Waste Reduction Coordination for Headquarters Renovation

Meeting Summary
May 19, 1992

Attendees: Glen Taylor, Joanna Karl, Berit Stevenson, Michel Gregory, Jim Goddard

(Additional distribution: Debbie Palmerni, Flor Matias, Leigh Zimmerman, Pat Varley, Andy Sloop, Steve Kraten,Genya Arnold)

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<u>Design & Construction Work</u>: Concrete ramps are being poured in the parking area in the building. Final cutouts in the floors have been made. The last demolition phase will be removal of basement walls around boiler room and removing elevators.

<u>Salvage & Construction Site Recycling</u>: Rejuvenation House Parts has salvaged flooring from the building. They will finish by 5-22. Final quantity of salvaged flooring needs to be documented.

<u>EPA Position</u>: Applications have been received, and interviews will be held May 21 with an expected start date of June 1 for the successful candidate.

<u>Status of Buy Recycled</u>: .The ceramic tiles will soon be specified. Berit will discuss the tiles with the architect prior to completion of specifications. The architect has called Rasmussen to investigate the possibility of lightening the color of the recycled paint. Information has been received about tarrazo flooring with recycled glass. It is possible this may be used as accents for the *1% for Art* projects. Possible price supports provided by Washington State's Recycled Glass Committee need to be investigated. The recycled product vendors have been contacting the architect directly, providing samples and information as required.

<u>Public Affairs.</u> A large-scale press conference with Rena Cusma, Neil Saling, and Vicki Rocker is being investigated.

<u>Energy Report</u>:. Joanna and Glenn met with Glumac during the week of May 11. They discussed the contents of Joanna's review letter. A written response from Glumac has not been received. Glenn investigated TRAV systems with a number of consultants. The consensus is that it's a good idea that has not been proven in the Northwest. The system specified for the headquarters building can easily be retrofitted with little expense to a TRAV system. The benefit is that the risk of extensive de-bugging of a new type of system will be eliminated. The parking garage Fin Answer model has not yet been completed; however, it appears that changing the lighting will be financeable. Two additional articles are attached, these were referenced by Amory Levins during his speech to AIA in Portland.

<u>Water Conservation</u>: Rosemary Furfey will meet with the landscape architect and review the drawings to see if there is any opportunity for additional input in the landscaping and water usage for the project.

Action Items:

Berit Stevenson: Discuss recycled content tiles with Bob Thompson: May 20, Check status of recycled paint discussions between Bob Thompson and Rasmussen: May 20, Give Rosemary Furfey the name/phone of the landscape architect: May 22.

Pat Varley: Investigate the possibility of price support for the Tarrazo recycled glass flooring: May 26.

Jim Goddard: Interview EPA positions and attempt to fill by June 1. Determine quantities of hardwood flooring/subflooring removed from the headquarters building. May 26.

Michelle Gregory: Continue to publicize details of the renovation project: June 2.

Glenn Taylor: Obtain answer to energy questions from Glumac: June 2.

JG:gbc
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From:

Joanna Karl
Engineer
Solid Waste Department

5/14/92

Glenn–

Here is the first of the 2 articles cited by Amory Lovins in the videotape– "Efficient Use of Electricity."

Also - I've attached material on the NMB Bank near Amsterdam, out of the book - "Green Architecture", by Brenda and Robert Vale.

cc: Jim Goddard

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Efficient Use of Electricity

Advanced technologies offer an opportunity to meet the world's future energy needs while minimizing the environmental impact. Both suppliers and consumers of electricity can benefit from the savings

by Arnold P. Fickett, Clark W. Gellings and Amory B. Lovins

Electricity is fundamental to the quality of modern life. It is a uniquely valuable, versatile and controllable form of energy, which can perform many tasks efficiently. In little over 100 years electricity has transformed the ways Americans and most peoples of the world live. Lighting, refrigeration, electric motors, medical technologies, computers and mass communications are but a few of the improvements it provides to an expanding share of the world's growing population.

Many analysts believe that regional electricity shortages could occur in the U.S. within the next 10 years, perhaps as early as 1993. Given the importance of electricity to all sectors of the economy, such shortages would have severe consequences. Yet financing large-scale power plant construction could push America's $170-billion-a-year electricity costs higher: a large (one billion watts) power plant costs more than $1 billion and may entail lengthy regulatory and environmental approvals. Thus there is growing pressure for utilities to provide needed generating capacity or to reduce electricity demand, or both.

A kilowatt-hour of electricity can light a 100-watt lamp for 10 hours or lift a ton 1,000 feet into the air or smelt enough aluminum for a six-pack of soda cans or heat enough water for a few minutes' shower. To save money and ease environmental pressures, can more mechanical work or light, more aluminum or a longer shower be wrung from that same kilowatt-hour?

The answer is clearly yes. Yet estimates as to how much more range from 30 to 75 percent. Also at issue is how fast efficiency can be improved, and at what cost.

Since the oil embargo of 1973, energy intensity—the amount of energy required to produce a dollar of U.S. gross national product—has fallen by 28 percent. Plugged steam leaks, caulk guns, duct tape, insulation and cars whose efficiency has increased by seven miles per gallon have helped to extract more work from each unit of fuel. Applications of electricity, too, have made important contributions to productivity and to a more information-based economy. Electricity accounts for a growing fraction of energy demand, and its relation to the gross national product has held relatively steady in recent years. It is not clear, however, that electricity and economic growth must continue to march in lockstep. Technologies and implementation techniques now exist for using electricity more efficiently while actually improving services. Harnessing this potential could get society off the present treadmill of ever higher financial and environmental risks and could make affordable the electric services that are vital to global development [*see illustration on next page*].

Historical patterns are already starting to change. California reduced its electric intensity by 18 percent from 1977 to 1986 and expects the trend to continue. Nevertheless, in such major industries as cars, steel and paper, Japan's electric use per ton is falling while the U.S.'s is rising—chiefly because American companies are still adopting new fuel-saving "electrotechnologies" already common in Japan. But companies there are improving their efficiency at a faster rate. The resultant widening efficiency gap contributes to Japanese competitiveness.

Other industrialized nations are also setting higher standards for efficiency. Sweden has outlined ways to double its electricity efficiency. Denmark has vowed to cut its carbon dioxide output to half the 1988 level by 2030 and West Germany to 75 percent of the 1987 level by 2005; both nations emphasize efficiency.

These encouraging developments reflect rapid progress on four separate but related fronts: advanced technologies for using electricity more productively; new ways to finance and deliver those technologies to customers; expanded and reformulated roles for electric utilities; and innovative regulation that rewards efficiency.

The technological revolution is most dramatic. The 1980's created a flood of more powerful yet cost-effective electricity-saving devices. If anything, progress seems to be accelerating as developments in materials, electronics, computer design and manufacturing converge. Rocky Mountain Institute estimates that in the past five years the potential to save electricity has about doubled, whereas the average cost of saving a kilowatt-hour

ELECTRICITY carried by power lines in Torrance, Calif., runs appliances, heats homes and lights buildings. Technology can improve these services and at the same time save electricity and money.

ARNOLD P. FICKETT, CLARK W. GELLINGS and AMORY B. LOVINS are consultants to the power industry. Fickett is vice president of the Customer Systems Division at the Electric Power Research Institute (EPRI). He received an M.S. in electrochemistry from Northeastern University. Fickett has more than 30 years of experience in the research, engineering and application of energy-related technologies. Gellings, who is director of the Customer Systems Division at EPRI, has a master's in mechanical engineering from the New Jersey Institute of Technology and a master's in management science from the Stevens Institute of Technology. He spent more than 20 years in energy-related technologies as well as in marketing, forecasting, demand-side management, least-cost planning and conservation. Lovins directs research at Rocky Mountain Institute, a nonprofit resource policy center. He and his wife, L. Hunter Lovins, founded the center in 1982. Winner of the Onassis Foundation's first Delphi prize, he was educated at Harvard and Oxford universities.

has fallen by about two thirds. The institute has also found that most of the best efficient technologies are less than a year old.

Of course, while some innovations are saving electricity, others will use electricity in new ways in those areas where electricity has an advantage over other forms of energy. For example, electricity can be environmentally beneficial and cost-effective in ultraviolet curing of finishes, microwave heating and drying, induction heating and several other industrial uses. Such electrotechnologies save money and fuel and reduce pollution overall. The Electric Power Research Institute (EPRI) estimates that by 2000 these new technologies will save as much as half a quadrillion British thermal units (Btu's) of fuel per year yet will increase electricity use in the U.S. only slightly.

How much electricity could be saved if we did everything, did it right and fully applied the best technologies for efficiency? Agreement is growing that an astonishing amount of electricity—far more than the 5 to 15 percent cited a few years ago—could be saved in the U.S. According to a 1990 report by EPRI, it is technically feasible to save from 24 to 44 percent of U.S. electricity by 2000—some of it rather expensively—in addition to the 9 percent already included in utility forecasts. Thus, theoretically, aggressive efficiency efforts might capture as much as three to five times the savings that EPRI forecasts to happen spontaneously, about four to seven times as much as current utility programs plan to capture (80 billion watts before 2000). Rocky Mountain Institute estimates a long-term potential to save about 75 percent of electricity at an average cost of .6 cent per kilowatt-hour—several times lower than just the cost of fuel for a coal or nuclear plant. Even more could be saved at higher costs. The differences between these estimates are less important than their agreement that substantial amounts of electricity can be saved in a cost-effective manner.

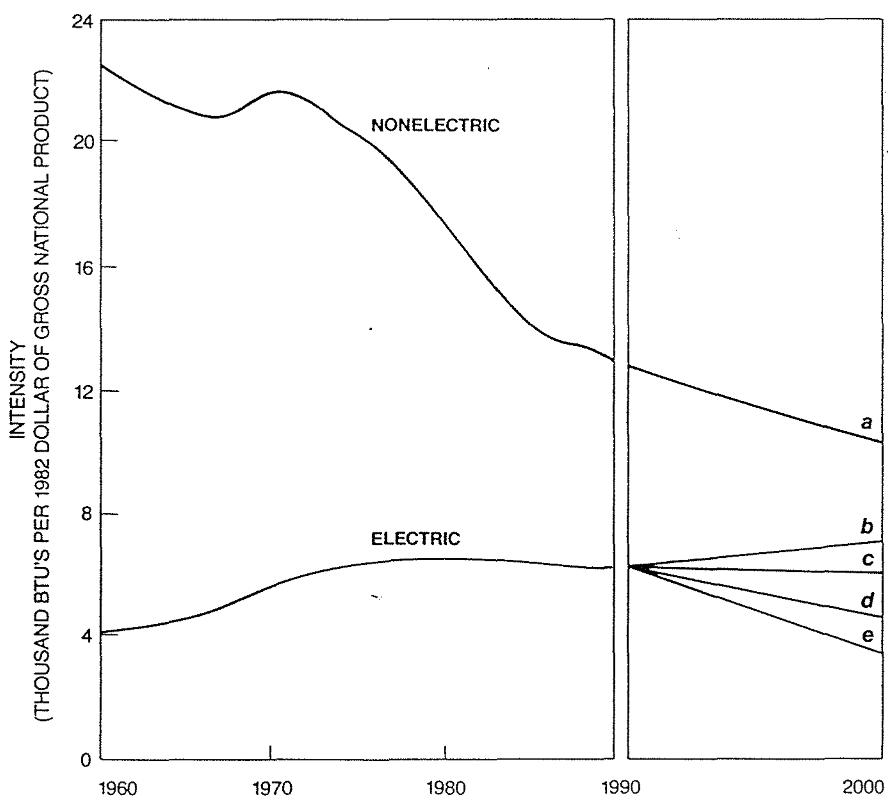
How do potential electricity savings in the U.S. compare with analyses for other countries? Potential savings vary, mainly because of differences in climate, in use of appliances and in price and economic structure. Western Europeans and the Japanese have already captured more of the potential electricity savings, and, as these nations continue to progress, they will pay more for less electricity savings than Americans, but the differences are probably not substantial. Studies have found potential savings of 50 percent in Sweden at an average cost of 1.3 cents per kilowatt-hour, 75 percent in Danish buildings at 1.3 cents per kilowatt-hour and 80 percent in West German households at a cost repaid in 2.6 years [*see illustration on page 68*].

Strong anecdotal evidence suggests that in most developing and socialist countries, many electric devices are several times less efficient than in the U.S. Improved devices are often costly there today because they require electronics or special materials that are not readily available. But as global markets for these devices expand, lowering their international prices, it is reasonable to expect that the potential electricity savings will be even greater in the countries that are the least efficient today. The U.S. potential may therefore prove to be not a bad surrogate for the global average.

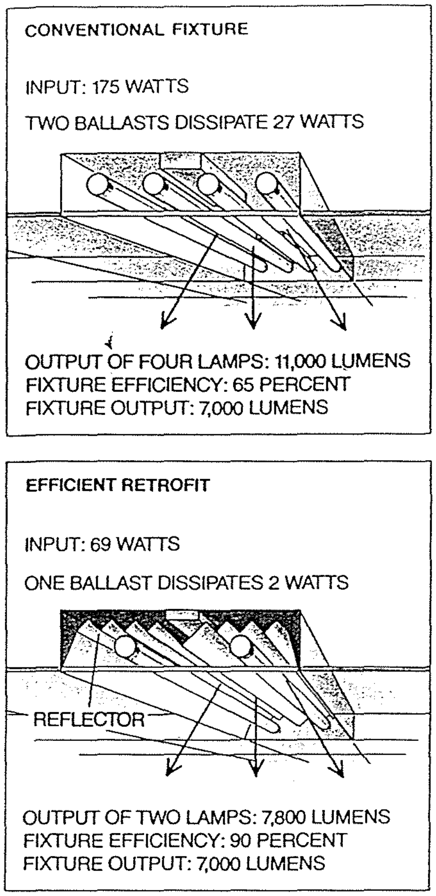
To understand the pitfalls involved and the effort required to move toward a more efficient economy, consumers and suppliers of electricity must understand how major savings can be achieved. Electricity, like other forms of energy, can be saved by demanding fewer or inferior services—warmer beer, colder showers, dimmer lights. No such options are considered here. If technology is applied intelligently, electricity can be saved without sacrificing the quality of services. In fact, many new devices actually function better than the equipment they replace: they provide more pleasing light, more reliable production and higher standards of comfort and control.

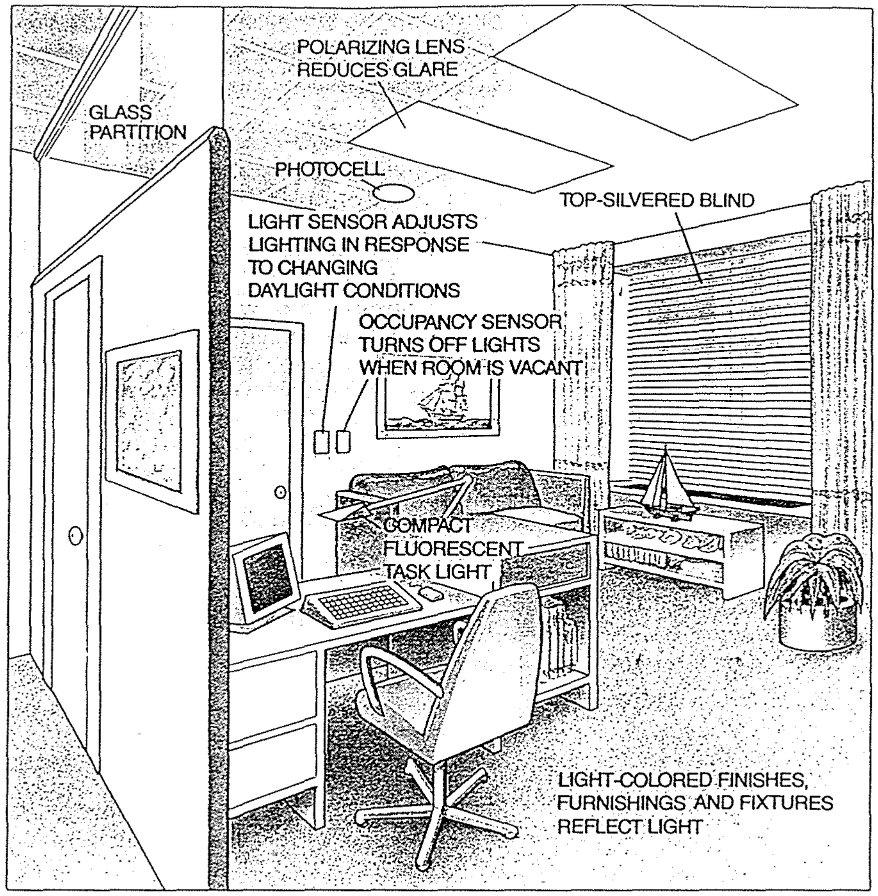
The biggest savings in electricity can be attained in a few areas: lights, motor systems and the refrigeration of food and rooms. In the U.S. lighting consumes about a quarter of electricity—about 20 percent directly, plus another 5 percent in cooling equipment to compensate for the unwanted heat that lights emit. In a typical existing commercial building, lighting uses about two fifths of all electricity directly or more than half including the cooling load. Converting to today's best hardware could save some 80 to 90 percent of the electricity used for lighting, according to Lawrence Berkeley Laboratory. EPRI suggests that as much as 55 percent could be saved through cost-effective means.

Compact fluorescent lamps, for instance, consume 75 to 85 percent less electricity than do incandescent ones.



RELATION between U.S. electricity consumption and the economy has remained relatively steady over the past three decades, whereas the intensity of other forms of energy has declined, partly because of the increased use of electricity. Efficient use of electricity, however, can reduce intensity. The graph shows a projection of nonelectric intensity (*a*), a projection of electric intensity at current efficiency levels (*b*), a projection that also includes utility efficiency programs (*c*), a conservative estimate of efficiency potential (*d*) and an optimistic estimate of the potential (*e*).





1.5 BILLION LIGHTING FIXTURES in U.S. buildings could use about 60 percent less electricity—typically from 70 to 90 percent less when using dimming technologies available in 1988. Lamp output is improved by phosphors, cooler fixtures and operation at high frequency (about 30 kilohertz). The retrofit costs less than $130 per fixture, saves $50 in long-term maintenance costs and pays for itself in one or two years. It saves electricity at a net cost of about .6 cent per kilowatt-hour. The further options shown can save even more, approaching 100 percent in new specially daylit buildings.

They typically last four to five times longer than incandescent floodlamps and nine to 13 times longer than ordinary incandescent bulbs. If one balances the higher initial cost of the lamps against the reduction in replacement lamps and installation labor (longer-life bulbs do not need to be changed so often), one can recover the cost of the fluorescent lamps and still save many dollars over the life of each lamp. One can thus make money without even counting the savings in electricity. This is not a free lunch; it is a lunch you are paid to eat.

Efficient lighting hardware is now available for almost any application. Most devices provide the same amount of light as older systems do, with less glare, less noise, more pleasant color and no flicker. These aesthetic improvements can unlock even bigger savings: improving productivity by 1 or 2 percent is usually worth more to an office's bottom line than eliminating electric bills.

Together the lighting innovations that are commercially available can potentially save one seventh to one fifth of all the electricity now used in the U.S. These innovations would cost about one cent per kilowatt-hour to install. The reduced maintenance costs, Rocky Mountain Institute calculates, would save the user an additional 2.4 cents per kilowatt-hour saved. The savings in electricity would reduce the need for about 70 to 120 billion watts of power plants that would cost from $85 to $200 billion to build and from $18 to $30 billion per year to operate. Thus, lighting innovations may be the biggest gold mine in the entire economy [*see illustration above*].

After lights, electric motors offer the best opportunity to effect major savings. Motors consume 65 to 70 percent of industrial electricity and more than half the electricity generated in the U.S. The annual electricity bill for motors exceeds $90 billion, or about 2 percent of the gross national product.

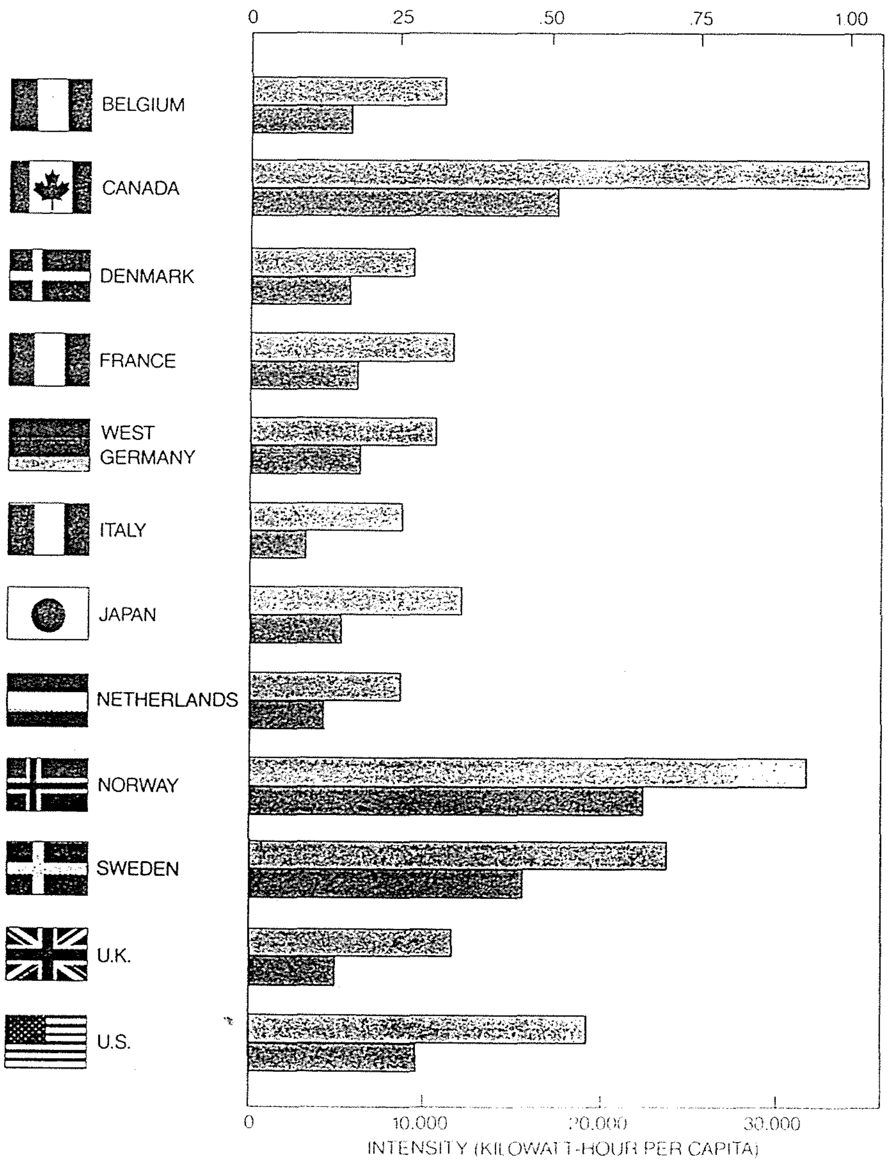
A typical large industrial motor consumes electricity that costs some 10 to 20 times its total capital cost per year: its capital cost is only about 1 to 3 percent of its total life-cycle cost. Over a motor's life, a one-percentage-point gain in efficiency typically adds upward of $10 per horsepower to the bottom line. Multiplying the many percentage points of available savings by the hundreds or thousands of horsepower for each big motor reveals very large potential savings. And one industrial processing plant can have hundreds of such motors [see "Energy for Industry," by Marc H. Ross and Daniel Steinmeyer, page 88].

Many machines, especially pumps and fans, need to vary their output to accommodate changing process needs. This is often done by running the pump or fan at full speed while "throttling" its output with a partly closed valve or damper—like driving with one foot on the gas and the other on the brake. Electronic adjustable-speed drives can reduce this waste. When you need only half the flow from a pump, you can in principle save seven eighths of its power and in practice nearly that much, because electronic drives are very efficient. Savings can range from 10 to 40 percent, with typical applications reducing total U.S. motor energy by about 20 percent. Paybacks range from six months to three years, averaging one year.

A new breed of high-efficiency motors represents another important advance. These motors are better designed and better made from higher-quality materials than conventional motors are, thereby squeezing down their magnetic, resistive and mechanical losses to less than half the levels of a decade ago. Although such motors are widely found in North America, Western Europe and Japan, they are not available in some industrialized countries, such as Australia, or in much of the socialist or developing world, where motor efficiencies are often very low.

Most engineers think only in terms of adjustable-speed drives and high-efficiency motors. Although both are important, they account for only half of the total potential electricity savings in U.S. motor systems. The other half comes from 33 other improvements in the choice, maintenance and sizing of motors, three further kinds of controls and the efficiency with which electricity is supplied to the motor and torque is transmitted to the machine. Improved motor systems can run on about half the electricity, which amounts, in principle, to electricity savings equivalent in the U.S. to about 80 to 190 billion watts of power plants. Furthermore, the cost of the new motors can usually be recovered in about 16 months, because after a company pays for only seven of the 35 improvements (including adjustable-speed drives and high-efficiency motors), the other improvements are free by-products.

Progress in motor and lighting technologies is matched by advances in superefficient appliances. Refrigerators and freezers can now consume 80 to 90 percent less electricity than conventional models; commercial refrigeration systems can save 50 percent, televisions 75 percent, photocopiers 90 percent and computers 95 percent. Rocky Mountain Institute, for example, installed efficient lights and appliances in its 4,000-square-foot headquarters, decreasing consumption of electricity tenfold, to only $5 a month. The institute also lowered its water consumption by 50 percent and eliminated 99 percent of the energy it needed to heat space and water. (The building is so well insulated that even though it is located in the subarctic climate of the Colorado mountains it needs no furnace.) Moreover, all of this seven-year-old technology paid for itself within a year.



VARIATIONS in the habits of many developed nations suggest that each one has considerable flexibility in choosing strategies for consuming and supplying electricity. Blue bars indicate electricity consumption per 1986 dollar of gross domestic product; red bars show electricity consumption per person in 1986.

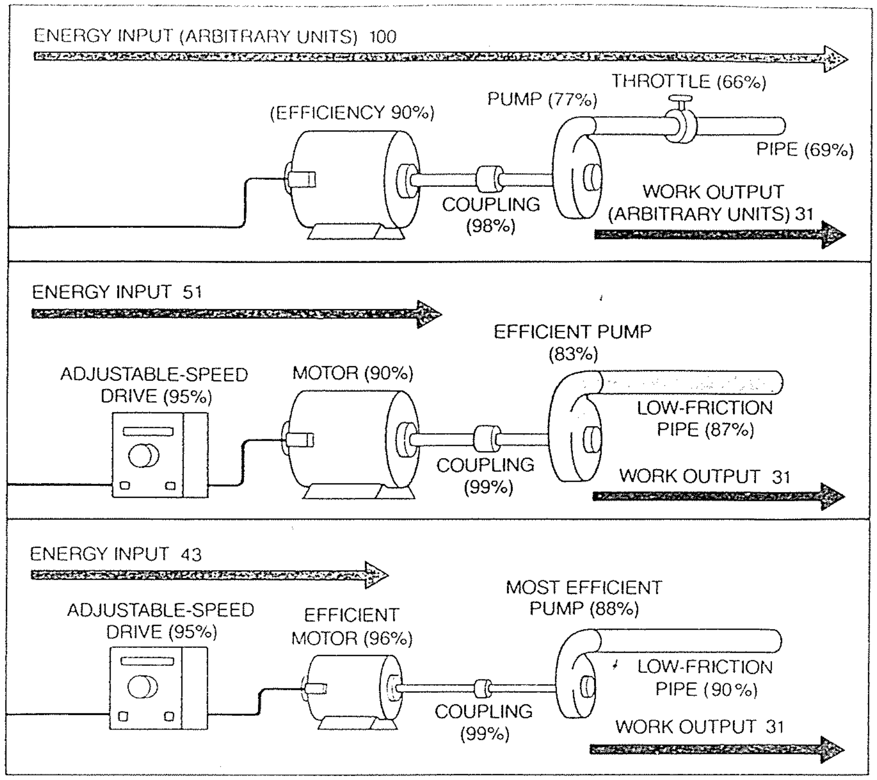
Exploiting the full menu of efficiency opportunities can double the quantity and more than halve the cost of savings, because saving electricity is like eating a lobster: if you extract only the large chunks of meat from the tail and claws and throw away the rest, you will miss a comparable amount of tasty morsels tucked in crevices. To capture major electricity savings cheaply, one must not only install new technologies but also rethink the engineering of whole systems, paying meticulous attention to detail.

Such rethinking will require a new infrastructure to deliver integrated packages of modern technologies. Only a handful of firms provide comprehensive, up-to-date lighting retrofits; few if any provide similar services for motors. Yet retrofits that save electricity represent a global business opportunity ultimately worth perhaps hundreds of billions of dollars a year—an ample prize to elicit entrepreneurship [see "Energy for Buildings and Homes," by Rick Bevington and Arthur H. Rosenfeld, page 76].

The potential to save electricity will not be realized until—like power plants—electricity-saving programs are planned, designed, financed, built, commissioned and maintained. Just as one might extract a mineral resource from the ground, one must determine how much electricity can be profitably saved employing existing technology and how to convert that reserve to actual production.

Efficient technologies are often underused because of the lack of customer demand (market pull) or the lack of a sufficient distribution channel (market push), or both. If electricity consumers want efficient appliances and ask retailers to provide them, retailers will then ask wholesalers to supply them, and wholesalers in turn will seek manufacturers to produce those products. If consumers fail to act, then the whole string of potential benefits unravels.

To create market pull, energy planners must understand how consumers make energy choices. Most planners are puzzled to find that customers sometimes shun efficiency even when it is accompanied by attractive economic incentives. In the past, manufacturers and retailers have not considered efficiency to be an important feature in new products, because they have found that consumers rarely decide to make a purchase based on efficiency. The factors that most consistently affect their choices are appearance; safety; comfort, convenience and control; economy and reliability; high-technology features; the need to have the latest equipment; the desire to avoid hassles; and resistance to having utilities control energy use. Because human nature is diverse, the weighing of these factors varies enormously, and retailers must adjust their marketing strategies accordingly. Businesses have analogous concerns, including product quality, production reliability, fuel flexibility, environmental cleanliness, a clean workplace and low risk.



RETROFIT can raise the efficiency of a typical motor-pump system (*top*) from 31 to 72 percent and can pay for itself in two to three years (or less counting saved maintenance costs). An electronic drive (*middle*) affects the efficiency of the other components. Here the drive's net effect is a 21 percent savings, not counting lower pipe losses. A more efficient and properly sized motor and pump, as well as better pipes, saves even more (*bottom*), partly by fixing the damage caused by improper repairs to the old motor. Further refinements may cut energy use by 40 percent.

If efficient technologies are to be widely deployed, a third party, such as the electric utility or government, may need to assume responsibility for both market push and market pull. As we shall see, utilities have a special interest in influencing customers' demand—treating it not as fate but as choice—in order to provide better service at lower cost while increasing their own profits and reducing their business risks. Utilities can choose from a wide range of market push and pull methods designed to influence consumer adoption and reduce barriers. These include rebates or other financing options, direct contact with their customers, special tariffs, advertising, education, and cooperative ventures with architects, engineers and suppliers of efficient technology. Collectively, such efforts are part of demand-side management, which seeks to change the demand for electricity while still meeting customers' needs.

More than 60 utilities serving almost half of all Americans now offer rebate programs to promote the buying or selling of efficient devices. The overwhelming majority (92 percent) pay rebates to purchasers to create market pull; about 24 percent pay appliance dealers to create market push.

Utility rebate programs can rapidly stimulate market development. Efficient lighting equipment was unavailable in Las Vegas, for instance, until Nevada Power Company started offering rebates, whereupon within six months, 20 wholesale and retail outlets were competing in the price and breadth of efficient lighting systems.

Many utilities have begun to pay consumers for each kilowatt-hour saved, no matter how it is done. They have also tried to reward "trade allies" who remove old, inefficient equipment or who sell, specify or install electricity-saving devices. Utilities sometimes offer rebates to consumers who beat a government performance standard, thus eliciting better technologies so the standard can be raised until cost-effectiveness limits are reached.

Other financial incentives complement rebates: low- or no-interest loans, gifts and leases. Southern California Edison Company, for example, has given away more than 800,000 compact fluorescent lamps. The Taunton Municipal Lighting Plant in Massachusetts leases such lamps for 20 cents each per month and replaces them for free. Thus, customers can pay for efficiency over time, just as they would otherwise pay for power plants. The makers of compact fluorescent lamps have relied on both their own and utilities' marketing strategies to achieve annual U.S. sales of about 20 million units. Those sales are doubling or tripling each year, and such lamps already dominate the West German market.

These well-established methods are so effective that when Southern California Edison Company had a peak load of 15 billion watts, in 1983-1984, it was able to reduce its forecast of peak demand by more than 500 million watts in a single year. At the same time, California's appliance and building standards increased electricity savings even more. Annual savings represented 8.6 percent of the utility's peak demand at the time and cost the utility only about 1 percent as much as building and running a new power station. If all Americans saved electricity as fast as those 10 million did, the U.S. economy could grow by several percent every year while total electricity use decreased.

Such success stories are now spreading in the U.S. and abroad. In some instances, skillful and imaginative marketing has captured 70 to 90 percent of specific efficiency markets, such as housing insulation, in just a year or two. Some utilities, such as the Bonneville Power Administration, are saving businesses money through commercial efficiency programs whose cost is about .5 cent per kilowatt-hour.

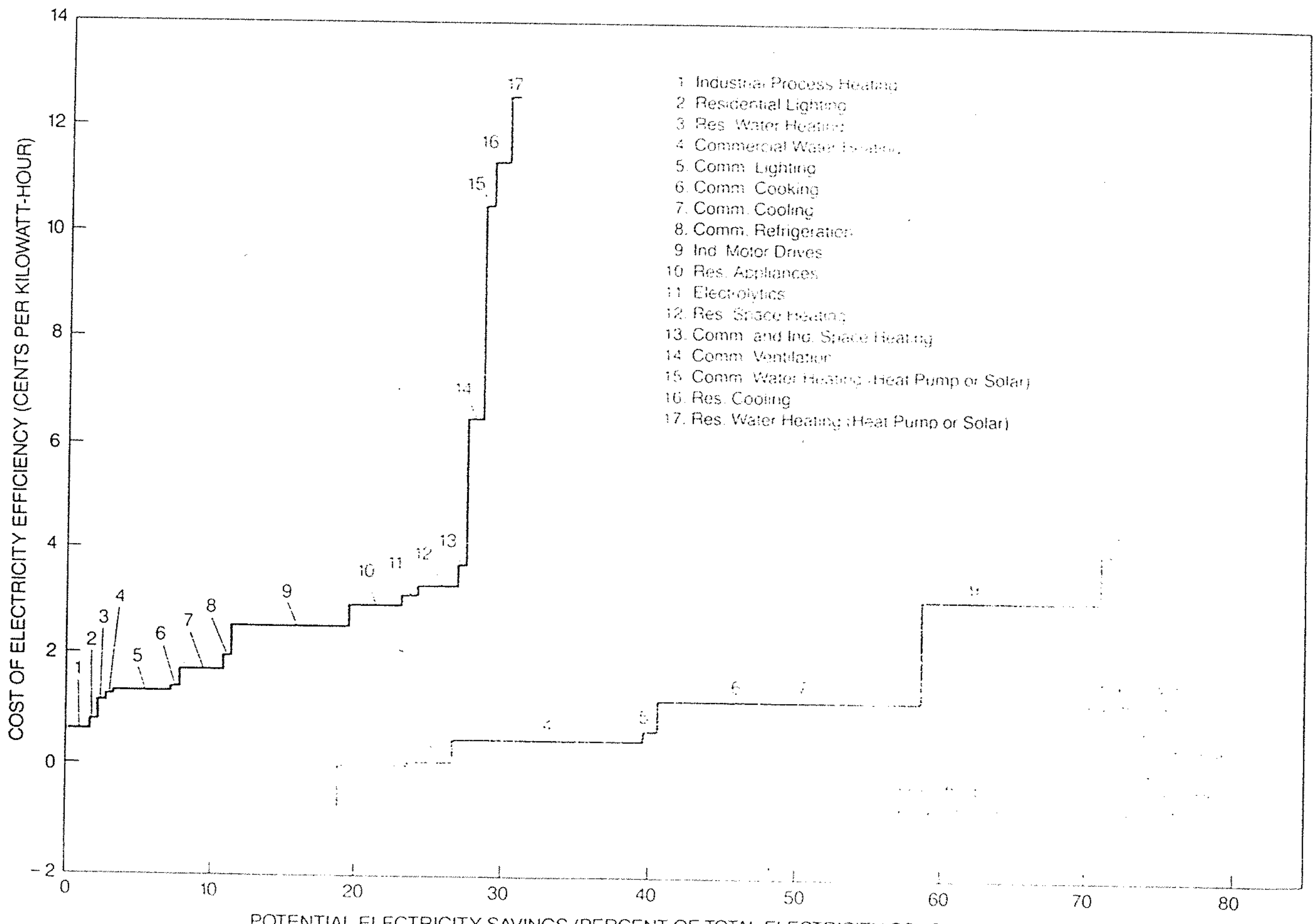
Utilities such as North Carolina's Duke Power Company offer lower rates to efficient customers. Others require minimum efficiency levels as a condition of service; Atlantic Electric in New Jersey, for example, has such an air conditioner standard. Several states are now trying or considering a sliding-scale hookup fee: when a utility connects a new building to the power grid, it charges a fee that is tied to the building's efficiency. Consideration is also being given to using such fees to pay rebates ("feebates") for the most efficient buildings.

Still further savings may be achieved by methods that seek not merely to market "negawatts" (saved electricity) but to make markets in negawatts: saved electricity can be treated as a commodity just like copper or sowbellies. This strategy can maximize competition among means of savings and among providers of savings and so drive down the cost. For example, some utilities run competitive bidding processes in which all ways to make or save electricity compete.

Saved electricity can be converted to money and traded between utilities or between customers. Some utilities may even want to become "negawatt brokers" and make spot, futures and options markets in saved electricity. Others are considering buying contracts from their customers to stabilize or reduce demand. The contracts could be resold in secondary markets, just as some brokers already buy and sell air pollution rights.

Some aggressive utilities competing in the emerging negawatt market even sell efficiency in the territories of other utilities. Puget Sound Power and Light Company sells electricity in one state, but its subsidiary sells efficiency in nine states.

Even though some utilities and consumers have taken the lead in electricity efficiency, most of the potential savings remain untapped. Customers use very different financial criteria to assess ways to save electricity than utilities use to assess new power plants. On the one hand, if customers invest money to save electricity in their home or business, they will probably want to recoup their investment within about two years—perhaps



EFFICIENT TECHNOLOGIES offer the potential to reduce long-term U.S. electricity consumption as estimated by the Electric Power Research Institute (*red line*) and by Rocky Mountain Institute (*blue line*). Estimates are given in 1990 dollars.

as long as five years for a few far-sighted industries and less than one year for low-income renters. On the other hand, if utilities build plants to increase capacity, their technical and financial strength lets them recover costs over a 20-year period.

The gap between the payback horizon of consumers and utilities tends to make society buy too little efficiency and too much supply. The result in the U.S. alone is the $60 billion per year now spent in expanding electricity supplies that could be partly displaced by investments in efficiency. The payback gap also dilutes price signals. If customers can avoid a tariff of six cents per kilowatt-hour by saving electricity, then without other incentives they will buy efficiency costing up to .6 cent per kilowatt-hour—about a tenth of the tariff, because the tariff is calculated at the utility's payback horizon of 20 years, but the customer invests on the basis of a two-year horizon. Just getting the prices right will therefore not necessarily induce people to buy as much efficiency as would benefit society at large. However, correct pricing is important: only prices that tell the truth can inform customers about how much is enough. Prices should be adjusted to the time and season of use—perhaps ultimately with sophisticated new kinds of electronic meters—and reflect real-time spot prices in order to provide the most accurate signals.

Utilities around the world are reexamining their purpose. Is their mission the production and sale of electricity, or is it the profitable production of customer satisfaction? Utilities that take the latter view believe that if electricity costs more than efficiency, then customers will eventually realize they can save kilowatt-hours and money and still get hot showers and cold beer with high-performance shower heads and superefficient refrigerators. The only relevant question, then, is who will sell efficiency? If efficiency is cheaper than electricity, customers will buy less electricity and more efficiency. It is generally a sound business strategy to satisfy customer needs before someone else does.

Utilities are the logical organizations to expedite the use of energy-efficient products: they have technical skill, permanence, credibility, close ties to customers, a relatively low cost of capital and a fairly steady cash flow. At present, however, they have little motive to expedite energy efficiency. The conflict is obvious: Why spend money to reduce sales?

In principle, utilities can profit in several ways from making their customers more efficient. They can avoid operating costs in the short run, construction costs of new power plants in the medium run and replacement costs of old power plants in the long run. They can also earn a spread on financing efficiency, just as a bank would. Legislation such as the amended U.S. Clean Air Act may allow utilities to use efficiency to generate pollution rights, which they can resell. And finally, under new regulations now being adopted in some states in the U.S., utilities may be able to receive exemplary financial rewards for money-saving investments.

A major breakthrough occurred in 1989 when new regulations were accepted in principle nationwide for consideration by state regulators. The proposed rules would uncouple utilities' profits from their sales, removing a utility's disincentive to invest in efficiency. In effect, the utilities will be compensated for the revenue they would otherwise lose by selling less electricity—and will get to keep part of the savings.

Such rules have already proved effective in a few cases. Pacific Gas & Electric Company in California and a group of environmentalists, government administrators and consumers recently agreed that the utility should keep 15 percent of any money saved by certain new efficiency programs. Customers will benefit by getting 85 percent rather than all of nothing.

In New York Niagara Mohawk Power Corporation has proposed another way to profit from efficiency services. Under the plan, the utility's 12 efficiency programs, which cost $30 million to implement in 1990, will be allowed to recover costs and clear a $1-million profit if the utility's 12 programs achieve the state's goal of saving 133 million kilowatt-hours, which is worth about $10 million a year in reduced energy cost for participating customers. By 1992 the programs should save 240 million kilowatt-hours per year. Where does the money come from? Prices per kilowatt-hour will rise by as much as 1.4 percent, yet participating customers will still pay lower bills because they will consume less.

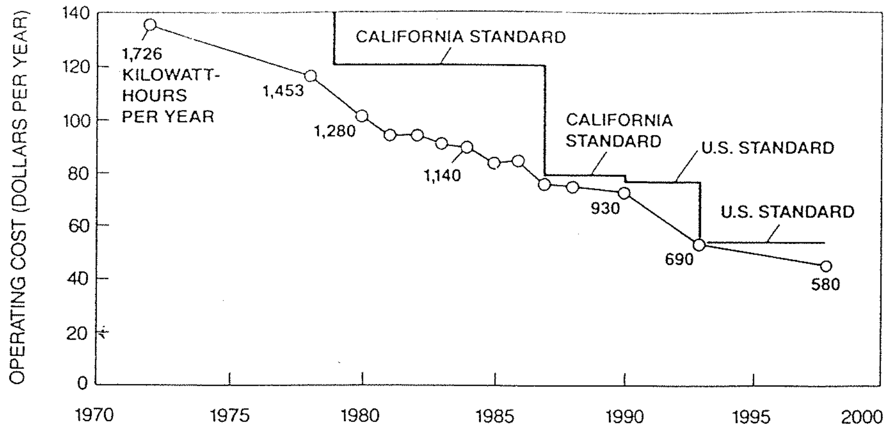
Niagara's residential low-cost measures program, for example, provides each participating household with a low-flow shower head, a compact fluorescent light bulb and insulation to wrap their electric water heaters and pipes. The equipment should save 960 kilowatt-hours per participating household per year. For each household, the utility loses about $72 in annual energy sales but saves about $40 on fuel and capacity costs. The difference ($32 a year) is charged to the residential customers each year for eight years and includes a $5 profit for the utility. For the equipment, each participating household pays $6 a year for eight years. Therefore, each household will save $272 over eight years.

As efficient technologies and implementation techniques spread, how will they change the economics of our businesses, the services we receive and the health of our environment? Consider first the effect of efficiency on local business. In Osage, Iowa (population 4,000), a utility manager launched a nine-year program to weatherize homes and control electricity loads at peak periods. These initiatives saved the utility enough money to prepay all its debt, accumulate a cash surplus and cut inflation-corrected rates by a third (thereby attracting two factories to town). Furthermore, each household received more than $1,000 of savings a year, boosting the local economy and making shops noticeably more prosperous than in comparable towns nearby. If other communities in the U.S. followed the lead of Osage, they could create economic vitality that would reverberate from Main Street to Wall Street.

Electric efficiency can also enhance industrial competitiveness. When the rod, wire and cable business fell on hard times around 1980, for example, the biggest independent U.S. firm, Southwire, responded by saving, over eight years, about 60 percent of its gas and 40 percent of its electricity per ton of product. The savings yielded virtually all the company's profits during a tough period. The efforts of two engineers may have saved 4,000 jobs at 10 Southwire plants in six states.

Electric efficiency could also break a major logjam in global development. In developing nations, electricity generation already consumes a fourth of global development capital, and in the next few decades the utilities of those nations are projected to need about eight times more capital than is expected to be available—a prescription for power shortages. But efficiency can be the key to saving the capital desperately needed for other development tasks.

Electric efficiency can also ease environmental pressures. If a consumer replaces a single 75-watt bulb with an 18-watt compact fluorescent lamp



GOVERNMENT STANDARDS have pushed manufacturers of refrigerators to produce more efficient models. The average new refrigerator in 1990 costs about $64 less per year to run than one made in 1970. The data were compiled by the Association of Home Appliance Manufacturers and Lawrence Berkeley Laboratory.

that lasts 10,000 hours, the consumer can save the electricity that a typical U.S. power plant would make from 770 pounds of coal. As a result, about 1,600 pounds of carbon dioxide and 18 pounds of sulfur dioxide would not be released into the atmosphere, reducing the contribution of these gases to global warming and acid rain. Alternatively, an oil-fired electric plant would save 62 gallons of oil—enough to fuel an American car for a 1,500-mile journey. Yet far from costing extra, the lamp generates net wealth and saves as much as $100 of the cost of generating electricity. Since saving the fuel is cheaper than burning it, environmental problems can be abated at a profit. (Power plants that run on fossil fuel use three units of fuel to make one unit of electricity, whereas in socialist and developing countries they often use five to six units to do the same.)

No matter how electric efficiency is used to reduce emissions, consumers and suppliers of electricity will achieve the biggest reduction at the lowest cost in the shortest time only if they choose the best buys first. Suppose a government wants to reduce carbon dioxide emissions by reducing the amount of electricity generated by coal-fired power plants. To replace that electricity, the government should invest in low-cost efficiency options such as lighting or motor retrofits before considering alternative high-cost technologies such as solar or nuclear power. Otherwise each dollar spent will replace less coal burning than it could have. As we compete for limited resources, the order of environmental priority should be the order of economic priority.

The best-buys-first sequence can be determined either by "least-cost utility planning" or "integrated resource planning"—a formal procedure now required by utility regulators in most of the U.S.—or by an equivalent market process in which all ways to make or save electricity compete fairly for marginal investment.

Electric efficiency, wisely bought today, can go far to stretch the electricity supply. It can also provide time to perfect and deploy renewable energy resources such as solar power, an area where recent progress has been so encouraging. If efficiency decreases the demand for electricity, then renewable resources can be deployed more easily and provide more electricity to more people. Both in the broad sense and in detailed design, electric efficiency and renewable resources are natural partners.

The electric utility is only one of many organizations that should be encouraging energy efficiency. State and local agencies can be particularly helpful in educating customers. Federal support for such programs, which were largely abandoned over the past decade, should be restored.

America's largest landlord—the U.S. government—can take the lead by starting a massive, modern retrofit program in federally owned buildings. The government could be the key to developing market push in certain technologies. It could provide funds to help underwrite the high initial manufacturing costs that penalize new technologies. In addition, state and federal authorities could encourage manufacturers to make more efficient products and broaden performance labeling [*see illustration above*].

Governments could also do more to assist in the research and development of efficient technology. Investments in efficiency are far out of line with potential benefits. Not only do consumers and suppliers of electricity need more and better hardware choices, but they also need better ways to help designers choose from the bewilderingly large array of technologies that are already available.

A formidable challenge to electric utilities and governments, then, as well as to customers, design professionals and many other stakeholders, is to integrate the technical, economic, cultural, marketing and policy innovations into coherent efforts to capture the efficiency potential. It is encouraging that many are rising to this challenge. The seriousness of some U.S. utilities' effort, such as that of the New England Electric System, is indicated by their commitment to allocate as much as 4 percent of their gross revenues to improving customers' end-use efficiency. In recent weeks, five U.S. utilities have added nearly $1 billion to their efficiency budgets. Some utilities in Western Europe and Japan, too, have undertaken similarly impressive programs. With such efforts, electric and economic growth need not march in lockstep—if we choose to use electricity in a way that saves money and the environment.

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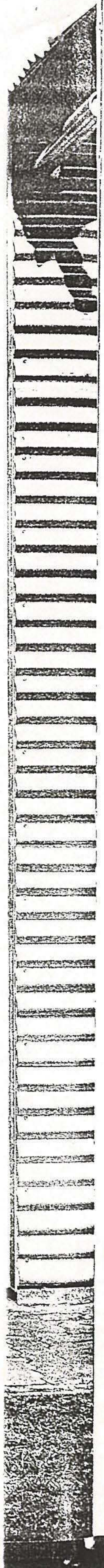

BRENDA AND ROBERT VALE

Green ARCHITECTURE

Design for an energy-conscious future

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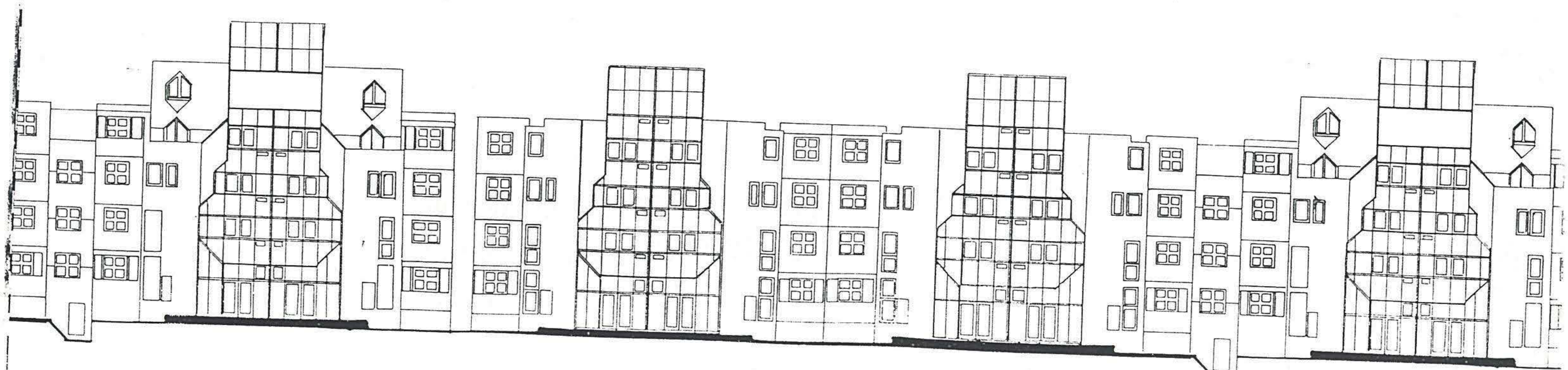


in nearly every room cannot easily be supplied with hot water from a central source. In the consulting rooms, doctors and nurses need to be able to rinse their hands but not to run a sink full of water. If the water came from a central source a lot of cold water would have to be run off before it reached the tap hot, so a decision was made to use electric under-sink water heaters to supply temperature-controlled hot water at the point of use. It is not efficient in primary energy terms to use electricity for heating, but in this case a value judgement had to be made about relative energy use.

Lighting energy use has also been considered in the design of the building. It was thought inappropriate to use fluorescent strip lights as these would create too much of an institutional atmosphere, but tungsten lights produce too much heat. The decision was made to use compact fluorescent lamps in a variety of fittings. The result is a saving in lighting energy demand of 80 per cent.

Finally, it is appropriate to describe the architectural expression of the Medical Centre. In order to achieve the required ecological aspects of the design within a fixed budget it was essential that the design remained simple. The choice of form – a rectangular shed, and materials – brick, concrete tiles and timber windows, was determined by the need for economy in initial cost as well as, in the case of materials, economy in energy of manufacture and maintenance. The brick shed with a pitched roof that resulted is modified by the use of angled brick buttresses at the corners and at the junctions between the three blocks. These are used to tie the building visually to the earth by breaking the abrupt transition from horizontal ground to vertical wall. Against the slope of the buttresses and the 1:12 fall of the site, the building's horizontality is emphasized by the use of brick bands at floor, cill and head level.

The Arts and Crafts dictum that one should do nothing to a material except that which honours it best has been the driving force behind the architectural expression. Everything is what it seems to be, and materials have been used deliberately to express aspects of construction that are usually hidden. Wooden lintels support the brick walls over openings; the pegs that join the inner and outer lintels project visibly from the faces on both sides (but, being timber they cause no cold bridge); creasing tiles form drips and cills where needed to keep rain from the timber, and small dowels reveal the location of boron preservative rods. Internally the timber beams that can be seen, while decorative, are the beams that support the building. Where the ceilings are cut away to reveal the skeletal trusses behind, they are standard trusses with the usual imperfections; they have not been specially treated for display. The sloping eaves provides a visual link with the sloping buttresses, but also shows the thickness of the superinsulated roof construction, and reveals where air can enter to ventilate the roof voids above the insulation. Internally, white painted plaster and stained timber provide the simplest possible background for the pictures and hangings provided by the users, and reflect the sunlight that streams through the roof windows to reduce the need for electric light.

The building, because of the nature of the industry which operates at this scale of construction, is a craft product, but it is made of standard mass-produced components, and an attempt is made to express this, also. It is a demonstration that it is possible to produce a green building within existing parameters and technologies.

NMB Bank headquarters

The second building chosen as embodying most of the green principles is a project on a vastly different scale. In 1978 the NMB Bank decided to build a new headquarters in a suburb in the south east of Amsterdam.[2] In Britain or the United States most organizations rent their office space. Buildings are put up as investments by speculative developers who benefit both from the rents that they can charge and from the increasing market value of their buildings, against which can borrow to finance further developments. The NMB Bank followed the very different Dutch and German pattern of office development.

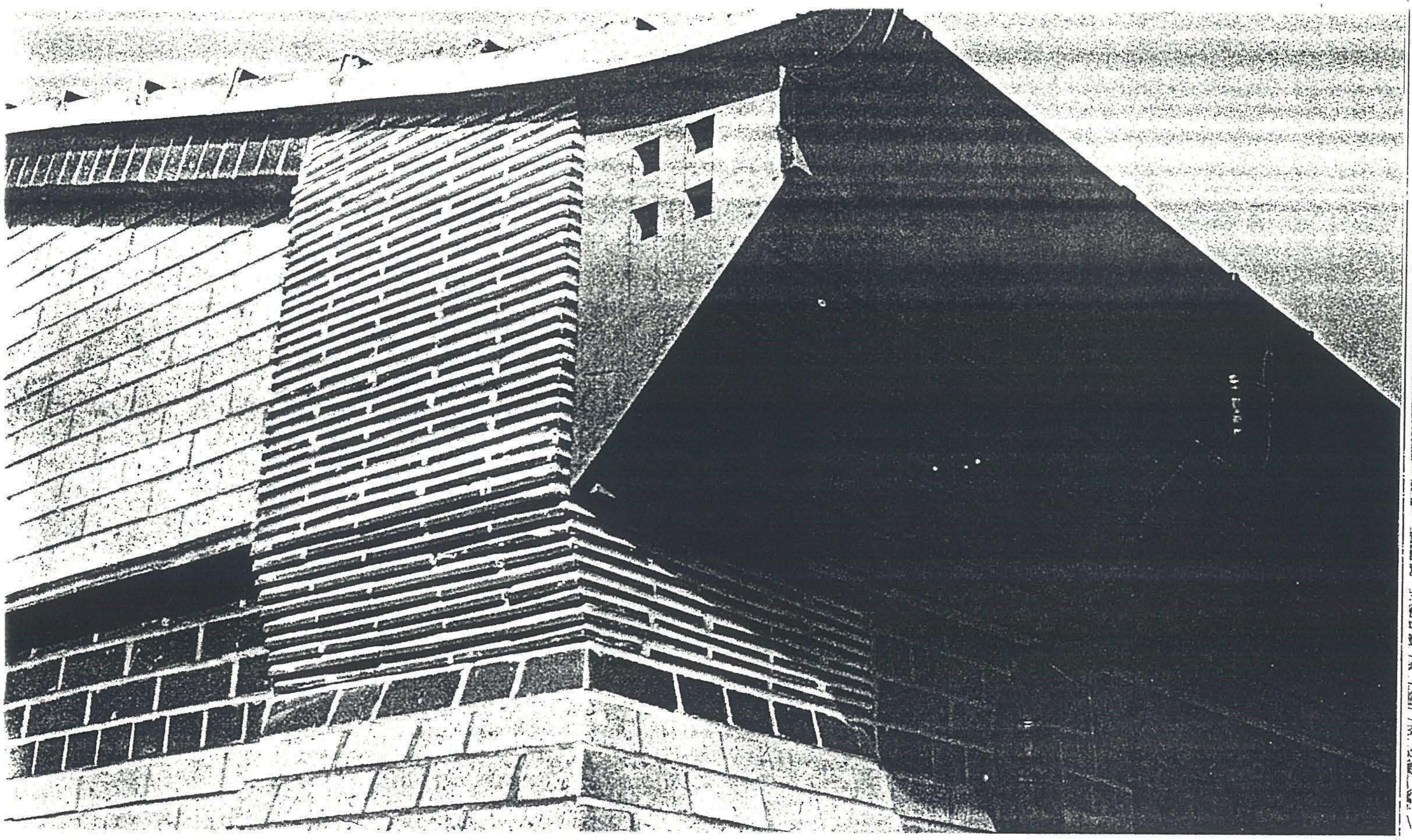
BUILDING WITH LOCAL MATERIALS

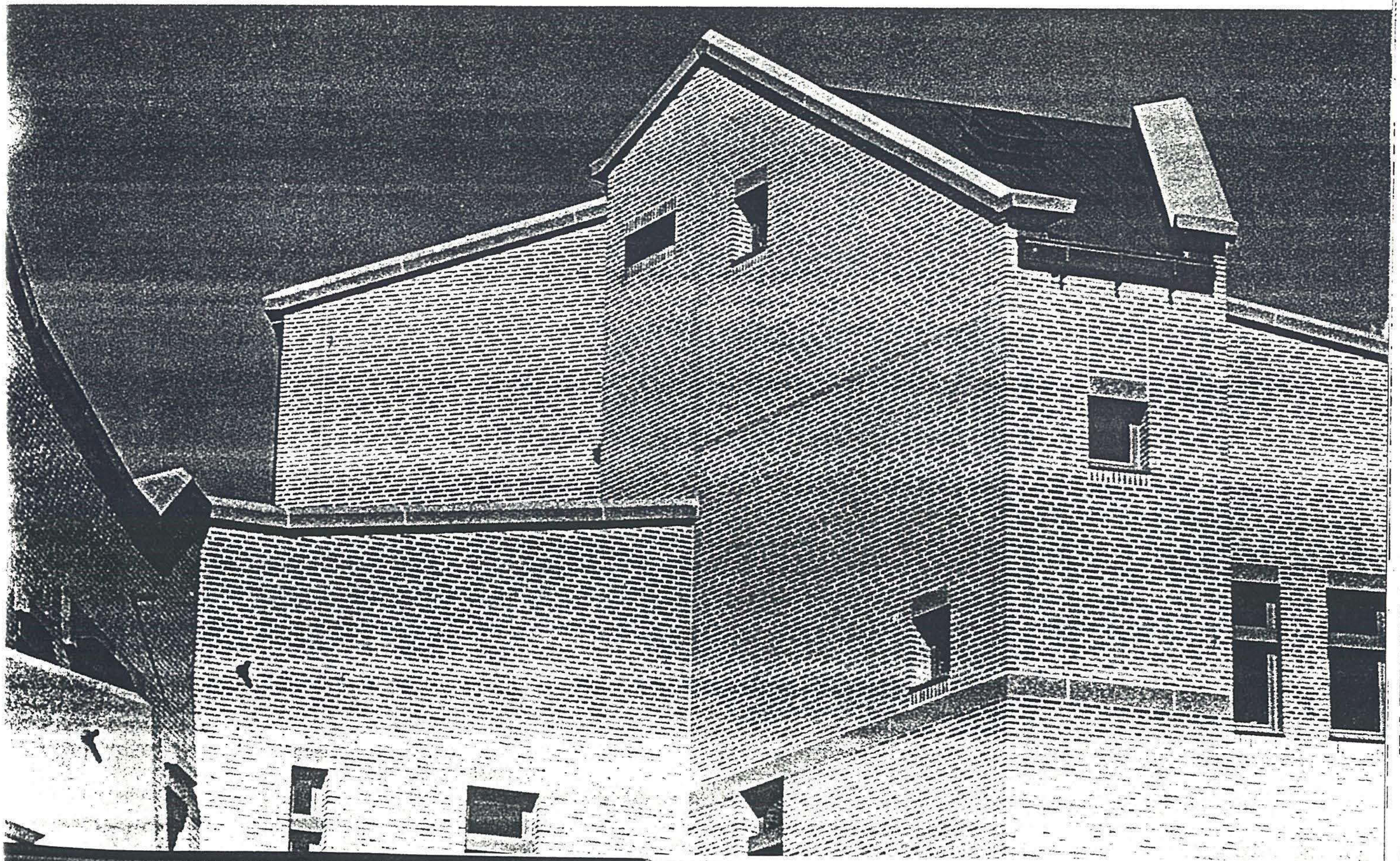
RIGHT, ABOVE
47 Eaves of the Woodho[...] Medical Centre, Sheffield. Their depth is one of the visual clues to the buildi[...] superinsulated construc[...] Decoration is derived pu[...] from the materials used - local bricks and clay tiles and the way they are put together

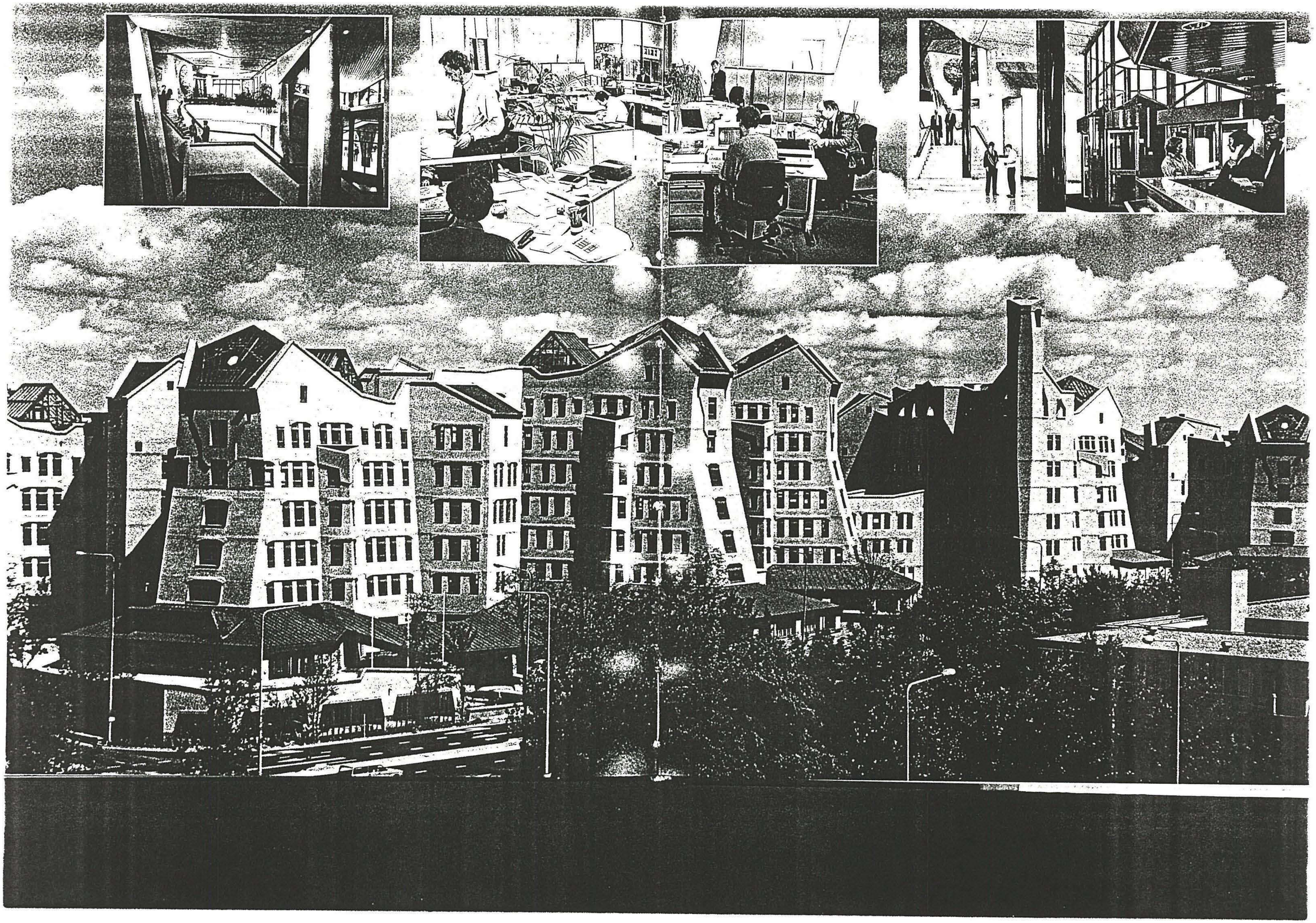
RIGHT, BELOW
48 Top of a circulation tower, NMB Bank headquarters building, Amsterdam. The use of traditional Dutch brick l[...] a human scale to an offic[...] development the size of a small town. Pentagonal s[...] collectors on the roof pr[...] heat ventilation air

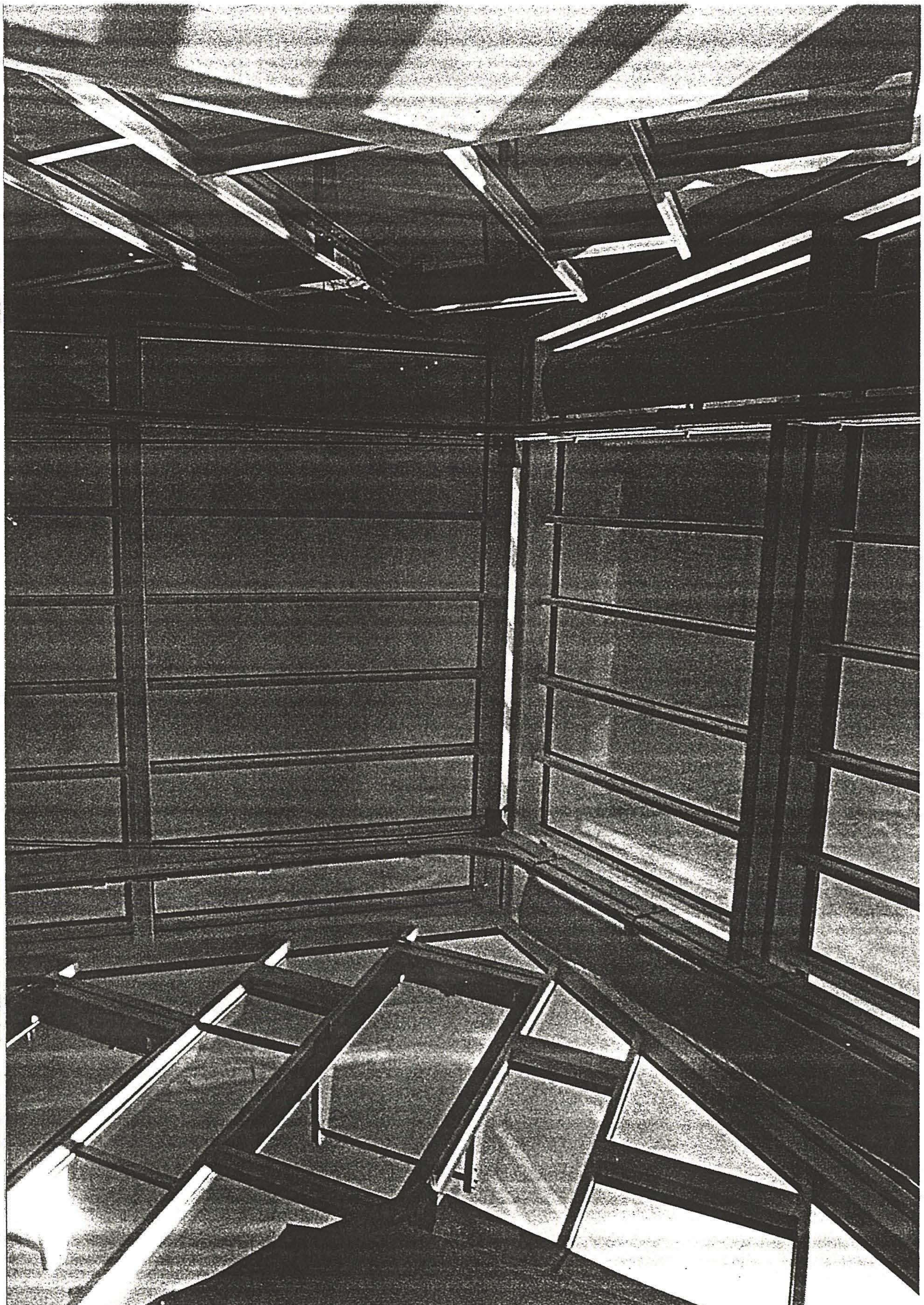
OVERLEAF
49 The NMB Bank headquarters took its sha[...] from a variety of green principles, including consultative planning. Th[...] result is a highly distincti[...] looking building that is th[...] pride of all involved with

INSET, LEFT TO RIGHT
50–52 Informal meeting[...] encouraged by a design o[...] generous public spaces. Durable natural materials such as the marble for the floors are not confined to reception lobbies, but ext[...] to all the public areas. Off[...] have good daylighting an[...] flexible spaces to encoura[...] working in small groups

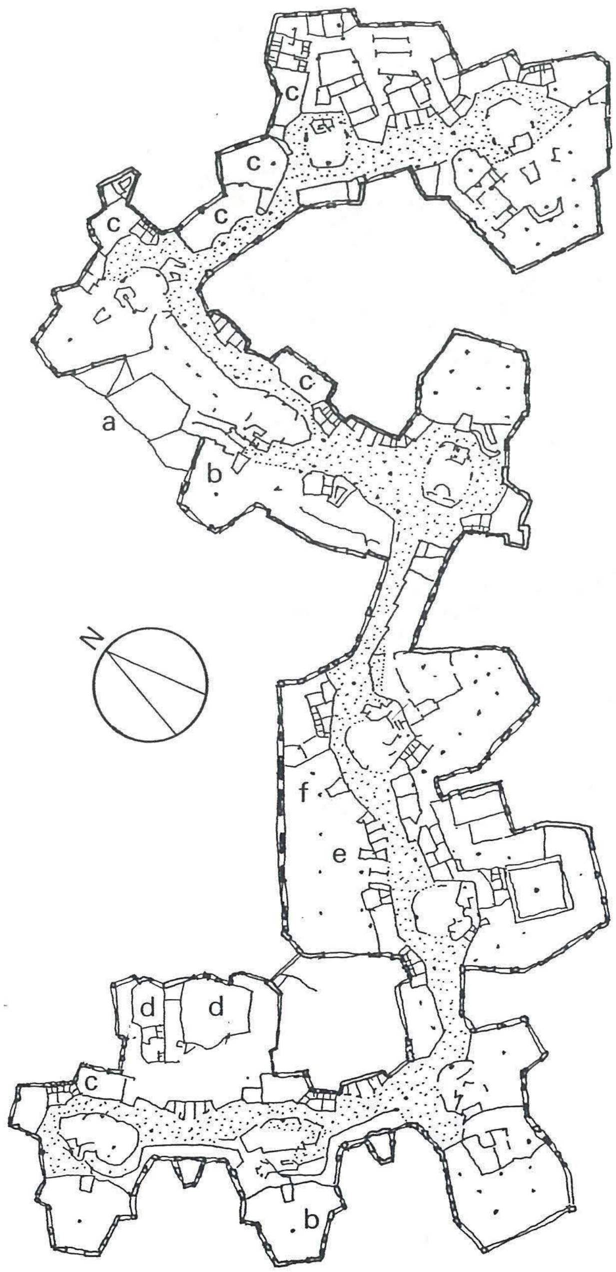








53 The glazed roof of an NMB Bank circulation tower allows sunlight to pour down into the linking street below



Layout of NMB Bank, showing the wide internal street running through the centre of the building. Major spaces include: **a** entry; **b** restaurant; **c** meeting room; **d** public relations centre; **e** post room; **f** print room

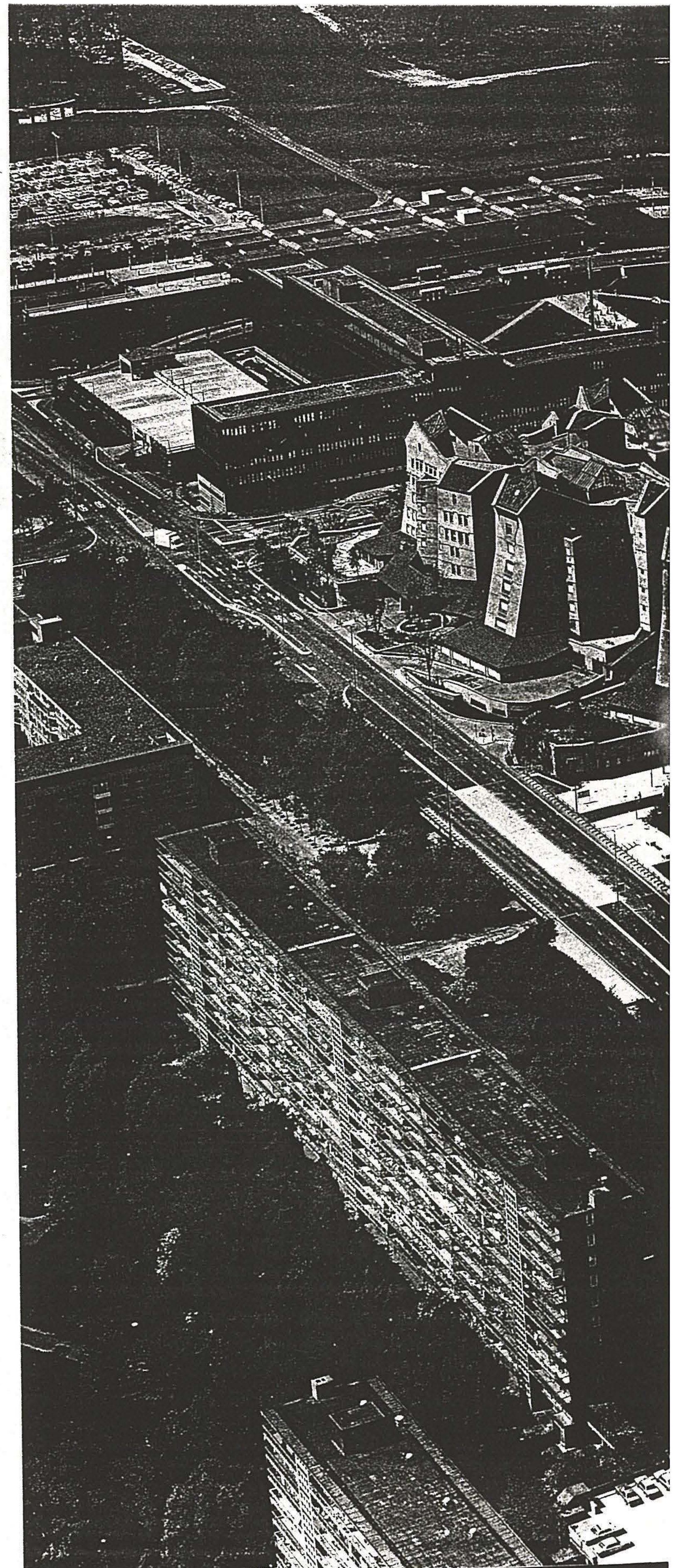
By this custom, a firm wanting a new office borrows money from a bank, appoints an architect or holds an architectural competition, and builds its own specially designed office building to suit its own needs.

NMB is one of the three largest banks in the Netherlands, and needed a large building to accommodate 2,000 staff. The choice of site was the result of a vote among the staff, who were able to opt for the location that would provide the easiest journey to work for the majority. The same degree of participation was carried through to many other aspects of the design process. Workers' Councils have the right under Dutch law to be involved when an employer plans to make changes to the working environment. The people who were to work in the new bank were not simply told to transfer to the new building on a certain date, as would have been likely in Britain or the USA. They were involved in design and technical considerations such as the need for a view to the outside, and the desire to have opening windows rather than air conditioning. They also discussed the materials of the building; the result is careful use of 'natural' materials wherever possible, and avoidance of materials that are polluting in manufacture, such as foamed plastics made with CFCs, or that may have hazards in use, such as chipboard that emits formaldehyde gas.

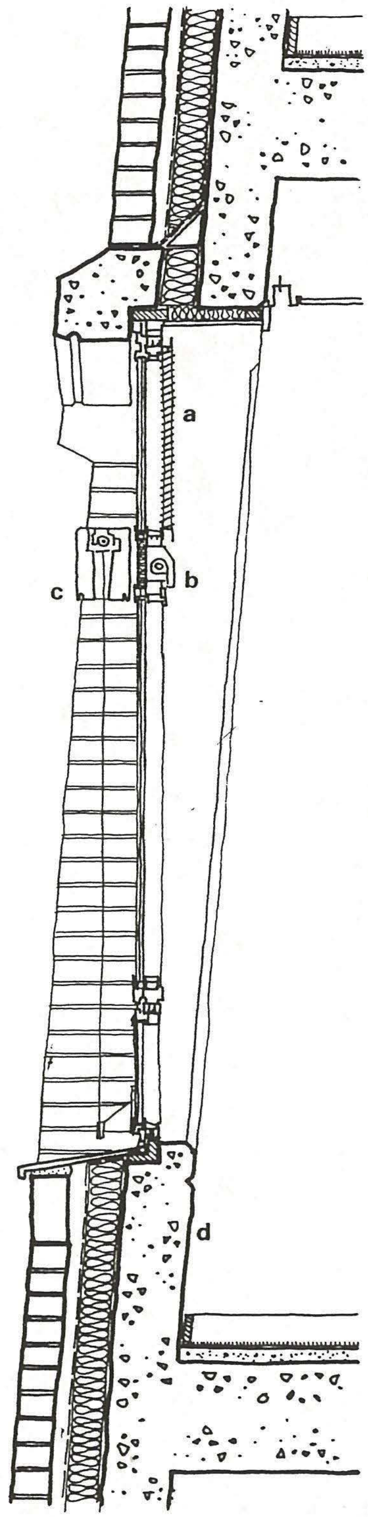
The involvement of the users of the building in its design was one aspect of an alternative approach to the design process, but of equal importance in the creation of the finished work was the unusual organization of the design team. The conventional model for the design of a large office block is that the architect is in control of the whole design, and calls in consultants to provide the technical detail for areas that are outside the architect's competence. For example, a services engineer might design the electrical system, a structural engineer would ensure that the building will stand up, and so on. The architect for the NMB Bank, Ton Alberts of Amsterdam, took a much less central role in the design team than is usual. The team who produced the design for the building included a representative appointed by the Bank to oversee the whole process of building procurement from the client's point of view; the architect; the structural engineer; a building physicist; interior design consultants; acoustic advisers and landscape designers. While this is not an unusual team to be assembled for the design of a large, complex building, there was none of the conventional hierarchy that might be found in such a team. Each member of the group was able to comment on the input of any other member, and the whole team was responsible for the final design. The consultative structure avoided the usual situation where different consultants may be in conflict with one another and with the architect. It mirrors the involvement of the users, as part of the democratization of the process of design. Each member of the team provided his or her particular expertise, and was still responsible for the detailed design of particular aspects of the building, but the design was the result of the creative interaction of all the design team members.

The obvious criticism of this approach, from those used only to the normal method of proceeding, is that it would result in 'design by committee', giving a bland and uninteresting building as the final result. Because of the commitment of the Bank to produce a high quality and ecologically sound building, combined with the enthusiasm of the design team for these concepts and for the novel design process, the result is a building that is unlike any other. Rather than a bland, inoffensive form, the NMB Bank has acquired a headquarters which is instantly recongnizable and uniquely suited to its needs. The involvement of the staff throughout the design process also reduces the sense of alienation that can result when people are forced to move into a building that is not of their choosing. The whole design process has stimulated rather than stifled creativity.

The NMB Bank is of necessity a large building. It has about 50,000 m^2 of floor space plus a further 28,000 m^2 of basement car parking. It is nearly a kilometre in length. Built as a traditional office block set down in a modest suburb, such a volume of space would have an enormously destructive impact. Instead of



The NMB in its neighbourhood. Note the contrast with office blocks of conventional design



NBM Bank, section through external wall and window: **a** louvred light deflector; **b** internal blind, manually operated; **c** computer operated external blind; **d** concrete structure

building a large block (which might have been the cheapest solution in simplistic economic terms) the designers have broken the office accommodation into a series of ten individual but linked units, each centred on a small glass roofed space containing stairs and a lift. The lifts and stairs are linked by a curving internal street that runs down the centre of the building at ground level. Off this street are restaurants, meeting rooms, a cinema and other shared facilities, with the office spaces above.

No two blocks of office accommodation are the same. They vary in height, plan shape and orientation, although each working space is designed to allow groups of roughly twenty people to work together. These groups are the basis of the Bank's working organization. There is no sign of the rigid rectangular layout of a typical British or US office with its obsession with movable partitioning to allow any occupier to alter it to fit. The NMB building is designed specifically for one user, and while the user might have problems if it were to change radically the way it wished to organize its activities, this is unlikely to happen. Moreover, the NMB building provides space that could be used by a variety of organizations in a variety of ways. Flexibility is produced, not by making all the walls movable as in the conventional speculative office block, but by making spaces of a size for groups of people to work together.

The great advantage that the NMB building has in organizational terms over the conventional rectangular block is that the designers have deliberately created spaces with which individuals can identify. This approach to office organization was pioneered by the Dutch architect Herman Hertzberger in his Centraal Beheer building. Within a building for a large organization, Hertzberger managed to create a sense of individual spaces for individual users without partitioning the space into little cells. People had space that they could personalize, but they were also recongnizably part of a larger space and a larger organization.

The people who work there in the NMB building are occupants of a building that holds 2,000 workers, but the division of this

Each of the NMB Bank circulation towers has a different form, but all have prominent stairways to encourage walking up rather than using the elevator

large block into ten separate units has created something akin to a small town. Each of these units is centred on the circulation tower through which light enters, and each tower holds the stairs and lifts. The height of the blocks is low enough that using the stair is the preferred means of movement, and the design of the stairs encourages this, with emphasis placed on them rather than on the lifts. The blocks of offices are further differentiated from one another by their differing orientations and their different views over the landscaped gardens. The gardens help to connect the artificially created town of the Bank with the real suburb where it is situated, and provide benefit both to office workers looking out and local residents looking in.

The ten buildings of this artificial town are joined together on all floor levels, but the street at ground level is the major linking element. As it curves between the blocks it provides a series of views of the different gardens, alternating with light coming from the rooflit access towers of the office blocks. The most striking aspects of this street are its scale and richness of detailing. In a speculative office building the circulation space is seen as 'unprofitable' because it is not bringing in rent. The result is that it is reduced to a minimum. There may be a lobby on the ground floor with a marble floor to create an impression of luxury at the entrance, but that is usually the limit. At the NMB building the circulation space is designed to be an enjoyable experience. It is architecturally stimulating, and filled with sculpture, plants and water. There is no sense of penny-pinching.

The headquarters of the NMB Bank is undeniably striking as a work of architecture. In avoiding the form and appearance of a conventional office block, the design team has gone to the opposite extreme and produced a building in which no two lines are parallel or vertical. The result is a building that is unique and immediately recognizable. It acts as publicity for the Bank merely by virtue of its existence. By breaking the space down into units that are almost domestic in scale, the designers have avoided the need for complex structural systems, and have been able to use a simple reinforced concrete frame, externally finished in brick. This enhances the domestic feel of the building, and continues the Dutch tradition of exquisite brickwork detailing used to create expressionist forms, typified by the work of the Amsterdam School in the early part of the twentieth century. It is unusual to see this approach to architecture used to create an office building. Visually, the sloping walls help to tie the building to the ground by making its emergence less abrupt. They also serve to reduce the impact on the surroundings by allowing the Bank to taper away from its neighbours rather than loom over them.

The breaking down of the plan into smaller, more intimate areas has been followed through in the design of every element. There are no standard solutions endlessly repeated, as would be found in most offices. Each block is subtly different in detailing and colour scheme, but all make use of the same architectural language. The result is variety within a formal framework.

The NMB Bank would be remarkable for its attempts to respond to users, its democratic design team and its appearance alone, but it is also, according to the Dutch building research organization TNO, the most energy efficient office building in the world. The energy efficiency starts with the construction, which uses materials such as brick and reinforced concrete which are in themselves low in manufacturing energy content. The design team were enabled to make use of such materials because their planning had created a building form which did not need wide spans or advanced cladding systems; this is another example of the benefit when all the consultants are acting together.

The floors are in reinforced concrete, as are the 180 mm-thick inner leaves of the external walls. This high mass structure is wrapped round with 100 mm of mineral fibre insulation with a cavity of 30 mm on the external face and an outer skin of brickwork. The mass of the building helps to give good acoustic performance, but its principal task is to even out temperature fluctuations by absorbing heat gains from people, computers, lights and sunlight, and giving warmth out later when the spaces start to cool.

The double-glazed windows are metal framed, with a coloured finish to reduce maintenance needs. The possibilities of cold bridging are reduced by the inclusion of thermal breaks in the frames. Cold bridging has also been avoided in the window reveals by careful separation of the inner and outer leaves of the external wall construction. Thermal breaks of rigid insulation are used between inner and outer lintels, with the addition of separate insulated linings to the window openings.

The windows were one of the design elements affected by the comments of the people who were to work in the building. They wanted good natural lighting and natural ventilation, and also to exclude external noise. The design team had to meet these requirements while avoiding excessive heat loss or overheating through the large window areas typically required for high levels of daylight. The result was a window design that allowed overall glazing area to be limited to 20 per cent of the external wall area, while giving highly satisfactory lighting levels of 500 Lux. The natural lighting was enhanced by the provision of a fixed pane of glass at the top of the window, backed by reflecting louvres. These louvres, looking like silvered venetian blinds, reflect daylight on to the ceiling of the room which further reflects it into the back of the space. These windows, together with the designers' care to ensure that no workplace is more than 7 metres from a window, contribute to the building's low energy needs during daylight hours. The layout of the ten office towers ensures that all receive sunlight at some period of the day. This helps to reduce heating demands during the winter months, but it can be undesirable from an energy point of view in summer. The building is equipped with computer-controlled sunblinds on the outer face of the glazing to eliminate unwanted solar gain, and internal blinds can be operated by the occupants if they find the sunlight too strong (see p. 164).

The windows are a good example of the integrated design approach. The users wanted the pleasure of views and sunlight in their workplaces, as well as comfortable working conditions; the designers want to achieve good energy performance. The care given to the design of the glazing allowed these often mutually exclusive demands to work together to give good light and views without resorting to a highly glazed and energy-losing façade.

Glazing is also important in the roof. The access towers to the offices have glazed tops to allow light to filter down to the internal street, but large areas of roof glazing are also used as part of the energy system of the building. Pentagonal glazed areas collect solar energy which is used to pre-heat the ventilation air to the building, so that at an external air temperature of 7 degrees C, the internal temperature can be 21 degrees C without the use of any additonal energy from the central boiler plant, which has a rated output of 1,000 kW.

The heat is derived not only from solar energy, but also from a heat store in the basement consisting of 100 cubic metres of water in four large insulated tanks. The tanks are heated partly by waste heat from the building's own electrical generators, fuelled by gas or oil. By making its own electricity and collecting the waste heat the Bank can make use of energy normally wasted in the generation of electricity. The heat stores also collect waste heat from sources such as the lift machinery and the computer equipment. By 'dumping' waste heat into the insulated tanks, the plant operators can save it for use when it is needed inside the building, rather than allowing it to be uselessly dissipated.

Energy is also saved by the fact that the building has no air conditioning plant. The workers in the building wanted to have control over their environment, and they called for opening windows and simple controls that would allow them to adjust the system in local areas to their own liking. A speculatively built office would be likely to have air conditioning installed as a norm, and have higher running costs in consequence. If current thinking on 'sick building syndrome' is correct, it would not necessarily lead to better working conditions, and air conditioning installations are also implicated in many out-breaks of Legionnaires' disease. By opting for a building without air conditioning, the workers at NMB have avoided possible problems and given themselves more control over their environment. The environmental control system mirrors the decentralized plan form and the decentralized planning process which created the building.

The success of the energy design can be shown by comparing the new NMB headquarters with the Bank's former building. The new building has a primary energy demand for the whole year of 111 kWh/m^2. The earlier building, completed in the 1970s, had a demand of 1,320 kWh/m^2. The saving in energy costs was about £1.3 million per year, but the additional cost attributable to the energy saving measures was less than a quarter of that sum.

It is easy to criticize the NMB Bank headquarters as yet another vast office development. In a future 'green' world, will there still be a role for huge organizations like the NMB Bank? Can a building be considered even remotely green if it has a large basement car park?

The real importance of the building is not that it solves every problem, but that it demonstrates there is another way. It shows that the users can have a meaningful involvement in the procurement of a new workplace, and that a big organization will not be destroyed by the process of consultation. It demonstrates that the conventional model of conflicting interests and rule by the architect is not the only approach to designing a large building. The pride of the Bank in the finished product suggests that an ecologically sound building can be prestigious. The extraordinary appearance of the building, inside and out, shows that environmental awareness and energy efficiency are no brake on architectural creativity; rather, they have served here as a stimulus to the design team.