EXECUTIVE SUMMARY

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FIGURES

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Americans are responding to a changed energy situation by rapidly curtailing the direct use of energy in their homes. The patterns of energy use established by households in the 1960's have changed dramatically, Residential energy use, which grew at a rate of 4.6 percent per year during the 1960's, has grown at an average annual rate of 2.6 percent since 1970. In 1977, Americans used 17 quadrillion Btu* (Quads) of energy in their homes, 22 percent of the total national energy use. Had the growth rate of the 1960's continued, the Nation would have used an additional 2.5 Quads–equivalent to 430 million barrels of oil – in 1977.

As impressive as these figures are, they can be better. Savings of more than 50 percent in average use by households, compared to the early 1970's, are already being achieved in some new homes, and experiments with existing homes indicate that similar reductions in heating requirements can be realized through retrofit. These savings can be achieved with existing technology, with no change in lifestyle or comfort— and with substantial dollar savings to homeowners. However, more sophisticated design, quality construction, and careful home operation and maintenance will be required.

For the residential sector as a whole, the potential energy savings can be seen in another way. If the trend of the 197o's were to continue for the balance of the century, the residential sector would use about 31 Quads of energy in 2000. But if investments were made in home energy conservation technologies up to the point where each investor received the highest possible dollar savings (in fuel costs) over the investment's life, energy use in the year 2000 would be reduced to between 15 and 22 Quads, depending on the price of energy. The cumulative savings between now and 2000 compared to the 1970's trend would be equivalent to between 19 billion and 29 billion barrels of oil. Despite the sound economic reasons for achieving these savings, there are reasons why they may not be reached. This report examines the underlying problems and what to do about them.

Following this section, the study's major findings are presented. They lead to these conclusions, among others:

1. Analysis of data on price and consumption, combined with research on consumer motivation, indicates that the desire to save money is the principal motivation for changes in energy habits (turning down the thermostat at night) and investment in conservation (purchasing insulation or having the furnace improved). This report outlines the approximate level of energy savings that might result from investments up to the point where dollar savings over the life of the investment are greatest. If it is national policy to encourage energy savings beyond this point—for example, to the point where investments in energy savings provide smaller economic return but greater energy savings– additional incentives would be required. The difference between these two points is substantial in energy terms, because once a dwelling is efficient, costs of operation are relatively insensitive to energy prices. Such a shift would be analogous to the standards set in 1975 to improve energy performance of new cars. In addition to price or economic incentives, regulation could also increase energy savings.
2. One of the principal ways to improve energy use lies in the area of information and technology transfer. Those who actually implement policy need more training. Policy may be made in Washington, but is carried out by tradespersons, builders, local code inspectors, loan officers, appraisers, energy auditors, heating technicians, State and local officials, do-it-yourselfers — literally thousands of individuals. The essentially human nature of the effort is both a strength and a weakness — many are willing to take some action, but there are many obstacles to perfect performance.

*A Quad = 1 quadrillion Btu = 1.055 exajoule (E J).

3. The diversity of the housing stock, number of persons involved, requirements for technology transfer, and product availability all argue for careful pacing of Federal policy, based on setting goals over at least a decade. For example, short-term programs, aimed at one particular solution, appear to constrain the market and may not encourage optimal solutions. This is particularly true of programs aimed at the existing housing stock. Anticipation of the tax credit for insulation caused increased prices and spot shortages and may not have produced substantial insulation beyond what would have occurred in any event. Another reason for deliberate policymaking is that knowledge of the nature of a house as an energy system is imperfect. Although a good deal is already known about saving energy, more remains to be learned. Because choices will vary with climate, local resources need to be developed; these resources will include both trained personnel and improved data.

Policy choices will reflect the goals for savings and costs. If the current trajectory is appropriate, present programs appear to be adequate in number and range. A lower growth rate can probably be accomplished by vigorous congressional oversight, some administrative adjustments, review and fine-tuning of program operation, and improved information efforts. If the sector is already moving fast enough, less emphasis could be placed on residential energy use. In order to move much more rapidly, stronger measures will be required. A great deal of energy could be saved in homes above present levels; these savings would still be cost-effective to the consumer. A stronger program approach might reflect national security goals and a high return on the housing dollar.

The following sections consider the trends illustrated by this volume and the major factors affecting residential energy use and conservation: price, consumer attitudes, the poor, existing housing stock, building industry response, design opportunities, the role of States and localities, the utilities, and Government programs.

Trends in Residential Energy Consumption

The decade of the 1970's has brought significant changes in the historical patterns of growth in energy consumption in the residential sector. Earlier, Americans as a group were increasing their use of energy in the home at an average rate of 4.7 percent per year; in the 1970's, the annual growth rate has averaged 2.6 percent. Moreover, the remaining growth is attributable primarily to a growth in the number of households; the amount of energy used in each household has remained almost constant between 1970 and 1977. In 1970, 63.5 million households collectively used 14 quadrillion Btu of energy (Quads) or about 230 million Btu apiece. (A Quad is equivalent to 500,000 barrels of oil per day for 1 year—or the annual energy required for the operation of eighteen 1,000-MW powerplants–or 50 million tons of coal.)

In 1977, residential use of energy accounted for 22 percent of total energy consumption, totaling 17 Quads. By comparison, the commercial sector in 1977 used 11 Quads (1 4.5 percent of total), transportation accounted for 20 Quads (26 percent), and industry used 28 Quads (37 percent). Total 1977 U.S. energy use was 76 Quads.

Many factors have contributed to the slowed growth in residential energy use in this decade. Among them are energy price increases, economic fluctuations, demographic trends, the OPEC embargo, and consumers' responses to rising awareness of energy. Demonstrating a precise cause-and-effect relationship between any one of these factors and the lower growth rate is statistically impossible. Fortunately, isolating and quantifying the contribution of each factor is probably of limited utility to policymaking.

The rapidity of the slowdown suggests that actions taken to reduce consumption so far are primarily changes in the ways people use their

existing energy equipment — e.g., turning down thermostats and insulating. A longer time frame is normally required to bring about widespread replacement or improvement of capital stock, including heating equipment and housing units.

No one can say with certainty whether the residential energy growth rate will stabilize at today's rate, drop still further, or creep back up toward earlier trends. Countervailing forces could work in either direction. The current demographic trend toward slower population growth is expected to continue for the near term, but household formation rates are likely to exceed population growth rates. Energy use in the residential sector can be expected to grow faster than population as long as new households are forming at a higher rate, although construction of highly efficient new housing would alter that presumption.

On the other hand, if energy prices continue to rise, greater investments in conservation (energy productivity) measures will become cost-effective for consumers. Moreover, while there will be more households, each is likely to be smaller; having fewer people at home generally means smaller dwelling units and lower levels of energy consumption in each home. Very few experts believe that residential energy growth rates will ever again approach the very high pre-1970 rates.

If residential energy use were to continue growing by 2.6 percent annually until the year 2000, total residential consumption in that year would approximate 31 Quads. This is considerably lower than the 48 Quads American homes would consume in 2000 if growth patterns of the 1960's had continued. Yet actual consumption in 2000 might be even lower than 31 Quads, driven down by rising prices and a number of other factors, including improved design and technology as well as evolving consumer awareness of the economic benefits of conservation.

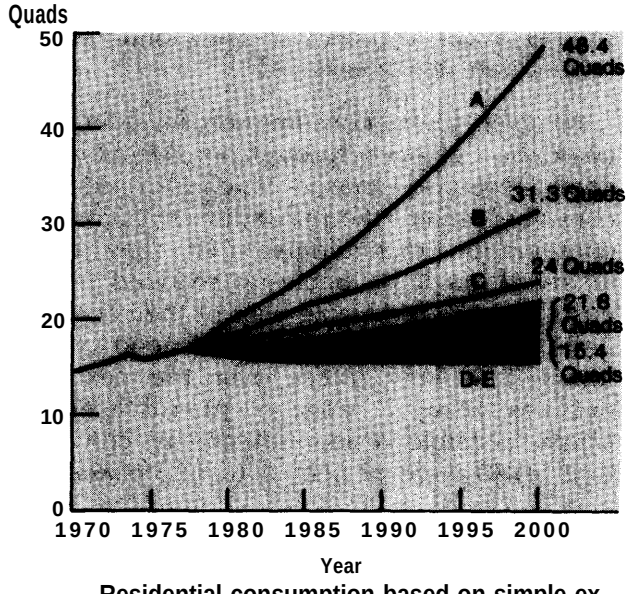
If residential energy growth were to match the rate of household formation — that is, if the energy consumption per household were to remain constant between now and 2000—total residential sector consumption in that year would be 24 Quads. This trend would represent an annual growth rate of 1.6 percent, which is the household formation rate projected by the Oak Ridge National Laboratory housing model. This modest decline from 1970-77 trends would appear to be relatively easy to achieve under current laws and programs (with improvements in their implementation in some cases) and without sacrificing personal comfort, freedom, or social goals that require increases in energy consumption for those at the low end of the economic spectrum. Much of the decline could be accomplished through replacement of capital stock and construction of smaller, more efficient housing units to accommodate new households.

An even lower consumption level in 2000 could be achieved through an optimal economic response — one in which all residential consumers made the maximum investment in conservation technologies that they could justify through paybacks in reduced energy costs over the remaining lives of their dwelling units. Such responses would depend on the levels of energy prices over the next two decades. Using a range of plausible energy prices, possible residential energy consumption levels were projected to be between 15 and 22 Quads in 2000, based on optimal economic response. Few observers expect the lower end of the range to be achieved even using the highest price assumptions, because of imperfections in the marketplace. Circumstances requiring especially vigorous public policies could create additional incentives to consumers to approach this level of savings.

The middle ground between the 1970's trend and the optimal economic response trend is seen by many as a reasonable public policy target. Measuring our progress toward this conservative goal would be relatively easy; each year, the goal would be to maintain constant national average energy consumption per household by keeping the growth in residential energy use to a rate determined by the household formation rate. This target appears to be manageable within our current social, political, and economic situation. This option would not involve sacrifice, because it would allow for a constantly improved level of residential

amenities that can be achieved by means of improved energy productivity (less energy per unit of amenity provided). Some critics will view this goal as too easy, too modest; considering depletion of nonrenewable resources, maximum return on housing dollars, environmental quality, and the national security implications of our oil imports. (Comparative energy use projections showing these Quad levels appear graphically in figure 1.)

Figure 1 .—Comparative Energy Use Projections (Residential sector)



A— Residential consumption based on simple extrapolation of 1970-77 trend.

B— Residential consumption based on simple extrapolation of 1960-70 trend.

C – Residential consumption based on constant level of energy use per household; growth results from increase in number of households.

D-E – Range of "optimal economic response" based on assumption that energy saving devices are installed as they become cost-effective. Range is formed by price; upper boundary represents response to lowest projected price, lower boundary represents response to highest projected price.

NOTES: These curves are not given as predictions of the future, but as points of comparison for discussion See chapter I for detailed information.

For SI users. Quads can be substituted using exajoule (EJ) on this figure within the accuracy of the calculations. One Quad ≅ 1 EJ.

Residential Energy Prices

Rising energy prices appear primarily responsible for reduced residential consumption in recent years. Rapid growth in the 1960's accompanied a decline in real energy prices, while the growth slowdown of the 1970's has concurred with a rise in real prices. The increase in energy prices has been especially marked since 1974, when the embargo reached its peak and the Arab oil cartel began a quintupling of oil prices. The OPEC nations' recent decision to raise oil prices in 1979 and other Middle East developments can be expected to affect U.S. energy consumption patterns further

For the residential consumer, the 1970's have already brought a 65-percent rise in home oil-heating bills, a 37-percent increase in the natural gas bill, and a 25-percent rise in the electricity bill (in constant 1976 dollars). In current dollars, the increases have been far more dramatic Even so, price controls on oil, average costing of electricity, and Government regulation of natural gas prices at the wellhead have resulted in subsidized retail prices that fail to reflect the full replacement cost of oil, gas, and electricity generated from either nuclear or fossil fuels.

It is important that energy prices represent true replacement costs whether this is higher or lower than current energy prices. It is only under this circumstance that consumers have a correct signal to use in determining how much to invest in conservation if they are to achieve maximum dollar savings. Furthermore, if society decides that information on items such as environmental damage, resource depletion, and reliance on foreign oil would not be accurately given by normal market forces, than it is possible to adjust the replacement cost accordingly or to provide equivalent financial incentives. In any case, since dollar savings are the principal motivation for energy conservation, it is important that conservation policy be concerned with energy prices.

Price increases clearly mean less disposable income for consumers. Stretching the available resources through higher productivity of energy use is a less costly approach than developing new supplies. Improving energy productivity in household use helps to counter the inflationary impact of rising costs. A number of policy responses are possible between holding prices steady or allowing them to rise directly in response to costs; these include matching

price increases with income subsidies for all or some portion of the population, using taxes to protect against windfall profits, and other strategies. Price-based policy will be unacceptable to those who believe that consumers cannot withstand higher costs, or who believe that price increases do not reflect true scarcity or rising marginal costs.

Consumer Attitudes

The level of energy use in a given home is greatly influenced by the attitudes, choices, and behavior of its occupants, within a range circumscribed by the limitations of the structure itself. Energy consumption in identical houses may vary by as much as a factor of two depending solely on these variables.

Available research data indicate that consumer motivation to invest in conservation measures stems largely from a basic desire to save money and resist rising prices. This is the prime concern of homeowners. Energy costs are now about 15 percent of the average annual cost of homeownership, and in the heating and cooling season monthly payments may approach the level of the mortgage payment. The dramatic increase in fuel costs, over the very low costs of the 1960's and early 1970's, has graphically demonstrated to residents that reducing direct energy use is a wise investment. Early experiments in helping consumers to change their energy use patterns suggest that providing feedback, or quick response information on how much energy a home is using, helps people conserve. Experiments with special meters, report card billing by utilities (bills that compare use for a month compared to the same month last year), and similar techniques are now underway.

Consumers are frequently unsure about what changes are most effective. Knowledge about effective communication argues for improving local resources. Consumers have more trust in information from their locality or State than from remote institutions. The information provided by the Federal Government and by large oil companies is not well received.

It is unreasonable to expect that consumers will make major housing or behavioral choices based on energy alone. Having adequate space for a growing family, being near schools and shops, feeling certain that a home is warm enough to ensure health and comfort—these, too, are important consumer values.

Data on attitudes and behavior indicate that information programs that emphasize the positive economic benefits of conservation are more likely to show results than those based on ethical urgency. Moreover, public statements or campaigns that link conservation and sacrifice, such as suggestions that conservation means residents should be cold in their homes, may be ineffective, if not counterproductive.

More research on actual household energy use patterns, as well as attitudes and behavior, would improve the policy makers' ability to select successful motivational strategies.

Low-Income Consumers

Although rising energy prices provide a strong incentive for widespread conservation, they present special hardships for low-income consumers who cannot absorb higher utility and fuel bills, and have little access to investment capital. For the 37 million persons (17 percent of the U.S. population) with household incomes at 125 percent of the poverty level or below, utility costs typically consume between 15 and 30 percent of the family budget.

Some low-income families spend as much as half their budgets on energy in the heating season, yet a significant portion of this heat is lost because of substandard housing. Poor and near-poor households in rented housing are handicapped with regard to energy, as they usually do not control their heating systems or their dwelling's maintenance and improvement.

Efforts to relieve the energy-based economic problems of the poor have taken two ap-

preaches: first, providing home improvements intended to reduce energy needs, and second, providing financial assistance to meet energy bills. Neither approach has been totally satisfactory or adequately deployed. Although direct aid by "weatherization" appears highly cost-effective in the long run, it is impossible under current funding to reach more than 3 percent of all eligible homes each year. Labor shortages and other programmatic problems have also hampered the Federal weatherization efforts, although the basic concept is both sound and popular. Because the poor frequently cannot reduce consumption and have no access to capital to improve their housing, Federal funds can cause energy savings that would not be achieved without such assistance, as well as improved living conditions.

Financial assistance for payment of utility bills is more controversial. Questions about this approach reflect a larger issue, which may be described as the "right to energy" doctrine. As energy is as necessary as decent housing, adequate nutrition, and medical care— al I of which the Government subsidizes to some extent— consumer advocates have argued that a basic minimum quantity of energy should also be subsidized for low-income persons. So-called "lifeline" utility rates are one means of subsidizing energy; early experiences with such rates suggest, however, that they may provide neither conservation incentives nor adequate financial relief for many of the poor.

Other proposals include energy stamps and large programs of emergency financial aid, legal aid for poor persons dealing with utilities and fuel providers, and procedures to prevent shutoff of heat and power because of nonpayment during winter months. These programs meet social needs but do not provide resiliency to the problem. Because of a growing concern among elected officials and the wider public about the inability of financial aid programs to address basic causes of poverty, weatherization and broader housing programs designed to put all persons in decent homes may offer a better approach. Such a policy subsidizes energy efficiency rather than price.

Existing Housing

Improving energy efficiency in existing housing will be a principal area of policy emphasis in the next decade, as most of the population will continue to be housed in the 80 million existing units. Both the largest savings of energy and the largest amount of protection against the impact of rising prices will come from "retrofitting" existing homes. owner-residents, rather than builders, are the principal audience for this effort.

Making homes use less energy without lowering the level of comfort is not technically difficult, but it requires careful attention to the specific needs of the structure, quality workmanship in improvements, and continuing attention to the energy use patterns of the residence. An audit by someone trained in home energy use is necessary to identify the optimal package of changes for a specific home. Data on the energy characteristics of the existing stock are inadequate, and this complicates policy formulation. While Federal level efforts at data collection may be the most effective, States and localities are in a better position to stimulate local conservation efforts and to provide accurate technical information and guidance to occupants. States and localities, along with trade and professional groups, will bear major responsibility for training and for improving the quality control of retrofit projects. Dissemination of technical information by the Federal Government and Federal work on appliance labeling and standards will underpin local efforts.

I n addition to the savings available through tightening the thermal shell of the building, substantial energy savings can be obtained through retrofit of the heating and cooling equipment, and through replacing the heating and cooling devices with more efficient systems.

Present tax credits will encourage retrofit, although such credits may represent a substantial revenue loss while not adding a large increment of investment. (The Congressional Budg-

et Office estimates that many persons who install insulation, for example, would have done so without the credit.) Grants and direct assistance, such as weatherization, are most responsive to the needs of low-income persons. Home improvement loans have not been attractive to those making changes to their homes costing less than $1,000, but this could change if fuel prices continue to rise and pressure to retrofit is increased.

As in the case of new housing, lending institutions that finance mortgage lending could play a critical role. If lending institutions reviewed energy costs of a home when considering a mortgage application, a total cost picture would be made available to the prospective purchaser. Funds available to the buyer to finance conservation investments through the mortgage would be amortized over a long period and would bring down monthly operating costs. A more vigorous policy initiative would require that existing housing be brought to a specified standard of energy efficiency prior to sale, or prior to utility connection.

Building Industry Response

The homebuilding industry appears to be responding to consumer demand, information, and price and taking advantage of opportunities to improve energy efficiency. Typical new construction already matches the preliminary energy standards recently adopted by many States (ASH RAE 90-75 or Model Code levels). New building reflecting these standards is still considerably below the level of energy efficiency indicated as cost-effective by OTA analysis. Tighter code requirements, combined with information targeted at builders and buyers, will help sustain and intensify the trend to better homes.

Although the design and construction industry is fragmented and generally cautious toward major change, it can respond quickly and readily re-adapt its designs and methods once the economic and technical feasibility of new housing features or construction techniques are proven and accepted in the marketplace. For example, many builders are now altering frame construction to utilize 6-inch studs instead of the standard 4-inch studs. This technique makes it easy to increase the amount of insulation in the walls, and the distance between the studs allows the change without economic penalty. Encouraging change in the industry requires making economic and technical determinations, judging what will work and what will save money, and providing that information to the key actors at the right time. Principal actors for the residential sector are:

1. 100,000 builders, who make the basic decisions to build in response to what they perceive market demand to be, within the requirements of specific building codes and available materials;
2. 21,000 lending institutions, which approve financing for both builders and buyers; and
3. homebuyers, who by their purchasing decisions determine the demand for housing of varying types and prices, and thus influence the perceptions and decisions of builders and lenders.

Building standards and codes directly affect new construction. The stringency of codes will reflect the policymaker's views of the abilities of the industry and the urgency of the energy situation. Performance standards, now being drafted by the Federal Government, are needed to allow for flexibility and experimentation in construction. Application of performance standards in housing may be particularly delicate, because of problems of methodology and the resources of builders. The average U.S. homebuilder constructs less than 20 homes a year, does not use sophisticated architects or engineers, and works in a highly leveraged market. These builders may prefer a simple code that can be easily followed by carpenters and laborers.

I n addition to standards and codes, changes in the economics of the market can encourage energy conservation. Broad interpretation of tax credits and use of tax incentives, particularly tax incentives provided directly to the builder, will stimulate greater change in new housing.

Affordability

Properly selected conservation choices will lower utility' costs and thus reduce the total costs of homeownership and operation. The possible effect of eliminating marginal buyers from the housing market must be weighed against the consequences of encouraging these buyers to acquire homes that are likely to have substantial and rapidly increasing monthly energy bills. As fuel costs continue to rise, a broader view of "affordability" is necessary. Better dissemination of information on cost-effective opportunities and lifecycle costs to builders, equipment suppliers, lenders, and buyers may be a promising approach for increasing conservation investments.

Energy conservation features often add to the initial cost of homes. Builders and lenders are cautious about decisions to increase purchase costs, especially in light of dramatic increases in the price of housing in recent years. Slightly increased first costs mean that marginal buyers may have to scale down their expectations. First-time homebuyers who have limited savings for downpayments are more affected by increased downpayments than are previous owners who have an equity to invest.

On the other hand, a substantial amount of energy can be saved without great expense—typically $1,500 to $2,000--and without complicated or untried devices. Some of the most effective actions involve reducing air infiltration through caulking and weatherstripping, investments in storm windows and insulation, and improving the energy efficiency of heating and cooling systems. The energy efficiency of many new homes can be substantially increased by adding enough thermal protection to allow a reduction in the size of heating and ventilating equipment; in some instances this choice has actual [y meant lower first costs.

Lending institutions can improve the flow of information on total costs of homeownership and operation by including energy costs when calculating monthly payments on mortgage applications. The mortgage transaction is a critical intervention point, as buyers are focused on the home and money is being borrowed to be repaid over a long time period. A calculation that includes likely energy costs would give buyers, and lenders, a more complete estimate of total costs and could encourage cost-cutting investments. Federal leverage could be used to provide additional funding for conservation improvements at the time of sale, subsidize downpayments or interest rates for energy-efficient homes, or deny mortgage funding to homes not meeting an energy standard. Federal and State energy agencies could help lending institutions determine standards appropriate to local conditions.

Design Opportunities

Energy-conscious design is a paradox: once the most ancient of the builders' skills, it is being rediscovered as a modern trend. Proper orientation of the home on the lot, thoughtful placing and sizing of the windows, and planned-in natural ventilation combined with shading by eaves and trees produce houses that use astonishingly little energy. Even though the ideas are as old as shelter itself, modern materials and design techniques can adapt and improve the concepts for urban America. Such homes are neither expensive nor outlandishly designed, and need to be encouraged by Government action. However, policy actions are difficult to develop because energy-conscious design is part of the fabric of the building itself. Unlike discrete, technological add-ens, energy-conscious design features cannot easily be listed in a tax regulation or building code. Special policy focus by Government on such designs may be particularly appropriate because there are few natural market forces to promote such building choice.

Even if the full advantages of energy-conscious design are not explored, quite conventional, off-the-shelf technologies now exist to reduce heating and cooling loads at least 50 percent below those of homes built in the early 1970's. Houses built using these technologies will reduce energy use through greater efficiency with no change in living habits or level of comfort. In fact, comfort may be increased through reduction of drafts and cold spots. The real bonus results from the low purchased-energy costs of operating such homes. These

technological solutions to energy consumption — such as heat exchangers, "smart" thermostats, and draft-excluding devices — can be easily encouraged by Government action assisting the market.

Improved data collection is needed on homes that use little purchased energy. Construction of such homes on a demonstration basis, perhaps one in every county, could provide the type of direct learning experience most valuable and influential for builders and buyers.

Technologies now in the development or commercialization stage will offer opportunities for energy savings well beyond the options now available. More efficient furnaces, new approaches for the design and construction of walls and windows, and electronic systems to monitor and control the operation of homes are now being tested and used experimentally. As these devices become more reliable and lower in cost, the options for reducing home energy use will increase dramatically.

States and Localities

States and localities bear the major responsibility for implementation of federally authorized residential conservation programs. Building code revision and enforcement, information and education efforts, quality control, and regulation of utilities all come within the jurisdiction of States, counties, and towns. The priority assigned to conservation goals by these levels of government will directly influence the level of effort and thus the resources available to consumers and builders.

Current Federal policies both help and hinder State and local efforts. Central difficulties include rapid pacing of Federal initiatives that may not match the capabilities of the locality; failing to involve States and localities in preparing guidelines and regulations; placing responsibility for administering a large number of complicated programs on State energy offices that are frequently small, understaffed, and underfunded; and imposing Federal priorities that may not match local needs. Programs designed with the needs and capabilities of the States in mind are most likely to take root and remain effective as Federal priorities change and Federal funding fluctuates.

Localities work most closely with new construction through the building permit process. Local code inspection offices may require special help, both technical and financial, to improve their level of activity. This will certainly be the case if Federal actions to mandate energy changes in building codes continue. While the needs of localities may press a State energy office beyond its capabilities, these off ices must recognize the importance of providing resources to localities.

Transfer of information and technology from the Federal 'Government can be improved. Trained personnel, either from Washington offices or regional offices, could greatly assist States in working out technical problems and establishing ground rules for program operation.

Utilities

The ways in which gas and electric utilities can most effectively stimulate energy conservation in the residential sector are just beginning to be understood and exercised. As experience with utility-based conservation activities is gained, early concerns about utility involvement in nontraditional activities (such as insulation financing) and uncertainty about the impacts of innovative pricing and service delivery options (particularly time-of-use pricing and load management) are being replaced with encouraging empirical data.

Utilities can encourage residential energy conservation through information programs and home energy audits; financing and/or marketing insulation and other conservation devices; altering the rate structures to reflect costs that vary with time of use; and instituting programs of load management in the residential sector. Relatively few utilities have carried out aggressive conservation programs to date, although most electric and gas companies have undergone some adjustments in their management and planning functions as a result of changing circumstances. While eco-

nomic and social criteria encouraged rapid energy growth in the years before 1973, more recent phenomena — including rising fuel costs, massive increases in capital requirements for new capacity, uncertainty about future demand, and changing regulatory requirements – have all caused utilities to expect and even encourage diminished growth.

Activities authorized by the National Energy Conservation Policy Act of 1978 should yield useful data over the next few years. The effects of audit programs, cost-based rates, load management, and time-of-use pricing should be carefully analyzed and the information widely shared. Following evaluation, Congress may wish to consider removal of the prohibition against utility involvement in sale or installation of residential conservation measures.

Indoor Air Quality

Potential health effects of changes in the quality of indoor air caused by energy conservation must be carefully monitored, and attention should be given to preventing negative effects as houses become tighter. As new standards lower the amount of "fresh" air moving through homes to reduce heat (and cooling) losses, concentrations of undesirable substances already present in indoor air will be intensified. Technological control measures are available to prevent the buildup of concentrations of pollutants indoors.

There is strong evidence that concentrations of several air pollutants tend to be high indoors. Existing houses with gas heating and cooking appliances have been shown to experience levels of carbon monoxide (CO) and nitrogen dioxide (NO_2) that approach or exceed ambient air quality standards. Other pollutants that may be significant in the indoor environment include respirable particulate, particulate sulfur and nitrogen compounds, nitric oxide (NO), sulfur dioxide (SO_2), radon, and various organics. Aside from heating and cooking appliances, the sources of these pollutants include building construction materials, cigarettes, aerosol sprays, cleaning products, and other sources. If air exchange rates of new and existing houses are significantly decreased from present rates, indoor concentrations of these pollutants will increase.

Control measures currently available to reduce the concentrations include filters and electrostatic precipitators to reduce particulate levels; kitchen ventilation to reduce cooking-generated pollutants such as CO, NO, NO_2, and SO_2; spray washing, activated carbon filters, and oxidizing chemicals to reduce airborne chemicals and odors; and forced ventilation with heat recovery (to minimize heat loss) to reduce concentrations of all indoor-generated pollutants. A comprehensive approach should include reduction of emissions by improved maintenance and design of stoves and furnaces, reduction in household use of polluting chemicals, and similar measures.

Evaluation of these control measures requires an understanding of health effects of ambient levels of indoor pollutants and the concentrations of such pollutants with and without controls in different housing situations. Thus far, the Federal Government does not appear to have recognized the significance of indoor air quality as a potential health problem. The Department of Energy (DOE) and the Environmental Protection Agency (EPA) have sponsored some early work in this area, but the level of support has been very small. As might be expected from the scarcity of research conducted, the level of understanding of the effects and causes of indoor air quality is insufficient to allow the definition of an optimum strategy for linking energy saving construction requirements and air treatment requirements.

Federal Conservation Programs

Federal programs support housing production and the maintenance of existing housing by providing subsidies to certain classes of occupants, as well as mortgage loans, insurance, and guarantees to lenders and property owners. Federal programs affect housing through standards for construction and rehabilitation of housing, regulation of the lending industry, maintenance of a secondary market for mortgage lending, research and development (R&D), financial assistance for community development, tax credits and incentives, and

programs specifically designed to provide information or technical assistance to encourage conservation. Direct Federal construction, such as housing provided by the Department of Defense, affects the market for housing technology and appliances through the procurement process and the use of standards.

Because of the wide variety of programs influencing both housing and conservation, many mechanisms exist to affect energy consumption in homes. Recent legislative and administrative changes will help to save energy. Energy conservation has not been a major priority for most Federal programs, and there has not been strong coordination of the various departmental efforts. A stronger commitment to energy conservation, combined with improved technical work and more sophisticated cost analysis, could mean a much stronger response to conservation goals from both the public and the private sector.

Some of the most important Federal actions are listed here.

HOUSING STANDARDS

As a result of postembargo legislation, the Federal Government is now more deeply involved than ever in defining energy-based housing standards, which will eventually influence local building codes. Codes are an effective mechanism for altering construction practices, but they are implemented at the local level, and great care is needed to ensure that adequate time and resources for training accompany this new Federal-State-local approach.

States have been encouraged through Federal funding and training to adopt codes based on an engineering approach. Existing legislation calls for the adoption of performance-based standards by 1980. Performance standards offer a unique and valuable way to encourage energy efficiency while allowing innovation and providing equal market access to all types of construction. This type of standard is also a totally new method, and there is no agreement on the correct methods for calculation and review, particularly for residential buildings. Despite a sincere desire by DOE to solicit comments on draft standards, time pressures generated by the current schedule do not allow for adequate review and thoughtful analysis. As a result, commitment to the current schedule will almost assuredly result in litigation and dissatisfaction by both supporters and opponents of the standards.

A substantial period may be needed for review and field testing of the new standards in certain areas and markets. Transition to performance standards closely tied to existing methods of analysis and review will increase the likelihood of compliance.

RESEARCH AND DEVELOPMENT

The short-term focus of current DOE conservation R&D ignores some longer term options that also have high returns. The attention to commercialization strategies that characterize the program is questionable, as rising prices should enable the private market to absorb commercialization costs. Research on attitudes, energy use patterns, institutional and legal barriers to conservation, and similar important areas have not received adequate emphasis. Research and policy decisions on energy technology do not adequately consider the conservation applications of new technologies; the potential of conservation to reduce demand and provide time for shifting to new energy systems is not fully appreciated. The policy appears to reflect an attitude by DOE and the Office of Management and Budget that conservation should be viewed as a stop gap that merits little Federal research funding, in sharp contrast to new production approaches.

TAX POLICY

Federal tax policy is probably the major element in decisions by owners of rental property on construction and rehabilitation. Historically, the tax code has encouraged low first-cost (and therefore energy inefficient) housing, and has protected owners to the extent that most program efforts to improve tenant energy use have been futile. Broader use of tax incentives should increase the conservation response. At least, policies should be examined to ensure

that they do not continue to encourage energy-wasteful construction.

Similarly, the tax system can be used to reward homeowners for investing in conservation. Critics of this policy believe that homeowners are sufficiently rewarded by the savings in fuel bills, and that the number of people who invest because of the credit is small, while the number who claim the credit is large. This policy does not allow for the fact that many conservation investments can save much energy but are only a breakeven choice without additional incentives. Early Internal Revenue Service decisions on the eligibility of items under the recently authorized conservation tax credits show a reluctance to interpret the law broadly, and raise special problems for energy-conscious design approaches.

FEDERAL HOUSING PROGRAMS

Federally owned and subsidized housing represents both a special responsibility and a special opportunity for saving energy and lowering total costs. Energy conservation has had very low priority in most of this housing. Funds and authorizations recently approved by Congress will help to improve the efficiency of these dwellings. Improved levels of conservation would demonstrate real Federal commitment, improve the comfort level of the housing, and save money as utility costs, which are frequently subsidized, continue to rise.