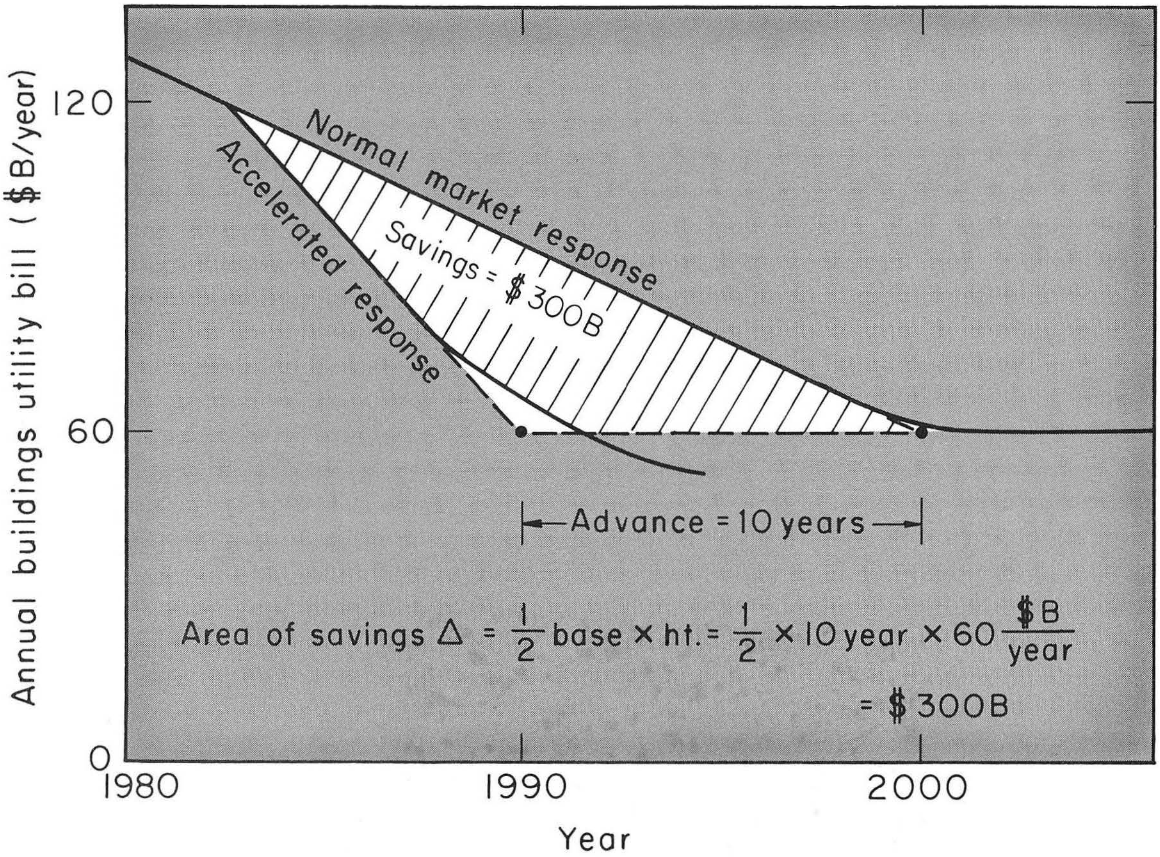
"The final goal of all these models ar computer programs is to lay the groundwo for something that's very hot in the energ business right now: labeling of houses. E labeling I mean exactly the same sort of thin that consumers have come to expect whe they buy cars and refrigerators—a label th gives specific information about the lon term energy costs.

"What we would like to see is a label c every house before it's sold, so that the buye can make an informed decision. This idea fast gaining momentum. Recently, the tw big quasi-governmental agencies that r purchase and underwrite home loans, th Federal Home Loan Mortgage Corporatic (affectionately known in the trade as Fredc Mac) and the Federal National Mortgage A sociation (alias Fanny Mae), announced th energy-efficient houses will earn their buye a break on home loans. Specifically, th agencies said that the debt-to-income rat permitted prospective borrowers can be mor favorable for energy-efficient homes. Natu rally, in order to prove to Freddy Mac c Fanny Mae that you're buying an energ efficient home, either standards enforced b the government or clear, informative labelin will be necessary."

Free Market: "Between standards and l beling," Rosenfeld continues, "I prefer l beling. After all, it's the American way. Go ernment-enforced standards were all rig when there was no alternative, no techniqu and programs available for calculating th hidden energy costs of buildings. But nov with CIRA and DOE-2, the bigger comput program that we designed a few years ag to calculate the cost effectiveness of conse vation strategies, there's no reason to clir to this approach. Let the free market decid just as it is already doing very nicely in th case of refrigerators and cars."

Rosenfeld is betting on the fact that hom buyers won't need any arm-twisting to pe suade them to choose an energy-efficient a ternative if it saves them thousands of dolla over the life of a house. It remains to b seen if Americans will be as wise throughou the building sector, choosing the conservatic alternatives that could save us all thre hundred billion dollars over the next twent years.

—JUDITH GOLDHABE



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In 1982, about $120 billion went to pay the utility bills for U.S. buildings. As their energy efficient increases, that bill should drop to one-half (ignoring an increase in the floor area), as shown. Two scenarios are drawn — with and without government R&D and incentives. Government programs could advance the market response by 10 years. The area between the two decreasing lines represents a possible savings of $300 billion.

*Reprinted from the Fall/Winter 1982–83 edition of the LBL Newsmagazine, published by the Public Information Department of Lawrence Berkeley Laboratory. We have added this page to show the drawing in the photo that was cropped on page 2 of this article.