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AUTHOR Tiedeman, Thomas V.
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ABSTRACT

This manual was developed to provide assistance to public officials first considering energy conservation in existing public buildings. The manual focuses on management decisions which must be made in implementing energy conservation programs for existing buildings. It provides assistance in developing a plan of attack, establishing schedules, selecting buildings, creating preliminary energy savings estimates, developing engineering work statements, evaluating consultants, estimating fees, and rough estimating of construction costs. An initial assumption is made that many jurisdictions already have begun low-cost conservation measures such as lowering thermostat settings, night temperature set backs, de-lamping and closing off unused spaces. Attention, therefore, is directed toward additional steps often requiring some capital expenditure that can be taken to gain further substantial energy savings. Retrofit for energy conservation in existing buildings, as addressed in this manual, should be applicable to many state, county and local governments and special purpose districts. Experience has proven that energy can be saved and energy costs reduced significantly by concentrating on modifications to building use patterns, operating procedures and design aspects. These savings can occur without sacrificing occupant comfort or important functions to be performed within the facility. (Author/BB)

ENERGY CONSERVATION RETROFIT FOR EXISTING PUBLIC AND INSTITUTIONAL FACILITIES

National Science Foundation
RANN-Research Applied to National Needs

PUBLIC TECHNOLOGY, INC., WASHINGTON, D. C. AND PASADENA, CA.

Public Technology, Inc. is a non-profit, tax-exempt, public interest organization established in December 1971 as an institutional mechanism for applying available technologies to the problems of state and local governments. Sources of such technologies include federal agencies, private industries, universities, and state and local jurisdictions themselves. PTI works in both the hardware and software fields.

PTI works on specific problems that have been defined and given a high priority by state and local government officials. A problem also must be common to many units of government throughout the nation, and one that is susceptible to technological solution. In this way two major organizational goals are realized: (1) costs and benefits of large-scale undertakings are shared; and (2) private sector, Federal agency and foundation investment in the solution of public sector problems is encouraged by the aggregation of specific markets at the state and local levels of government.

The technology application process consists of these steps: problem definition; location of applicable technology; development of new or improved products or systems; appropriate packaging of the technology for state and local governments; and help in adapting and implementing the technology at the operating level. Emphasis is placed on transfer and subsequent utilization of the technology by the largest possible number of jurisdictions. On-site assistance is provided, upon request, to make certain that state and local jurisdictions fully utilize the technology.

PTI was originally organized by the officers of the Council of State Governments, International City Management Association, National Association of Counties, National Governors' Association, National League of Cities, and U.S. Conference of Mayors.

AN ENERGY CONSERVATION RETROFIT PROCESS FOR EXISTING PUBLIC AND INSTITUTIONAL FACILITIES

Prepared for

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Public Technology, Incorporated
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As one of the first local governments to develop a serious commitment to energy conservation in existing buildings, West Hartford has provided a test site for the energy conservation retrofit process described in this manual. We are glad that these demonstration efforts will lead to significant energy savings for Massachusetts and West Hartford and also have provided a base of knowledge that other state and local government jurisdictions can utilize in their own retrofit efforts.

The Energy Systems Division of the Grumman Corporation is another group to which we owe special appreciation. Working as a partner with PTI, Grumman provided many insights into the technical concerns of energy conservation in existing buildings. Grumman demonstrated in Massachusetts, West Hartford, with facilities of the National Aeronautics and Space Administration, and within its own buildings that the retrofit process described in this manual is workable, reliable, and effective.

We are indebted to the many people who gave freely of their own time to review draft copies of this manual and provided suggestions for refinement. Throughout our review process we have been impressed with the objectivity, thoroughness and insight of comments received. We are most grateful for comments received from state and local governments which have implemented retrofit projects and from jurisdictions using draft copies of the manual to aid their consideration of new retrofit efforts. Individuals from two cities in particular, based their revision on successful use of the draft manual to initiate retrofit programs in their cities. These individuals are Robert Flade (Durham, North Carolina) and Andrew Hirsch (Rochester, New York).

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Griffith C. Burr, P.E., Office of Griffith C. Burr, Inc.

James M. Childress, American Consulting Engineers Council

William J. Collins, Jr., P.E., Collins Soter Engineers, Inc.

Fred S. Dubin, P.E., Dubin-Bloome Associates, P.C.

John P. Eberhard, AIA, AIA Research Corporation

Herbert Epstein, FAIA, Epstein, Greenfield Architects, P.C.

J. Michael Haggans, AIA Research Corporation

David Johnston, Associated General Contractors of America

Jack McKee, National Society of Professional Engineers

Clifford S. Nakata, AIA, Clifford S. Nakata and Associates, P.C.

Joseph Newman, Tishman Research Corporation

David L. Perkins, FAIA, Perkins, Guidry, Young Architects

Campbell Reed, Associated General Contractors of America

Lawrence G. Spielvogel, P.E., Lawrence G. Spielvogel, Inc.

Michael Sizemore, AIA, Sizemore and Associates

Douglas S. Stenhouse, AIA, AIP, Energy Management Consultants, Inc.

Ish Sud, Ph.D., P.E., Center for the Study of Energy Conservation, Duke University

Rolland M. Wilkening, Barton-Malow Company

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Thomas V. Tiedeman was the principal author of this document. William Mascenik conducted PTI's demonstration efforts with the Commonwealth of Massachusetts, providing much of the information upon which this manual is based. Robert N. Sockwell, AIA, contributed especially in the areas of energy consumption studies and documentation of retrofit experience.

INTRODUCTION

An Energy Conservation Retrofit Process for Public and Institutional Facilities was developed by Public Technology, Inc. to provide assistance to public officials first considering energy conservation in existing public buildings. The manual focuses on management decisions which must be made in implementing energy conservation programs for existing buildings. It provides assistance in developing a plan of attack, establishing schedules, selecting buildings, creating preliminary energy savings estimates, developing engineering work statements, evaluating consultants, estimating fees, and rough estimating of construction costs. Details for conducting necessary engineering analysis are not covered in this manual, this being a subject unto itself treated within a large body of existing literature and practice. In short, this is a manager's manual for retrofit start-up.

An initial assumption is made that many jurisdictions already have begun low-cost conservation measures such as lowering thermostat settings, night temperature set backs, de-lamping and closing off unused spaces. Attention, therefore, is directed toward additional steps (i.e., retrofit) often requiring some capital expenditure that can be taken to gain further substantial energy savings.

The manual's basic goal is to aid in planning and administering an energy conservation program with emphasis on fast-payback conservation options. This document stems from experience gained by PTI in assisting jurisdictions with energy conservation programs; and the experience of others in state and local governments, private industry and the federal government in pursuing savings through retrofit.

Retrofit for energy conservation in existing buildings, as addressed in this manual, should be applicable to many state, county and local governments and special purpose districts. Experience has proven that energy can be saved and energy costs reduced significantly by concentrating on modifications to building use patterns, operating procedures and design aspects. These savings can occur without sacrificing occupant comfort or important functions to be performed within the facility.

Generally speaking, greater expenditures for energy conservation will yield greater energy savings. Much variation, however, exists among even similar facilities because of climate, design, siting, building usage, and conservation measures already initiated. The key for each jurisdiction conserving energy is to select facilities where the greatest savings can be achieved, and to gain the most long term good from retrofit funds which are available.

As an overall estimate the Federal Energy Administration notes that a building owner may expect to save 10%-20% in energy use without any initial cost, another 10% with minimal first costs, and 10%-20% more with an investment which can be paid back by savings in three to ten years. Case studies identified by PTI tend to agree with these estimates.

Figure 1 is a concise representation of PTI's case study results described later in detail. It shows that regardless of the funds available for retrofit, viable options for energy conservation retrofit are likely to exist. This holds equally well for jurisdictions which can only spend $.10 per square foot and others which can spend perhaps $.80 per square foot of building space.

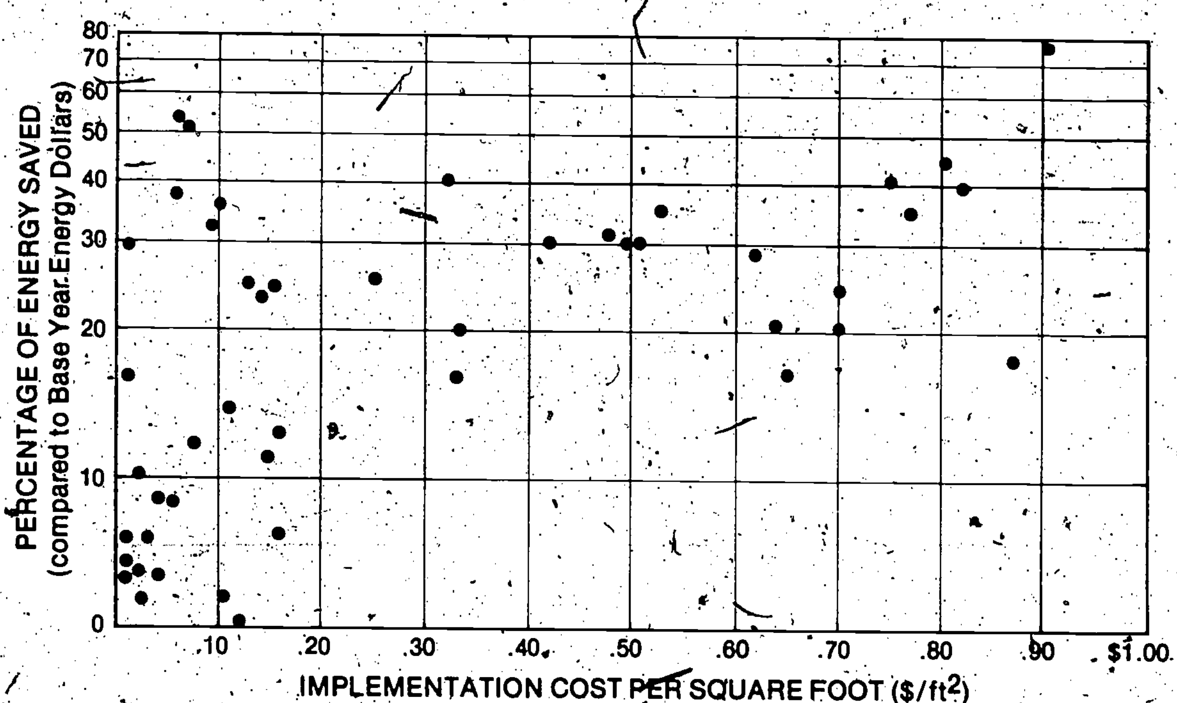


Figure 1
Savings Versus Retrofit Costs For Recent Projects
(See Figures 15 and 16 beginning on page 00 for greater detail)

An energy conservation retrofit process for public and institutional facilities stresses three areas:

Planning a phased program for achieving retrofit.

Conducting energy consumption studies to select the most promising facilities for achieving energy savings through retrofit modification.

Initiating and managing a detailed engineering and architectural study of potential conservation measures.

<u>An Energy Conservation Retrofit Process for Existing Public and Institutional Facilities</u> has resulted from initiatives of Public Technology, Inc., beginning in 1973. At that time PTI developed several conclusions about the future of the energy problem relating to buildings which still appear to be valid.

Energy price increases, fuel shortages, and fluctuations in relative costs for alternative fuels will continue to exist in the foreseeable future.

The real conservation problem will center on existing, rather than on new buildings. Most buildings that will be standing in the year 2000 have already been built.

"Quick-fixes" and public awareness can help advance energy conservation, but in the long-run, redesign and modification of building energy systems will be a real necessity.

New energy sources--solar, geothermal, advanced nuclear, coal gasification, coal liquefaction, and other technologies--will not be in widespread use soon in public buildings. Some may prove useful in only limited sections of the country.

These conclusions led to a decision on the part of PTI to develop methods for assisting state and local governments in achieving significant energy conservation in existing public buildings, especially through mechanical and electrical systems modification, revised building operating procedures and adjustment of functions and use patterns of building occupants.

As a result of this decision, two efforts were begun simultaneously. The first focused on developing a strategy to assist jurisdictions in achieving rapid short-term reductions in fuel expenditures, mainly through modifications of their operating procedures and building use patterns. The second strategy was to provide managers with the information needed to make rational decisions with regard to capital expenditures to modify the design and operation of buildings for long-term energy conservation without serious reductions in occupant or employee functions. The latter strategy is represented by this manual.

The first conservation strategy was aimed at providing "quick-fix" energy conservation measures. It derived from a PTI program already underway to assemble information on innovative responses to the energy problem. In conjunction with the International City Management Association, PTI published Local Government Approaches to Energy Conservation, suggesting a number of areas in which local governments can save energy.

In 1975 PTI published a handbook, Energy Conservation: A Technical Guide for State and Local Governments, consisting of fundamentals for organizing and implementing an overall energy conservation program at the state and local levels of government with emphasis on "quick-fix" options. PTI also conducted energy conservation workshops around the country for state and local government officials. Several other documents suggesting "quick-fix" energy conservation measures are now available. Appendix 1 of this document summarizes some of the major elements of a "quick-fix" program.

The second strategy--energy retrofit--was seen as a long-term but potentially more important energy conservation activity than immediate savings gained through "quick-fixes". Once a phased professional approach to retrofit was defined, the next step was to find an innovative organization which shared this view and one whose applications of technology made it possible to achieve the goal of long-term energy conservation that would result in permanent long-term cost savings. In 1973, before many design firms entered the retrofit market, a national search was conducted with the final conclusion that the Energy Systems Division of the Grumman Corporation utilized a phased methodology that, when applied, would result in significant energy savings in public buildings, with payback options identified. Working with Grumman, PTI was able to gain first hand experience on several retrofit projects for public buildings.

The building energy retrofit process described here is divided into four distinct work phases and has been employed in the same basic form on numerous retrofit projects:

Phase I:	Review of current energy consumption and selection of the most promising facilities for retrofit.
Phase II:	Detailed engineering and architectural study of potential energy conservation modifications for selected facilities. Prioritization of options in terms of energy savings and payback.
Phase III:	Implementation of desirable retrofit changes.
Phase IV:	Monitoring of energy savings achieved and aggressive follow-up maintenance programs.

Certain owners making alterations for energy conservation have combined two or more of these steps into a single work phase in their retrofit programs; PTI, however, suggests keeping the four phases distinct. The main reason is to provide a mechanism for management control of the effort, especially to assure that costs for retrofit work stay in line with energy savings benefits.

Special emphasis in the retrofit process is directed toward a detailed engineering and architectural analysis of a wide range of available energy conservation options for each facility. Because energy usage for equipment within buildings is highly interrelated, changes in any major component within the facility can affect the operation of all other components. The energy use of the facility as a whole can only be understood accurately after a thorough analysis is conducted.

This is an important fact for the administration. Only after a thorough analytical study of the entire facility and its operation as an energy consuming system will the administrator have the assurance that the best set of retrofit modifications with the highest payback has been selected. Installation of double glazing is a good example. While it is intuitively obvious that double glazing can cut energy losses, it may not be as obvious that in some cases the payback period may be well over ten years. Less obvious conservation measures may provide a much better return. Automatic shutoff devices for lighting systems, as an example, may appear at first glance to be an expensive way to perform a very simple task. Surprisingly, in several instances these control devices have paid for themselves in less than a year.

An energy retrofit effort may be conducted independently, or better still, in combination with other repair and alteration efforts. It is safe to assume that energy conservation measures should be considered and included whenever a building is remodeled or expanded:

To accommodate required functional use changes

To replace inoperative or obsolete equipment

To serve a completely new function

When deteriorated building components require replacement for safety or code compliance.

State and local governments or other public institutions making major alterations to facilities normally must follow building code requirements for safety and health. It is worth noting that recently developed model building code requirements for energy conservation applying to new buildings are likely to be adopted in many states and localities. These codes may be imposed on existing buildings where such a code is in effect and if the intended facility modifications involve major space additions or changes in occupancy type. Most new codes and standards for energy conservation in buildings are intended as minimum requirements, and are not based on the specific economics of optimal energy saving in individual buildings.

Many somewhat interrelated approaches can be pursued to deal with energy problems in existing buildings. Several appear below:

Life Cycle Costing - An analytic technique involving study of all costs of owning and operating a facility including initial costs and energy costs, over its remaining lifetime.

Peak Load Reduction - Concentrates on reducing energy use from public utilities during peak demand periods. Peak load reduction does not necessarily reduce total energy usage. Usage may only be shifted in the time when it occurs. By reducing peak load, however, it may be possible to qualify for more desirable utility rates. Peak load reduction programs in the long run may save utilities the need to maintain huge reserve capacities for power supply.

Use of Alternative Fuels - Because of possible fuel curtailments, or because of fluctuating fuel rates, many building owners have developed a capability to shift as necessary from one fuel to another. While not necessarily saving energy, this capacity may help to save on energy bills and can be extremely important during fuel shortages.

Solar Heating and Cooling - Existing facilities may be retrofitted with solar systems to cut use of non-renewable fossil fuels. Often solar retrofit will be initiated in conjunction with other energy conservation measures aimed primarily at total energy use reduction such as suggested in this manual.

This manual on retrofit is interrelated with several of the concepts above. By emphasizing short-term payback it is a limited application of Life Cycle Costing. The architectural and engineering analysis suggested in this document includes consideration of peak load reduction and use of alternative fuels among other retrofit modification possibilities. Solar heating and cooling, however, is not addressed specifically in this manual. Owners interested in solar applications will find a significant body of information developing on this topic.

The decision to concentrate on fast payback retrofit programs (approximately one to seven years) reflects the belief of Public Technology, Inc. that the majority of state and local government building owners will find this to be the most practical energy conservation approach at this time. Following success with near-term payback efforts, jurisdictions are likely to reevaluate their buildings as energy situations change, and also may gain the confidence necessary to pursue options with relatively long-term paybacks.

Energy conservation in existing public facilities is of paramount national importance: to save energy; to reduce the strain of energy consumption costs on state and local government budgets; and to stimulate energy conservation in residential and private sector facilities. Preliminary estimates by Public Technology, Inc., indicate that several billion square feet of facility space is occupied by state and local governments resulting in billions of dollars each year in energy costs. Since all indications point to continuing escalation of energy costs for the foreseeable future, Public Technology, Inc. hopes that An Energy Conservation Retrofit Process for Existing Public and Institutional Facilities can assist jurisdictions in this important area.

A PHASED MANAGEMENT APPROACH TO ENERGY CONSERVATION IN EXISTING BUILDINGS

Most existing buildings of states, counties, local governments and special purpose districts were designed and constructed during an era of abundant and inexpensive energy. Initial costs for buildings and their component systems loomed higher in decision making than did the costs of energy or concern over limited fuel supplies. As a result, energy conservation generally was not an important feature of their design.

Huge escalations in energy prices and the reality of fuel shortages now make it economically desirable to redesign, modify and, in general, to retrofit buildings, their operations and their usage to save as much energy as is practical. Practical savings, not maximum savings, is the key concept which applies in a voluntary energy conservation program.

Many available technical and non-technical options with varying degrees of effectiveness can save energy in buildings. Some modifications can be achieved with little or no cost. Other conservation options can be expensive. Still others may unfavorably sacrifice occupant comfort or functional use of the building.

Faced with this wide range of possibilities--and also confronted with limited financial resources--a government administrator is well advised to first call for a detailed study of many alternatives and then to implement the options which will save the most energy in the shortest time within existing financial constraints. Frequently, only options with the shortest payback period can be afforded in the near future.

A distinction can be made between achieving energy conservation in new buildings and retrofit of existing buildings. With new buildings it may be desirable to make energy related design decisions on the basis of long-term payback identified by Life Cycle Costing techniques--an analytic method involving consideration of not just initial costs, but all costs, including energy, of owning and operating a building over its expected lifetime. Life Cycle Cost analysis often will demonstrate that building systems with incrementally higher initial costs will pay for themselves over the life of a building through better performance and less required maintenance.

As a practical matter, several state and local government jurisdictions successfully employ life cycle payback in considering new building design. Of the retrofit case studies identified by PTI, however, few jurisdictions chose to conduct retrofit programs on the basis of life cycle payback. Most selected a shorter payback period than the remaining life of a building--often between one and seven years. The exceptions to this involved buildings with short remaining lifetimes, and buildings in which major systems were due for replacement anyway.

Basic Approach

In seeking to maximize the impact of a limited financial commitment toward energy conservation in existing buildings, a basic plan of attack similar to that which follows can be set:

The energy usage of all buildings is monitored periodically (e.g., monthly). A study of energy use is conducted for each building.

Energy conservation options with little or no initial cost, such as suggested in Appendix 1, are implemented in all buildings. These low cost options often will be identified as part of the initial energy use study.

The most inefficient energy consuming buildings receive a thorough architectural and engineering study to analyze conservation alternatives.

The jurisdiction establishes a reasonable payback period goal for retrofit modifications. Retrofit options which meet the payback criteria are prioritized and implemented in the buildings that are least efficient in energy consumption. Implementation decisions finally must be based on the amount of money available.

In succeeding years as funds become available the jurisdiction moves on to other wasteful facilities. Over, perhaps, a three to five year period all wasteful facilities can be retrofitted. Buildings are reevaluated as energy cost and supply conditions change.

Energy Consumption Study	Identify and quantify the problem of energy inefficiency Gain support of local officials and citizens Establish accountability for energy use Select buildings to be retrofitted Establish payback goal
Detailed Engineering Analysis	Assign in-house staff or selected consultant under contract Site-survey and review of plans Detailed analysis of a wide range of possible modifications Prioritize options Develop implementation cost and savings projections Present recommendations and gain management approval
Implementation	Prepare necessary plans and specifications Let construction contracts Modify operating procedures
Monitoring	Establish monitoring procedures Review modified building systems Assure that buildings are performing up to expectations Provide continued attention on maintaining energy savings.

Figure 2
A Four Phase Approach for Energy Retrofit of Existing Buildings

Here the overriding strategy is simple. Save as much energy as possible with the least capital outlay. Demonstrate that energy conservation makes good economic sense. Then, build a case showing that energy conservation is worth pursuing further, gaining support from the community and elected officials. Push retrofit forward until a point of diminishing returns is encountered. Respond to changing energy conditions and facility needs.

Phased Management Process

With this basic strategy established, the next problem to be addressed is the actual management and operation of the retrofit program in a logical fashion. The management process recommended below is divided into four work phases. The separation is for a simple reason: it allows the public sector building owner to control the retrofit process and to keep the time and capital spent for achieving energy savings in line with the scale and certainty of the expected savings. One important aspect of the process is to assure that costly building modifications will not be made until management is convinced that the most productive set of building and operation modifications have been selected. Another is to assure that the time period during which energy savings pay back retrofit costs will be satisfactory.

The four phases of the retrofit process as discussed below are shown diagramatically in Figure 2. When first considering the potential for energy conservation in existing buildings, most state and local governments and special district agencies will support energy conservation in principle. But it is much too early to make large scale financial commitments because costs and benefits have not yet been clearly defined.

The Phase I - Energy Consumption Study is an inexpensive and fairly rapid procedure to develop priorities for action and rough estimates of potential results. At the end of Phase I, without having spent much money, a jurisdiction can determine whether energy conservation in specific existing buildings should be pressed further.

Phase I may identify a number of low cost energy saving approaches which can be implemented and begin to pay for the costs of other retrofit work, especially if savings can be directed to a retrofit budget account. In the Engineering Analysis of Phase II, the jurisdiction, with in-house engineering and architectural staff or a competent consultant, ventures a relatively small outlay of time and funds to determine the basic modifications that should be made, estimated energy savings, and estimated retrofit costs for buildings that have been selected.

At the end of Phase II, if construction monies are not available or if payback periods will not be acceptable, the jurisdiction can stop work until conditions change. Note the low cost options identified in Phase II may be implemented even if construction funds are tight.

When the jurisdiction continues on with Phase III, Implementation, it is assured within the limits of reliable and conservative engineering estimates that energy savings will result, and knows in advance approximately what the savings will cost to achieve. The monitoring activities of Phase IV are an inexpensive means to document program results and assure that the expected savings are being realized. Monitoring also provides accountability for energy use and keeps a spotlight centered on the continuing effectiveness of conservation efforts. This is shown in Figure 3.

PHASE	RELIABILITY OF ESTIMATES	FINANCIAL COMMITMENT
I Study of Current Energy Consumption	Rough	Very Low
II Engineering Analysis	Reliable Conservative Estimates	Moderate
III Implementation	Precise Calculations	Significant
IV Monitoring	Actual Results	Minimal

Figure 3
Accuracy in Estimating Procedures Compared to Commitment of Resources Through the Retrofit Process

Phase	Activities
PHASE I Energy Use Analysis	Energy use study of town and school buildings Presentation of consumption results to elected officials, Citizens Energy Committee and administrative personnel Citizens Energy Committee evaluates feasibility of conservation program and, if positive, drafts resolution to the Town Council requesting the administration to proceed in preparing a program definition Town Council adopts resolution Administration prepares program definition to Citizens Energy Committee for review and recommendations
PHASE II Engineering Analysis	Administration reviews proposals, hosts interviews and recommends consultant to Citizens Energy Committee Citizens Energy Committee reviews consultant selection, and if positive, drafts resolution to the Town Council requesting funds for the consultant survey phase of the project Town Council adopts resolution and appropriates funds Administration signs contract for survey and engineering analysis phase of the project
	Consultant conducts energy conservation survey and engineering analysis, then presents conclusions and recommendations to Citizens Energy Committee and the administration
	Administration, in conjunction with the Citizens Energy Committee, prepares a definitive plan for implementation Citizens Energy Committee drafts resolution to the Town Council requesting funds for consultant implementation services Town Council adopts resolution
PHASE III Implementation	Administration signs contract for consultant implementation services Consultant prepares project plans, specifications and estimates
	Administration accepts bids and selects contractor to perform necessary modifications Administration drafts resolution to Town Council requesting funds to implement consultant recommendations
	Town Council adopts resolution Contractor, with consultant overview, completes modifications
PHASE IV Performance Monitoring	Administration and Consultant monitor energy usage to verify energy conservation, maintain program awareness, and identify new objectives and opportunities.

Figure 4
Energy Retrofit Program Flow of Activities
West Hartford, Connecticut

Figure 4 illustrates one retrofit process as it was successfully applied in West Hartford, Connecticut. As a New England town with a high degree of citizen participation, West Hartford chose to utilize extensive citizen involvement in retrofit decisions. Other jurisdictions will need to modify details of this process--especially time estimates required for each phase and precise decision making patterns--but the West Hartford process can be used as a point of departure and is a representative of public sector building retrofit efforts. It should be noted that after West Hartford completed retrofit on its first group of buildings, it began a follow-on program for remaining buildings.

Each jurisdiction establishing a retrofit project must consider questions regarding delegation of tasks to either in-house staff or outside consultants and possible combination of work phases. Phase I may be performed either by in-house staff or an outside professional. If funds are tight, then the initial energy consumption review is probably best performed in-house. If great detail or extensive technical judgement is desired in Phase I, or if staff time is difficult to make available, perhaps an experienced outside consultant should be commissioned.

Phase II engineering analysis probably will be performed by an experienced outside architectural and engineering group unless a strong in-house engineering staff is available. If an outside group is utilized, then it may or may not be the same firm which conducted Phase I consumption studies. The Phase I firm already will have developed a working knowledge of the jurisdiction's facilities, but the jurisdiction still must determine if that firm is the best one available for the detailed studies of Phase II.

Similarly, an argument can be made that the engineering group conducting Phase II studies should perform final design development during Phase III. This may be advantageous since the firm already would be familiar with the design and operation of the jurisdiction's buildings. One situation where a jurisdiction may select a different firm would occur if the jurisdiction selected a firm for Phase II engineering from outside its boundaries. In this case the jurisdiction may find that a local design firm might be selected for Phase III detailed drawings and specifications because of its more intimate knowledge of local codes, material rates, labor conditions, and other factors.

If an outside consultant is enlisted for more than one phase of the retrofit process it may be desirable to commission the work in stages. This in no way prevents a single firm from providing continuing services through the retrofit process. It will make it easier, though, to terminate services if work is less than satisfactory and makes it easier to deal with delays in project funding.

At least one jurisdiction believes that a staged program for commissioning consultants leads to highly objective work by consultants and best results for the city.

Two variations in use of outside consultants deserve mention at this point. The first involves services donated by local design professionals or public spirited firms willing to contribute services to the community, especially to prove to the jurisdiction on a demonstration facility that retrofit is feasible and practical. The second variation on consulting services is to obtain assistance from nearby colleges or universities. Several jurisdictions, sometimes with assistance from their state energy offices, have developed agreements with engineering or architectural departments of nearby institutions. Several jurisdictions highly recommend this approach.

Developing a Multi-Year Program

The phased management process outlined above applies directly to retrofit of a single building or to a number of facilities processed together as a group (i.e. - an initial energy consumption study is first performed for all buildings in the group, then all receive an engineering study, then all are retrofitted and monitored as a group). Jurisdictions with a sizeable number of buildings, however, may want to modify this batch processing approach because of financial and manpower constraints. Few jurisdictions, for example, as indicated earlier, are likely to want retrofit construction costs for all buildings to occur in a single year. Similarly, the jurisdiction may want to cut peaks in manpower loading by spreading the work over a period of several years. This can be achieved by having a certain amount of auditing, engineering analysis, and implementation occurring simultaneously.

Figure 5 is a schematic representation of a multi-year retrofit program. Note that in this example existing buildings were divided into three groups (A, B, C). The first group in most cases will be the largest and least energy efficient buildings. All buildings are first audited for energy use. Then as money and manpower become available each group of buildings receives an engineering study, low cost modifications are initiated immediately, then the remaining retrofit modifications are implemented. In this sample plan, detailed monitoring continues for a one year period following implementation.

Figure 6 represents the accumulated cost impact of the sample multi-year program. In this example the largest cost impact falls in the first year of the retrofit program. Extending the duration of the effort would lower costs occurring in any one year.

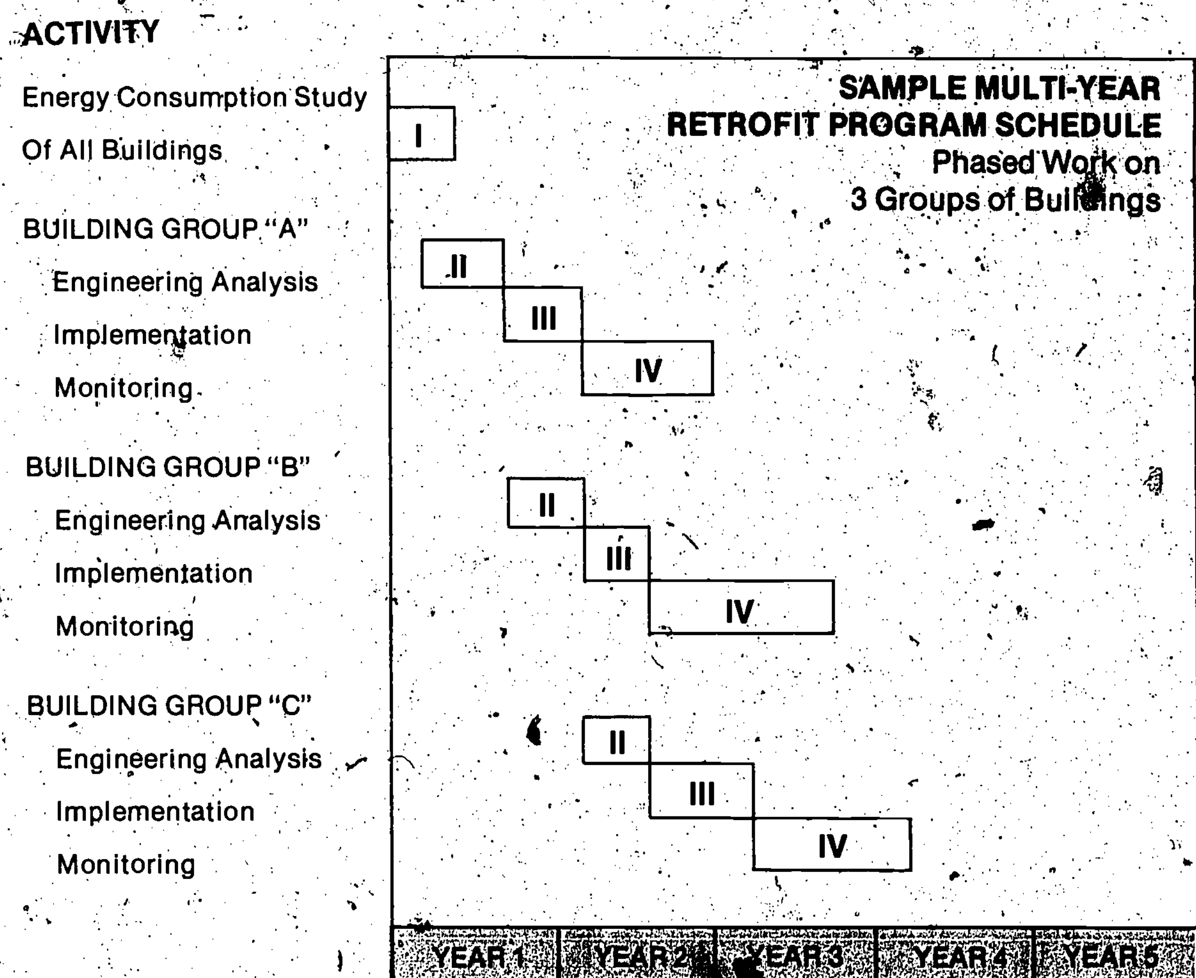


Figure 5
Sample Multi-Year Retrofit Program Schedule

SAMPLE MULTI-YEAR RETROFIT PROGRAM:
Total Accumulated Expenses for Retrofit for Three Groups of Buildings (A,B,C)

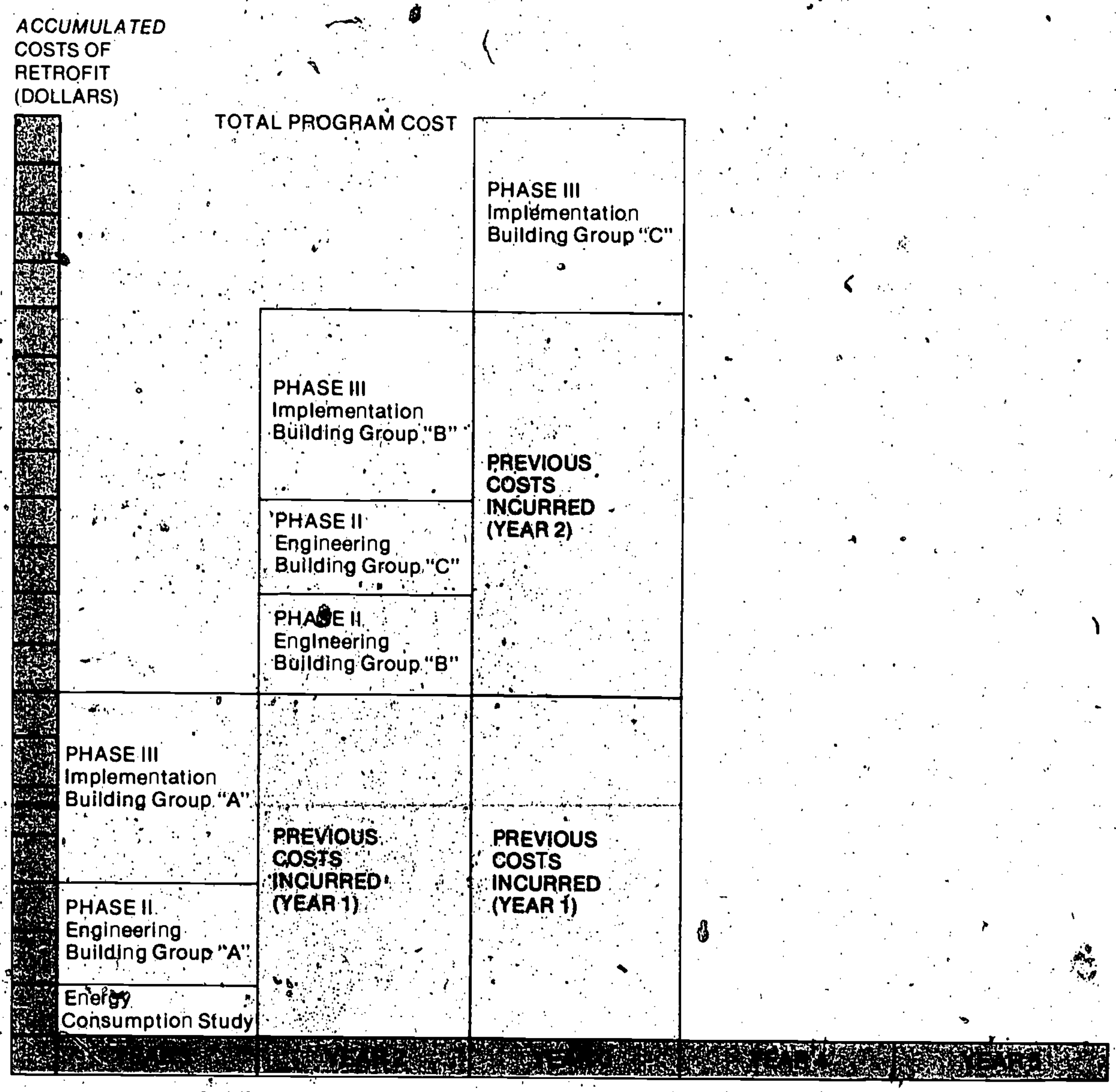


Figure 6
Total Expenses Over Time for a Multi-Year Retrofit Program

Figure 7 applies to the same multi-year program example and represents accumulated energy savings from the start of the program. Some savings occur immediately from implementation of low cost options. Growth in rate of savings accumulation depends on how much retrofit has been implemented.

Net-savings-to-date for the example program is shown on Figure 8. This plot of accumulated savings minus accumulated retrofit costs over a period of time is helpful for planning the duration of a retrofit program. In essence, this chart shows management how much front end investment is required to gain a given amount of energy savings within a given time period.

In developing an overall retrofit plan spanning several years, the manager begins with very rough assumptions and estimates which later are replaced with more accurate data as it becomes available. The estimating data in Figure 9 is provided to assist the manager with initial rough estimates of the basic scope of retrofit capital costs, manpower requirements and savings. These estimates are based on past experience. The data is rough and should be used with care.

Once the jurisdiction estimates how much capital (or bond financing) it can expend each year to achieve retrofit, the estimates of Figure 9 may be useful in calculating the square footage of space that can be retrofitted each year. Resultant annual energy savings and energy cost savings can then be derived, again, using estimates from Figure 9. Finally, management can project accumulated energy retrofit costs and savings for a multi-year program such as in Figures 6, 7 and 8. Through each step in the retrofit process the jurisdiction can refine these planning charts by substituting improved estimating data based on its own experience.

Several reviewers of this document have stressed the desirability of partially financing retrofit work through energy savings achieved by earlier retrofit efforts. Among other things, this approach demonstrates to citizens that the retrofit program is designed to save public money as well as to save energy. For this approach to be workable, energy savings occurring on paper should be set aside on a separate budget line, and not simply returned to the general treasury.

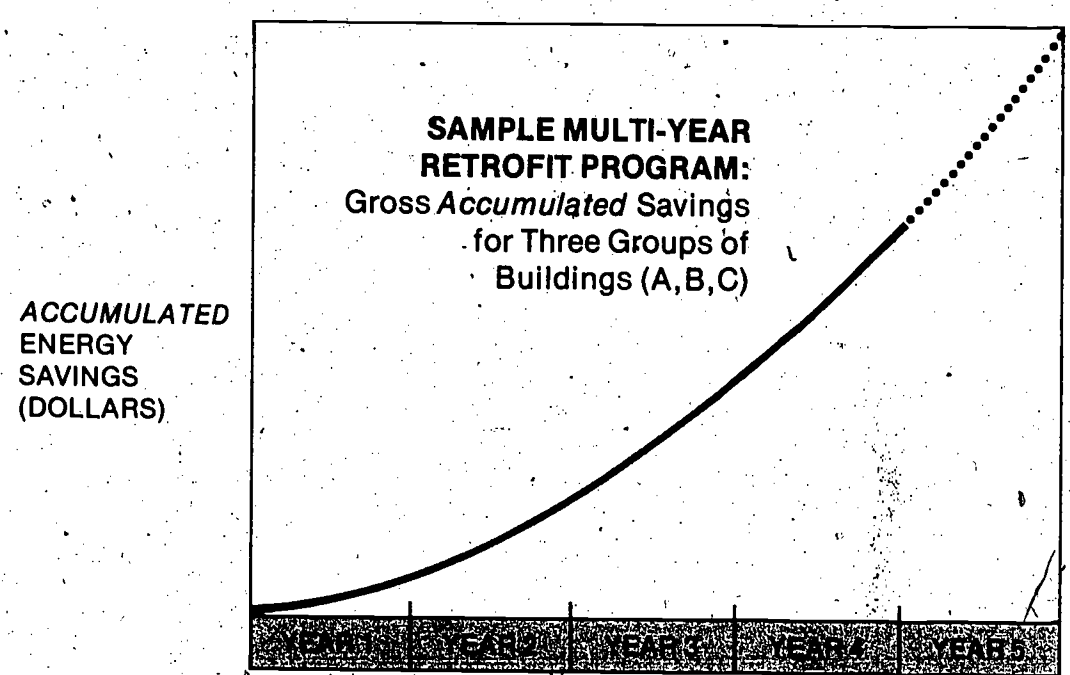


Figure 7
Gross Savings Over Time
Multi-Year Retrofit Program

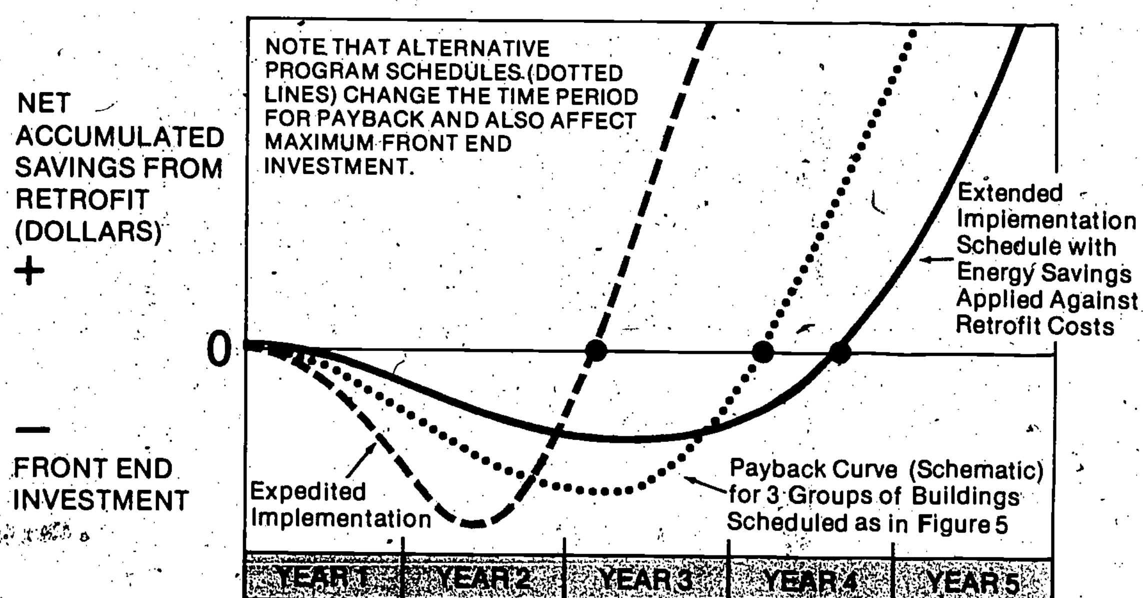


Figure 8
Net Savings Over Time for Sample Multi-Year Retrofit Program (Accumulated Savings Minus Accumulated Expenses)

Figure 9

SAMPLE GUIDELINES FOR ESTIMATING POTENTIAL COSTS AND SAVINGS OF AN ENERGY RETROFIT PROGRAM
(See Figure 15, page 46 for examples of recent retrofit)

1 Cost for Performing Initial Energy Consumption Study and Spotting No Cost Conservation Approaches (Phase I)

a Buildings under 15,000 square feet: 1 man day for an engineer

b Buildings of 100,000 square feet: estimate 3 man days for an engineer

2 Cost for Phase II Engineering Survey and Analysis

a Estimate costs beginning at about $.07 per square foot of space for a thorough engineering analysis. Costs from $0.10 to $0.15 have occurred in several instances. Fees should be based, however, on accurate manpower requirements, not arbitrarily. The engineering fee estimate here is subject to much variation. Several jurisdictions have performed in-house engineering at very low cost. This estimate tends to reflect the higher range of fees required for a very detailed study. Fees are affected by the number and complexity of buildings being studied.

3 Cost for Construction and Implementation in Phase III

a Estimate $0.30 to $0.80 per square foot for 3-4 year payback* goal, or

b Estimate $1.00 per square foot for 6 year payback goal

4 Estimate of Current Energy Costs (if data is not available) Estimate between $0.60 and $1.00 per square foot

(More)

(Figure 9 continued)

5 Estimate of Potential Annual Energy Savings (FEA Estimates)

a 10% to 20% savings with little or no investment (no retrofit)

b 10% or more with minimal initial cost (limited retrofit - "quick-fix")

c Still another 10% to 20% more with payback of 3 to 10 years (retrofit)

d Savings depend on many factors including how much energy conservation work has already been done.

*Construction cost estimates were derived as follows:

a (10% savings) x ($1 per square foot/year) x (3 years for payback) = $0.30 per square foot.

b (20% savings) x ($1 per square foot/year) x (4 years for payback) = $0.80 per square foot.

c Case studies as shown in Figure 15 tend to support these rough approximations.

STUDY OF CURRENT ENERGY CONSUMPTION
(Phase I)

In beginning an energy conservation retrofit program, these basic steps must be taken: 1) top management places priority on saving energy; 2) accountability for energy use among agency departments and building supervisors is established; 3) the practicality of retrofit is shown by means of a study of current energy use; and 4) funds are committed for further retrofit analysis. The discussion below concentrates on alternative means to conduct an energy use study in public buildings and ways to analyze the data. Before broaching this subject, however, it may be helpful to discuss in more detail the other activities which should proceed at the same time.

Management and Citizen Interest

Commitment of top level management to retrofit is mandatory. Experiences from several sources have demonstrated this fact consistently. The interest of citizens and elected officials often can be just as important as support within the administration. Several jurisdictions have found citizen participation to be essential and an important source of advice and voluntary help. Depending on the structure of the jurisdiction the mechanisms for reaching elected officials and citizens vary: City Council Study Committee, Citizen Energy Committee, Architectural Review Board, or possibly other groups. When the jurisdiction chooses to proceed, it can be very important to involve and inform people other than technical experts concerning the retrofit process. This broad based support cannot be underestimated in importance.

Establishing Accountability for Energy Use

The same need for commitment exists for the actual end users of energy in the jurisdiction--agency personnel and operating staff, especially building supervisors.

Several large scale building owners have found that establishing accountability--one responsible person for the energy use of each building and a standard reporting procedure to track energy use--is an important step in the retrofit process. Initiating a system of periodic energy use reports for all facilities is an approach to this problem which several state and local government jurisdictions and other large scale building owners have used successfully.

By setting up procedures for monthly energy use reports, management both begins to collect data needed for retrofit analysis and also demonstrates to building supervisors that it is highly concerned about energy consumption. An important benefit of the reporting system is that it makes it possible to recognize the real efforts of agencies and individuals to reduce energy use in their facilities, and places a spotlight on facilities where little progress is being made.

Employee suggestion and reward programs can also be an important part of a conservation program. They have been tried and have been shown to work. Continued emphasis and fine tuning are necessary otherwise the program may fall into neglect. Rewarding people for saving energy, however, should be approached with some care.

One large scale facility operator in private industry has noted that the amount of energy saved for a particular building is not necessarily the best guide to how well the energy conservation program is operated: a poorly run facility may gain major savings with a very small conservation program simply because so much waste existed initially. An efficiently operated facility on the other hand may gain only small energy savings even with an intensive energy conservation program.

Conducting a Study of Current Energy Consumption

The energy consumption study provides objective information needed to identify buildings that are wasting energy. Facilities that can be improved effectively can then be designated for further architectural and engineering study. Though several approaches may be taken in performing the energy consumption study, each is based on consumption records of existing facilities, review of building plans, and on-site observation.

The alternative energy consumption studies described on the following pages are presented in order of increasing level of detail, accuracy of estimates, and difficulty to perform. Emphasis is given to the "Method 2" analysis which has been the most frequently applied method. Methods 1 and 2 can be performed without great engineering expertise. Method 3 may require participation of a competent design professional.

Method 1: Rough Estimate. In facility complexes lacking separate metering for each building or in cases where records have been lost, selecting the best buildings for retrofit study is most difficult. If time and resources do not permit going into great analytic detail (such as in Method 3 below), about the best that can be achieved is to select the largest facilities occupied for the greatest time periods each week. Old heating, ventilation, and air conditioning systems, and obvious energy waste recommend further study. Faced with a situation of this type in one facility complex, the National Aeronautics and Space Administration set the following criteria to select the first buildings for detailed retrofit study. Local governments lacking energy consumption data may choose to set similar selection criteria.

Largest facilities
Known major energy users with obvious flaws
Lighting greater than 4 watts per square foot
Facilities having a terminal reheat system
Facilities utilizing waste heat rejection
Facilities occupied or operated 24 hours a day

Method 2: Estimate Based on the Energy Utilization Index (EUI). The second method for performing an energy consumption study is based on past records of energy usage, a walk-through survey of each facility and a review of specifications and drawings. This study may be conducted either by in-house staff or by an engineering consultant. Greater analytic detail at this stage of the retrofit process, such as described in Method 3 below, may not be required to make the management decision to proceed with the Phase II engineering study in selected facilities. Users of this audit method have found it effective in quickly identifying the least energy efficient facilities--the most promising for retrofit.

The basic output of this energy consumption study effort is derivation of an Energy Utilization Index (EUI) for each facility. The Energy Utilization Index is nothing more complicated than the total energy consumption of each facility in MBTU's (thousands of British Thermal Units) per square foot per year. Grouping similar facilities and comparing their EUI results will point out the facilities operating least efficiently and probably the most amenable to retrofit (see Figure 10).

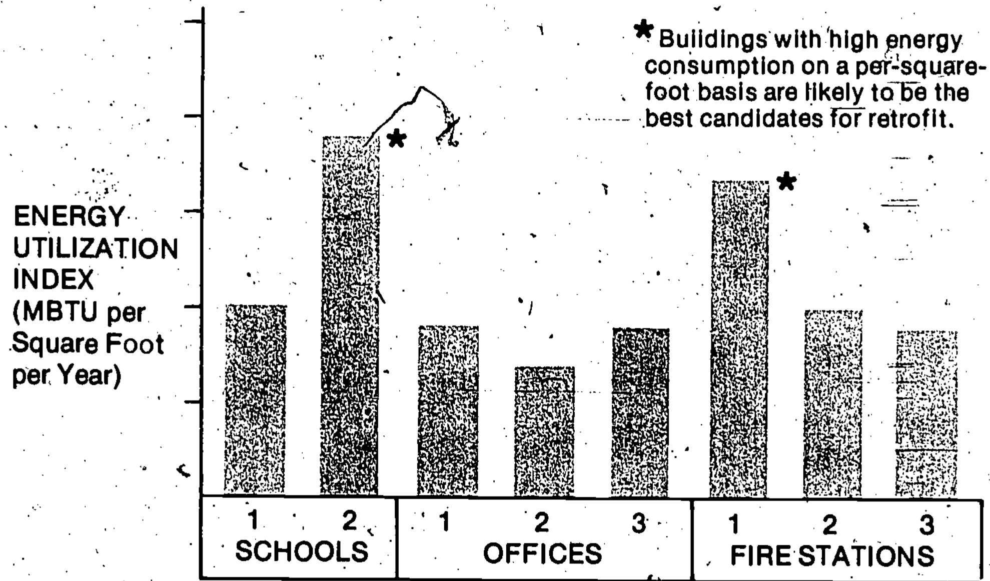


Figure 10
Energy Utilization Index Used to Set Retrofit Priorities

Basically, the data required to complete the consumption form in Appendix 2 are as follows:

1 Records of energy consumption for each building.

a Utility billings (electricity, steam).

b Fossil fuel billings (oil, coal, gas)

2 Functional characteristics of each building.

a Type of use

b Period of occupancy, (i.e., daily, weekly)

c Operational characteristics

3 Climatic data, heat gain, and loss characteristics.

4 Architectural, electrical, and mechanical drawings of each building.

If possible, utility and fuel billings should be compiled for several calendar years, including periods prior to and after any "quick-fix" retrofit modifications. Energy consumption in a base year of normal weather conditions may be compared with that of other years to draw conclusions on variations in consumption. Utility companies often may be helpful in selecting an appropriate base year with normal weather conditions. "Quick-fix" retrofit modifications may be evaluated by determining energy reductions which have been achieved. Cross-checking data from similar buildings may uncover problems in similar energy systems now using dissimilar amounts of fuel.

An EUI figure is derived for each building using the forms and methods shown in Appendix 2. By comparing EUI figures for buildings similar in type, design and use (e.g., offices, schools, or garages) management can determine which specific buildings of a given group of buildings are least efficient energy users. Final selection of the most promising facilities for further retrofit study can then be made on the basis of EUI ratings and total magnitude of energy costs for each building. Generally the largest buildings with the highest EUI ratings will bs selected. After this selection is made the jurisdiction proceeds with engineering analysis of Phase II.

Method 3: Analysis on a Component-by-Component Basis. A much more detailed consumption review can be accomplished using procedures developed by the Federal Energy Administration and used for estimating retrofit potentials in federal facilities for the Federal Energy Management Program. Combining engineering test data, experience and the results of computer analyses, the process works as follows:

1 A list of promising retrofit options is obtained from charts showing basic climatic conditions and building types. These charts are included in Appendices 4 and 5.

2 Each promising option is analyzed for potential energy savings independently following a step-by-step procedure provided in the FEA manual. The procedures are largely based on reading charts and following straight forward arithmetic calculations.

3 Construction cost estimates are developed based on unit installation costs that are provided in the FEA manual, then the estimates are modified by multipliers for regional cost variations and cost escalations due to inflation.

Appendix 3 provides an example of the FEA audit procedure and describes how pertinent manuals can be obtained. While more detail is gained using the FEA procedure than in Methods 1 and 2 above, it also requires much more time to complete and greater technical expertise. The FEA method, for example, requires the availability of detailed data about energy consumption characteristics of components of the building HVAC system. Jurisdictions without available technical staff may do well to limit themselves to the Method 2 approach. One final caution is necessary because of the young state-of-the-art of the retrofit field. Though the FEA procedures are more detailed than Methods 1 and 2, there is no guarantee that they are more accurate. The question of accuracy is now receiving substantial technical review.

Technologies for energy consumption studies are now undergoing rapid development. One example of this is utilization of ground-based and airborne infrared thermography. In several demonstration applications, sensitive scanners have successfully mapped areas of unusual heat loss or heat gain on building exteriors. One example of this is a roof insulation performing inadequately because of moisture build up. Airborne thermography for buildings is especially useful for studying roofs. Flights may scan a wide path so that energy loss from all buildings in a town or a major facility complex may be reviewed. Several cities and utilities have used this approach successfully. The National Aeronautics and Space Administration has been a leader in the airborne thermography field. Hand held infrared scanners increasingly are being employed to study exterior walls and interior building components, again, to identify areas of unusually high heat loss or heat gain.

Presenting Results

While the initial energy consumption study can be accomplished by many jurisdictions with in-house staff in relatively short order, substantial resources are required for work to proceed further. The detailed engineering study of Phase II generally will require a decision by the jurisdiction to either contract with an architectural and engineering consultant, obtain free assistance or to utilize considerable time of the jurisdiction's own technical staff. As such, the decision to go ahead must be justified and shown to be promising.

The presentation of the energy consumption study results must be clear and comprehensive. Use of charts and graphs is recommended. The data that should be presented includes:

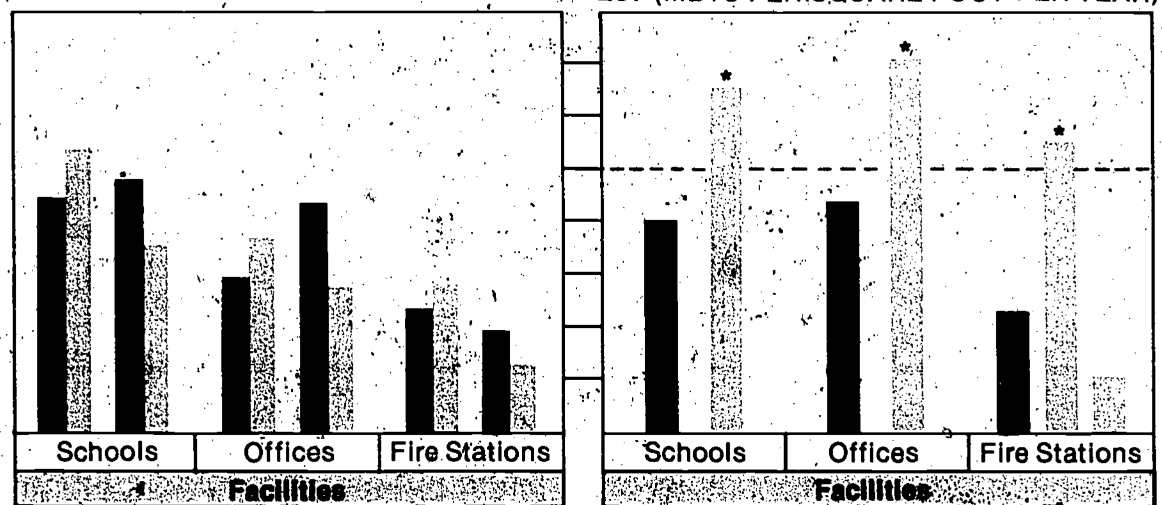
1. Background, methodology and explanation of terms.

TOTAL ENERGY: ______ BTU

TOTAL COST: $____________

EUI ≈ RELATIVE ENERGY CONSUMPTION

EUI (MBTU PER SQUARE FOOT PER YEAR)



Yearly Energy Costs (Dollars)

Current Energy Use (BTU X 1000)

*Buildings with high energy consumption—Best candidates for Retrofit.

RECOMMENDATIONS

	Description	Estimated Cost	Yearly Savings	Payback Period in Yrs.
A	Install Low Cost Modifications Into All Buildings	$ ______	______ %	1.0
B	Retrofit This Year (Building Group "A")	$ ______	______ %	2.1
C	Retrofit Next Year (Building Group "B")	$ ______	______ %	3.0

Figure 11
Sample Schematic Formats for Presenting Energy Audit Results

2. Total yearly energy consumption by all buildings.

3. Total annual cost of building energy consumption.

4. Annual energy consumption for individual buildings shown in two ways: (1) on an annual MBTU per square foot basis, (i.e., EUI figures); (2) as annual dollar cost for each facility.

5. Preliminary recommendation of buildings most suitable for retrofit.

6. Preliminary implementation cost and energy savings estimates plotted over time. If Methods 1 and 2 were used, guidelines for costs such as in Figure 9 on page 21 can be used to develop rough estimates. If Method 3 was used for the energy consumption review, savings estimates and retrofit cost estimates are developed using procedures provided within the FEA reference documents.

Figure 11 shows schematic means to represent this information. If it has not occurred earlier, at this point it may be desirable to involve people from several departments, elected officials and possibly a citizen's advisory group to review and refine the basic retrofit plan developed thus far. Priorities can be adjusted, estimating procedures explained and critiqued, and schedules shifted. If the analysis withstands this test, and continues to demonstrate the importance of energy conservation in existing buildings, then support of financial authorities may be forthcoming.

BUILDING SURVEY AND ENGINEERING ANALYSIS
(Phase II)

The building survey and engineering analysis phase of a project requires serious and detailed architectural and engineering study of retrofit alternatives. Jurisdictions may choose to perform this study with existing in-house architectural engineering staff, may utilize the services of a competent architectural engineering firm, may make arrangements with nearby universities, or in some instances may receive volunteer assistance from local design professionals. The competence and experience of the study group is of paramount importance. Though written in terms of a commissioned outside engineering consultant performing the study, the work description and evaluation procedures below may also be used by a jurisdiction to review capabilities of in-house staff and to direct their efforts.

Developing Work Statements

A preliminary work statement is first developed by the jurisdiction describing required engineering study tasks. This accomplishes several purposes:

1. Provides candidate consultants or in-house staff with a fair understanding of the work to be required of them.
2. Provides the jurisdiction with the basis to estimate and negotiate the cost and time period for analytic work.
3. Provides the jurisdiction with means to evaluate candidate firms.

Management may wish to ask the advice of consulting firms in refining a preliminary scope for the task description. By discussing the subject with a representative sample of firms, a fair understanding of work statement possibilities will develop.

A sample work statement is illustrated in Figure 12 and may be modified for the project at hand. The sample work statement calls for a detailed and comprehensive study, a plan for instrumentation, and development of a plan for implementation. This basic form of work statement has been used successfully for engineering services on several past projects. Management may choose to scale down the work statement if it desires, eliminating, for example, consideration of conversion to alternative fuel sources.

Several past retrofit projects reduced the scope of work and have proceeded with less extensive engineering analysis than described in Figure 12. The experience of Public Technology, Inc., however, supports the importance of a comprehensive study, especially to gain the assurance that a wide range of conservation alternatives has been reviewed and the most promising selected.

Solicit Qualifications Statements and Release Request for Proposals

Depending on current consultant selection procedures of the jurisdiction, proposals from potential consulting firms frequently will be solicited as follows: A notice is published and invitations are sent requesting qualifications from various firms. Consulting firms submit qualification statements; the statements from several firms are screened; then a limited number of qualified firms are requested to submit detailed project proposals.

If it is desired that all firms submit their credentials within a common format the jurisdiction may choose to utilize or adapt the standard Federal GSA qualification statements (Forms 254 and 255), samples of which are contained in Appendix 6.

Because there will be a diversity among the retrofit programs of individual jurisdictions, it may be desirable to hold a briefing for interested consulting firms. The work statements developed above will help to clarify the extent of analysis which the jurisdiction desires.

A sample Request for Proposals is included within Appendix 7 of this document.

Review of Consultants and Selection of Firm for Negotiation

If the jurisdiction is seeking professional services for Phase II, the level of service and fee probably will be negotiated, not bid. Frequently a review committee such as an architectural review board or a citizen's (see page 36)

Figure 12

ENERGY CONSERVATION RETROFIT STUDY
SAMPLE WORK STATEMENT

A This study shall include an analysis of the specified buildings from the standpoint of energy usage and shall identify alterations, modifications or additions which could feasibly be made to the building or its use to: (a) reduce the overall consumption of conventional fuel and energy; and (b) reduce the peak demand for individual fuel and energy sources, where more nearly constant demand would be advantageous.

B The study shall include:

a An overall survey of the building use and occupancy to identify facility use patterns and functions performed by building occupants which contribute to energy use within the specified building(s).

b A detailed survey of the building envelope and its space heating, cooling, domestic water, electrical and lighting systems; operating equipment and practices; and other factors affecting energy usage, by means of appropriate and accepted analysis techniques.

(1) Calculate heat gains and losses for existing buildings based on existing operating loads and outdoor air conditioning during occupied and unoccupied hours. Also calculate electric loads and consumption. Provide corresponding comparative monthly energy consumption data based on actual historical utility billings (monthly, yearly, or long-term median values as appropriate).

(2) Identify and describe types of existing heating and cooling systems and how they are configured with respect to the heat gains and losses in (a) the building envelope; (b) interior or core areas; and (c) special purpose areas.

(More)

(Figure 12 continued)

c The development of recommendations for alterations, modifications, additions of equipment, systems or materials to the building and its existing systems, or modifications to operating procedures to reduce the consumption of conventional energy sources, or total conversion to less critical energy sources where applicable. The recommendations shall include gathered data, followed by engineering and economic analysis which are sufficiently documented to lead to the recommended solutions.

(1) The recommendations should cover changes that would not adversely affect environment, productivity, aesthetics, or safety of the building occupant or visitors.

(2) Each recommendation should be supported by a preliminary estimate of the cost to perform the work, together with an estimate of savings in energy (BTU's) and critical fuels and operating costs, plus a forecast of payback time.

(3) Recommended options should be prioritized to facilitate selection of individual items, should limited funds be available. Further information should be included as to which work could best be performed during one particular season and work that could be performed with the building occupied or partially occupied.

d The development of an acceptable methodology and instrumentation plan to measure performance as compared to prediction. If actual physical instrumentation is required, provide individual itemized cost estimates. Instrumentation should be planned so that readings can be taken <u>before</u> energy savings proposals are employed. (Desirable instrumentation, if any, will vary among buildings and perhaps may include nothing more than normal fuel and electric meters.)

(More)

(Figure 12 continued)

C In carrying out this study, the consultant shall consider the ideas in existing guideline documents for energy conservation in existing buildings. Energy conservation concepts including, but not limited to, the following shall be prioritized and considered for each building:

Modify current building operations and occupancy schedules.

Reduce heat gains and heat losses through the building envelope.

Eliminate simultaneous heating and cooling of a room or zone.

When loads are reduced, modify cooling and heating systems to operate without waste of energy.

Modify systems to operate at greater efficiency.

Cool or heat with outside air whenever advantageous.

Utilize heat recovery systems whenever advantageous.

Reduce use of new energy for humidification and dehumidification.

Shed loads for peak demand periods and consider off-peak energy storage.

Match equipment power to actual loading.

Reduce energy utilized for artificial illumination.

Utilize high efficiency light sources.

Utilize interior finishes which absorb less light.

Utilize more highly flexible manual and automatic switching of energy consuming systems (light switches, thermostats).

Take advantage of natural lighting.

Use thermostats with larger deadbands (allow greater temperature swing).

energy advisory group with sufficient technical expertise will be utilized to select one or more firms for contract negotiation. Evaluation criteria such as those in Figure 13 may be used to assist in this process.

Detailed Negotiation with Consulting Firm and Contract Authorization

Using the final work statement, a contract is developed and clarified. Fee proposals and levels of service are discussed and agreed upon. For planning purposes, a jurisdiction may estimate a consultant's fee for the survey and engineering analysis as beginning at about $.07 per square foot of floor space. Several owners have incurred engineering costs in the range of $.10 to $.15 per square foot. This data, however, is from a small number of past retrofit projects for office occupancies and is meant only to be illustrative. It should not be used to develop precise estimates of fees since they will depend mainly on engineering man-hours which in turn relate chiefly to building complexity, the extent of analysis which will be desirable, and the number of buildings to be surveyed.

A situation may exist whereby a candidate consulting firm may offer to link its fee in some fashion to energy savings received by the jurisdiction (if allowed by local procurement regulations). While this may appear to be an attractive offer, it requires careful evaluation of results to assure fairness and to avoid legal problems. Base year consumption, prices, and a payback period against which to measure energy savings and appropriate fee bases must be agreed upon. If, for example, the following year is used to evaluate results and the jurisdiction has not completed retrofit modifications, or if weather conditions are unusually severe, then the consultant would be unfairly penalized. Because the consultant's fee is subject to risk, jurisdictions should assume that the final fee on the average will be higher than if the consultant was not in a risk situation. Also the jurisdiction should consult legal counsel if a fee structure of this type is considered, especially if state or Federal money will be involved. Several design professionals reviewing this document do not approve of this form of fee basis on ethical grounds. It has, however, been used.

On Site Survey and Data Collection

In conjunction with building operations staff of the jurisdiction, the consultant will conduct a thorough on-site survey of each building and will review available drawings. Building operating procedures should be discussed

Figure 13

SAMPLE EVALUATION CRITERIA FOR BUILDING SURVEY AND ENGINEERING ANALYSIS CONSULTANT

1 Review of references and experience of the firm or joint venture and the particular project team in successfully conducting similar projects. Ability to perceive jurisdiction's goals and approach.

2 Familiarity with and availability of existing documents, data, and manuals for energy conservation analysis.

3 Building management experience, particularly experience in cost control and testing for heating, ventilating, air conditioning, electrical and control systems.

4 Engineering design experience, particularly in conceptual design, comparison of alternative systems, and cost estimating.

5 Architectural programming experience especially regarding user needs for space utilization and comfort requirements.

6 Experience with and ability to use various analytical and computer techniques for modeling and studying energy use within the building.

7 Ability to evaluate energy savings and energy cost savings over several years for alternative energy conservation approaches including architectural, electrical, heating, ventilating, air conditioning, control systems, and lighting.

8 Cost estimating ability for repair and alterations work in similar types of facilities.

9 Experience in developing architectural and engineering work statements.

(More)

(Figure 13 continued)

10 Adequacy of firm to provide sufficient experienced technical and support personnel for the project.

11 Acceptable performance period for completing the survey and engineering analysis.

12 Suitable scope and detail of survey proposed.

---

in detail and progress already made in "quick-fix" savings should be reviewed. Additional low cost changes should be identified. Measurements taken as part of this on-site survey may include as examples: lighting levels, temperatures in various rooms, and heating system efficiency checks such as exhaust stack temperatures.

Following the on-site survey the consultant should review preliminary findings with administration officials.

Detailed Engineering Analysis

While use should not be mandatory, computer programs for analysis of energy flows may be employed by the consultant to provide an overall model of energy utilization in sizeable or complex facilities. Reliance upon one or more computer programs becomes desirable to gain accuracy in studying the many interacting patterns of energy flow. For instance, reducing light fixture wattage has the direct effect of reducing electrical energy use. In addition, one indirect effect may be to lower summer cooling loads and to increase winter heating requirements, since less heat will be released by the lower wattage lighting system. Further, once the substantial amount of building-related data is fed into a computer, many building retrofit options can be evaluated--including their interaction--with relative ease, thereby reducing engineering manpower requirements.

Several computer programs are available for use in the engineering analysis. Appendix 8 lists a number of the programs which now exist. Many consulting firms that do this type of work have their own programs. When the group performing the study selects a program, care must be exercised to assure that all promising retrofit possibilities can be analyzed, including concerns for variations in the heating, ventilation, and air conditioning systems such as dew point reheat and set point control, dual duct, multi-zone, demand and humidity overdrive and variable volume systems. Lighting, weather data, insulation, configuration, building orientation, and numerous other factors must be included for the analysis to be effective.

For smaller and less complex public facilities the jurisdiction may choose to reduce its study costs by foregoing the extensive computer analysis described above. While manual estimates may not be as accurate, the absolute amount of potential energy savings in a <u>small facility</u> (though not necessarily the proportionate size of energy savings) will not be as significant nor will construction costs for retrofit modifications. In this situation, approximate calculation procedures mentioned in Appendix 3 may be of assistance to the jurisdiction.

Development of a Workable Plan for Implementation

Before financial commitment can be made to go ahead with implementation, a workable schedule [illegible] developed. Frequently this is prepared by the jurisdiction's en[illegible]ltant. Operational changes and low cost options should be ini[illegible] use staff as soon as possible. In fact, in-house maintenance staff m[illegible] able to do a substantial portion of the retrofit work itself. One jurisdiction has considered having firemen perform some retrofit work on their stations between calls. Another portion of the specified work can be sent directly to construction contractors for bids. Some options, however, may require further detailed architectural and engineering design development before construction can begin. The implementation plan for each jurisdiction will be unique. Before a final decision is made to go ahead, the plan should be well outlined defining: Who is to do what; how much their share of the work will cost; how long it will take; and how the work is to be integrated with existing building operations.

Presentation of Results and Recommendations

Figure 14 is a sample format for the engineering study team to present study results to management that has been used on several past projects. It allows management to quickly compare retrofit-alternatives for energy savings, cost for realization and payback period. Each of three criteria; savings, construction cost, and payback is important in an implementation decision.

Payback period criteria alone, may not be sufficient to make decisions. If, for example, certain retrofit options can produce major energy savings, but have somewhat less than a desirable payback period, perhaps management should consider their implementation anyway. Similarly, a retrofit option with a very high construction cost but acceptable payback may be by-passed in favor of a combination of several low cost but slower payback options. Overall, the jurisdiction will seek to gain the maximum energy savings possible within available financial resources.

	Electrical Savings		Implementation	Payback
	KWH/Yr	$/Yr	Cost - $	Years
1 Additional Zone Controls	43,291	1,429	2,000	1.4
2 Automatic Warm-Up Cycle (Optimum Start)	173,752	5,734	1,539	.3
3 Schedule Supply Air Temperature vs. O.A.T. and Set Minimum Air to 10%	862,275	28,455	20,300	.7
4 Night Set Back to 55 F	187,753	6,196	—	—
5 Enthalpy Controls	27,060	893	3,160	3.6
6 Double Glazing	244,309	8,602	63,000	7.9
7 Insulate Garage, Roof and Walls	158,000	5,214	2,000	.4
8 Light Reduction	68,999	2,277	—	—
9 Locker Room—Recirculate Air at Night	107,000	3,531	7,600	2.2
10 Domestic Water—Heat at Night	—	1,258	500	.4
11 Load Cycling	184,392	6,085	8,200	1.3
TOTALS	2,056,831	$69,13[illegible]	$108,299	1.6

Figure 14
Sample Format for Engineering Analysis Results

IMPLEMENTATION
(Phase III)

Once the jurisdiction has performed a thorough analysis of energy conservation options in its existing buildings, the actual implementation of retrofit is straightforward. Generally, modifications will involve standard materials, readily available equipment, and standard contracting procedures.

Implementation tasks normally fall within a few categories:

Low cost modifications

Low cost modifications identified during the initial energy consumption study and subsequent engineering analysis phases may be implemented immediately, frequently by in-house staff. Examples include weather stripping, adjustment of thermostats and revised procedures for equipment operation. Some low cost options, such as a boiler tune up, may require a specialty contractor.

Work that can be sent directly to construction contractors

Another category of work involves construction or alteration which, because of its cost and labor equipment, will be performed by outside construction contractors. Standard contracting procedures of the jurisdiction normally will be used for specified work including: public notice, formal competitive bidding, award based on lowest responsible fixed price, and use of routine construction contracts. Either staff of the jurisdiction or its engineering consultant will be assigned to monitor this construction activity.

Work where detailed design is required

Depending on contractual arrangements made if an engineering consultant was employed for Phase II, some retrofit modifications may require further architectural or engineering design. One situation where this might occur would be if an engineering firm from outside the jurisdiction's state performed the Phase II analysis. In this case, the jurisdiction might want final plans and specifications to be prepared by either in-house engineering staff or a local engineering and architectural firm.

If a firm is engaged to prepare final drawings and specifications, then standard evaluation, selection, and A/E contract procedures of the jurisdiction usually will be employed. The firm preparing the final detailed design often will assist the jurisdiction in preparation of contractor bid packages and in monitoring work accomplishment and schedules.

MONITORING
(Phase IV)

Continued monitoring of energy use in buildings for a year or more is an essential portion of a phased management approach to retrofit. The exact procedures for monitoring may vary considerably--from simple tracking of fuel bills to elaborate instrumentation of individual buildings. Whatever methods are used, however, several basic objectives can be achieved through the monitoring program:

1 Measuring the effectiveness of retrofit modifications by comparing fuel consumption after implementation with base year data.

2 Monitoring buildings in which initial retrofit has been done, to help determine whether retrofit should be initiated on similar buildings in later years.

3 Maintaining records in the event that major unforeseen changes in fuel supplies and costs occur, such as complete curtailment of a particular fuel; or in the event that a major new energy conservation option (such as solar) becomes more desirable due to technological or economic change.

4 Continuing a vigilant watch on fuel use to assure that old habits of energy waste do not return and that maintenance programs are working. Monitoring can be a major means to achieve accountability in energy use, to reward users who seriously strive for conservation, and to identify wasteful energy users.

5 In the event that the jurisdiction selects a consultant who proposes a fee based on performance (a given amount of energy reduction), monitoring will be necessary to determine the appropriate final fee.

Monitoring of results can become difficult at times. Energy use characteristics of the building may have changed from the consumption base year established by management. "Quick-fix" conservation measures may have been implemented, and equally important, occupant use of the building may have changed. Given this situation, management must decide if monitored results should be compared to the base year or if allowance should be made for developments occurring since the base year.

A further complication develops if facility use has changed, or if "quick-fix" conservation measures are implemented during the retrofit process. It becomes difficult to separate the effects of the changes occurring simultaneously.

More problems evolve in monitoring if the jurisdiction seeks to separate out the effects of each of several specific retrofit measures which may have been implemented during the retrofit program. Without elaborate instrumentation, which may be prohibitive in cost, it is difficult to know if a particular retrofit measure is performing up to the engineer's expectations.

A major problem which can develop during monitoring is this: What does the jurisdiction do if retrofitted buildings do not perform up to the consultant's estimates even after each modification has been checked out to see if it is operating properly? Even if conservative engineering analysis is employed this situation may develop since engineering procedures for retrofit in some cases are still very rough and approximate.

Some jurisdictions have obtained some form of contractual guarantee from their architectural/engineering consultant to cover this situation. In some way the consultant's fee is linked to energy savings realized by implementation. As pointed out earlier this approach has certain drawbacks, one being possible conflict with the jurisdiction's architect/engineer procurement regulations. Another drawback is the probability of a higher fee to cover the risk assumed by the consultant.

Overall, the most important action which the jurisdiction can take to assure that estimated and actual energy savings results compare favorably is to select a competent engineering and architectural study group in the first place for Phase II analysis. A competent group, whether in-house staff or outside consultants, will be able to use experienced judgement to assure that estimates are conservative and also can indicate to management the specific state-of-the-art estimating procedures used which may have a considerable margin for error.

RECENT EXPERIENCE WITH RETROFIT

Many large scale building owners in private industry and government established emergency procedures for energy reduction during the oil embargo and more recently during natural gas shortages. When top management has continued to emphasize energy conservation, these emergency measures still produce good results, frequently with savings of from 10% to 30% in energy consumption. Several local government jurisdictions however, have relaxed their attention toward energy conservation and are experiencing greater fuel consumption as a direct result.

In seeking to assess the status of long-term building retrofit efforts within state and local governments, PTI has been intimately involved in several projects, including activities of the 27-city Urban Technology System, and has pursued numerous leads to jurisdictions interested in energy conservation. While the results which follow are not comprehensive, we believe that they are indicative of the current state-of-the-art.

Energy retrofit of existing buildings is just beginning as a national effort. Several jurisdictions have pioneered the field and expect to receive significant annual energy savings through their efforts. More jurisdictions are now seriously considering retrofit. Many have created either formal or ad hoc energy committees. Several have performed energy consumption studies and have conducted detailed engineering studies. Relatively few have yet reached the point of implementation. Energy savings projections which have been identified through engineering studies appear to be consistently promising.

The retrofit efforts identified by PTI generally appear to have followed the phased approach discussed in this manual. Most jurisdictions have focused initially on a few of their most energy inefficient buildings and have sought payback periods of between one and seven years. Buildings being considered for retrofit are not always old. At least one jurisdiction is especially concerned about a new building which has not yet been occupied. PTI has not identified a single jurisdiction accepting payback periods in the 20 to 30 year range for existing buildings unless equipment was due for replacement anyway.

Several jurisdictions have proceeded directly from the energy consumption study to implementation without first conducting a thorough engineering survey of a wide range of potential conservation approaches. These jurisdictions, it appears, will save energy. Based on its experience, however, PTI believes that it may be unwise to bypass the engineering and architectural analysis as this may lead to sub-optimal results.

Cases of retrofit identified by Public Technology, Inc. show much variation. Acceptable payback period, percent energy savings and financial commitment to retrofit are the three most significant variables. Figure 15 is intended to illustrate this situation. Each retrofit case for which data could be obtained is shown on the graph for two characteristics: percent of energy cost savings (estimated or actual) and cost of implementation per square foot in dollars (estimated or actual). Figure 16 supports this graph with tabular data. Overall, the examples range from very low cost and quick payback efforts to projects with costs of $0.90 per square foot and energy cost savings of eighty percent.

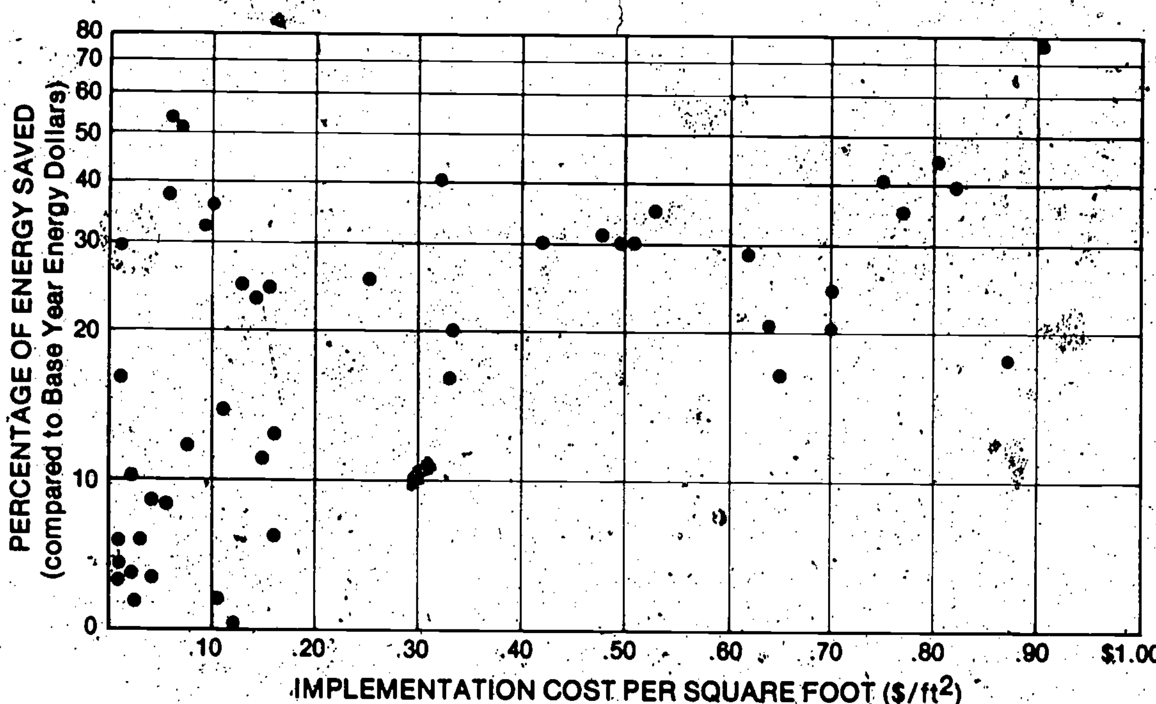


Figure 15
Energy Cost Savings (%) Versus Retrofit Costs ($/ft^2) For Several Recent Retrofit Projects

[illegible]	Implementation [illegible]	[illegible]	[illegible]
1 School	$0.010	3.3 %	Massachusetts
2 School	.012	3.0	Massachusetts
3 School	.026	10.3	Connecticut
4 School	.046	2.9	Massachusetts
5 School	.046	8.75	Massachusetts
6 School	.056	38.3	Connecticut
7 School	.06	55.4	New Jersey
8 School	.066	51.8	New Jersey
9 School	.078	12.0	Connecticut
10 School	.091	32.9	Connecticut
11 School	.128	25.3	Connecticut
12 School	.144	22.3	Connecticut
13 School	.16	12.4	Connecticut
14 School	.33	16.7	Massachusetts
15 School	.53	35.6	Massachusetts
16 School	.64	20.7	Massachusetts
17 School	.65	16.6	Massachusetts
18 School	.70	20.9	Massachusetts
19 School	.77	35.1	Massachusetts
20 School	.82	39.5	Massachusetts
21 Educational Center	.12	.01	Massachusetts
22 Educational Center	.75	40.8	Connecticut
23 Community College	.32	40.7	Massachusetts
24 Community College	.48	32.0	Massachusetts
25 Library	.01	.3	Massachusetts
26 Library	.62	29.0	New Mexico
27 Community Center	.256	25.8	Connecticut
28 Town/City Hall	.023	5.0	Iowa
29 Town/City Hall	.10	36.6	Connecticut
30 Town/City Hall	.334	20.8	New Jersey
31 Town/City Hall	.51	30.0	Florida
32 Town/City Hall	.875	17.8	Massachusetts
33 Fire Station	.025	1.5	Massachusetts
34 Fire Station	.104	1.6	Massachusetts
35 Fire Station	.148	24.0	Massachusetts
36 Fire Station	.15	11.9	Massachusetts
37 Fire Station	.158	5.2	Massachusetts
38 Fire Station	.904	78.0	Massachusetts
39 Office Building	.017	16.4	New York
40 Office Building	.108	13.8	Massachusetts
41 Office Building	.607	45.0	Maine
42 Hospital	.70	24.6	Massachusetts
43 Auditorium	.012	30.0	Iowa
44 Townhouse	.010	5.0	Massachusetts
45 Public Works	.054	8.0	New Jersey
46 Public Works	.496	30.0	Massachusetts
47 City (14 Bldgs)	.42	30.0	Ohio

Figure 16
Savings Versus Retrofit Costs for Recent Projects (Tabulation)

Figure 15 tends to confirm the estimates of energy savings versus retrofit costs provided earlier. First, for low cost retrofit (below $0.15 per square foot) numerous jurisdictions have received significant savings of from one percent to slightly under 25 percent in energy costs. Greater expenditures appear to have provided greater energy savings.

Retrofit efforts with higher capital expenditure--between $0.30 and $0.90 per square foot--generally yield considerably larger energy savings than do low cost efforts. Here the savings range from eight percent to nearly 80 percent. Most cases appear to fall between 15 percent and 40 percent in energy cost savings.

Two points of clarification are necessary for the data contained in Figures 15 and 16. First, the costs for engineering analysis are not included in the implementation costs cited. Second, several of the facilities achieved additional energy savings beyond those indicated from low-cost energy conservation alternatives implemented before the retrofit program began.

Some Examples of Successful Retrofit

Commonwealth of Massachusetts. The Commonwealth of Massachusetts owns and operates more than 4,000 buildings statewide. Between 1971 and 1975 energy rates nearly tripled making energy conservation most important.

In April 1975 the Commonwealth began to develop an energy conservation program and workable strategies for achieving near term energy savings in state buildings. A phased program was developed and tested.

One hundred and twenty one buildings on 21 sites were selected as a cross section of functions and locations. Comparisons of data in Phase I, the Energy Consumption Study identified candidates for Phase II, Analysis and Phase III, Implementation in this study.

- Fuel cost savings identified - 19.3% or $105,047
- Electricity cost savings identified - 37.1% or $173,632
- Overall dollar savings - 27.3% or $278,679

Greenfield Community College Complex

Electricity savings identified - $69,134/yr. or 32%

Implementation cost (est.) - $108,299 (payback of 1.6 yrs.)

Bunker Hill Community College Complex

Fossil fuel savings identified - oil cost reduction = $33,330/yr. or 47% in equivalent oil consumption

Electricity savings identified - $34,904/yr.

Implementation cost = $90,564 (payback 1.3 yrs.)

Worcester State Hospital Complex

Fossil fuel cost savings identified - oil = $71,717/yr. or 15.5%

Electricity cost savings identified - $69,594/yr. or 62.7%
(Savings primarily from rehabilitation of turbo generator system)

Overall payback = 3.0 years
(Without power generation, oil savings is 20.4% and electricity reduction is 2.7%)

From the Energy Consumption Study of 121 Commonwealth buildings, a significant number emerged as candidates for Phase II and III work. The study indicated that practical application of the phased process to remaining state buildings has potential for additional savings.

West Hartford, Connecticut. The town of West Hartford, Connecticut, owns, operates and maintains approximately 25 major administrative and school buildings. From 1973 to 1975 the energy costs increased 92% while low cost conservation measures reduced consumption by 29%. Petroleum fuels generate about 70% of the BTU's consumed by the town and public buildings account for about 70% of the energy budget.

To determine the impact of current technical conservation measures on its energy consumption, the town formed a Citizens Energy Committee to coordinate its phased energy program and report to the Town Council. An Energy Consumption Study (Phase I) was performed for 21 buildings.

West Hartford decided to place major emphasis on mechanical systems as opposed to structural modifications, as there seemed to be lower cost modifications available in this area. The ten buildings with the highest cost-savings ratios were selected for Phase II and III work.

Impact (Using 1974 base year for costs)

Heating oil savings identified - $82,649/year

Electricity savings identified - $7,886/year (savings primarily from building modifications)

Cost of program and implementation of modifications - $224,011

Overall payback = 2.5 years (from energy savings)
(Expected completion of implementation - March 1977; comprehensive monitoring for one (1) year)

Follow-up Because the conservation program was successful, the town has determined to initiate retrofit in several other facilities.

Suffolk County, New York*, commissioned a study of six county buildings to identify low-cost energy saving measures with short payback periods. The study found that fuel consumption in the six buildings could be reduced by 47% through such measures as: rehabilitating existing time clocks and controls; installing new controls to provide automatic shut-down of heating, ventilating and air conditioning (HVAC) systems; reducing the hours and level of operation of HVAC systems; and lowering lighting levels. The cost of implementation was $47,800, with an estimated savings of $57,025 a year, amounting to a payback time of 10 months.

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*The case study examples for Suffolk County, New York; Nassau County, New York; Mecklenburg County, North Carolina; Los Angeles County, California; and Lake Charles, Louisiana were reprinted from: A Guide to Reducing . . . Energy Use Budget Costs. Prepared by the Energy Projects of the National Association of Counties, the National League of Cities, and the U.S. Conference of Mayors.

Mecklenburg County, North Carolina, has initiated a vigorous energy conservation program in county buildings. After conducting an energy audit, the Engineering Department suggested a number of energy conservation measures, computing their cost, their energy saving potential and the estimated payback time. The Engineering Department identified 37 no-cost changes and 36 measures involving a combined total cost of about $50,806. The estimated cost saving during the first year was $50,730.

Lake Charles, Louisiana, worked with the Lake Charles-McNeese Urban Observatory, Inc. to identify opportunities for reducing the city government's energy consumption. Among the findings of the resulting study were:

The city could achieve a 17.5% reduction in fuel used for cooling by reducing air conditioning by 1 1/2 hours daily in an 8-hour day

The city could save 20% of the energy being used to heat water in one municipal building by heating incoming 60 F water to a tap temperature of 130 F instead of 150 F

The city could effect a 5% electricity saving for each degree the thermostat is set back in winter and a 3% saving for each degree set up in summer

Nassau County, New York, established a county-wide building energy audit. By correcting conditions uncovered by the audit (primarily unnecessary lighting) the county reduced energy use by 23%, saving $1.5 million.

Los Angeles County, California, estimates that the computerized building management system installed in its county courthouse has by itself reduced energy consumption 25%. By combining the computers with time clocks, the county has reduced energy use by more than 50%.

Sioux City, Iowa, inspected six municipal buildings on a central system and initiated actual energy conservation efforts on three of them (Auditorium, City Hall, Municipal Building). The low cost modifications implemented were installation of steam traps, thermostats, and other control devices to reduce energy use.

Auditorium - $12,000 spent, savings $1,500/yr. (76) = 30%, payback estimate 8 years

City Hall - $1,200 spent, savings $700/yr. = 5%, payback 1.7 years

Municipal Building - $800 spent, savings $800/yr., payback 1 year

Further study of cost-effective measures is underway.

St. Petersburg, Florida, proposed energy conservation measures for its City Hall. Insulation, solar film for windows, and mechanical system (HVAC) operating periods were involved. Provision was made to consolidate 24 hour operations in part of the building with a separate HVAC system.

Implementation = 4 months (not including engineering costs of $11,654 and $300 to test and balance existing system).

Initial cost of modifications = $32,000 (including 24 hour operation(s)

Savings based on 1975 - $16,500/yr. = 30% (electricity cost)

Payback 2 years (near 3 years if engineering and testing costs added)

Pueblo, Colorado, initiated a program for conservation of electricity (natural gas and coal produced). Lighting levels at work stations were surveyed and general levels were reduced for 15 public buildings. Voluntary city departmental cooperation and periodic meetings on efforts and results have highlighted this on-going program. No heavy expenditures have been made.

Program in operation one year

Savings - Electricity 17.6% a year, gas (adjusted for degree days) 24.9%

Payback - none required

Utilizing the facilities of Texas A&M University, Pueblo is conducting a comprehensive energy survey and analysis of the City Hall. A computer simulation for modification options and benefits will be run.

Kettering, Ohio, completed a comprehensive retrofit evaluation and modification program after its natural gas crisis began in 1972. Fifteen city buildings were surveyed, all in-place systems were analyzed and potential retrofit modifications were value-engineered. Recovery of waste energy was made a primary concern.

Program has been in effect since 1973

Implementation costs = $83,000

Natural gas cost savings = 30% for 1976 or $50,000

Paybacks required = 1.6 years

Percentage of energy budget in public buildings = 50%

Pasadena, California, has designated an active energy coordinator in each public department to audit lighting, appliance and natural gas use by that unit. Delamping and curtailing use of appliances has netted 20% to 25% overall energy savings.

Police Department - cost savings (electricity, fuel, gas) $18,000/yr. = 15%

Human Services Department - cost savings $1,000/yr. = 23%

Personnel Department - 42%

City Manager's Department - 40% = $1,400/yr.

Worcester, Massachusetts, no-cost modifications have reduced energy consumption in City Hall, schools and other public buildings. Worcester has delamped and turned down the heat to earn an FEA Award for City Hall and save significant energy elsewhere, without going to an active retrofit program.

City Hall energy savings = 30% electricity (FEA Award)

High Point, North Carolina, in an effort to reduce energy consumption at City Hall, the city embarked upon a program of lighting cut-backs, turning off HVAC system fans and compressors at night, and weather stripping windows. Time clocks were put on fans and domestic hot water was eliminated entirely. Ventilation was reduced.

Implementation = 3 months

Implementation costs = several hundred dollars

Energy savings = 30-35% year round with best savings in spring and fall

Akron, Ohio, the natural gas shortage and the rapid rise in cost of natural gas and electricity have motivated City Management to focus on reducing heating and cooling energy consumption in City buildings. A model of heating and cooling systems for one building was tested with a computer simulation to gain consumption estimates for gas and electricity with an accuracy of 98.3% and 91.5% respectively.

Potential annual natural gas savings = 36.3%

Potential annual electricity savings = 40%

Albuquerque, New Mexico, in an effort to improve the present and future performance of its Main Library Building, identified modifications to its lighting system, operational changes for its mechanical systems and installation of an energy management system.

Potential annual electricity cost savings = 29%

For Albuquerque's Erna Fergusen Library, a change in the billing status with the electrical utility and operational changes for the HVAC system have been identified.

Potential energy cost savings = 11.5%

Problems in Retrofit

As shown in the case studies, retrofit of public buildings for energy conservation works. It has consistently produced significant energy consumption savings with rapid payback and continuing annual savings. A retrofit activity, however, will run into problems with a fair share of headaches, and must be followed closely by management.

The following paragraphs are excerpted from a progress report on one city's effort to retrofit several of its buildings. They illustrate quite well the kinds of problems which invariably develop. It may be noted that the comments which follow were made by the Project Manager of one of the most effective local government retrofit efforts now being conducted, one which already has experienced major energy savings. The comments were written late on a Friday afternoon.

Steam System. After the first phase of work on the steam system was completed, the system was found to be functioning improperly. New specs were drawn up, and added to the original contract. Council failed to approve the extension at the first and second meetings and the issue was tabled. It was finally approved later, but resulted in a loss of approximately three weeks of schedule. The system is now functioning properly. All offices now are able to control their own heat. A small amount of steam is still blowing down but it is in the process of being traced.

A word of advice. Modifications to old systems can be the basis for losing some sleep. Proceed with caution--what might seem obvious and logical--sometimes is not.

Light Controller. The automatic light controller equipment was finally installed in the shop facility. Prior to installation, elapsed time meters were connected to the circuits to determine their use pattern. During this period it was ascertained that the lights were left on 24 hours per day, seven (7) days per week. The controller was activated and in the first 17 days of operation the lights have been used only 16 hours total. Projected over the year the savings will be $3,000 for this building. The controller cost only $636. The most rewarding part of this project is that nobody misses the lights.

Automatic Door Closer. After much harrassment, pulling, yelling, etc. the automatic door closer supplier finally delivered the required materials at the end of January. The initial purchase order had been submitted in September. The first door was modified with help from our contractor. Shop personnel are still not convinced it's a good idea, but they are learning to live with it. Progress is slow for subsequent installations. City personnel are obligated by the contract to install the equipment on more than 20 other doors. We won't be able to evaluate the equipment this heating season.

Window Weather Stripping and Area Reduction. The modifications have been completed, and the reaction now is that the building is too warm. Last year the occupants wore sweaters and coats to combat the infiltration losses. This year, even with temperature extremes the normal attire is short sleeves. The thermostats and control valves in this building are inoperative, which results in the overheating condition.

Delamping. We tried going around during the day pulling out unnecessary lights. The protest was unbelievable. Finally, we gave up and instead pulled out the lights after everyone had gone home. So far, I have had only one complaint. Most people still do not appear to have noticed that anything has changed.

APPENDIXES

APPENDIX I

Don't Neglect the 'Quick-Fix'

By now most government jurisdictions have taken at least some steps toward energy conservation in existing buildings. Figure 17 outlines a set of steps suggested by the Federal Energy Administration for achieving immediate energy savings in existing buildings without significant cost. The U. S. General Services Administration which operates more than 10,000 buildings has used steps such as these over a two-year period to save 30% of annual energy use in its existing buildings. PTI has found that numerous other building owners in the private sector and state and local government have achieved comparable results.

Many check lists are available for considering low-cost, high-return conservation options. Several of these are referenced in these Appendices. The most comprehensive and analytic of the documents reviewed by PTI was produced for the Federal Energy Administration. Guidelines for Saving Energy in Existing Structures: Building Owners and Operators Manual (ECM1) provides not only very detailed check lists of quick-fix ideas, but explains the why and how of each. Importantly, ECM1 provides clear-cut analytic procedures for estimating how much energy each idea can save in any building, and how much (if anything) it will cost to make the change. This document is highly recommended and is available as indicated in the bibliography.

Another manual emphasizing low-cost conservation options has been developed by the Commonwealth of Massachusetts to assist local governments in that state to achieve energy conservation. The book, Energy Management in Municipal Buildings includes a check list of low-cost retrofit options and guidance on performing a walk-through building survey. Several case studies are included. The manual is available as described in the bibliography.

Figure 17

TEN STEPS FOR IMMEDIATE ENERGY SAVINGS

1 Walk through your building. Are there areas that are unoccupied, or which can be vacated by making better use of the remaining areas? If so, turn off air conditioning, lights, ventilation and heating (where freezing is not a hazard) permanently. Isolate these areas from other spaces by doors, walls, or other means. If 10% or 15% of the building can be vacated, energy savings will follow almost in the same proportion.

2 Repair broken windows and leaking pipes or ducts; clean filters, radiators, light bulbs and fixtures; caulk leaks around doors, windows, louvers and openings. In many cases 5% to 15% energy savings are possible, especially in cold climates where infiltration of cold air increases the heating load and causes your heating system to operate longer hours.

3 Shut off lights where not needed. Post colored signs alongside the switch to remind the occupants to do so.

4 Lower thermostats to 68°F in occupied areas during the heating season, and even lower in less critical areas. Lower the relative humidity settings to 20% in the winter. Raise thermostats to 78°F* or higher in the summer if your building is air conditioned, and shut off the air conditioner, fans and pumps at night, weekends and holidays. Savings of 6% to 15% in energy can be realized simply by resetting the control points.

5 Repair all leaky outdoor air dampers, and shut off all ventilation systems when the building is unoccupied. Outdoor air which must be heated or cooled often accounts for as much as 30% of the energy used in many buildings. More than half can be saved by night and weekend shutdown since there are more hours of low occupancy in those periods.

6 Have your oil burner and boiler or furnace checked. Clean soot and scale and adjust the firing rate, draft and combustion. The heating bill can be reduced by as much as 10% to 15% in many buildings; the colder the climate, the greater the savings.

7 Replace lamps with more efficient ones giving more lumens per watt; remove lamps in unoccupied spaces and disconnect ballasts. Many areas in the building require less illumination than others. Reduce lighting

* Exception where terminal reheat systems are installed.

levels in less critical areas by removing lamps and disconnecting ballasts. In schools, office buildings, and retail stores, lighting often accounts for up to 40% of all energy used and the heat from the lights also forms a major part of the air conditioning load. The energy used for lighting can be reduced by up to 20% to 40% in many buildings.

8 Clean your windows to let in more natural light. You may find that doing so will permit turning off some of the electric lights near the windows.

9 Set the aquastat lower on your water heater to save energy. In schools, hospitals and housing, domestic hot water often uses from 25% to 40% of the amount of energy required for space heating even in cold climates.

10 There are dozens of other energy conservation opportunities available with little, if any capital costs required (often labor only), depending upon the building orientation, number of windows; the roof and wall materials; the building location and use; and the characteristics of the heating, lighting and air conditioning systems.

SOURCE: Guidelines for Saving Energy in Existing Buildings; Building Owners and Operators Manual (ECM1), Federal Energy Administration, June 1975.

APPENDIX II

Energy Consumption Study Data Requirements: Method #2

The first step in establishing retrofit priorities is to collect basic energy consumption data for all buildings operated by the jurisdiction. This data is then compared for buildings of similar type (schools, offices, garages, fire stations, etc.). One commonly used method of comparison is to convert all energy consumption data to an MBTU (thousand British Thermal Unit) per square foot per year figure. The resulting number is called the Energy Utilization Index (EUI), or alternatively the Annual Efficiency Index (AEI). This index provides a first approximation of relative energy use for a group of buildings irrespective of the fuels they use. Higher EUI figures mean higher relative energy consumption. One note of caution, special factors such as climate and differing use patterns, for example, more hours of occupancy, may give an energy efficient building a higher EUI figure than a less used and less energy efficient building.

Figure 18 provides a data collection form which may be used for the energy consumption survey. One form is completed for each building. A Remarks and Comments section is provided on the form for use during a walk through survey or to note any special considerations or conditions that may affect the evaluation of the building. Figure 19 lists the energy conversion factors needed to convert fuel amounts into MBTU's.

The following is an explanation of the entries on the Building Energy Consumption Survey, Figure 18. They are listed in the order of their completion.

Building: Prepare the form for each building and identify the building by name.

Use Type: Identify the general function of the building, for example: school, fire station, garage, office, etc.

Expected Remaining Life: State the approximate number of years during which the jurisdiction will continue to use the building. Obtain data from the jurisdiction's capital development plan.

Year: Twelve month period for which data has been collected. Include the first and last months of the data collection period.

Annual Heating/Cooling Degree Days: Obtain data from weather bureau. Heating and cooling degree days are the differences between 65°F and the outdoor mean daily temperature added for each day of the year.

Gross Area: Obtain square foot data from building plans or from measurement. Use inside wall-to-wall dimensions.

Heated Area: Include the square feet of space normally heated during the winter. Subtract any unheated spaces, such as storage rooms, from gross square feet to arrive at this figure.

Cooled Area: Floor area, in square feet, only of those spaces which are air conditioned. Subtract area of spaces not air conditioned from gross square feet to arrive at this figure.

Normal Winter Thermostat: Identify thermostat setting (in degrees Fahrenheit) or average temperature maintained for winter operation during the year for which data was obtained.

Normal Summer Thermostat: Identify thermostat setting (in degrees Fahrenheit) for air conditioned areas. If unit is not controlled by a thermostat, write "manual."

Operating Hours: Indicate the hours of use for the building on a daily basis.

Operating Days: Write the number of days per week the building is in use and number of days the building is used during a year.

Street Address: Self explanatory.

Electricity: From previous electrical bills or meter readings indicate the total kilowatt hours of electrical energy consumed during the survey year. For MBTU's of electrical energy use the conversion factor in Figure 19. Also indicate cost of electricity for the year, obtained from billing records.

Gas: Obtain volume of gas consumption in MCF (thousand cubic feet), and annual gas charges from utility bills. Use Figure 19 to obtain annual MBTU's of gas energy.

Oil: Sum gallons of oil use by grade of oil (e.g. #2 oil, #4 oil). Note that different grades of oil have varying energy contents (Figure 19).

Steam: Enter total consumption of purchased steam in thousands (M) of pounds as shown on utility bills. Obtain energy content from Figure 19.

Coal: From previous bills indicate the amount (in short-tons) and cost for coal use. Energy content for coal is included in Figure 19.

Total: Sum MBTU/YR values for each fuel used. Sum costs in dollars for each fuel.

Annual Energy Cost per Square Feet: Divide annual energy costs obtained above by the square footage of heated or cooled space.

Energy Utilization Index: Divide the total energy consumption for all forms of energy (in MBTU's) by the square footage of heated or cooled space.

BUILDING ENERGY CONSUMPTION SURVEY

[illegible]

Building ______________________________

Use Type ______________________________

Heated/Cooled Space ______________________________ Sq. Ft.

Annual Energy Cost Per Sq. Ft. ______________________________ $/Yr.

Expected Remaining Life ______________________________ Years

Energy Utilization Index ______________________________ MBTU/Sq. Ft./Yr.

[illegible]

Year ______________________________ (From __________ to __________)

Annual Heating Degree Days ______________________________

Annual Cooling Degree Days ______________________________

[illegible]

Gross Area ______________ Sq. Ft.

Normal Winter Thermostat Setting __________ °F Heated Area __________ Sq. Ft.

Normal Summer Thermostat Setting __________ °F Cooled Area __________ Sq. Ft.

Operating Hours __________ Hours/Day

Operating Days __________ Days/Week __________ Days/Year

Street Address ______________________________

[illegible]

Electricity	________	KWH/Yr.	________	MBTU/Yr.	________	$/Yr.
Gas	________	MCF	________	MBTU/Yr.	________	$/Yr.
Oil	________	Gal.	________	MBTU/Yr.	________	$/Yr.
Steam	________	Mlbs	________	MBTU/Yr.	________	$/Yr.
Coal	________	Short tons	________	MBTU/Yr.	________	$/Yr.
TOTAL			________	MBTU/Yr.	________	$/Yr.

[illegible]

____

____

____

____

____

____

Figure 18
Building Energy Consumption Survey

ENERGY CONVERSION FACTORS (MBTU)

Electricity	____ KWH	x 3.41 =	________
#2 Oil	____ Gallons	x 139.0 =	________
#4 Oil	____ Gallons	x 150.0 =	________
#5 Oil	____ Gallons	x 152.0 =	________
#6 Oil	____ Gallons	x 153.0 =	________
Natural Gas	____ MCF (thousand cubic feet)	x 1031. =	________
Steam	____ Pounds x 1000	x 900 =	________
Coal	____ Short tons	x 26,000 =	________

Figure 19
Energy Conversion Factors (MBTU)

Sources: *Energy Management in Municipal Buildings*, Massachusetts Department of Community Affairs

Energy Conscious Redesign of Existing Buildings, AIA Research Corporation

APPENDIX III

FEA Method for Energy Consumption Study: Method #3

In conducting the Federal Energy Management Program, the Federal Energy Administration developed detailed procedures for energy consumption studies as discussed below. Its focus is to assist building managers in quickly identifying specific retrofit opportunities with high payoff.

Climatic charts used in the FEA method are contained in Appendix 4. Specific retrofit opportunities discussed by FEA are listed in Appendix 5.

There are numerous engineering and government manuals that include building retrofit projects that will save energy. The examples provided in those manuals are based on the success of similar projects in prior applications. The method provided by FEA is designed to build on this success by relating the appropriate, proven projects to specific energy use systems that can be easily identified in a given building or facility.

The method employed parallels that used in a full-scale engineering survey. However, checklists, reference tables, and simple calculations based on the experience of others are substituted for the more complex analysis and measurements entailed in a full-scale engineering effort. The method, of course, cannot provide the precision of an engineering study, but it is not intended to. Its purpose is only to identify sound retrofit projects and provide approximate measures of their relative merits for budgetary planning; not to develop engineering designs of the projects themselves. Moreover, FEA's need for results within a 3-month time frame dictated that the survey method be streamlined and simplified.

There are four steps in this procedure. They are:

<u>Step 1</u> - Collecting Energy Use Data - This step provides fuel cost data necessary to calculate cost savings in a later step, and also provides an overall sense of priority for retrofit projects. Fuel forms that account for the largest part of the total fuel bill should receive greatest emphasis in planning retrofit projects.

Step 2 - Categorizing Buildings - In this step, all of the buildings at a facility are ranked in terms of size, and thus by their probable energy use; buildings are categorized into types; and the climate zone that corresponds to a facility's location is identified.

Step 3 - Identifying Retrofit Options - In this step, reference tables link appropriate candidate retrofit options with specific energy systems as a function of building type and the climate zone in which the building is located. In addition, retrofit projects already planned can be easily incorporated.

Step 4 - Evaluation and Ranking Retrofit Projects - In this step the energy cost and cost savings of individual retrofit projects are calculated, along with their associated investment costs. The options are then ranked in terms of the time it would take for them to pay back their investment cost.

For each task, either a sample table, referenced tables, or worksheet is provided. When completed, these materials can be combined to provide reports on retrofit options for individual buildings and for the entire group of buildings that make up a facility.

The following example on roof insulation illustrates how the FEA audit procedure works:

EXAMPLE: INSTALL ROOF INSULATION

If the building is three stories or less, the installation of roof insulation can save energy. If no insulation exists, then it is possible to save 10 percent of the energy used for heating by installing six inches (or equivalent) of insulation.

Preliminary Data Collection - Measure the square footage of roof area that does not have insulation. To find the potential energy savings, the amount of BTU's used for heating must be known. If separate fuel bills are available for the building, and if the fuel source for heating is fuel oil, the BTU use for heating is represented directly by the fuel bills. If gas is used as the fuel for heating, 80 percent of the total bill can be used as the estimate of the amount of heating. If the buildings are heated with electricity, or if bills are not available for individual buildings, an engineering estimate is needed to provide inputs of sufficient accuracy to estimate the potential of this option.

Energy Savings (BTU's/year) - .1 x number of BTU's used for heating.

Energy Cost Savings/year - Energy savings x $/BTU.

Capital Cost ($) - As an estimate, insulation probably will not exceed $3.00 per square foot of roof area.

Three manuals can be obtained by jurisdictions interested in the FEA auditing procedures:

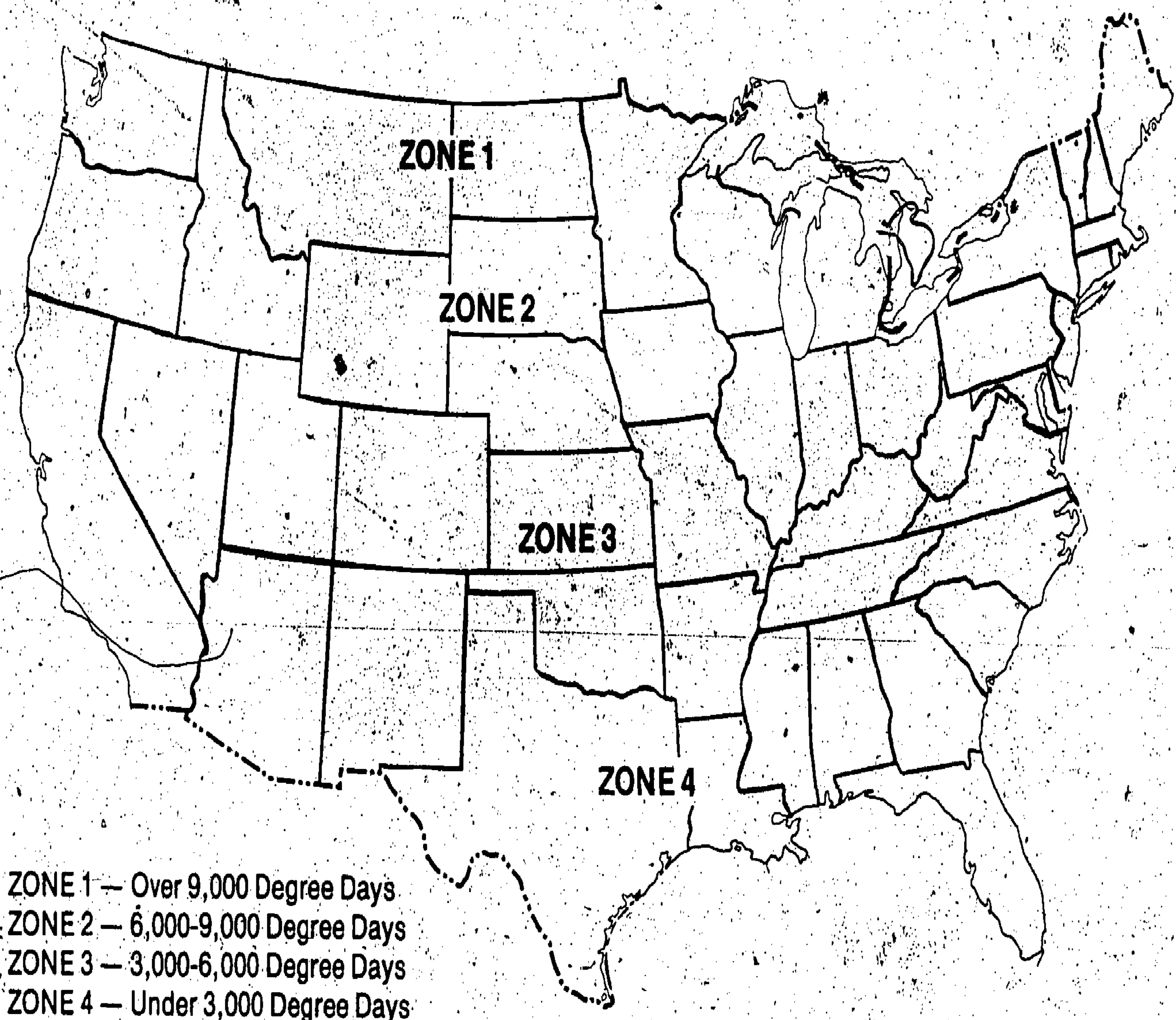
Identifying Retrofit Projects for Federal Buildings, Federal Energy Administration, July 1976.

Energy Conservation: Guidelines for Saving Energy in Existing Buildings; Building Owners and Operators Manual (ECM1), Conservation Paper No. 20, Federal Energy Administration, Office of Energy Conservation and Environment, June 16, 1975.

Energy Conservation: Guidelines for Saving Energy in Existing Buildings: Engineers, Architects and Operators Manual (ECM2) Conservation Paper No. 21, Federal Energy Administration, Office of Conservation and Environment, June 16, 1975.

APPENDIX IV

United States Climatic Zones



ZONE 1 — Over 9,000 Degree Days
ZONE 2 — 6,000-9,000 Degree Days
ZONE 3 — 3,000-6,000 Degree Days
ZONE 4 — Under 3,000 Degree Days

Appendix 4
United States—Climatic Zones

APPENDIX V

Retrofit Options by Climate Zones

ZONE 1
RETROFIT OPTIONS

		POTENTIAL OPTIONS BY BUILDING TYPE				
		Office	Hospital	Research and Development	Multi-Family Housing	Warehouses
Heating and Ventilation	Insulate Hot Bare Pipes	•	•	•	•	•
	Install Caulking and Weather Stripping	•	•	•	•	
	Install Roof Insulation			•	•	•
	Install Double Glazing				•	
	Install Wall Insulation				•	•
	Install Loading Dock Door Seals					•
	Preheat Combustion Air	•	•	•	•	•
	Replace Worn Boiler Controls	•	•	•	•	•
	Insulate Steam Lines	•	•	•	•	•
	Install and/or Replace Steam Traps	•	•	•	•	•
	Return Steam Condensate to Boiler	•	•	•	•	•
	Install Economizer Cycle	•	•	•		
	Shut Down Air Distribution System	•		•		
	Reduce Air Volume	•	•	•		•
	Install Automatic Thermostats	•		•	•	•
	Close Off Unoccupied Areas	•	•	•	•	•
	Install Heat Recovery Equipment	•	•	•		
	Prevent Air Stratification					•
Lighting	Use Energy Conserving Fluorescent Lamps	•	•	•	•	•
	Remove Lamps or Fixtures	•	•	•	•	•
	Install Switching	•	•	•		•
	Replace Incandescent Lighting					•
	Use More Efficient Lighting Sources	•	•	•		•
	Design Lighting for Specific Task	•	•	•		
	Lower Height of Lighting Fixtures					•
	Remove Lights Over Stacks					•
	Control Exterior Lighting	•	•	•	•	•
Cooling	Replace Inefficient Air Conditioners	•	•	•	•	
	Install Time Clocks for Air Conditioners	•	•	•		
	Install Temperature Controller and Sensor	•	•	•	•	
	Install Amperage Limiting Devices	•	•	•	•	
Water Heating	Install Decentralized Water Heating		•		•	
	Install Efficient Nozzles and Faucets		•		•	
	Use Waste Heat for Water Heating		•		•	
	Insulate Hot Bare Pipes	•	•	•	•	•
Miscellaneous	Control Elevator Operation	•	•	•	•	
	Correct Poor Power Factor	•	•	•	•	•

Appendix 5a
Climate Zone 1 Retrofit Options

ZONE 2
RETROFIT OPTIONS

		POTENTIAL OPTIONS BY BUILDING TYPE				
		Office	Hospital	Research and Development	Multi-Family Housing	Warehouses
Heating and Ventilation	Insulate Hot Bare Pipes	•	•	•	•	•
	Install Caulking and Weather Stripping	•	•	•	•	
	Install Roof Insulation			•	•	•
	Install Double Glazing				•	
	Install Wall Insulation				•	•
	Install Loading Dock Door Seals					•
	Preheat Combustion Air	•		•	•	•
	Replace Worn Boiler Controls	•	•	•	•	•
	Insulate Steam Lines	•	•	•	•	•
	Install and/or Replace Steam Traps	•	•	•	•	•
	Return Steam Condensate to Boiler	•	•	•	•	•
	Install Economizer Cycle	•	•	•		
	Shut Down Air Distribution System	•		•		
	Reduce Air Volume	•	•	•		•
	Install Automatic Thermostats	•		•	•	•
	Close Off Unoccupied Areas	•	•	•	•	•
	Install Heat Recovery Equipment	•	•	•		
	Prevent Air Stratification					•
Lighting	Use Energy Conserving Fluorescent Lamps	•	•	•	•	•
	Remove Lamps or Fixtures	•	•	•	•	•
	Install Switching	•	•	•		•
	Replace Incandescent Lighting					•
	Use More Efficient Lighting Sources	•	•	•		•
	Design Lighting for Specific Task	•	•	•		
	Lower Height of Lighting Fixtures					•
	Remove Lights Over Stacks					•
	Control Exterior Lighting	•	•	•	•	•
Cooling	Replace Inefficient Air Conditioners	•	•	•	•	•
	Install Time Clocks for Air Conditioners	•	•	•		
	Install Temperature Controller and Sensor	•	•	•	•	
	Install Amperage Limiting Devices	•	•	•	•	
Water Heating	Install Decentralized Water Heating				•	
	Install Efficient Nozzles and Faucets		•		•	
	Use Waste Heat for Water Heating		•		•	
	Insulate Hot Bare Pipes	•	•	•	•	•
Miscellaneous	Control Elevator Operation	•	•	•	•	
	Correct Poor Power Factor	•	•	•	•	•

Appendix 5b
Climate Zone 2 Retrofit Options

ZONE 3
RETROFIT OPTIONS

		Office	Hospital	Research and Development	Multi-Family Housing	Warehouses
		POTENTIAL OPTIONS BY BUILDING TYPE				
Heating and Ventilation	Insulate Hot Bare Pipes	•	•	•	•	•
	Install Roof Insulation			•	•	•
	Install Loading Dock Door Seals					•
	Preheat Combustion Air	•	•	•	•	•
	Replace Worn Boiler Controls	•	•	•	•	•
	Insulate Steam Lines	•	•	•	•	•
	Install and/or Replace Steam Traps	•	•	•	•	•
	Return Steam Condensate to Boiler	•	•	•	•	•
	Install Economizer Cycle	•	•	•		
	Shut Down Air Distribution System	•		•		•
	Reduce Air Volume	•	•	•		•
	Install Automatic Thermostats	•	•	•		•
	Close Off Unoccupied Areas	•	•	•	•	•
	Install Heat Recovery Equipment	•	•	•		
	Prevent Air Stratification					•
Lighting	Use Energy Conserving Fluorescent Lamps	•	•	•	•	•
	Remove Lamps or Fixtures	•	•	•	•	•
	Install Switching	•	•	•		•
	Replace Incandescent Lighting					•
	Use More Efficient Lighting Sources	•	•	•		•
	Design Lighting for Specific Task	•	•	•		•
	Lower Height of Lighting Fixtures					•
	Remove Lights Over Stacks					•
	Control Exterior Lighting	•	•	•		•
Cooling	Replace Inefficient Air Conditioners	•	•	•	•	
	Install Time Clocks for Air Conditioners	•	•	•		
	Install Temperature Controller and Sensor	•	•	•	•	
	Install Amperage Limiting Devices	•	•	•	•	
Water Heating	Install Decentralized Water Heating		•		•	
	Install Efficient Nozzles and Faucets		•		•	
	Use Waste Heat for Water Heating		•		•	
	Insulate Hot Bare Pipes	•	•	•	•	•
Miscellaneous	Control Elevator Operation	•	•	•	•	•
	Correct Poor Power Factor	•	•	•	•	•

Appendix 5c
Climate Zone 3 Retrofit Options

ZONE 4
RETROFIT OPTIONS

		POTENTIAL OPTIONS BY BUILDING TYPE				
		Office	Hospital	Research and Development	Multi-Family Housing	Warehouses
Cooling and Ventilation	Replace Inefficient Air Conditioners	•	•	•	•	
	Install Time Clocks for Air Conditioners	•	•	•		
	Install Temperature Controller and Sensor	•	•	•	•	
	Install Amperage Limiting Devices	•	•	•	•	
	Control Solar Heat Gain	•	•	•	•	
	Install Economizer Cycle	•	•	•		
	Shut Down Air Distribution System	•		•		•
	Reduce Air Volume	•	•	•		
	Install Automatic Thermostats	•	•	•		•
	Close Off Unoccupied Areas	•	•	•	•	•
	Install Heat Recovery Equipment	•	•	•		
	Prevent Air Stratification					•
Lighting	Use Energy-Conserving Fluorescent Lamps	•	•	•	•	•
	Remove Lamps or Fixtures	•	•	•	•	•
	Install Switching	•	•	•		•
	Replace Incandescent Lighting					•
	Use More Efficient Lighting Sources	•	•	•		•
	Design Lighting for Specific Task	•	•	•		
	Lower Height of Lighting Fixtures					•
	Remove Lights Over Stacks					•
	Control Exterior Lighting	•	•	•	•	•
Heating	Insulate Hot Bare Pipes	•	•	•	•	•
	Preheat Combustion Air	•	•	•	•	•
	Replace Worn Boiler Controls	•	•	•	•	•
	Insulate Steam Lines	•	•	•	•	•
	Install and/or Replace Steam Traps	•	•	•	•	•
	Return Steam Condensate to Boiler	•	•	•	•	•
Water Heating	Install Decentralized Water Heating		•		•	
	Install Efficient Nozzles and Faucets		•		•	
	Use Waste Heat for Water Heating		•		•	
	Insulate Hot Bare Pipes	•	•	•	•	•
Miscellaneous	Control Elevator Operation	•	•	•	•	
	Correct Poor Power Factor	•	•	•	•	•

Appendix 5d
Climate Zone 4 Retrofit Options

APPENDIX VI

GSA Qualification Statement Forms

STANDARD FORM (SF) 254

Architect-Engineer and Related Services Questionnaire

Standard Form 254
General Services Administration,
Washington, D. C. 20405
Fed. Proc. Reg. (41 CFR) 1-16.803
Armed Svc. Proc. Reg. 18-403

Purpose:

The policy of the Federal Government, in procuring architectural, engineering, and related professional services, is to encourage firms lawfully engaged in the practice of those professions to submit annually a statement of qualifications and performance data. Standard Form 254, "Architect-Engineer and Related Services Questionnaire" is provided for that purpose. Interested A-E firms (including new, small, and/or minority firms) should complete and file SF 254's with each Federal agency and with appropriate regional or district offices for which the A-E is qualified to perform services. The agency head for each proposed project shall evaluate these qualification resumes, together with any other performance data on file or requested by the agency, in relation to the proposed project. The SF 254 may be used as a basis for selecting firms for discussions, or for screening firms preliminary to inviting submission of additional information.

Definitions:

"Architect-engineer and related services" are those professional services associated with research, development, design and construction, alteration, or repair of real property, as well as incidental services that members of these professions and those in their employ may logically or justifiably perform, including studies, investigations, surveys, evaluations, consultations, planning, programming, conceptual designs, plans and specifications, cost estimates, inspections, shop drawing reviews, sample recommendations, preparation of operating and maintenance manuals, and other related services.

"Parent Company" is that firm, company, corporation, association or conglomerate which is the major stockholder or highest tier owner of the firm completing this questionnaire; i.e. Firm A is owned by Firm B which is, in turn, a subsidiary of Corporation C. The "parent company" of Firm A is Corporation C.

"Principals" are those individuals in a firm who possess legal responsibility for its management. They may be owners, partners, corporate officers, associates, administrators, etc.

"Discipline", as used in this questionnaire, refers to the primary technological capability of individuals in the responding firm. Possession of an academic degree, professional registration, certification, or extensive experience in a particular field of practice normally reflects an individual's primary technical discipline.

"Joint Venture" is a collaborative undertaking by two or more firms or individuals for which the participants are both jointly and individually responsible.

"Consultant", as used in this questionnaire, is a highly specialized individual or firm having significant input and responsibility for certain aspects of a project and possessing unusual or unique capabilities for assuring success of the finished work.

"Prime" refers to that firm which may be coordinating the concerted and complementary inputs of several firms, individuals or related services to produce a completed study or facility. The "prime" would normally be regarded as having full responsibility and liability for quality of performance by itself as well as by subcontractor professionals under its jurisdiction.

"Branch Office" is a satellite, or subsidiary extension, of a headquarters office of a company, regardless of any differences in name or legal structure of such a branch due to local or state laws. "Branch offices" are normally subject to the management decisions, bookkeeping, and policies of the main office.

Instructions for Filing (Numbers below correspond to numbers contained in form):

1. Type accurate and complete name of submitting firm, its address, and zip code.

   1a. Indicate whether form is being submitted in behalf of a parent firm or a branch office. (Branch office submissions should list only personnel in, and experience of, that office.)

2. Provide date the firm was established under the name shown in question 1.

3. Show date upon which all submitted information is current and accurate.

4. Enter type of ownership, or legal structure, of firm (sole proprietor, partnership, corporation, joint venture, etc.)

   4a. Check appropriate box indicating if firm is minority-owned. (See 41 CFR 1-1.13 or ASPR 1-332.3(a) for definition of minority ownership.)

5. Branches or subsidiaries of larger or parent companies, or conglomerates, should insert name and address of highest-tier owner.

   5a. If present firm is the successor to, or outgrowth of, one or more predecessor firms, show name(s) of former entity(ies) and the year(s) of their original establishment.

6. List not more than two principals from submitting firm who may be contacted by the agency receiving this form. (Different principals may be listed on forms going to another agency.) Listed principals must be empowered to speak for the firm on policy and contractual matters.

7. Beginning with the submitting office, list name, location, total number of personnel and telephone numbers for all associated or branch offices, (including any headquarters or foreign offices) which provide A-E and related services.

   7a. Show total personnel in all offices. (Should be sum of all personnel, all branches.)

8. Show total number of employees, by discipline, in submitting office. (If form is being submitted by main or headquarters office, firm should list total employees, by discipline, in **all** offices.) While some personnel may be qualified in several disciplines, each person should be counted only once in accord with his or her primary function. Include clerical personnel as "administrative."

Standard Form 254 July 1975
Prescribed By GSA Fed. Proc. Reg. (41 CFR) 1-16.803

STANDARD FORM (SF) 254

Architect-Engineer and Related Services Questionnaire

Standard Form 254
General Services Administration
Washington, D.C. 20405
Fed. Proc. Reg. (41 CFR) 1-16.803
Armed Svc. Proc. Reg. 18-403

[illegible] any additional disciplines – sociologists, biologists, etc. – and number [illegible] each, in blank spaces.

9. [illegible] (below) insert appropriate index number to indicate range of [illegible] services fees received by submitting firm each calendar year for [illegible] recent year first. Fee summaries should be broken down to [illegible] each year for (a) work performed directly for the Federal [illegible] grant and loan projects) or as a sub to other profes[illegible] directly for the Federal Government; (b) all other [illegible] U.S. and possessions, including Federally-assisted projects, and [illegible] all other foreign work.

Ranges of Professional Services Fees

INDEX		INDEX	
1.	Less than $100,000	5.	$1 million to $2 million
2.	$100,000 to $250,000	6.	$2 million to $5 million
3.	$250,000 to $500,000	7.	$5 million to $10 million
4.	$500,000 to $1 million	8.	$10 million or greater

10. Select and enter, in numerical sequence, **not more than thirty** (30) "Experience Profile Code" numbers from the listing (next page) which most accurately reflect submitting firm's demonstrated technical capabilities and project experience. **Carefully review list.** (It is recognized some profile codes may be part of other services or projects contained on list; firms are encouraged to select profile codes which best indicate type and scope of services provided on past projects.) For each code number, show total number of projects and gross fees (in thousands) received for profile projects performed by firm during past five years. If firm has one or more capabilities not included on list, insert same in blank spaces at end of list and show numbers in question 10 on the form. In such cases, the filled-in listing **must** accompany the complete SF 254 when submitted to the Federal agencies.

11. Using the "Experience Profile Code" numbers in the same sequence as entered in item 10, give details of at least one recent (within last five years) representative project for each code number, up to a **maximum** of thirty (30) separate projects, or portions of projects, for which firm was responsible. (Project examples may be used more than once to illustrate different services rendered on the same job. Example: a dining hall may be part of an auditorium or educational facility.) Firms which select less than thirty "profile codes" may list two or more project examples (to illustrate specialization) for each code number so long as total of all project examples does not exceed thirty (30). After each code number in question 11, show: (a) whether firm was "P," the prime professional, or "C," a consultant, or "JV," part of a joint venture on that particular project (New firms, in existence less than five (5) years may use the symbol "IE" to indicate "Individual Experience" as opposed to firm experience.); (b) provide name and location of the specific project which typifies firm's (or individual's) performance under that code category; (c) give name and address of the owner of that project (if government agency indicate responsible office); (d) show the estimated construction cost (or other applicable cost) for that portion of the project for which the firm was primarily responsible. (Where no construction was involved, show approximate cost of firm's work); and (e) state year work on that particular project was, or will be, completed.

12. The completed SF 254 should be signed by a principal of the firm, preferably the chief executive officer.

13. Additional data, brochures, photos, etc. should not accompany this form unless specifically requested.

NEW FIRMS (not reorganized or recently-amalgamated firms) are eligible and encouraged to seek work from the Federal Government in connection with performance of projects for which they are qualified. Such firms are encouraged to complete and submit Standard Form 254 to appropriate agencies. Questions on the form dealing with personnel or experience may be answered by citing experience and capabilities of individuals in the firm, based on performance and responsibility while in the employ of others. In so doing, notation of this fact should be made on the form. In question 9, write in "N/A," to indicate "not applicable" for those years prior to firm's organization.

Experience Profile Code Numbers
for use with questions 10 and 11

001 Acoustics; Noise Abatement
002 Aerial Photogrammetry
003 Agricultural Development; Grain Storage; Farm Mechanization
004 Air Pollution Control
005 Airports; Navaids; Airport Lighting; Aircraft Fueling
006 Airports; Terminals & Hangars; Freight Handling
007 Arctic Facilities
008 Auditoriums & Theatres
009 Automation; Controls; Instrumentation
010 Barracks; Dormitories
011 Bridges
012 Cemeteries *(Planning & Relocation)*
013 Chemical Processing & Storage
014 Churches; Chapels
015 Codes; Standards; Ordinances
016 Cold Storage; Refrigeration; Fast Freeze
017 Commercial Buildings *(low rise)*; Shopping Centers
018 Communications Systems; TV; Microwave
019 Computer Facilities; Computer Service
020 Conservation and Resource Management
021 Construction Management
022 Corrosion Control; Cathodic Protection; Electrolysis
023 Cost Estimating
024 Dams *(Concrete; Arch)*
025 Dams *(Earth; Rock)*; Dikes; Levees
026 Desalinization *(Process & Facilities)*
027 Dining Halls; Clubs; Restaurants
028 Ecological & Archeological Investigations
029 Educational Facilities; Classrooms
030 Electronics
031 Elevators; Escalators; People-Movers
032 Energy Conservation; New Energy Sources
033 Environmental Impact Studies, Assessments or Statements
034 Fallout Shelters; Blast-Resistant Design
035 Field Houses; Gyms; Stadiums
036 Fire Protection
037 Fisheries; Fish Ladders
038 Forestry & Forest Products
039 Garages; Vehicle Maintenance Facilities; Parking Decks
040 Gas Systems *(Propane; Natural, Etc.)*
041 Graphic Design
042 Harbors; Jetties; Piers; Ship Terminal Facilities
043 Heating; Ventilating; Air Conditioning
044 Health Systems Planning
045 Highrise; Air-Rights-Type Buildings
046 Highways; Streets; Airfield Paving; Parking Lots
047 Historical Preservation
048 Hospitals & Medical Facilities
049 Hotels; Motels
050 Housing *(Residential, Multi-Family; Apartments; Condominiums)*
051 Hydraulics & Pneumatics
052 Industrial Buildings; Manufacturing Plants
053 Industrial Processes; Quality Control
054 Industrial Waste Treatment
055 Interior Design; Space Planning
056 Irrigation; Drainage
057 Judicial and Courtroom Facilities
058 Laboratories; Medical Research Facilities
059 Landscape Architecture
060 Libraries; Museums; Galleries
061 Lighting *(Interiors; Display; Theatre, Etc.)*
062 Lighting *(Exteriors; Streets; Memorials; Athletic Fields, Etc.)*
063 Materials Handling Systems; Conveyors; Sorters
064 Metallurgy
065 Microclimatology; Tropical Engineering
066 Military Design Standards
067 Mining & Mineralogy
068 Missile Facilities *(Silos; Fuels; Transport)*
069 Modular Systems Design; Pre-Fabricated Structures or Components
070 Naval Architecture; Off-Shore Platforms
071 Nuclear Facilities; Nuclear Shielding
072 Office Buildings; Industrial Parks
073 Oceanographic Engineering
074 Ordnance; Munitions; Special Weapons
075 Petroleum Exploration; Refining
076 Petroleum and Fuel *(Storage and Distribution)*
077 Pipelines *(Cross-Country—Liquid & Gas)*
078 Planning *(Community, Regional, Areawide and State)*
079 Planning *(Site, Installation, and Project)*
080 Plumbing & Piping Design
081 Pneumatic Structures; Air-Support Buildings
082 Postal Facilities
083 Power Generation, Transmission, Distribution
084 Prisons & Correctional Facilities
085 Product, Machine & Equipment Design
086 Radar; Sonar; Radio & Radar Telescopes
087 Railroad; Rapid Transit
088 Recreation Facilities *(Parks, Marinas, Etc.)*
089 Rehabilitation *(Buildings; Structures; Facilities)*
090 Resource Recovery; Recycling
091 Radio Frequency Systems & Shieldings
092 Rivers; Canals; Waterways; Flood Control
093 Safety Engineering; Accident Studies; OSHA Studies
094 Security Systems; Intruder & Smoke Detection
095 Seismic Designs & Studies
096 Sewage Collection, Treatment and Disposal
097 Soils & Geologic Studies; Foundations
098 Solar Energy Utilization
099 Solid Wastes; Incineration; Land Fill
100 Special Environments; Clean Rooms, Etc.
101 Structural Design; Special Structures
102 Surveying; Platting; Mapping; Flood Plain Studies
103 Swimming Pools
104 Storm Water Handling & Facilities
105 Telephone Systems *(Rural; Mobile; Intercom, Etc.)*
106 Testing & Inspection Services
107 Traffic & Transportation Engineering
108 Towers *(Self-Supporting & Guyed Systems)*
109 Tunnels & Subways
110 Urban Renewal; Community Development
111 Utilities *(Gas & Steam)*
112 Value Analysis; Life-Cycle Costing
113 Warehouses & Depots
114 Water Resources; Hydrology; Ground Water
115 Water Supply, Treatment and Distribution
116 Wind Tunnels; Research/Testing Facilities Design
117 Zoning; Land Use Studies
201 ______________________
202 ______________________
203 ______________________
204 ______________________
205 ______________________

OMB Approval No. 29-RO234

STANDARD FORM (SF) 254
Architect-Engineer and Related Services Questionnaire

1. Firm Name / Business Address:

1a. Submittal is for ☐ Parent Company ☐ Branch Office

2. Year Present Firm Established:

3. Date Prepared:

4. Type of Ownership:

4a. Minority Owned ☐ yes ☐ no

5. Name of Parent Company, if any:

5a. Former Firm Name(s), if any, and Year(s) Established:

6. Names of not more than Two Principals to Contact: Title / Telephone

1)
2)

7. Present Offices: City / State / Telephone / No. Personnel Each Office

7a. Total Personnel ______

8. Personnel by Discipline:

___ Administrative	___ Electrical Engineers	___ Oceanographers	______
___ Architects	___ Estimators	___ Planners: Urban/Regional	______
___ Chemical Engineers	___ Geologists	___ Sanitary Engineers	______
___ Civil Engineers	___ Hydrologists	___ Soils Engineers	______
___ Construction Inspectors	___ Interior Designers	___ Specification Writers	______
___ Draftsmen	___ Landscape Architects	___ Structural Engineers	______
___ Ecologists	___ Mechanical Engineers	___ Surveyors	______
___ Economists	___ Mining Engineers	___ Transportation Engineers	______

9. Summary of Professional Services Fees Received: (insert index number)

Last 5 Years (most recent year first)

	19___	19___	19___	19___	19___
Direct Federal contract work, including overseas					
All other domestic work					
All other foreign work*					

*Firms interested in foreign work, but without such experience, check here: ☐

Ranges of Professional Services Fees

INDEX
1. Less than $100,000
2. $100,000 to $250,000
3. $250,000 to $500,000
4. $500,000 to $1 million
5. $1 million to $2 million
6. $2 million to $5 million
7. $5 million to $10 million
8. $10 million or greater

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10. Profile of Firm's Project Experience, Last 5 Years

Profile Code	Number of Projects	Total Gross Fees (in thousands)	Profile Code	Number of Projects	Total Gross Fees (in thousands)	Profile Code	Number of Projects	Total Gross Fees (in thousands)
1)			11)			21)		
2)			12)			22)		
3)			13)			23)		
4)			14)			24)		
5)			15)			25)		
6)			16)			26)		
7)			17)			27)		
8)			18)			28)		
9)			19)			29)		
10)			20)			30)		

11. Project Examples, Last 5 Years

Profile Code	"P", "C", "JV", or "IE"	Project Name and Location	Owner Name and Address	Cost of Work (in thousands)	Completion Date (Actual or Estimated)
		1			
		2			
		3			
		4			
		5			
		6			
		7			

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		28			
		29			
		30			

12. The foregoing is a statement of facts

Signature: ____________ Typed Name, and Title: ____________

Date:

STANDARD FORM (SF) 255

Architect-Engineer and Related Services Questionnaire for Specific Project

Standard Form 255
General Services Administration,
Washington, D.C. 20405
Fed. Proc. Reg. (41 CFR) 1-16.803
Armed Svc. Proc. Reg. 18-403

Purpose:

This form is a supplement to the "Architect-Engineer and Related Services Questionnaire" (SF 254). Its purpose is to provide additional information regarding the qualifications of interested firms to undertake a specific Federal A-E project. Firms, or branch offices of firms, submitting this form should enclose (or already have on file with the appropriate office of the agency) a current (within the past year) and accurate copy of the SF 254 for that office.

The procurement official responsible for each proposed project may request submission of the SF 255 "Architect-Engineer and Related Services Questionnaire for Specific Project" in accord with applicable civilian and military procurement regulations and shall evaluate such submissions, as well as related information contained on the Standard Form 254, and any other performance data on file with the agency, and shall select firms for subsequent discussions leading to contract award in conformance with Public Law 92-582. This form should only be filed by an architect-engineer or related services firm when requested to do so by the agency or by a public announcement. Responses should be as complete and accurate as possible, contain data relative to the specific project for which you wish to be considered, and should be provided, by the required due date, to the office specified in the request or public announcement.

This form will be used only for the specified project. Do not refer to this submittal in response to other requests or public announcements.

Definitions:

"Architect-engineer and related services" are those professional services associated with research, development, design and construction, alteration, or repair of real property, as well as incidental services that members of these professions and those in their employ may logically or justifiably perform, including studies, investigations, surveys, evaluations, consultations, planning, programming, conceptual designs, plans and specifications, cost estimates, inspections, shop drawing reviews, sample recommendations, preparation of operating and maintenance manuals, and other related services.

"Principals" are those individuals in a firm who possess legal responsibility for its management. They may be owners, partners, corporate officers, associates, administrators, etc.

"Discipline", as used in this questionnaire, refers to the primary technological capability of individuals in the responding firm. Possession of an academic degree, professional registration, certification, or extensive experience in a particular field of practice normally reflects an individual's primary technical discipline.

"Joint Venture", is a collaborative undertaking of two or more firms or individuals for which the participants are both jointly and individually responsible.

"Key Persons, Specialists, and Individual Consultants", as used in this questionnaire, refer to individuals who will have **major** project responsibility or will provide **unusual or unique** capabilities for the project under consideration.

Instructions for Filing (Numbers below correspond to numbers contained in form):

1. Give name and location of the project for which this form is being submitted.

2. Provide appropriate data from the *Commerce Business Daily* (CBD) identifying the particular project for which this form is being filed.

2a. Give the date of the *Commerce Business Daily* in which the project announcement appeared, or indicate "not applicable" (N/A) if the source of the announcement is other than the CBD.

2b. Indicate Agency identification or contract number as provided in the CBD announcement.

3. Show name of the individual or firm (or joint venture) which is submitting this form for the project.

3a. List the name, title, and telephone number of that principal who will serve as the point of contact. Such an individual must be empowered to speak for the firm on policy and contractual matters and should be familiar with the programs and procedures of the agency to which this form is directed.

3b. Give the address of the specific office which will have responsibility for performing the announced work.

4. Insert the number of personnel by discipline presently employed (on date of this form) at work location. While some personnel may be qualified in several disciplines, each person should be counted only once in accord with his or her primary function. Include clerical personnel as "administrative." Write in any additional disciplines—sociologists, biologists, etc.—and number of people in each, in blank spaces.

5. Answer only if this form is being submitted by a joint venture of two or more collaborating firms. Show the names and addresses of all individuals or organizations expected to be included as part of the joint venture and describe their particular areas of anticipated responsibility, (i.e., technical disciplines, administration, financial, sociological, environmental, etc.)

5a. Indicate, by checking the appropriate box, whether this particular joint venture has successfully worked together on other projects.

Each firm participating in the joint venture should have a Standard Form 254 on file with the contracting office receiving this form. Firms which do not have such forms on file should provide same immediately along with a notation

STANDARD FORM (SF) 255

Architect-Engineer and Related Services Questionnaire for Specific Project

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regarding their association with this joint venture submittal.

6. If respondent is not a joint venture, but intends to use outside (as opposed to in-house or permanently and formally affiliated) consultants or associates, he should provide names and addresses of all such individuals or firms, as well as their particular areas of technical/professional expertise, as it relates to this project. Existence of previous working relationships should be noted. If more than eight outside consultants or associates are anticipated, attach an additional sheet containing requested information.

7. Regardless of whether respondent is a joint venture or an independent firm, provide brief resumes of key personnel expected to participate on this project. Care should be taken to limit resumes to only those personnel and specialists who will have major project responsibilities. Each resume must include: (a) name of each key person and specialist and his or her title, (b) the project assignment or role which that person will be expected to fulfill in connection with this project, (c) the name of the firm or organization, if any, with whom that individual is presently associated, (d) years of relevant experience with present firm and other firms, (e) the highest academic degree achieved and the discipline covered (if more than one highest degree, such as two Ph.D.'s, list both), the year received and the particular technical/professional discipline which that individual will bring to the project, (f) if registered as an architect, engineer, surveyor, etc., show only the field of registration and the year that such registration was first acquired. If registered in several states, do not list states, and (g) a synopsis of experience, training, or other qualities which reflect individual's potential contribution to this project. Include such data as: familiarity with Government or agency procedures, similar type of work performed in the past, management abilities, familiarity with the geographic area, relevant foreign language capabilities, etc. Please limit synopsis of experience to directly relevant information.

8. List up to ten projects which demonstrate the firm's or joint venture's competence to perform work similar to that likely to be required on this project. The more recent such projects, the better. Prime consideration will be given to projects which illustrate respondent's capability for performing work similar to that being sought. Required information must include: (a) name and location of project, (b) brief description of type and extent of services provided for each project (submissions by joint ventures should indicate which member of the joint venture was the prime on that particular project and what role it played), (c) name and address of the owner of that project (if Government agency, indicate responsible office), (d) completion date (actual or estimated), (e) total construction cost of completed project, (or where no construction was involved, the approximate cost of your work) and that portion of the cost of the project for which the named firm was/is responsible.

9. List only those projects which the A-E firm or joint venture, or members of the joint venture, are currently performing under direct contract with an agency or department of the Federal Government. Exclude any grant or loan projects being financed by the Federal Government but being performed under contract to other non Federal governmental entities. Information provided under each heading is similar to that requested in the preceding Item 8, except for (d) "Percent Complete." Indicate in this item the percentage of A-E work completed upon filing this form.

10. Through narrative discussion, show reason why the firm or joint venture submitting this questionnaire believes it is especially qualified to undertake the project. Information provided should include, but not be limited to, such data as: specialized equipment available for this work, any awards or recognition received by a firm or individuals for similar work, required security clearances, special approaches or concepts developed by the firm relevant to this project, etc. Respondents may say anything they wish in support of their qualifications. When appropriate, respondents may supplement this proposal with graphic material and photographs which best demonstrate design capabilities of the team proposed for this project.

11. Completed forms should be signed by the chief executive officer of the joint venture (thereby attesting to the concurrence and commitment of all members of the joint venture), or by the architect-engineer principal responsible for the conduct of the work in the event it is awarded to the organization submitting this form. Joint ventures selected for subsequent discussions regarding this project must make available a statement of participation signed by a principal of each member of the joint venture. ALL INFORMATION CONTAINED IN THE FORM SHOULD BE CURRENT AND FACTUAL.

OMB Approval No. 29-RO235

STANDARD FORM (SF) 255 Architect-Engineer Related Services for Specific Project	1. Project Name / Location for which Firm is Filing:	2a. *Commerce Business Daily* Announcement Date, if any:	2b. Agency Identification Number, if any:

3. Firm (or Joint-Venture) Name & Address

3a. Name, Title & Telephone Number of Principal to Contact

3b. Address of office to perform work, if different from Item 3

4. Personnel by Discipline:

___ Administrative
___ Architects
___ Chemical Engineers
___ Civil Engineers
___ Construction Inspectors
___ Draftsmen
___ Ecologists
___ Economists
___ Electrical Engineers
___ Estimators
___ Geologists
___ Hydrologists
___ Interior Designers
___ Landscape Architects
___ Mechanical Engineers
___ Mining Engineers
___ Oceanographers
___ Planners: Urban/Regional
___ Sanitary Engineers
___ Soils Engineers
___ Specification Writers
___ Structural Engineers
___ Surveyors
___ Transportation Engineers
___ Total Personnel

5. If submittal is by Joint-Venture list participating firms and outline specific areas of responsibility (including administrative, technical and financial) for each firm: (Attach SF 254 for each if not on file with Procuring Office.)

5a. Has this Joint-Venture previously worked together? ☐ yes ☐ no

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6. Outside Key Consultants/Associates Anticipated for this Project (Attach SF 254 for Consultants/Associates Listed, if not already of file with the Procuring Office)

Name & Address	Specialty	Worked with Prime before (Yes or No)
1)		
2)		
3)		
4)		
5)		
6)		
7)		
8)		

7. Brief Resume of Key Persons, Specialists, and Individual Consultants Anticipated for this Project

a. Name & Title:

b. Project Assignment:

c. Name of Firm with which associated:

d. Years experience: With This Firm ___ With Other Firms ___

e. Education: Degree(s) / Year / Specialization

f. Active Registration: Year First Registered/Discipline

g. Other Experience and Qualifications relevant to the proposed project:

a. Name & Title:

b. Project Assignment:

c. Name of Firm with which associated:

d. Years experience: With This Firm ___ With Other Firms ___

e. Education: Degree(s) / Years / Specialization

f. Active Registration: Year First Registered/Discipline

g. Other Experience and Qualifications relevant to the proposed project:

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7. Brief Resume of Key Persons, Specialists, and Individual Consultants Anticipated for this Project

a. Name & Title:	a. Name & Title:
b. Project Assignment:	b. Project Assignment:
c. Name of Firm with which associated:	c. Name of Firm with which associated:
d. Years experience: With This Firm ___ With Other Firms ___	d. Years experience: With This Firm ___ With Other Firms ___
e. Education: Degree(s) / Year / Specialization	e. Education: Degree(s) / Years / Specialization
f. Active Registration: Year First Registered/Discipline	f. Active Registration: Year First Registered/Discipline
g. Other Experience and Qualifications relevant to the proposed project:	g. Other Experience and Qualifications relevant to the proposed project:

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7. Brief Resume of Key Persons, Specialists, and Individual Consultants Anticipated for this Project

a. Name & Title:	a. Name & Title:
b. Project Assignment:	b. Project Assignment:
c. Name of Firm with which associated:	c. Name of Firm with which associated:
d. Years experience: With This Firm ___ With Other Firms ___	d. Years experience: With This Firm ___ With Other Firms ___
e. Education: Degree(s) / Year / Specialization	e. Education: Degree(s) / Years / Specialization
f. Active Registration: Year First Registered/Discipline	f. Active Registration: Year First Registered/Discipline
g. Other Experience and Qualifications relevant to the proposed project:	g. Other Experience and Qualifications relevant to the proposed project:

7. Brief Resume of Key Persons, Specialists, and Individual Consultants Anticipated for this Project

a. Name & Title:	a. Name & Title:
b. Project Assignment:	b. Project Assignment:
c. Name of Firm with which associated:	c. Name of Firm with which associated:
d. Years experience: With This Firm ___ With Other Firms ___	d. Years experience: With This Firm ___ With Other Firms ___
e. Education: Degree(s) / Year / Specialization	e. Education: Degree(s) / Years / Specialization
f. Active Registration: Year First Registered/Discipline	f. Active Registration: Year First Registered/Discipline
g. Other Experience and Qualifications relevant to the proposed project:	g. Other Experience and Qualifications relevant to the proposed project:

8. Work by Firm or Joint Venture Members **which Best Illustrates Current Qualifications Relevant to this Project** (List not more than 10 Projects)

a. Project Name & Location	b. Nature of Firm's Responsibility	c. Owner's Name & Address	d. Completion Date (actual or estimated)	e. Estimated Cost (in thousands)	
				Entire Project	Work for which Firm was/is responsible
(1)					
(2)					
(3)					
(4)					
(5)					
(6)					

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9. **All work by firms or Joint Venture members currently being performed directly for Federal agencies**

a. Project Name & Location	b. Nature of Firm's Responsibility	c. Agency (Responsible Office) Name & Address	d. Percent complete	e. Estimated Cost (In Thousands)	
				Entire Project	Work for which firm is responsible

10. Use this space to provide any additional information or description of resources supporting your firm's qualifications for the proposed project

11. The foregoing is a statement of facts.

Signature: ______________________ Typed Name and Title: ______________________

Date:

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APPENDIX VII

Sample Request for Proposal for an Engineering Consultant

The Town of ______________ is currently inviting proposals for the purpose of conducting a survey, the purpose of which is to identify energy conservation alterations and modifications to the Town's current building energy systems.

The project shall include the survey of ___ Town Buildings, including the HVAC system, pneumatic electric temperature controls, electrical systems and architectural modifications.

Consultants wishing to be considered for this project should submit written proposals (3 copies) on or before ____________________ to:

Town Manager

The proposals should include information on the following matters.

1) Qualifications. A statement of the firm's capabilities and experience, specifically in similar projects.

2) Time Schedule. A proposed date for completion of the survey, assuming you were hired on ________________.

3) Assistance. An outline of the assistance which you feel must be provided by Town Personnel in order to adequately complete the above defined survey.

4) Program Definition Commentary. Comments or suggestions as to changes, additions or deletions in the attached program definition.

5) Present a five (5) page simulated report giving in specific detail, the format of the final survey report, complete with examples and procedures.

APPENDIX VIII

Computer Programs

ENERGY PROGRAMS

Name	Author
Commercial Programs	
ECUBE	American Gas Association
HCC-III	APEC
Energy Analysis	Caudill Rowlett Scott
AXCESS	Electric Energy Association
Glass Comparison	Libbey-Owens-Ford
Energy Program	MEDSI
Energy Analysis	Meriwether and Associates
Building Cost Analysis	PPG Industries
TRACE	TRANE Company
Energy Program	Westinghouse Corporation
HACE	WTA Computer Services, Inc.
Research Programs/Negotiable	
CADS	UCLA
SIMSHAC	Colorado State University
FINAL	Dalton, Dalton, Little and Newport
HVAC Load	Giffels Associates, Inc.
Energy Program	Honeywell, Inc.
NBSLD (Honeywell)	Honeywell, Inc.
Energy Program	University of Michigan
NBSLD	National Bureau of Standards
B. E. A. P.	Pennsylvania State University
Post Office Program	
DEROB	University of Texas
TRANSYS	University of Wisconsin

In-House Program/Proprietary

Energy Program	General Electric Company
Residential and Small Commercial Energy Program	Honeywell, Inc.
	IBM

SOURCE: Energy Conservation: Guidelines for Saving Energy in Existing Buildings: Engineers, Architects and Operators Manual (ECM2) Conservation Paper No. 21, Federal Energy Administration, Office of Conservation and Environment. June 16, 1975.

BIBLIOGRAPHY

1 ASHRAE Standard 90-75: Energy Conservation in New Building Design. The American Society of Heating, Refrigerating and Air-Conditioning Engineers, 345 E. 47th Street, New York, New York. $5.00

2 Energy Conscious Redesign of Existing Buildings: Workbook and Design Manual. AIA Research Corporation, 1735 New York Avenue, N.W. Washington, D.C. 20006. July, 1974. Unpublished draft, Contact: Thomas Vonier, AIA/RC.

3 Energy Conservation. A Technical Guide for State and Local Governments. Prepared by Public Technology, Incorporated for the National Science Foundation, RANN Program. March, 1975. Available from Public Technology, Inc., 1140 Connecticut Ave., N.W., Washington, D.C. 20036. Price: $10.

4 Energy Conservation and the Building Shell. Educational Facilities Laboratories, Building Systems Information Clearinghouse, 3000 Sand Hill Road, Menlo Park, California 94025. Price: $3.00 per single copy (25% off on orders of 100 or more).

5 Energy Conservation Design Guidelines for Office Buildings. Second Edition, by Dubin - Bloome Associates, and AIA Research Corporation for the U.S. General Services Administration, Public Buildings Service. Available from GSA Regional Business Centers, 1977. $2.00

6 Energy Conservation Guidelines for Building Operations. U.S. General Services Administration, Public Buildings Service. Available free from GSA Regional Business Centers.

7 Energy Conservation Guidelines for Existing Office Buildings. Second Edition, by AIA Research Corporation and Consultants for U.S. General Services Administration, Public Buildings Service. February, 1977. Available from GSA Regional Business Centers for $2.00.

8 Energy Conservation in Buildings: Techniques for Economical Design. Griffin, C.W., Washington, D.C., The Construction Specifications Institute, 1974. Available from C.S.I., 1150 17th Street, N.W., Washington, D.C. 20036. Price: $20.00.

9 Energy Management in Municipal Buildings. Massachusetts Department of Community Affairs, Energy Conservation Project, 1977, Available free of charge from: Massachusetts Department of Community Affairs, Energy Conservation Project, 73 Tremont Street, Room 800, Boston, Massachusetts 02108.

10 Guide to Reducing...Energy Use, Budget Costs. Prepared by the Energy Projects of the National Association of Counties, The National League of Cities, U.S. Conference of Mayors, 1977. Available free from Federal Energy Agency Regional Offices.

11 Guidelines for Saving Energy in Existing Buildings: Building Owners and Operators Manual (ECM 1). Federal Energy Administration, Office of Conservation and Environment. June 16, 1975. Available from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. Order number PB 249928/3BA. Price Code - 13A.

12 Guidelines for Saving Energy in Existing Buildings: Engineers, Architects, and Operators Manual (ECM-2), by Dubin - Bloome Associates for the Federal Energy Administration, Office of Energy Conservation and Environment. June 16, 1975. Available from NTIS. Order Number PB 249929/1BA. Price Code - 13A.

13 Hidden Waste: Potentials for Energy Conservation. David B. Large, Editor, The Conservation Foundation, 1717 Massachusetts Avenue, N.W., Washington, D.C. 20036. Published in 1976. Price: $4.00 per single copy.

14 Low Energy Utilization School, Research Phase I Interim Report. Board of Education, City of New York. Sponsored by the National Science Foundation, NSF-RA-N-74-117. August, 1974.

15 Model Code for Energy Conservation in New Building Construction. (Preliminary Draft) U.S. Energy Research and Development Administration. January, 1977. Available from National Conference of States on Building Codes and Standards, 1970 Chain Bridge Road, McLean, Virginia 22101. Final document available in July, 1977.

16 NBS Technical Note 789: Technical Options for Energy Conservation in Buildings. U.S. Department of Commerce, National Bureau of Standards. July, 1973. Available from U.S. Government Printing Office. Order Number 00300301163-1. Price: $2.35.

17 Total Energy Management. A practical handbook on Energy Conservation and Management (for use of owners and managers of office buildings and small retail stores). Developed by: The National Electrical Manufacturers Association (NEMA), National Electrical Contractors Association (NECA), U.S. Department of Commerce. Available from National Electrical Contractors Association, 7315 Wisconsin Ave., N.W. Washington, D.C. 20014. Price: $0.75.