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Statement on the Department of Energy Fiscal Year 1985 Conservation Budget Request for Buildings and Community Systems

for Hearings on Department of Energy
Conservation and Solar Energy Budget for FY'85
by the
U.S. House of Representatives
Subcommittee on Energy Conservation and Power
of the
Committee on Energy and Commerce

February 28, 1984

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SUMMARY

The DOE Budget Request for Buildings and Community Systems represents a welcome stabilization after three years of precipitous program decline, but the stability is at a level far below cost effectiveness. Potential savings in the buildings sector are $75B/year, and these savings will happen faster if the BCS budget is larger than $35M/year.

Some key activities have been dropped. Infiltration was dropped inadvertently in FY'84 and has not been restored, despite a potential for saving $5B/year. Building Systems Interactions has been dropped, removing support for research in Thermal Mass, Ventilation, and Heat Recuperation, and of course, Infiltration.

Indoor Air Quality research has an inadequate increase to $1.425M. This is a pitiful raise, considering that BCS now gives the LBL IAQ group $725K, compared to $1.7M in FY'81. We now know that several percent of the homes in the U.S. have radon levels that are unacceptable even for uranium miners, that radon exposure causes thousands of deaths annually in the U.S., and that indoor air quality is more important for public health than outdoor air quality. Yet EPA spends $328M on outdoor air (and has requested zero for indoor air next year), and DOE requests only $1.425M. EPA is also spending millions to keep risks from EDB in muffin mix or dioxin in water down to a few parts per million. My Fig. 1 shows the absurd inconsistency of the concern when compared with the risks of lung cancer from indoor radon, which can exceed one percent, i.e., 10 thousand parts per million; yet we spend less than $1M on indoor radon.

The Home Energy Rating System (HERS) request of $500K should be greatly increased to cover monitoring of the most ambitious homes, which are awarded the best ratings. HERS already has a magnificent potential for improving the energy efficiency and cost-effectiveness of the housing market, but it still needs the confidence that will be inspired by a monitoring program. Appendix II.1 discusses the French energy labelling program, which will spend $2M annually for HERS monitoring, plus $200M more for actual incentives to builders of efficient homes.

Urban waste is being moved to Biomass, but perhaps too suddenly.

Technology and Consumer Products is cut from $10M to $5M. Refrigeration research is dropped, endangering the U.S. refrigeration industry at a time when it is under severe competition from Japan.

Combustion Heating is dropped, just as several promising retrofit ideas are appearing. Most companies do not develop combustion retrofits because they can make more profit by selling new furnaces and because they are scared of liability problems; so if DOE backs out, retrofit effectiveness will be compromised.

Two encouraging new activities are proposed: a $2M fellowship program and a $1.5M Energy-Efficient Buildings Center, which I propose should quickly become a network of centers. I comment on the possibilities for the center at length.

FEMP (the Federal Energy Management Program for Federal Buildings) is raised from $1M to $2.5. Again, I make many suggestions for strengthening the program, which could easily save $1B/year.

I present Appendices suggesting new tech transfer and information programs.

I. Introduction

DOE/Conservation's Office of Buildings and Community Systems (BCS) has already significantly advanced the development of products (high-frequency ballasts for fluorescent lamps, energy-efficient light bulbs, efficient appliances,...) or technologies (heat mirrors as window coatings) or systems (Home Energy Rating Systems) which will save Americans $10-20 billion annually.

In 1983, the energy bill of the U.S. buildings sector was $150B. This corresponds to $1/ft2 (of residential plus commercial floor space). This annual $1/ft^2 has stimulated significant retrofit of existing buildings and equipment, the construction of efficient new buildings, appliances, and equipment. So our energy use is falling, but how far will it drop? According to the SERI Solar/Conservation Study [SERI, 1981] and similar subsequent studies, the least-cost scenario is for energy intensity (use/ft2) to fall to about half of current values (i.e., to $75B for today's stock at today's energy prices).

The next question is, "How long must we wait to achieve this $75B savings?". That depends on Federal policy and budgets, as implemented mainly by DOE. I would guess we will wait until 2020 without an aggressive Conservation policy but hope we could get there by 2000 with the help of research, demonstrations, and information and incentive programs.

The BCS budget is now $37.4M (1/40¢/ft2!). For FY'85, $35.3M is requested--a cut of 6% plus the cut of inflation. Why starve the goose that has been laying golden eggs?

In the following Section II, I shall comment on the BCS budget request. In Section III, I shall comment very briefly on BCS-related issues in the Schools and Hospitals and the Weatherization Programs. Then, in the Appendices, I shall describe some new programs which require budget increases as opposed to cuts.

I have tried to comment from a national perspective, not as a defender of LBL, but inevitably I'm most familiar with my own program (and proud of it)--so I hope you'll pardon my frequent reference to LBL.

II. Comments on the Budget Request for Buildings and Community Systems--Key Activities

The Key Activities are described, starting on page 36 of the DOE FY'85 Congressional Budget Request, Vol. 7, Energy Conservation. I will now go through these activities.

BUILDINGS SYSTEMS

- Envelope Systems and Materials

o Wall and Roof Systems (p. 36).
FY'84: $2.9M, cut in '85 to $1.275M.

I am not an expert in walls and roofs, and I want to confine my remarks to areas where I have some experience--but I have worked on thermal storage in concrete floor-ceiling slabs. In Sweden, this technology is called "Thermodeck." It is a great success and is used in about one-third of the new buildings in Stockholm (another one-third also use thermal storage, but in water). These buildings get through a Swedish winter with almost no space heating, i.e., during occupied hours heat from lights, people, and equipment warms the buildings and is stored in the concrete, where it is retained over the night or weekend for later use. Thermodeck buildings also get through a Swedish summer with no cooling. (In Miami we would still need cooling, but could use thermal storage to move it off peak.)

Thermal mass research alone would justify a constant budget, and it is clear that the rest of the important work now underway on walls and roofs cannot be completed in FY'84. This budget should not be cut.

o Insulation Materials (p. 37).
FY'84: $2.5M, cut in '85 to $1.5M.

Here again, the FY'84 program cannot be complete in '84 and should be maintained at a constant level.

o Windows and Daylighting (p. 37).
FY'84: $1.7M, raised in FY'85 to $2.425M.

Much of this work is under Stephen Selkowitz at LBL, so I am familiar with it and support this raise, plus another $300K for technology transfer.

Current U.S. windows leak about 3.4 quads of heat per year (1.7 Mbod, the output of the Alaska pipeline). Research and development under Selkowitz has so advanced heat mirrors that double-glazed heat-mirror windows are now on the market. They are thermally as efficient as bulkier and more expensive triple-glazed windows and will probably bypass them. Heat-mirror windows should save the U.S. about 1.5 quads (worth $9B/year). The advanced glazings currently under study could save an additional significant fraction of a quad (a quad costs $6B/year).

Therefore, the requested budget is well justified. I believe there should be another $300K for technology transfer and international collaboration. At LBL, we had a small tech transfer program and published a periodical survey of commercial products for windows and daylighting and even a windows insert for the Sweet's catalog. This was all dropped in 1981, despite many requests for it from builders and manufacturers. The private sector has not taken it over. Programs to transfer windows and daylighting research results to the building and components industry should be restarted. This will make for better buildings at home and make our components more competitive in international trade.

We are already participating in an eight-nation IEA windows research program. In addition, the Swedes, who are known for their high-quality window, are ready to start a collaborative Lund-Berkeley research program on windows and daylighting, with joint publications and an international version of our Products periodical. This would be efficient tech transfer of U.S. and European research and merits support.

o Indoor Air Quality (p. 38).
FY'84: $1.3M, raised in '85 to $1.425M.

This ten percent raise barely covers inflation. DOE/CE's support for Ventilation and Indoor Air Quality (VIAQ) at Berkeley is now down to less than half of its FY'80 level of effort, even though we have learned that indoor air quality is more important to public health than outdoor air quality, on which EPA spends $328M. (EPA spends $225M on air quality plus $15M for acid rain research and also grants $88M more to the states for enforcement.)

Figures 1 and 2 illustrate the absurd inconsistency of our concerns for indoor air pollutions vs. chemicals in water and food. EPA spends million on research, testing, sampling, and enforcement to prohibit lifetime risks of a few parts per million from EDB in muffin mix or dioxin in water, yet next year EPA and DOE will spend less than $1M on indoor radon, where the risk levels can reach 1% (10,000 parts/million!).

The lung cancer rate from indoor radon (an involuntary risk leading to an estimated 1,000 to 10,000 (1-10 thousand) lung cancers yearly) is only an order of magnitude below the voluntary (or addictive) risk from cigarettes (100,000 lung cancers/year). To make this comparison easier, I have noted on Fig. 1 that the line labelled on the left as a Rn concentration of 1 pico-curie per liter, and on the right as a lifetime lung cancer risk of 10^{-3}, is equivalent in lung cancer risk to smoking half a cigarette a day for 30 years [Hammond '66, Repace '84]. Thus, a few percent of the houses that we have surveyed so far can be characterized as approaching a pack a day, for every occupant, including children.

The funding problems of our VIAQ group are complicated by an administrative/appropriations mistake last year, in which Infiltration Research was dropped as a named key activity, and close to half of the indoor air quality funds were devoted to infiltration work in FY'84. I hope this gets straightened out before FY'85. Part of the confusion arose because some staffers thought that the "I" in VIAQ stood for Infiltration!

The problem is further compounded by EPA. Under Anne Gorsuch-Burford, EPA denied interest in, or responsibility for, IAQ research. Later, as a result of the work of the House Science and Technology Committee, EPA budgeted $2M for FY'84, but this has again been dropped for FY'85, endangering the EPA part of work in this area, which has major emphasis on a badly needed (and overdue) national indoor air quality survey.

EPA should probably take over the principal responsibility for IAQ survey efforts, but there is a distinct aspect to IAQ research that needs DOE expertise, and that is a clear part of DOE's mission, i.e., investigation of the dependence of indoor concentrations on building-related factors, e.g., ventilation and ventilation effectiveness. In any case, the DOE budget request should not endanger the most active U.S. (and international) group (at LBL) just because EPA may eventually assume its partial support. In fact, DOE ought to be devoting efforts to VIAQ comparable to earlier levels ($1.8M, not including the infiltration work).

There are pressing needs for research on each of the major classes of indoor pollutants. It is clear that formaldehyde and organics, given off by a variety of indoor sources, reach levels indoors that cause acute irritation and sickness and that--for some substances--have a substantial potential for causing cancer. Emissions from various kinds of unvented cooking and heating appliances, burning kerosene, gas, or wood, are known in many circumstances to reach concentrations considerably higher than outdoor and even occupational limits, with the actual concentrations depending substantially on both the appliance and the amount and effectiveness of ventilation that is provided. But probably the most pressing example of the need for research on IAQ is the knowledge that a few percent of the 80 million homes in the U.S. appear to have concentrations of radon (a natural radioactive gas) that approach or exceed limits for occupational exposure (see **Figs. 1** and **2**). It is thought that indoor radon exposures cause thousands of deaths annually in the U.S. due to lung cancer (**Fig. 3**). Here is a clear incentive for research on the factors affecting radon entry from soil into homes and for development of techniques for mitigation. If, as a result of a national survey effort, we confirm the current suspicion that something like a million families are unknowingly receiving radiation exposures that are unacceptable even for uranium miners, it is high time that we have the capability for identifying and rectifying the situations where this is occurring. And, because radon entry is strongly affected by how a building is constructed and operated, DOE--which examines these same factors from the point of view of saving energy--is in a unique position to investigate these questions, particularly considering the leadership in this area that has been demonstrated by LBL's VIAQ group.

Thus, considering the clear needs for increased attention to the exposures to air pollutants indoors, more--not less--effort ought to be devoted by the appropriate agencies to investigating indoor air quality. In the case of DOE's responsibility, which focuses on how building-related factors affect indoor

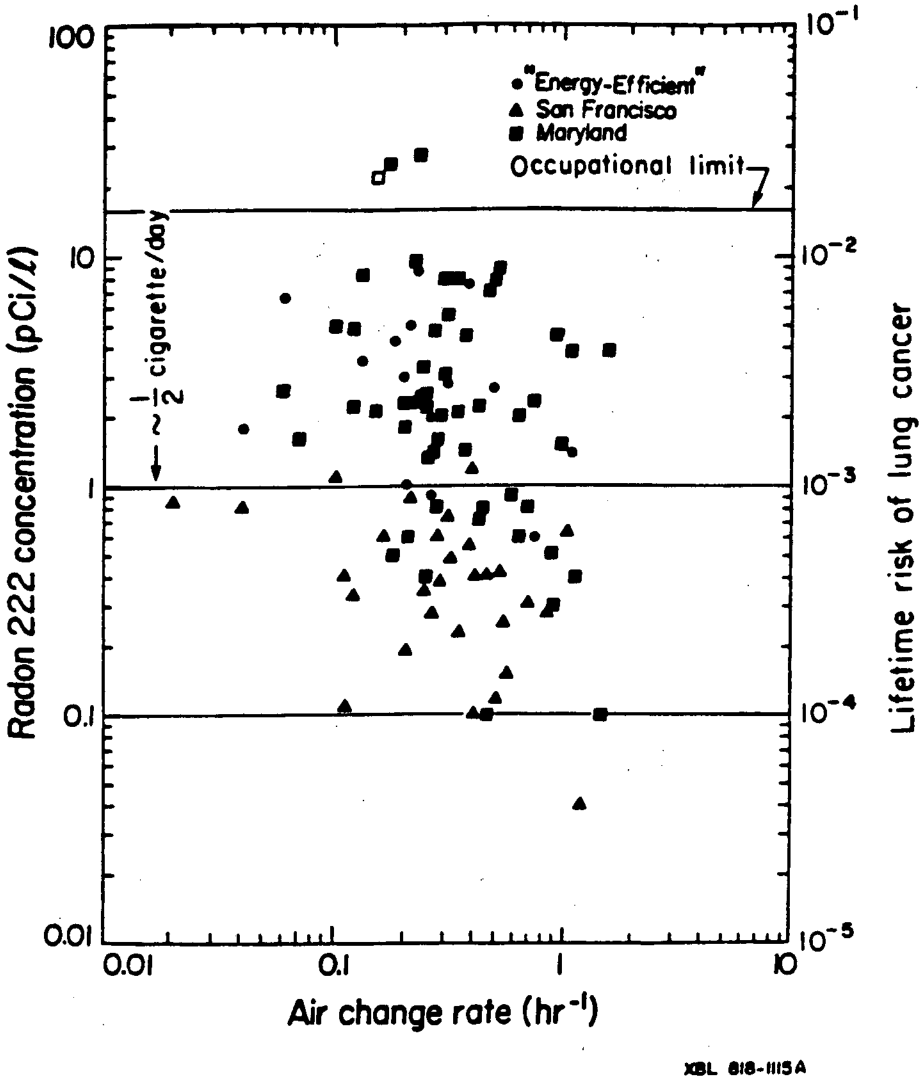

Figure 1. Concentrations of radon 222 vs. air infiltration rates in 98 homes, measured with the windows closed. Exposure to 1 pCi/liter is equivalent, in risk of developing lung cancer, to smoking about 0.5 cigarette daily. The scale giving lifetime risk of lung cancer assumes 1) daughter equilibrium such that 1 pCi/l average indoor concentration yields 0.2 Working Level Month (WLM) per year, 2) 1 cancer per 10,000 Working Level Months of exposure, and 3) 50 years of exposure at the given concentration (although it should be noted that opening of windows tends to lower concentrations for a portion of each year). The Occupational Standard (drawn above at 20 pCi/l) corresponds to an unusually large lifetime risk of getting lung cancer of about 1.6%. By contrast, most standards for chemicals in water and food correspond to risks of 1 to 10 parts per million, i.e., off scale below this figure.

Source: Nero et al., pp. 277-288 and 401-405 in Indoor Radon (A. V. Nero and W. M. Lowder, eds.), a special issue of Health Physics, Vol. 45, No. 2 (August, 1983).

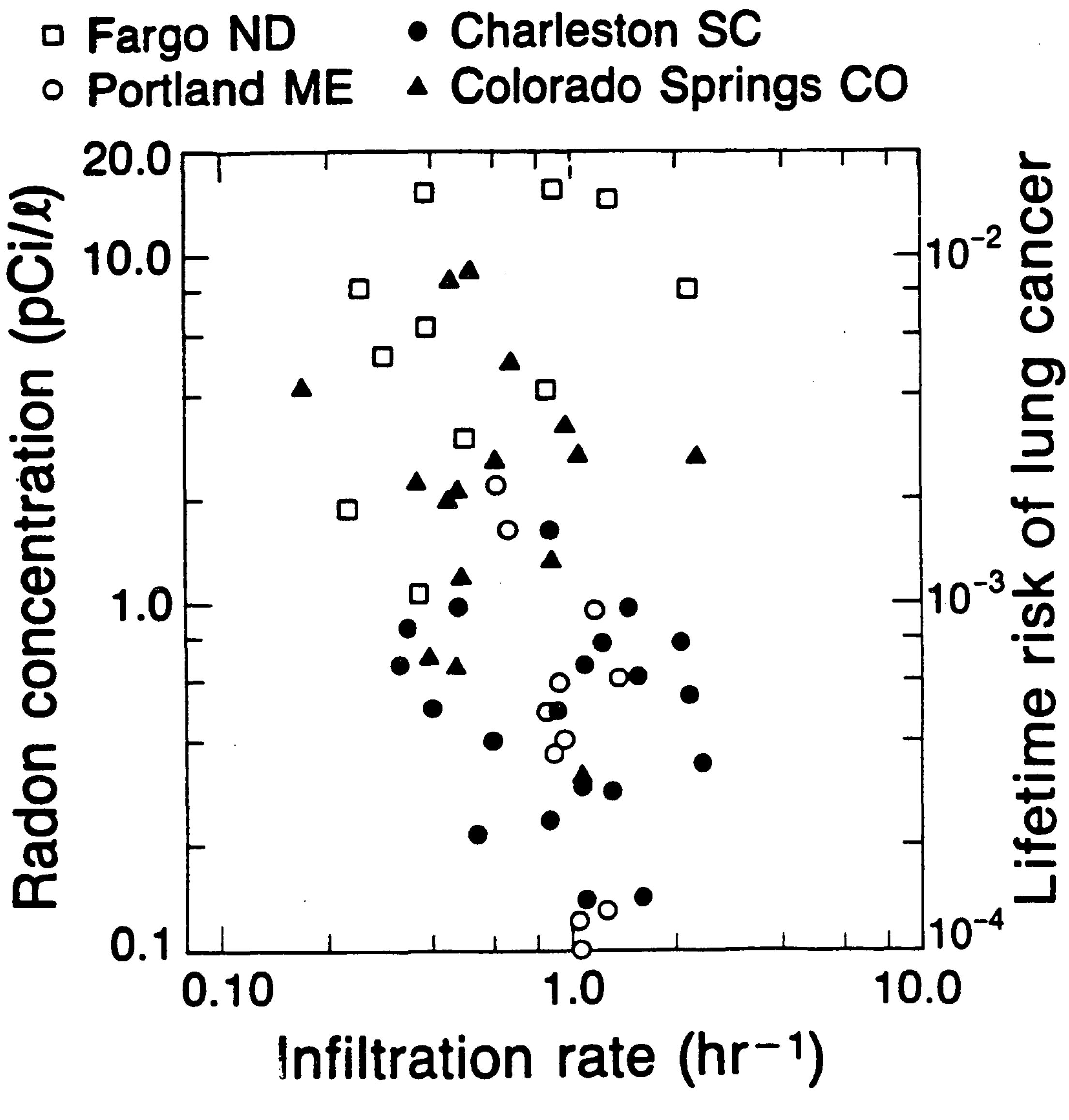

Figure 2. Scatter plot of radon concentration vs. infiltration rate for 58 new houses in four cities not included in Fig. 1. Measurements were made during a four-to-five month period between November, 1981, and May, 1982.

Source: Doyle et al., Time-Averaged Indoor Radon Concentrations and Infiltration Rates Sampled in Four U.S. Cities, Submitted to Health Physics, LBL-16595, EEB-Vent 83-16.

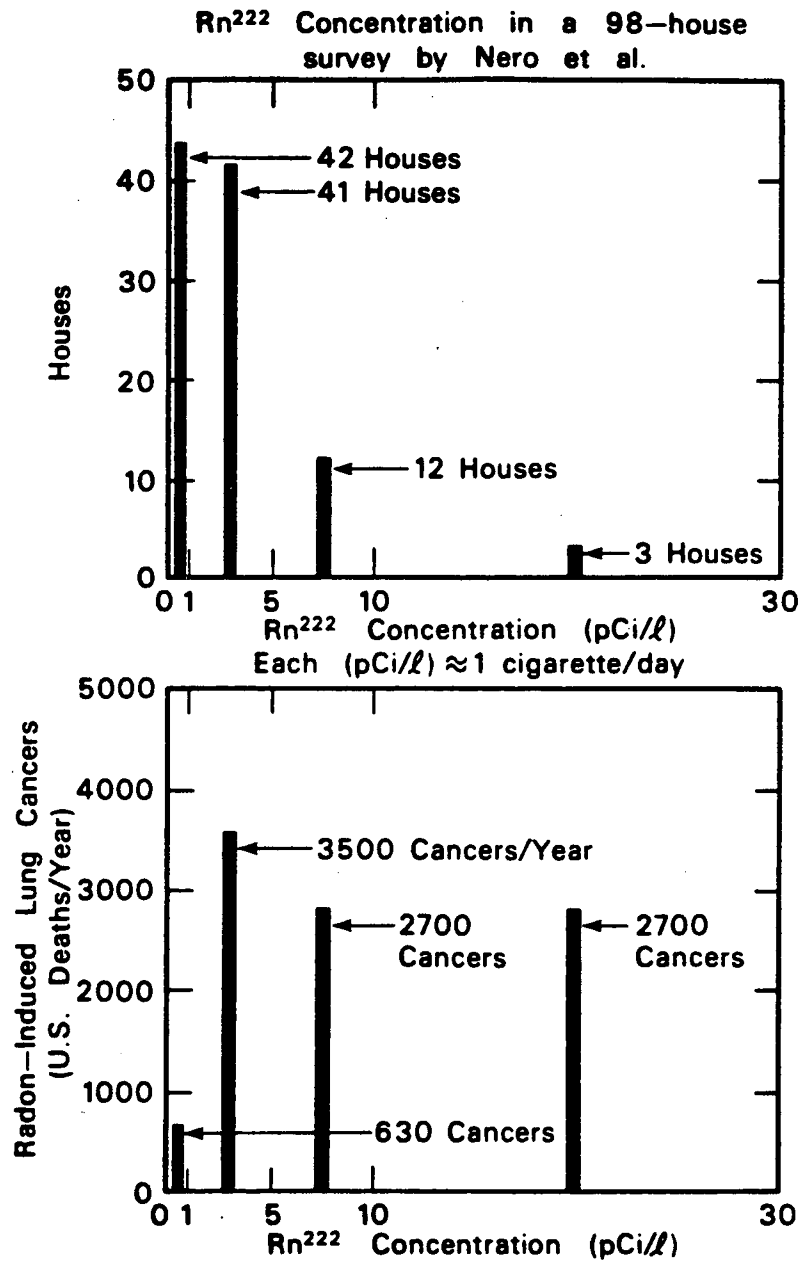

Figure 3. (top) Concentrations of Rn^{222} replotted from Fig. 1.

Figure 3. (bottom) Distribution among homes of annual lung cancers, induced by the concentrations in the top of the figure. The total incidence of radon-induced lung cancers is normalized to the often-cited EPA estimate of 10,000/year. Our own estimates of lifetime risk on Figs. 1 and 2 are smaller by a factor of 2 to 3.

concentrations, this requires a substantial increase in the indoor air quality portion of the conservation budget, if it is to include the infiltration work and exceed even half of the commitment made to indoor air quality as of 1980. Considering the inclusion of the infiltration work, and the $1.8M devoted to ventilation and indoor air quality in 1980, matching that previous level, even neglecting inflation, would require about $2.5M--nearly twice this year's appropriation. It would be more than twice the President's FY'84 budget if inflation were considered. Considering the importance of this area, this would be a barely sufficient commitment. It will give some hope of answering, within a reasonable time, the main question that a million homeowners would have if they knew how high air pollutant concentrations are in their own homes: "What should we do?".

o Performance Calculations (p. 38).
FY'84: $500K, raised to $1.250M in '85.

I am very pleased with the budget request.

o Research Utilization (p. 39).
FY'84: $1M, mainly taken over by Tech Transfer (page 51).

o Building Energy Retrofit Research (p. 40).
FY'84: $1M, expanded in '85 to $2.45M, for three areas--single-family, multi-family, and commercial.

I praise this new program; it can provide the information necessary to keep the retrofit industry up to date. I take as an example private homes. Ten years ago "retrofit" meant insulate your attic, wrap your water heater, and install storm windows and a clock thermostat. Later we learned about infiltration and attic bypasses and found that it is in fact ineffective and wasteful to insulate your attic without first sealing the leaks through which the hot air floats and is lost.

Now we are into "zoning" (turning off the heat in unoccupied rooms), and there are several retrofit products which can raise the efficiency of an old gas furnace to 90%, or even better. But we have little laboratory and field experience with these new products. How do we protect the water pipes in severely zoned homes? The furnace retrofit products and ideas are called "power burners" or the "Heat Extractor" or "electronic downsizing." But what is their reliability and useful lifetime, and how do we rank them by life-cycle cost?

I have talked about second generation residential retrofit to show that there is lots to do for $2.45M, without doing any monitoring, quality control, and feedback for major ongoing retrofit programs (like Weatherization) totalling half a billion dollars annually. These programs put little or no effort into self-improvement by monitoring their actual savings. It is not in the power of the new $2.5M Retrofit Research activity to monitor $500M ongoing programs, but I suggest that a few percent of Weatherization and Schools and Hospitals funds be transferred here for monitoring and evaluation, so as to use the considerable expertise of the national laboratories. I'll discuss this further in my Section III on State and Local Assistance Programs.

The Commercial Building part ($700K) of this Retrofit Research budget is too small. See my discussion of CACS (p. 44).

o HERS--Home Energy Rating System (p. 41).
FY'84: $500K, unchanged in '85.

Of all the technology transfer available to DOE, HERS has about the highest potential for improving the efficiency of new and existing residences. As soon as we are competent to do so, ratings should be extended to commercial buildings.

In Appendix II, I discuss the ambitious French program to rate new homes and to monitor 10,000 of the most ambitious ones each year. To do this monitoring, the French Agency for Energy Management will provide several million dollars annually (in contrast to the $500K requested here), plus $200M in incentives for building the better homes. I suggest we follow the French monitoring plans.

Several existing retrofit tools are adequate for predicting energy use for space heat and domestic hot water (corrected to standard home operating conditions), but no rating tool has yet been validated for all energy use in a home, particularly cooling. More work is needed and cannot be completed and demonstrated by the end of FY'85 at the proposed level of funding.

One of the first HERS demonstrations could be with the FEMP (Federal Energy Management) Program, for example, homes on military bases. BCS could also work profitably with FEMP to develop and test ratings for non-residential buildings.

o Building Systems Interactions (p. 41).
FY'84: $1.5M, zeroed in '85.

Although the name "Interactions" may have been vague and even unappealing, this is the home for research in whole-buildings performance, where all component research is integrated and measured in real buildings. This research is important and should not be dropped.

Without whole-buildings measurement applied to residences, we would not have discovered attic bypasses, or how to measure and control infiltration and attic moisture, or how to handle mechanical ventilation, or even have discovered serious problems in indoor air quality.

Virtually no comparable work has been done to investigate, through detailed field studies, the performance of multi-family and commercial buildings--or how to improve that performance through retrofits and better management. Federal and other public buildings could serve as valuable full-scale "test beds" for carefully planned field studies.

Buildings Systems Interactions should be the home of infiltration R&D, which was dropped in FY'84. Note that infiltration in existing U.S. homes runs 1/2 to 3/4 "ach" (air changes per hour) and can probably be safely reduced by 1/4 ach. Each 1/4 ach corresponds annually to 100 therms of gas per house or 0.8 quads for 80 million houses, worth $5B per year. LBL has now nearly completed an infiltration tester which is much more portable than the old blower door--it consists of a 1 Hz loudspeaker and microphone and will greatly simplify the measurement and repair of infiltration not only in homes, but in apartment buildings. Where is such R&D to be supported?

The development of Thermodeck for commercial buildings which (as I mentioned under Walls and Roofs, p. 36) is a good way to save energy in the winter and peak power in the summer, fits properly under whole-buildings research. In fact, Thermodeck is not part of the building envelope as funded under Walls and Roofs--it is a floor-ceiling slab. All thermal storage problems are whole-buildings problems.

This Activity may also be the one which should fund research and simulation of integrated equipment and appliances in homes, but I shall discuss that question under TCP (p. 48).

I simply cannot see how DOE can consider dropping this Activity.

RESIDENTIAL CONSERVATION SERVICE (RCS/CACS) (p. 43).

o RCS (p. 43). FY'84: $700K, reduced to $500K in '85.

Rather than cutting the budget, $200K should be cost-shared with utilities desiring to monitor and improve the retrofits initiated under the RCS program.

o CACS (Small Commercial and Apartment Conservation Service)
(p. 43). FY'84: 700K, raised to $800K in '85.

I praise DOE for this 14% increase, but it is inadequate. Millions of homes have been audited and retrofitted, so contractors have some ideas what to do. But carefully engineered and monitored apartment retrofits are rare. In our Retrofit Data Base [BECA-B] after searching the country, we have found only 26 thorough and evaluated multi-family retrofit projects. Clearly we are very inexperienced in retrofitting apartments, and the CACS information dissemination projects are something of a joke.

The CACS budget should be greatly expanded so that DOE can cost share with other agencies (particularly HUD) and learn how to efficiently retrofit apartment buildings and small commercial shops. It is a credit to DOE that it has requested $1.7M for CACS retrofit research (p. 40), but I consider that a bit small.

COMMUNITY SYSTEMS (p. 46). FY'84: $4.2M, cut to $2M in '85.

The support for the Urban Consortium ($2M) and the Georgetown University fluidized bed ($800K) have been dropped,. Urban Waste does not appear because it has been moved to Biomass.

1) Urban Waste. I am not an expert on Urban Waste, but have discussed it with Robert Williams of Princeton University's Center for Energy and Environmental Studies. He is concerned that the Wright-Malta demonstration is now dropped by DOE and is homeless, although it represents the most hopeful process in the U.s. (That leaves the Japanese with six commercial-sized demonstration projects, and the U.S. with none.)

Wright-Malta is a promising gasification/power generation process, which works both on urban waste and on biomass (so the administrative move makes good sense). A consortium of New York agencies, utilities, and private companies is prepared to fund a $1M demonstration if DOE will put up $250K, but DOE support is not forthcoming.

In summary, I support the methodical switch of Urban Waste to the Biomass program but want to be assured that it is not happening so fast that good projects get dropped in the shuffle.

2) The Urban Consortium. I know little of this wide-ranging Consortium but have worked with their Detroit and Kansas City Warm Rooms projects and wish to state that they have been conscientious and effective. If all their projects are so well conceived, they should certainly not be dropped.

TECHNOLOGY AND CONSUMER PRODUCTS (p. 48).
FY'84: $10M, cut to $4.9M in '85.

Refrigeration ($3.2M) and Combustion Heating ($1.85M) are dropped. Lighting ($1.95M) is held to $1.9M, which is a cut in real dollars.

Instead of shrinking, TCP should be starting a major new program in controls and a modest residential program in integrated equipment and appliances (see Appendix IV).

I will comment on five areas:

1. Lighting (p. 49): $1.9M.

U.S. lighting uses annually 400 BkWh, which costs $25B and represents the output of 80 1000-MW power plants. Under DOE, the group of Sam Berman at LBL has already helped to accelerate technical innovations that will, when they penetrate the market, add to a 40-50% electric savings (40 plants). But even now, the best fluorescent lamp has an efficacy of only 80 lumens per watt, whereas the physical limit is 220. Berman hopes to get to 170 lumens/watt in 10 years. One hundred and seventy lumens/watt is

10 times the efficacy of today's 100 W incandescent bulb. In ten years, there should be very energy-efficient screw-in high-technology fluorescent bulbs which can replace most high-use incandescents. These facts show that money invested by DOE in Berman's program have a societal payback time of months, not years. I cannot understand why DOE is not expanding the program.

2. Refrigeration Systems (p. 49).
FY'84: $3.2M; zero in '85.

This activity is needed not only to provide the U.S. with more cost-effective heating and cooling equipment, but it is also needed by the U.S. refrigeration industry if it is to survive committed foreign competition, mostly Japanese.

Professor Raymond Cohen, Director of Herrick Laboratory at Purdue, relates the following statistics on papers submitted to the biannual Purdue Compressor Technology conferences, which deal primarily with refrigeration. When he organized the first conference in 1972, there were 22 foreign papers and 62 domestic ones. By 1978, the foreign papers had exceeded domestics; by early 1984, the foreign/domestic submissions were running 3:1; by beating the bushes for U.S. papers he has managed to lower the ratio of foreign/domestic to 56/31, i.e., only 2:1.

Dr. David Didion of NBS tells me that U.S. refrigeration companies now do little scientific research and have not published anything indicating new equipment that will compete with the Japanese after about 1988 (with the heartening exception of a new Copeland compressor).

Whirlpool, the giant major appliance company, has until now made its own compressors, but it has announced that it will switch to buying from abroad.

This administration hopes that if government drops support of R&D, the private sector will rush in to take over. I'm learning that in a wry way this hypothesis is partly correct, but it's the foreign private sector that rushes in (often with additional support from its own government [MITI, 1983]).

Refrigeration research will not only help save our industry, it will save power plants. DOE's early programs emphasized saving energy, mainly by saving heat. These programs have been successful, and now it is more cost effective to address peak power savings, which in the U.S. is mainly a cooling problem. On a hot summer afternoon, about 40% of all U.S. power is devoted to air conditioning. (Forty percent of U.S. power represents about 160 standard plants.) A 10% improvement in air conditioning efficiency would free 16 plants (or the equivalent $50B of capital) for more productive uses, and 10% savings should indeed be achievable if TCP doesn't drop refrigeration research.

Refrigeration equipment is, of course, the heart of heat pumps, in which the U.S. is investing heavily. The research in non-azeotropic liquids which TCP supports at NBS could make heat pumps cheaper and 10-20% more efficient. Again, this research should not be dropped.

3. Combustion Equipment (p. 49).
FY'84: $1.85M; zeroed in '85.

Under Refrigeration, I said that TCP research would help U.S. refrigeration companies to survive. In the case of combustion heating, U.S. companies are developing nice new products, like the Lennox pulsed combustion furnace. But the major companies are not going after the retrofit market because they fear liability issues.

Smaller companies have developed clever new gas combustion retrofit equipment. Under Retrofit Research (p. 40), I have already mentioned power burners and the Heat Extractor and the use of microprocessors to raise combustion efficiency even as a retrofit.

TCP should not drop combustion; instead it should continue its base program and work with manufacturers to test and improve these retrofit devices and take advantage of microprocessors. U.S. homeowners deserve this support.

4. Controls (no page number; does not yet exist).

The elimination by DOE of Building Controls from its FY'84 budget and the continued non-existence of Controls in its FY'85 budget can only be described as extreme "short sightedness." Does the medical profession refrain from studying how the human brain and central nervous work to concentrate only on the well being of arms and legs? Does it neglect the interactions between the various organs and refuse to look at how the entire human system operates? If DOE was in charge of medical research, they just might!

The most cost-effective measures that are possible today in commercial buildings are those involving correcting poorly performing HVAC systems, implementing control strategies that eliminate energy waste, and optimizing the performance of the entire building/HVAC/controls system. I estimate that the implementation of these options in commercial buildings on a nationwide level could easily save six percent of the nation's fuel use--this is more than the annual rate of discovery of new gas and oil in the U.S.

It is a well-known fact that the HVAC systems in most new U.S. buildings work badly at first. (See my proposal for certifying new buildings in Appendix I.3.) Those in existing buildings may seem all right, but, in reality, most operate very inefficiently and waste a significant portion of the energy they use. In both cases, the poor performance is generally due to poor controls, inadequate equipment quality control, poor maintenance, and lack of knowledge and expertise on the part of both the suppliers and the operating staff.

A recent study at the U.S. Army Construction Engineering Research Laboratory showed that none of the pneumatic enthalpy controllers they tested worked as specified, and the humidity sensors frequently failed or fell way out of calibration in less than a single day. Chillers provided by a reputable major manufacturer started out 25-30% below their rated efficiency. Days of tuning by the manufacturer never got them up to specs. A 1981 study by the national Bureau of Standards of computerized Energy Management and Controls Systems (EMCS) showed that almost 30% of the users were dissatisfied with their system's performance. Estimation of percentage of EMCS systems installed on our military bases that do not work properly, or don't work at all, have ranged as high as 70%.

These problems may, however, be small compared to the ones the building community will face in the near future. There is increasing interest in this country in considering the integration of fire and security with EMCS. Yet there is no research being done to determine how this can best be done with the proper regard for safety; there is no effort to develop the performance standards, guidelines, and building codes necessary for the installation and operation of such systems. Downstream there will be a push to use local area networks and intelligent PBX's to integrate all building services--fire, security, HVAC, lighting, communication, word processing, data storage/retrieval, transportation, etc. The problems encountered with EMCS will be repeated with much graver consequences unless research is started now on how to properly apply these "high-tech solutions" to our building systems.

There are in the U.S. currently about 130 suppliers of EMC Systems, where just a few years ago there were only a half-dozen major building control manufacturers. Out of those 130 companies, only 3 or 4 can be said to do any form of, what I would call, "basic building controls research." And even then, if you were to add up all of the actual man-hours devoted to "basic research" in these few firms, it is my guess that the total would probably be on the order of a half-dozen man-years per year. The building industry in this country is second to none in its past and present practice of looking only at near-term profits at the expense of their and our future.

Because of the importance of building controls and the nature of the building controls industry in this country, I strongly recommend that DOE implement a strong government sponsored research program in this vital area. A $1M effort per year should be the minimum level of DOE activity beginning in FY'85. With the exception of maybe one company, the controls manufacturers are eager to work with DOE in both basic research and field testing. Such a program would have an incredibly rapid payback in terms of the energy saving benefits to this country.

5. Integrated HVAC Equipment/Appliances (no page number).

In Appendix IV, I make the case for a modest research program devoted to the inevitable integration which must take place in residential heating/cooling/hot water/appliances.

APPLIANCE STANDARDS (p. 50).
FY'84: $1.7M, raised to $2.5M in '85.

I praise DOE for the increase but have two small comments.

Consumer Education. In Appendix III, I discuss the need for fact sheets and guides to comparison shopping for appliances. For an additional $200K, the consumer education project could experiment with the success of such sheets.

Appliance Standards. Here I have a suggestion that would cost nothing. The present big yellow labels have been well received, but I believe they are all peeled off as soon as the appliance is delivered. This tends to remove the enhanced resale value for an efficient appliance. DOE should rule that a small **permanent** version of the label be attached to the appliance.

ANALYSIS AND TECHNOLOGY TRANSFER

o General Analysis and Tech Transfer

FY'83: $1M
FY'84: $200K
FY'85: $1M

I praise the increase to $1M, which returns the program to almost its FY'83 level of effort. In fact, $1M is still too small. Currently, the BECA data bases (BECA stands for Buildings Energy Use Compilation and Analysis) are under-funded at $500K, which comes from a variety of contributions from within the Office of Buildings Research and Development. BECA should be expanded to $600K and given a home under this Activity. The work at ORNL under Eric Hirst to evaluate major conservation programs (RCS, Weatherization, Schools, Hospitals,...) is also under-funded and should be expanded and supported by this Activity. The valuable continuing study of Lee Schipper at LBL, compiling and comparing international building energy uses, should be expanded.

o Energy-Efficient Buildings Center (p. 52).
A new $1.51M activity.

This is a great idea, but only a first step. To be cost-effective it should expand rapidly to a grid of 10-20 centers. Let me explain why there is a large threshold expense to start an energy-efficient buildings center, which I shall call EEBC.

An EEBC must be more than just another trade show. There are many of those, in which good and bad products are exhibited side by side, with no attempt made to analyze their life-cycle cost (or the "cost of conserved energy") or to compare them.

Before it sets up displays, DOE must ask serious question about where to draw the line of cost-effectiveness. There are problems at both extremes:

1. What will it do about widely advertised losers, like the diode button for incandescent lamps, which reduces the bulb output, extends its life, but even more greatly decreases its efficiency? It would, in fact, be a public service to exhibit the energy button, but along side to exhibit the far more cost-effective competition, which is simply an optimized long-life bulb. Is DOE prepared to be so creative and to caution consumers about bad "deals" as well as to encourage good ones?

2. The other extreme of displaying only the most efficient product is also tricky, because the most efficient refrigerator, furnace,..., is almost never the most economical buy. Thus, the highly advertized Lennox pulsed combustion furnace is very impressive, but furnaces of slightly lower efficiency are more economical. And before he or she buys a new efficient furnace, the owner of an old, inefficient one should be told to consider retrofit with a number of cost-effective products: power burners, the Heat Extractor, etc.

And there are problems of relations with DOE's Solar Program. To heat water, one must consider both heat pumps (Conservation) and solar collectors. To heat a house, one must choose the optimum area of south-facing glass (Passive Solar), combined with mechanical ventilation and heat recuperation (Conservation), etc. To heat a pool or a hot tub, one must correctly combine pool covers and solar collectors. The list is long and suggests to me that DOE's Solar Program should budget another $1.5M and co-sponsor the Center.

Both of the examples above illustrate one of Murphy's Laws--for the conscientious, it is easier to get into something than to get out of it. Once you display an intriguing new product, you have to collect and analyze all the competition and then produce fact sheets about the whole question. And once you go to all that work and expense, you should replicate the exhibit for a network of centers and probably travelling exhibits. From now on I shall refer to the EEBC's (in the plural).

I shall continue to expand on this point, but first let me restate my views of economy of scale. To organize a single outstanding center, which only a few percent of the U.S. will visit, will take a million dollars. To set up 19 satellites (some as travelling exhibits), accessible to most Americans, will take only a few million. The satellite centers should, of course, be somewhat specialized--emphasizing cooling in the south and heating in the north, solar where it pays best, oil heating measures in the Northeast, radon detection and mitigation in radon-rich regions, and electricity conservation where power is expensive.

I further suggest that the EEBC's should lend, rent, or sell a variety of test equipment and tools: radon detectors and passive indoor air quality samplers, wattmeters, watthourmeters, furnace efficiency testers, data loggers, energy audit programs, slide rules and work sheets for HERS (Home Energy Rating System), maybe even blower doors and smoke sticks to measure infiltration and pinpoint air leaks. You can see that I am describing high-budget centers, but I believe that they will be cost effective.

Next, I make two suggestions about relations between the National Laboratories, including NBS, (and other research centers) and the EEBC's.

1. Each exhibit, i.e., insulation, windows, ventilation, indoor air quality, gas furnaces, air conditioners, needs an organizer with expertise, independence, and resources such as are found best at the Labs. In fact, the Labs, which have both the independence and level of expertise necessary, are probably the only major source of technical support for an EEBC program. So, the labs should be funded to provide the exhibits and the fact sheets. [This issue is closely related to my Appendix III.]

2. Staff expertise. Visitors to the EEBC's, particularly builders and manufacturers, will have many questions and should be given access to experts. So, some of the EEBC's should be located at research centers.

At a very minimum, the Lab which produces an exhibit and fact sheets should first set up and debug the exhibit at its own headquarters and only then replicate it for the main EEBC and satellites. By thus organizing exhibits in parallel, the Center can be assembled in a year or so. The Center should sponsor training programs in such topics as Daylighting and Indoor Air Quality and publicize existing training programs.

I believe that the thorough but bold approach outlined above will significantly accelerate the rate at which the unaided market separates the winning products from the losers and adopts the winners. But it will be expensive, so get set for larger budget requests next year.

° Fellowship Program (p. 52). A new $2M activity.

I have nothing but praise for this initiative. Some of our best ideas at LBL have come from our many sabbatical visitors and visiting researchers, from the U.S. and many countries. The fellowship program should, of course, be open to researchers from abroad.

° Summary Comments on Tech Transfer

DOE's Tech Transfer program has dwindled in the last few years and should be rekindled, so the budget for Analysis and Tech Transfer should be $10M, not just $4.5M.

In the Appendices to this testimony, I have assembled descriptions of some possible demonstration and tech transfer programs. Many of these projects are already successful in France, Great Britain, and Sweden.

FEDERAL ENERGY MANAGEMENT PROGRAM (p. 53).
FY'84: $1M, raised to $2.3M in '85.

I praise the long-overdue growth in DOE support for FEMP. A factor 2.3 is probably as rapid growth as is efficient for one year, but I shall suggest new activities for FY'86--which could be planned during '85.

In 1983, the Federal energy bill was $13.3B, of which $4B was for buildings [FEMP '82, '83]. Our experience with retrofitting commercial buildings [BECA-C, 1982] is that it pays to invest about $1 per square foot, at which point annual savings are typically 40%. Given that Federal agencies operate 3.2 B ft2 of buildings, one would then contemplate an investment of $3.2B. Instead, between 1975 and 1983, the investment has been only $1.8B, and the savings in energy use per gross square foot is only 13%. In FY'85, the planned retrofit investment was $283M [FEMP '82]; at which rate it will take another 8.5 years to get the cumulative investment up to $1/ft2.

The 27% remaining potential savings represents $1B/year. To promote, plan, and evaluate this $1B potential, DOE proposes to spend $2.3M in FY'85; this is 0.23% of the desired savings--and should grow in FY'86.

One of DOE's responsibilities should be to set up a good data base of the energy intensities of individual Federal buildings (and the cost effectiveness of their retrofit) and then to compare these data points with energy intensities (and benefit/cost) for the private sector. At this point, a few agencies have such data bases, but most of the published reports by FEMP only include agency-level aggregate consumption.

Now I present four proposed extensions to the FEMP program.

1. Ratings for Federal Buildings. It is already planned that voluntary BEPS shall be mandatory for Federal buildings. I propose a logical extension, which makes building energy rating systems mandatory, too. Agencies could then pay incentives to builders, based on the ratings, and require that their building manager stay below the rated energy use or contact the contractor to explain the problems and fix them. This activity would also give DOE experience with validating and delivering rating systems, experience it needs badly in the tricky area of large commercial buildings.

2. City-Wide Programs. In some cities the FEMP program could be efficiently combined with conservation programs in public housing, schools, hospitals, etc., to create an active city-wide program as developed in France. See my Appendix II.2.

3. Retained Savings. In my hometown of Berkeley, the public schools and even my own campus have done minimal conservation, and I have decided that they won't do much until they see some motivation in the form of retained savings. There is a new California law which permits public bodies to borrow state funds for retrofit and to negotiate with the Department of Finance to retain up to 70% of the first year's savings. I would like to see DOE, as FEMP coordinator, propose to some Federal agencies to try this same approach. The loan fund could be provided by the individual agencies or by DOE. This proposal, of course, needs the support of OMB.

4. Pairing of National Laboratories and Federal Installations. The conservation expertise which resides in some of the National Labs could be fruitfully employed by pairing up Labs and federal installations (or HUD public housing). I believe that outstanding, showpiece efficiencies might be thus obtained.

PROGRAM DIRECTION (p. 54).
FY'84: $2.9M, raised to $3.1M in '85.

The 7% raise seems reasonable, but why is the staffing level reduced from 71 to 60? Of course, if the BCS budget is increased, as I have been arguing, then Program Direction must be raised accordingly.

CAPITAL EQUIPMENT (p. 27).
FY'84: $1M, raised to $2.5M in '85.

This increase is very encouraging to researchers who received no capital equipment in FY'83 and experienced reductions in FY'81 and '82, so that our reservoirs are long dry.

III. State and Local Assistance Programs (SLAP)

Proposed Use by SLAP of BCS for Technical Support of Monitoring, Quality Control, Analysis and Feedback

The Federal Government funds major retrofit programs (Weatherization, Schools-and-Hospitals, HUD, FEMP) and funds new construction for agencies.

Most of these programs report their retrofit efforts merely by "bean counting" ("xx attics retrofit," "yy EMCS's installed,"...) without actually measuring fuel and electric bills before and after retrofit. We know of no Federal retrofit program where a sample of homes or buildings is routinely submetered, monitored, and checked 1) to see what fraction of the predicted savings were achieved, and 2) to analyze and correct problems in auditing, installation, maintenance, etc.

Even a centralized industry like autos spends 10-20% of its effort on quality control. For energy aspects of buildings, it is clear that there is far too little quality control. A pilot program in monitoring and quality control could soon tell us how much could be saved with a full-scale program.

Congress has suggested (it should have required!) that 2-4% of weatherization and Schools-and-Hospitals funds go to monitoring, quality control, analysis, feedback, and program improvement, but little has happened. I propose that DOE's State and Local Assistance Program collaborate with BCS's Retrofit Research activity to plan and implement monitoring and analysis. BCS can in turn call on the National Laboratories, which have already developed systems to monitor homes and buildings, have evaluated programs, and have set up the BECA data banks (BECA = Buildings Energy Use Compilation and Analysis).

Although DOE Weatherization spends $190M/year, the whole federally supported Weatherization Program is larger: 7% of LIHEAP's $1.9B (so $135M) goes to weatherization, and Oil Overcharge payments to the states fund more of it. These programs also should monitor and collaborate with BCS and its data bases.

The above suggestions apply to HUD retrofit programs and to other federal agencies who retrofit and for new structures erected by GSA/Public Buildings Service. This calls for collaboration between the FEMP and Retrofit Research offices within BCS.

Thus, BCS should move into an important new technical support role for the whole federal energy efficiency program in buildings.

ACKNOWLEDGMENTS

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Goldman, C. A., Technical Performance and Cost-Effectiveness of Conservation Retrofits in Existing U.S. Residential Buildings: Analysis of the BECA-B Data Base, (BECA: Buildings Energy Use Compilation and Analysis) LBL-17088 (Thesis), October, 1983.

Hammond, E. Cuyler, "Smoking in Relation to the Death Rates of One Million Men and Women" (Statistical Research Section, Medical Affairs Department, American Cancer Society, Inc., New York, NY), National Cancer Institute Monograph No. 19 (1966).

MITI. The Japanese MITI (Ministry for International Trade and Industry) had a 1983 R&D budget of $500M and employs 4000 people. About 10% of the budget is for conservation.

Repace, J. L., and Lowrey, A. H., "Estimate of Non-Smokers' Lung Cancer Risk From Passive Smoking," submitted to the American Journal of Public Health (1984).

NOTE:

To calculate that a lifetime lung cancer risk of 10-3 corresponds to smoking 1/2 cigarette daily for 30 years, we first calculate the lifetime rate for smokers two different ways.

Method A. The crudest argument starts from the following facts:

1. In 1982, there were 110,000 deaths from lung cancer, of which the National Cancer Institute blames 85% on smoking--so we have 95,000 excess lung cancer deaths.

2. One-third of the U.S. adult population (so 55 million people) smoke an average of 32 cigarettes/day.

3. The U.S. death rate (mainly of adults) is 2M/year, so the share of deaths of the 1/3 who smoke is 667,000.

Hence, 95,000 lung cancers among 667,000 total deaths gives a lifetime risk of lung cancer of 14% from 32 cigarettes per day.

Method B. In the Appendix to their forthcoming paper, Repace and Lowrey start with the same facts used in Calculation A but assume that 92,000 of the cigarette-induced annual lung cancers are associated with the 29 million smokers of age 35 or over. The annual death rate per smoker is then 92,000/29M = 3.2 x 10-3.

We then estimate that the average smoker does so for 30 years. The product of 3.2×10^{-3} lung cancer/year x 30 years is 10%; which is slightly lower than Estimate A of 14%.

We shall use estimate B, and decrease it another 20% because each of today's filter-tipped cigarettes produces 15-25% less lung cancer than the cigarettes of 30 years ago, which are responsible for today's lung cancers.

Thus, 32 daily cigarettes in 1984 might cause only an 8% risk of lung cancer. Assuming linearity, 3.2 cigarettes daily will then cause 0.8% of a cancer, and our line on Fig. 1 corresponding to 0.1% is associated with smoking 0.4 cigarette daily. This sounds misleadingly precise, so I have labelled the line "1/2 cigarette per day."

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Appendix I. Pilot Demonstration Programs

In the last few years building scientists or practitioners in the U.S. and Europe have achieved successes which are ready for pilot-scale demonstration. Without a demonstration by DOE, however, they are not taking hold. It is time for Congress to encourage DOE to take the initiation to advance the acceptance of these cost-effective projects. I list four of them.

AI.1. School Thermostat Setback for Nights/Weekends/Vacations

Schools are fully occupied only about 40 hours/week, or less than 1/4 of full time; yet most of the time their thermostats are set for 50-60° F, because the custodian has heard ancient stories about peeling paint or other troubles from condensation.

A few of these "old custodian" tales are true; in fact pre-1930 buildings, without reinforced foundations, may develop cracks if their indoor temperature changes greatly every day. But in some modern Swedish schools we tried turning the heat OFF during unoccupied hours, with no problems. Good insulation and low infiltration, combined with thermal mass, simply kept the school floating well above freezing all during Christmas vacation. Further, the modern way to protect against condensation is with an air-to-air heat exchanger, not a furnace. In the USSR, buildings are designed to be kept at 40° F when unoccupied.

Individual school districts don't seem to have the expertise to classify schools by age and construction as safe or unsafe for deep thermostat setback, and will apparently not take the small risks involved in an experiment--at least very little has happened since 1973. One or two expert consultants, supported by DOE, could start a demonstration which would soon sweep the U.S.

AI.2. Retrofit Demonstrations for Apartments Without Thermostats
(particularly older apartments with radiators)

We know that in Page Homes in Trenton, Chaim Gold was able to get a payback of less then one year by switching the hot-water temperature "reset" from the outdoor controller to an Apple, which monitored the indoor temperature of many (or all) apartments. Fuel bills were halved.

The Swedes have even more spectacular results at almost no cost by measuring the exhaust air temperature for each zone, thus automatically averaging the indoor temperature of many apartments.

We propose to demonstrate this retrofit in many cities, presumably in collaboration with HUD.

AI.3. Commissioning of New Commercial Buildings

Testing of HVAC and Air Quality

The energy efficiency of the heating and air conditioning systems of every new building is compromised by "bugs," from one of five sources: a) mistakes in design, b) changes made during construction, c) faulty installation of equipment and controls, d) faulty equipment and controls, e) unenlightened operation and maintenance.

The main feedback to the building operator is complaints a) from uncomfortable occupants and b) from whoever pays the bills. This system tends to fix obvious faults (wrong temperatures, etc.) but permits faulty systems and equipment to go undetected for years, giving inefficient operation. In addition, the operator will simplify building operation to a level that he can understand but which is far from design.

In France, independent companies check out and diagnose new buildings, although with no particular emphasis on VIAQ. (The biggest of these "Bureaux de Controle" are Veritas and SOCOTEC.) In the U.S. there are companies which provide specialized services, such as balancing the ventilation, but we know of none offering a comprehensive acceptance test. We propose to assemble or develop the techniques and instrumentation to lay the base for a commercial check-out service in the U.S. Speculative builders won't like the delays that it threatens, so our first clients would be the purchasers of public buildings (Public Building Service/GSA, for example) or chains (retail, hotel, restaurant, etc.).

We propose to monitor these buildings both before and after they are debugged. Eventually this service could lead to monitoring of energy labels for commercial buildings, but today we probably don't know enough to certify the labels on commercial buildings.

The first step is to equip a van with a transportable GC/MS (gas chromatograph/mass spectrometer for measuring organic pollutants), and apparatus to measure ventilation and ventilation efficiency, and some miscellaneous data loggers. It would take two researchers to operate the van, at least one of whom should be trained in HVAC and IAQ (Indoor Air Quality). This van could probably survey and debug one new building a week--on a pre-arranged schedule, but available to move to a high-priority "problem building."

Technology Transfer. This new industry will eventually be taken over by the private sector, but there are now very few trained people, and the ventilation measurement techniques must still be developed. The project should be started as a collaboration between a national lab and a university, so as to start training professionals. The van crews should be solicited from companies which are already trying to break in to this field but who don't know how.

Note the efficient amplification of this research. Now, with no monitoring, there is no feedback. With monitoring and public-domain data, designers and controls companies will learn what not to do, and it may no longer be necessary to monitor every new building. Systematic commissioning is also an efficient way to train the staff who will operate the building.

AI.4. CALMS: The Smart English Electric Meter, Load Manger, and Clock Thermostat

Under the leadership of R. A. Peddie, its recent chairman, the South East England Electric Board is planning to introduce a smart residential meter/clock-thermostat/load-management system called CALMS (Credit and Load Management System). A side-band radio transmittal of the BBC will announce a price for electricity every 15 minutes. CALMS receives this signal and relays it around the house wiring by a ripple signal. Every major electrical device (water heater, washer, air-conditioner, etc.) is plugged in through a $7.50 "PID" (Priority Interrupt Device), which includes a 9-position switch with which the occupant can dial a "turn-off" price for electricity. Thus, he can decide ahead of time that he will not run his water heater when the price of a kWh is greater than 5¢, and his washer at more than 7¢.

CALMS will cost about $150, including a smart thermostat and a modem, and of course a microprocessor. So the customer can program night temperature set back, read his bill, and pay it by phone. He can read his current hourly or daily gas and electric costs.

For customers with unsatisfactory payment records the utility can require pre-payment. Applied to London apartments with lots of transients and lots of unpaid bills, this can save millions of pounds per year.

We are particularly impressed with the flexibility of CALMS. Seeboard can offer many different rates, with lower prices for more interruptibility. With the modem, the customer can control other gadgets with ripple control, modify his thermostat or turn on his oven remotely. And utilities can introduce their pet schemes, for example they can shed almost all of their residential appliances for five minutes while they ponder what to do about an overload, without turning off the customer's lights, clocks, or TV.

Status. A few dozen test units are up and running reliably over phone lines. Two manufacturers have been chosen. Plans are to produce several hundred thousand per year.

Recommendations. CALMS has great potential to save residential peak power in an attractive and cost-effective manner. DOE and EPRI should collaborate to introduce it to the U.S. and try it out.

Appendix II. Major New Outreach Programs: High-Tech Hardware and Buildings

AII.1. Monitored Home Energy Ratings to Demonstrate Low-Energy Homes

The purpose of this note is to advertise an ambitious French plan for offering and monitoring home energy ratings. I find the plan so impressive that I want to urge that we copy it.

Last July I spent two weeks in Paris as a guest of AFME [1] and CNRS [2]. This was the third trip to France during which I have given talks pushing home energy labels and have participated in meetings about labels. I was pleased to learn that these idea have taken root beyond my fondest expectations.

The French AFME and MUL [3] now plan not only to offer incentives for the voluntary labelling of all new dwellings, but also to monitor the best 10,000 new homes each year, and perhaps even to monitor their indoor air quality. So in this memo I'm switching from playing American missionary preaching to the French to the role of American foreign reporter preaching to the folks back home.

The facts and plans outlined below come mainly from Gilles Olive, consultant to Plan-Construction, within the MUL. Olive is responsible for the 1985 Norme [Standard] for new residential construction, and sees well-documented labelled homes as the ideal pilot program to test the validity of his proposed standards.

Fig. 1 shows the ratcheting down of the French space-heating normes. It is only approximate and symbolic, because the actual norme includes water heat, but I have re-interpreted for Americans who still tend to think in terms of space heat.

To understand Fig. 1, which is for Paris climate, you must know that 1 tep (tonne equ. of petroleum) is 40 MBtu, so the 1982 norme is not too remarkable. But in 1985 Olive and colleagues want to go to the optimum, which is about 0.5 tep, and that requires experience with hardware items (windows, shades, tiny furnaces, ventilation systems, controls, ...) which are not yet even on the market. So they are looking for builders who will serve as guinea pigs, and who will stimulate the market for some of the needed hardware..

The government will offer "LPHE" (Labelle Performance Haute Energetique) of 1* through 4*. The threshold for a 1* label is calculated savings of 15% compared to the present Norme '82. Each additional 10% merits another star. The incentive is a subsidized loan on the "surcout" (surcost), up to about $1000. A builder can get the label (and the loan) by showing his building plans and cost estimates to a local official.

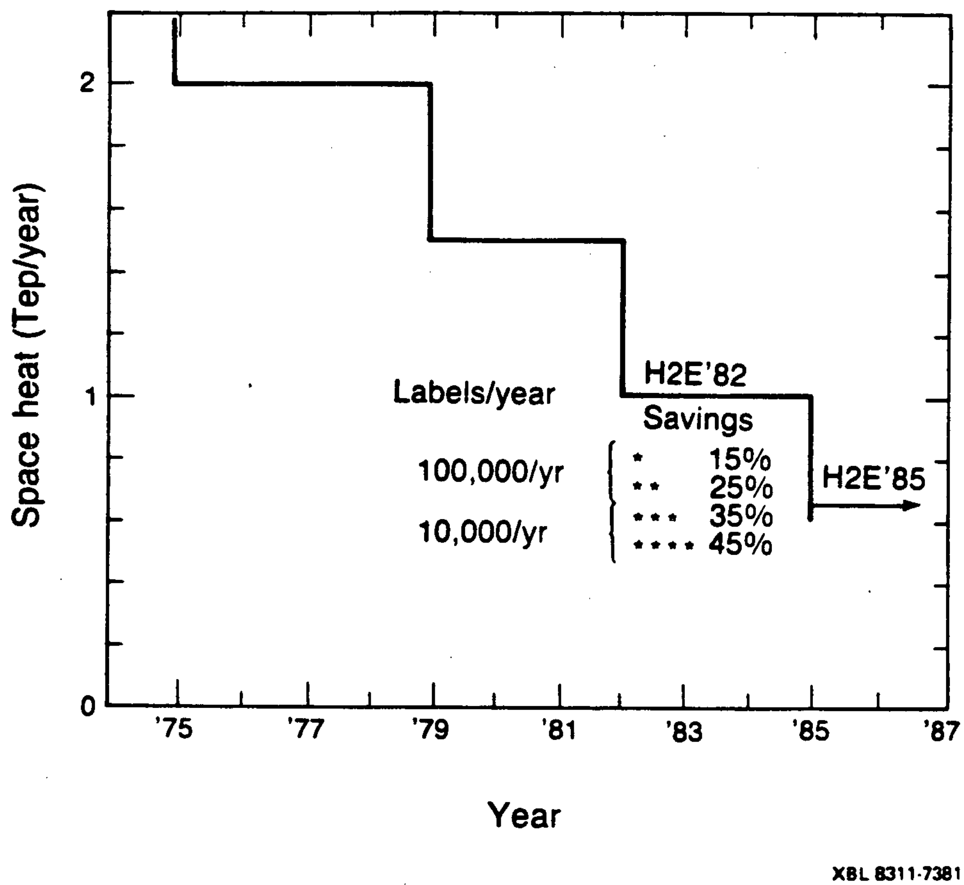

Fig. 1. Three-yearly tightening of French new home energy normes for the Paris weather region. Labels introduced in 1983 are given for savings relative to the current 1982 Norme. The 1985 Norme will come somewhere in the region of the 3* or 4* labels, depending on the results of the label monitoring program. The vertical scale is only approximate since the published norme includes energy for domestic hot water. Roughly $200 M over 3 years is available for incentives for 3* and 4* homes.

Units: 1 Tep (Tonne of equivalent petroleum) = 40 MBtu.

The most interesting homes are the 3*'s and 4*'s. Olive expects about 10,000/year of these two classes, and has a budget of $200M/3 years for the loans.

Starting this winter, he intends to monitor the utility bills of these houses, as they are completed and occupied. He plans to track the data, select the most interesting homes, and submeter them, starting the following winter. They may even use LBL's ESMs for the monitoring. Finally, Mme. Bouchardeau, the Minister of the Environment tells me that she's interested in a piggy-back survey of indoor air quality in some of the same homes.

In a few years this should result in 20,000 new homes, all over France, well understood in terms of cost, performance, and IAQ. If the U.S. BEPS had been supported by this sort of infrastructure, it might still be alive today, although doubtless in altered form, since the pilot homes will have a powerful feedback onto the proposed standards. But I suggest that we copy the French labelling plan even though we do not have to prepare for mandatory labels. It seems to me to be an ideal way to accelerate the rather slow progress of U.S. homebuilders towards energy efficiency.

The discussion above was for new homes only. In a year or so, after they can train 5000 more auditors, AFME will introduce labels for existing homes, at time of sale. Then they plan to go on to commercial buildings.

LBL's Energy Efficient Buildings Program is looking for utilities, state or local governments, or other institutions who might want to sponsor monitored/labelled homes. In the U.S., the subsidy may not be necessary, since Freddie Mac, Fannie Mae, and other wholesale lenders have already announced that they will give bigger and better loans on energy efficient homes. We would like to provide technical assistance to any interested parties.

FOOTNOTES

1. AFME. Agence Francaise pour la Maitrisse de l'Energie.

2. CNRS. Centre National pour la Recherche Scientifique

3. MUL. Ministere de l'Urbanisme et de Logement.

NOTE. Please see page 3 for an argument for lenient U.S. residential building energy performance standards (even voluntary ones).

Ratings as the pathfinder, standing on the shoulders of Standards

It is customary for prize-winners to say modestly that they owe most of their success to their colleagues and have achieved eminence only by standing on the shoulders of previous giants.

I want to suggest that the French approach demonstrates a similar effective relation between ratings (the new prize winner) and standards (the manifestation of good current practice). States or even the Federal Government should enact relatively lenient standards which serve two purposes:

1. Although conscientious builders will beat the standards, shoddy builders will at least have to meet them.

2. The standards can become the baseline for energy tax credits. It is inefficient now to subsidize retrofit of an inefficient existing home, yet not to subsidize the more cost-effective improvements one can make in the design of a new home. Each year there are, of course, many more retrofits than there are new homes built, so the new incentive would not cause a significant drain on the treasury. But even if we wanted to keep the total drain constant, it would be better to have a 13% subsidy on all homes instead of a 15% subsidy on new homes. Note that in California you can get a 55% subsidy on a new home or commercial building for costs aimed at beating the standard.

If the U.S. Government sponsors a major labelling/monitoring program, it must provide funds to:

a) Certify computer programs and rating systems, and

b) Help local governments or utilities set up to offer and police rating systems and to license auditors as raters.

AII.2. "Telecontrol" of EMCS in all Public Buildings in a City

AFME has sponsored the installation and supervision of EMCS (Energy Management Control Systems) in all public buildings in 17 major French cities. In the U.S. we are already familiar with EMCS which control many schools in a single district--some funded by the U.S. "Schools and Hospitals" (Institutional Buildings Conservation) program; but what's new about the French approach is that it offers trained personnel and economy of scale to all public buildings in a city or region. Thus Toulouse has 134 buildings, each with its "satellite" EMCS which runs the building and communicates with the city hall.

The average cost of the system, which includes a calorie meter to measure boiler output in the larger buildings, is about $11,000 per building. In addition AFME, invested about 10 man-years in software for the system.

Each satellite EMCS is capable of independent operation (indeed, some were in place before the cities joined the city-wide program), but each EMCS also has a communications card with a modem which communicates with a central mini-computer, typically at the city hall. The central operation is run by one skilled engineer who plays the role of city energy supervisor. This supervisor works with the building engineer at each satellite, individually ("Jean, your boiler efficiency has sagged.") or in groups, say at the weekly meeting of all the maintenance engineers of HLM (low-rent housing). Within this group he can use both carrots and sticks, and the group members can help one another, set up subcommittees to select auditors, etc.

Of course, the city administrator of HLM will follow the progress of all his maintenance engineers, and can reward the most successful.

The system operated in 3 cities last winter. Even before many retrofits were installed, one city saved 15%; one, 10%; and one, nothing. Of course, the mayor of each city will see these results and will apply strong pressure on the unsuccessful energy supervisor. Fourteen more cities will be added this winter.

Incentives. AFME paid half the cost of the first three cities. For the next 14, it pays 40% of the first 15 buildings. As the program takes over, the incentives can be reduced.

Incentives for a U.S. Program. We feel that this program is a logical but innovative extension of the current Schools and Hospitals Program and could be funded in the same fashion. Pilot programs can be done in collaboration with U.S. controls companies (Honeywell, Trane,...) and third-party investors, and perhaps utilities interested in its load-management features. "Schools and Hospitals" is a successful program and deserves to be renewed for many more cycles. My "Telecontrol" plan should extend it, not compete with it.

AII.3. Demonstration of Low Peak-Load Office Buildings

DOE seems to feel that its mandate is to conserve and produce energy (kWh), but it pays little attention to peak power (kW) even though new electric peak power now costs about $1000/kW. Power-shy utilities, of course, are interested in peak-saving. PG&E pays incentives up to $280/kW saved to induce its commercial customers to install more efficient lighting. I believe that Texas Utilities is up to almost $500/kW saved in its efficient residential air conditioning program.

Air conditioning accounts for 30-40% of U.S. peak power, but in designing new buildings it is easy to move this load off peak, thus dramatically flattening the utilities demand curve.

In those mild climates where summer nights fall to about 70 F, one can flush the building rooms and mass with cool air, and store enough coolth for the next day. Thus in Reno, two buildings designed by Syska and Hennessy have recently been built with no conventional chillers (I believe one has an evaporative cooler). Thus, further, by constructing a 4-million gallon tank, Stanford has moved its cooling entirely off peak.

Even in Miami, with reasonable, cost-effective coolth storage in the building, one can run conventional chillers only at night, when they are more efficient and electricity is cheap.

In addition to diurnal storage, designers can save peak power by shading sunny windows and by good controls which turn off lights when daylighting is available.

I propose a **cost-shared (DOE/Utility) program** to demonstrate a few hundred low-power commercial buildings. For a few selected demonstrations utilities could afford to put up $500/kW-saved, and the Federal Government could match it, adding up to an incentive of $1000/kW-saved. Only half of this should be paid early, based on building plans; the remainder should be paid slowly, based on the first few years' actual power bills.

Cost of the Program. About $10 M, estimated as follows.

An efficient new office building has a peak load of a few W/sq.-ft., and could easily save 2 W/sq.-ft. compared with a baseline of current building practice. Assume the proposed incentive of $1/Watt-saved. Then a 100,000 sq.-ft. building would save 200 kW, and receive an incentive payment of $200k, equally shared between the utility and DOE. The Federal cost is then $100M per substantial sized building, or $10M for 100 buildings.

Appendix III. New Information Programs to Make the Market Work Better and Faster

AIII.1. Evaluation and Testing of Energy-Conserving Concepts and Products

A. The Problem

Magazines are full of ads for energy-conserving devices, some of which are winners, many of which are lemons, and (in between) are others which can be winners or losers depending on the use to which they will be put.

One could require an efficiency label for the few devices with well-defined applications, like a refrigerator or gas furnace (and this point will be discussed below), but many new devices will have novel applications which do not lend themselves to simple test procedures. In these cases we need an impartial evaluation of laboratory performance.

A typical current example: LBL is interested in second generation residential gas furnace retrofits. There are available various stack dampers and heat exchangers which recuperate heat from the stack gases. They are not easy to compare: some preheat the combustion air, while another (the Heat Extractor) heats the indoor air. There are also available a number of "power burners" retrofit kits which can increase the furnace system efficiency by 30% for $400 installed. The effectiveness of each of these devices depends on the efficiency of the furnace to which they are attached, and on the home in which they operate, making them even harder to compare and rate them. We have asked PG&E for help, but our friends in their Gas Appliance laboratory don't know of any source of test data. As a result, we have jointly decided to test some of these devices. But once tested, PG&E will not publicize the results--utilities don't like to rank commercial products!

B. The Solution: Technical Part

The solution contains several parts which begin at the testing of the concept and eventually end with labels or other rating schemes that the consumer can directly use. Not all of these steps are the responsibility of DOE and, of those that are, not all should be done at national laboratories.

Step 1: Concept Testing

DOE should not get into the business of testing every product, but the underlying concept behind each <u>class</u> of products must be tested and evaluated both in the lab and in the field. Field testing will distinguish between, for example, furnace efficiency and overall heating system efficiency in a real house, with infiltration that increases when the furnace is on. Field testing will also begin to establish the useful life of the device, so that one can make respectable life-cycle cost calculations. This sort of testing is well suited to the national laboratories.

Step 2: Technology Transfer

Once the field measurements of the concept are complete, the information must be transferred to the professional societies such as ASHRAE or ASTM to be incorporated into standards and test methods.

Step 3: Product Testing

Once standard test methods have been decided, individual products can be tested. In general this should be done by private testing laboratories, but it may be necessary for DOE to do this for the first generation of a particular concept. Technical assistance from DOE could also be used to turn the test results into a label or fact sheet.

Step 4: Dissemination

The results of such testing must be stored in a public-domain database which can be consulted by governments, utilities, the media, and, of course, consumer.

Step 5: Incentives

To get the ball rolling DOE may wish to initiate an incentives program for purchasers to reward them for being guinea pigs. This program could be phased out once the market understanding of the product has stabilized.

The French AFME (Agence Francaise pour la Maitrise de l'Energie) already tests advertised devices. An engineer routinely scans ads and purchases samples for the appropriate testing laboratory. May more countries may do this. (I have written to Olivier de la Moriniere at AFME for details.) An interesting possibility is a joint French-U.S. concept-testing and dissemination program.

C. Discussion

This neglected problem is another example of the imbalance between incentives for supply and for investments in efficiency. Investors in wind farms are receiving tax credits long before wind turbines are cost effective, and accordingly the technology is being installed, debugged, and sorted out. As a counter example on the demand side, note that for years very cheap and cost-effective swimming pool covers sat virtually unnoticed because there was no program to compare them with expensive and less cost-effective solar collectors. Pool covers are now established, but a Federal Fact Sheet program could have advanced their acceptance by five years and saved millions of dollars (several hundred dollars annually per pool).

The concept of incentives for the first generation of purchasers of attractive devices is, of course, taken from the solar demonstration program. For a nice discussion of the value of information obtained from such an incentive program, see the paper by Berman and Fisher in advances in the Economics of Energy and Resources, 1980, Vol. III, p. 159.

D. More Labels for More Standard Devices

I return to a point made under Section A, "The Problem." I believe that a significant number of residential consumers like the basic appliance labels as applied to 13 basic appliances, and I feel that the labelling program should be extended to more residential appliances and many small commercial appliances. In the case of residential appliances, I suggest desk-top air filters (most of which are frauds and whose filtering action is very easy to measure) and unvented kerosene heaters. It is worth noting that a convective kerosene heater (convective heaters are the most polluting) needs a certain number of cubic feet per minute of fresh air to maintain safe indoor air quality. In Minnesota in January, this much air brings in enough cold to reduce the efficiency of the heater to roughly 50%. A radiative heater with the same thermal output, produced by the same manufacturer at the same price, requires only about a quarter as much fresh air and maintains an efficiency of 85%. Why can't we make this information available to consumers?

In the area of small commercial appliances, consider restaurant-sized refrigerators. At LBL, Brian O'Regan and Steve Greenberg estimate that commercial food service refrigeration units use about 11 billion kWh/year in the U.S., or the output of 2 power plants. There is an economic potential for about a 40% improvement, thus saving one-to-two billion dollars worth of power plants. Surely that's worth a labelling program. Other intriguing examples are water coolers. If they came with labels they would probably also come with clocks to turn them off nights and weekends. A third example are the refrigerators in the millions of soft-drink vending machines.

AIII.2. Most Economical Appliance Lists

The U.S. DOE provided lists of appliances ranked by energy efficiency (discontinued, I think, under President Reagan); but the most efficient is seldom if ever the most economical [see Goldstein and Rosenfeld, LBL 5910, Fig. 2b]. We believe that only Consumers Union identifies "Best Buys".

To advance the commercialization of economical appliances, DOE should provide alternative lists ranked by life-cycle cost. But two difficulties must be overcome.

1. Electricity prices vary greatly, so the DOE data should be "wholesaled" to utilities or states, with the "best buy" order tailored to their individual electricity costs. The utilities or states would then be the distributors.

2. Appliance prices vary day-to-day and store-to-store, so that a ranking based on manufacturers list prices would be only provisional. But the consumer can use it as a useful first move in a game of comparison shopping, and with phone calls to stores can quickly converge on the top few best buys.

Attached is a sample table to help the comparison shopper. This particular table uses just refrigerators in the January '83 Consumer's Union article, but we are suggesting a complete version. Our list is ordered by life-cycle cost (least cost first) based on list prices, so only the first page or so of even a long list will receive much attention.

Column A gives list price. CU gives a spread in list prices; we took the highest price listed for each brand--to play save. These are the data that must be gathered from the manufacturers, or if they fail to respond, through retail surveys.

Column B gives labelled annual kWh, obtained from DOE or AHAM lists.

Column C gives the "energy cost correction" compared to the tentative best buy on Line 1. This is simply the present value of 20 years of electricity savings (at BPA prices of 3¢/kWh in this example) between the model on line "n" ad the provisional Best Buy on Line 1. We have assumed that electricity price escalation offsets the real interest rate, but official escalation estimates could be used.

Column D, "Actual Price," is to be filled in by the consumer, based on phone calls and comparison shopping. We filled it in by hand with average prices quote by CU.

Column E, "Corrected Actual Price," is the Actual Price (Col. D) plus the break-even difference (Col. C). The Best Buy is, of course, the lowest price in Col. E. Note that in general the Best Buy will **not** be the original Line 1.

This approach gives the consumer a few good leads to start off with, but avoids tedious price collecting on poor buys. If the pamphlet is very successful, the local utility or state could refine the approach to give better leads to heavily discounted brands. For example, it could set up an 800 phone number and ask consumers and retailers to phone in information about attractive buys. These data could be displayed on cable T.V., "The Source," etc.

REFRIGERATOR LIFE-CYCLE COSTING GUIDE

(Data from Consumer Reports, January '83)

Model	A. List Price ($)	B. Annual Elec. Use (kWh)	C. Energy Cost Correction ($)	D. Actual Price ($)	E. Corrected Actual Price ($)	F. Your Least Cost Ranking
Frigidaire FPI-19TK	720	1092	0	643	643	(1)
Gibson RT19F9WM	800	1092	0	703	703	(3)
White-West. RT188E	739	1200	64	666	730	(4)
Kelvinator TMK 190SN	821	1092	0	678	678	(2)
Amana TSC-18E	999	960	-79	851	772	(5)
Wards 1982	720	1428	201	642	843	⋮
Hotpoint CTF19GBM	769	1380	172	654	826	
Magic Chef RB19.3A	724	1500	244	625	869	
Admiral NT-19B8	749	1464	223	628	851	
GE TBF-19ZBM	800	1380	172	701	873	
Sears 61921	800	1428	201	739	940	
Whirlpool EHT201VK	799	1524	259	682	941	

Columns D–F: Entered by Consumer

- Notes

Column C = Δ kWh/year(i.e., Row n - Row 1) x 3¢/kWh x 20 years
(3¢/kWh is appropriate for the B.P.A. service area.)

Column E = Column C + Column D

Appendix IV

The Case for an Integrated Appliance Program

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The Need:

We have been struggling for some months to propose some cost-effective configurations of integrated HVAC-and-appliances for low-energy houses. We have discovered that it is easy to find attractive combinations, but hard to actually optimize the many connections that come to mind.

As control microprocessors take over our world, we expect to see integrated HVAC-and-appliances spread slowly from office buildings to apartment buildings to homes. But we foresee many poorly optimized "pet" schemes marketed by unsophisticated enthusiasts.

To advance the development of efficient and profitable integrated utility stacks, we propose an industry/government collaboration to write a general-purpose computer model to simulate options and later to control actual hardware.

The Potential:

In a superinsulated house built in the Northern U.S. today, space heat costs less than hot water, which in turn costs less than electricity to run conventional appliances; i.e., the potential for improving efficiency has shifted to hot water and appliances.

We next show that there is a potential savings of 6000 kWh per year by combining appliances, equipment, and hot water.

Typical electric use in a superinsulated house is:

Heating	3000 kWh/yr
Hot Water	5000 kWh/yr
Clothes drying	1200 kWh/yr
Pools and spas	?

Heat recovery devices supplying hot water and improving the efficiency of clothes drying hold the major energy-saving potentials, at least 5600 kWh/yr, with greater potentials in houses with pools and spas. Air-conditioning energy usage can be reduced by 400 kWh/yr by whole-house fans, so that a total energy saving potential of 6000 kWh exists for combined appliances.

Savings on the first cost of equipment may also be possible in several ways. For example, if a heat pump is used for water heating, it may also be used to meet the relatively small additional space heat load. The cost of an air-to-air heat exchanger ($500-1000) may be largely avoided if the same heat pump is used to recover heat from an exhaust air stream and reinject it into the incoming air.

Finally, a peak load reduction of one kilowatt can be managed easily in a properly integrated system.

The Opportunity:

Realization that appliances interact in ways that can be used beneficially in an integrated system is not new; for example, useful heat for hot water has been obtained from air conditioners and refrigerators in a number of special cases. What is new is the cheap microprocessor, which makes it possible to program heat and load interchanges among variable combinations of appliances and a storage system. Program choices can depend on internal and external conditions, including demand patterns and programmed variations, in addition to such physical variables as temperatures. In particular, conventional appliances can be linked to more novel devices, like whole-house fans, evaporative coolers, ground water cooling coils, grey water, heat recuperators, and stoves which burn wood, coal, or refuse.

The Goals:

Before the necessary investments to produce real integrated appliances can be made, it is essential to develop a computer model that can accept system determinants such as different management strategies, user and weather variations, and energy costs and projections, together with simulations of device capabilities, costs, and lifetimes. It must evaluate the physical behavior and economics of any proposed system. Production of this model is the first goal.

The Tool:

The computer model must be a network program which permits the user to easily hook up and control many connections of active devices (furnace heat pumps, ventilators,...) and thermal storage devices (water, concrete, ground,...). It must be driven by building thermal loads for typical days in winter, spring, and summer, and typical water and appliance loads. Sensitivity to changing economic factors (such as time-of-day residential metering) should be easily determined. The program should serve as a design and verification tool both for system analysis and for component designers. The TRNSYS program for the transient analysis of active solar systems may be a good starting place.

A two-purpose computer language should be developed which will run both the computer model and the eventual control microprocessor for prototype hardware and the final commercial product. This efficiently integrates system design and later model validation.

The Participants:

Cooperation across the spectrum of interested parties will be required for the program goals to be met. LBL, with its expert areas in programming (DOE.2), building research and data, and indoor air quality, holds a major key--as does ORNL, with its history of appliance and HVAC responsibilities. Since ORNL has contracted significant work with A. D. Little, that firm's expertise should be drawn on, as well as that of

EPRI and GRI. Interested manufacturers (e.g., Amana, Carrier) and industry groups (NAHB, AHAM, and manufactured homes associations) must also be given full opportunity to interact at every stage of development to keep the program viable from the point of view of the ultimate program user.

An International Collaboration?

LBL already has tight collaborations with Paris and Lund (Paris metrified DOE.2). We should consider the possibility of an international collaboration to write the integrated appliance program, drawing on experience in the U.S., Europe, and perhaps Japan.

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