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HOSPITAL ENERGY AUDITS: A BIBLIOGRAPHY

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INTRODUCTION

An energy audit is an accounting of the various energy consuming systems contained in a building. The data collected in an audit may be used to rank energy conservation opportunities (ECOs), usually with the goal of reducing energy consumption in a cost-effective manner. In the U.S. today, energy consulting engineers, public utilities, state and federal energy agencies, and others employ a wide variety of energy audit procedures.

This booklet contains a bibliography with abstracts on the subject of hospital energy audits. We have divided the material into three parts:

1. Accounts of hospital energy audits;

2. Instructional material on hospital energy audits (including manuals, workbooks, instructional articles, etc.;

3. Miscellaneous documents.

For convenience in using this material, we have also provided tables at the back of this report that detail the specific subject areas of the various articles, books, reports, etc. Thus, one can look at the table to find what materials are discussed, for example, laundries or windows, or to see what materials provide economic analysis or describe computer simulations. In addition, we have provided a list of references consisting of additional relevant materials which are not abstracted here.

The editors of this volume recognize that the accelerating pace of energy conservation work in general, and for hospitals in particular, will shortly result in a great deal more information on these subjects. Nevertheless, it is our hope that this volume will improve accessibility to much of the valuable work that has been completed to date, and will therefore provide a useful introduction to the field. We regret that we may have omitted many useful documents from this bibliography, and we encourage all interested parties to contact their state energy offices and Department of Energy regional offices for more information.

HOSPITAL ENERGY AUDIT REPORTS

Anco Engineers Inc. Final Report: Energy Audit of St. John's Hospital and Health Center. Santa Monica, CA: ANCO Engineers Inc.; 1978 June; Report 1225-1; 43 p. Available from ANCO Engineers Inc., 1701 Colorado Avenue, Santa Monica, California 90404, 213-829-2624.

To identify energy use practices and to make recommendations for improvement, ANCO conducted an energy audit of St. John's Hospital. The major energy using systems were investigated through review of utility meter records and hospital floor plans; this report contains the results of calculations, recommendations, computer analysis, and other details of the energy audit. The largest energy savings were associated with heating, ventilation, and air conditioning modifications (energy savings approaching 16%); there were also proposals for changes in kitchen processes (e.g., purchase/use of additional microwave ovens, a maintenance program for kitchen appliances, more efficient use of refrigerator space, instruction of employees in efficient cooking strategies, and use of electric ignitors for gas appliances) as well as for reduction in lighting levels and delamping.

Colorado Energy Conservation and Alternatives Center for Commerce and Industry. Energy You Can Bank On. Denver, Colorado: 1978 June. Available from Colorado Energy Conservation and Alternatives Center for Commerce and Industry, 1576 Sherman St., Suite 304, Denver, CO 80203.

A self-help energy audit manual for business and industry; includes detailed sections written in nontechnical language dealing with reading utility bills, estimating energy use of mechanical and lighting systems, operations and maintenance procedures, retrofit options, and economic calculations. A series of appendixes are included covering a variety of retrofit options in the area of heating, cooling, ventilation, lighting, water heating, and structure. Additional appendixes describe details of monitoring and real-time controlling of equipment, and waste recycling. A glossary is also included.

Daystar Corporation. Hot Water System Efficiency Study at South County Hospital, Wakefield, Rhode Island. Burlington, MA: Daystar Corporation; 1978 June; NTIS A03\MF A01; 41p.

Daystar Corporation installed a solar/electric domestic water heating system in the Borda Wing of the South County Hospital Wakefield, R.I., in 1975. Initial performance measurements revealed that the overall water heating system efficiency was approximately 35%. This study was undertaken to identify the losses which caused this low efficiency, and improvements which could be made at the South County installation and in future similar installations.

Energy Management Services Incorporated & Fuel and Energy Consultants Incorporated. *Final Report of the Philadelphia Area Hospital Conservation Program (Draft)*. 1979 January; 50 p. Available from Energy Management Services, Inc., Architects Building, 117 South 17th Street, Philadelphia, PA 19103, (215) 665-1100.

This report contains the results from an effort to contain energy costs in 55 Philadelphia area hospitals. Savings for these hospitals were approximately 15% of their 1977 energy costs. Furthermore, the program was extremely cost-effective yielding an average 364% return on investment in the first full program year. The objectives of the program were achieved through the following interrelated activities: creation of an energy data base, an instrumented engineering survey, off-site engineering analysis, cost containment reporting, implementation of a management information system, and "hands-on" training workshops. The greatest potential for short-term savings was found to be in controlling environmental conditions--space temperatures, shutdown of equipment in non-use periods, hot water temperatures and lighting reduction. The average savings in this area was 7.9% of total hospital energy costs. Boiler systems were the next major area, showing an average 3.3% savings potential of the hospital's energy costs. Process equipment measures contain 0.1% savings, and environmental equipment measures showed a 3.3% savings potential. The recommendations in boiler operation and control involved combustion and utilization efficiency, steam pressure, maintenance procedures, and reduction of heat losses; in environmental equipment usage that involved outside air quantities, control calibration, ventilation rates, simultaneous heating and cooling, chiller usage, and relamping. Recommendations in process equipment usage involved laundry, dietary, and sterilization; while recommendations for control of environmental conditions involved hot water temperatures, space temperatures, equipment scheduling, electrical load scheduling, and lighting reduction.

Gard, Incorporated. *Energy Conservation Study of Veterans Administration Hospital, Hines, Illinois: Report 1-Facility Inventory; Report 2-Steam Systems and Incinerator Report; Report 3-Building and Building Systems Report; Report 4-Seasonal Operations and Summary*. Niles, Illinois: Gard, Inc.; 1977 November; 91 p. Available from Gard, Inc., 7449 North Natchez Avenue, Niles, Illinois 60648, 312-647-9000.

This study began with a facility inventory of the 1440 bed Hines VA Hospital, where attention was focused on the main hospital (Bldg. 200). Various systems requiring energy were analyzed: electrical, steam, lighting, chiller, air handling, pumping, and domestic hot water, and the central control panel. Detailed recommendations are given for energy conservation measures in the operation of the boiler plant. It is also recommended that the chilled water plant be run in accordance with its original design as a "piggy-back system"; that a waste water heat reclaiming system be instituted in the laundry; and that combustible solid wastes be incinerated in a plant built on the Hines site with waste heat recovered as steam. There are specific energy conservation recommendations for Building 200 (which consumes 50% of the facility's energy), involving installation of more efficient lamps, modifications to the cooling tower and the ductwork, installation of heat reclaim systems in the air handling systems, installation of air handling system controls, installation of room thermostats, and selective motor changing. The study concludes with analysis of the various energy systems: the steam system, the Bldg. 200 chiller system, and the major electricity consuming devices. There is also an evaluation in terms of economic attractiveness (return on investment and payback) as well as life-cycle energy savings.

Minnesota Energy Agency. The Chicago Project: Evaluation and Testing of Three Types of Energy Audit Processes for School Buildings. St. Paul, Minn.: 1976 February; report No. FEA/D-76/318; 280 p.

This report presents the findings of a project undertaken by the National Association of Counties to determine techniques for identifying and alleviating excessive and unnecessary energy use in U.S. public schools. Three methods for accomplishing these goals are analyzed: 1) a computer simulation model (PSECS) developed by Educational Facilities Laboratories; 2) the Mini-Audit system developed by the Minnesota Energy Agency; 3) extensive energy use audits (Maxi-Audit) that can be performed by qualified engineering firms. Appendix I contains reports for the pilot hospital Mini-Audit program (six hospitals). It includes recommendations in the areas of heating systems, domestic hot water, ventilation systems, air conditioning systems, laundry, lighting, and building structure.

Philips Laboratories. Stirling Total Energy Systems Study. Final Report, May 15, 1976--June 13, 1977. Briarcliff Manor, N.Y.: Philips Labs, 1977 August; NTIS MF A01; 190 p.

The application of Stirling cycle prime movers to total energy power generation systems was investigated. Electrical, heating, and cooling demand profiles for a typical residential complex, hospital, and office building were studied, and alternative Stirling total energy systems were conceptualized for each site. These were analyzed in detail and contrasted with purchased-power systems for these sites to determine fuel-energy savings and investment attractiveness. The residential complex and hospital would be excellent candidates for total energy systems; and prime movers in the 1000 kW output range would be required. Stirling engines with this great an output have not been built to date, although there would be no fundamental technical barrier to prevent this. However, careful consideration must be given to the following technological decision areas before arriving at a final design if its potential is to be realized: engine configuration, hotside heat exchange interface, engine control system, internal gas seals, and advanced coal combustion technology. In view of national concern over present and future dependence on oil, the principle advantage of a Stirling prime mover in this application is its ability to utilize low-grade liquid fuels and coal.

Pope, Evans and Robbins, Inc. Site and Building Energy Appraisal and Survey Methodology Study: ANL-Building 212 Energy Report. New York: Pope, Evans and Robbins, Inc., 1977 February, NTIS PC A19/MF A01; 427 p.

An energy survey of building 212 at the Argonne National Laboratory was performed to appraise the energy accounting methodology presented in the Building Energy Handbook (ERDA 76/163, Vols. 1 and 2), and to identify energy conservation opportunities (ECOs) in this office/laboratory-type building with emphasis on those conservation measures which could be applied to similar buildings. The methods and data used are discussed in detail. Seventeen ECOs are identified, and the cost of implementing these procedures and the savings expected are enumerated. It was concluded that 13 of the 17 ECO's identified could be implemented immediately with a minimum of investment and building use disruption, and that the most significant ECO concept is the variable air volume modification to all air systems. ECO appraisals done manually and with the aid of computers resulted in comparable conclusions. More frequent and more accurate metering of steam and electric power consumption is recommended. Systems analyzed include HVAC, incineration, the building structure, electrical (including lighting), maintenance, heat recovery, steam, monitoring, and domestic hot water.

Reynolds, Smith and Hills, Architects-Engineers-Planners, Inc. Energy Conservation Study of Veterans Administration Hospitals: Stage 1-Baseline Survey. Jacksonville, Florida: Reynolds, Smith and Hills, Inc.; 1974 February; AE&P file No. 73330; 109 p. Available from Veterans Administration, Department of Medicine and Surgery, Washington, D.C., 20420.

This report isolates each variable factor influencing energy consumption and analyzes its effect on fuel consumption in three VA hospitals: the 327,500 sq. ft. Lake City, Florida, hospital; the 690,400 sq. ft. San Diego, California, hospital; and the 902,300 sq. ft. Buffalo, New York, hospital. The general findings of this report were: 1) reporting of local and national energy data should be upgraded; 2) in each of the hospitals, heating and cooling use the most energy, while fuel conversion, laundry use and lighting are the remaining large items (patient and staff loads do not materially effect energy use); 3) baselines of important energy variables were developed as a basis for comparison with future performance improvements; 4) a management energy usage index was developed from the significant energy parameters; 5) the minimum requirements for significant energy reduction include improving maintenance, reducing building structure losses, and developing better operating procedures. The report concluded that it should be possible to cut energy consumption by at least 10% by cutbacks in energy usage through improved staff planning, decreases in energy losses due to poorly functioning equipment and ineffective insulation, reduction in standards for temperature and humidity control within building spaces, elimination of unnecessary air treatment, decreases in air infiltration and building heat loss/gain by reflection, insulation, improved maintenance, etc.

Reynolds, Smith and Hills, Architects-Engineers-Planners, Inc. Energy Conservation Study of Veterans Administration Hospitals: Stage 2--Operational Study. Jacksonville, Florida: Reynolds, Smith and Hills, Inc; 1974 March; AEP file No. 7330; 52 p.

This report reviews hospital operations and isolates areas of correctable losses. It details field inspection methods, and hospital system configurations and operations. The major findings were: 1) comfort heating/cooling consume the most energy and represent the areas of greatest losses, but corrective action can reduce losses through doors/windows, unnecessary use of building openings, and inadequate controls; 2) climate systems do not have adequate energy monitoring and control devices or operating procedures; also, negative pressures in buildings causes influx of large quantities of untreated air; 3) many non-patient areas are 24 hr. climate conditioned at patient levels, though not occupied on that basis; 4) energy transfer lines have inadequate or no insulation; the steam and hot water processing systems and laundry have no standard operating procedures; economically feasible heat recovery systems are not used; 5) there are unnecessarily high light levels and use of incandescent lamps; high energy consuming equipment has no peak demand delay controls, and some equipment is left operating when not in use; 6) many climate controlled patient areas are not occupied for this use; 7) an energy data reporting system will be developed (see Stage 3) to measure corrective action against baseline parameters; 8) observations on energy conservation implications for design of new facilities are detailed in the report.

Reynolds, Smith and Hills, Architects-Engineers-Planners, Inc. Energy Conservation Study of Veterans Administration Hospitals: Stage 3--Hospital Energy Control System. Jacksonville, Florida: Reynolds, Smith and Hills, Inc.; 1974 April; AEP file No. 73330, 85 p.

This report presents the programing specifications for a computer-based energy data reporting system to measure and compare energy usage for all V.A. hospitals. This reporting system aims to correct the erroneous and missing energy data reporting found to be so prevalent during the Stage 1 baseline survey. The findings of this report were: 1) minimum data reporting requirements were determined for all hospital energy consumption parameters, and a common data form was designed for historical baseline values and current monthly reporting; 2) a "Management of Energy Usage" index was defined, allowing energy effectiveness comparisons between all hospitals; 3) required mathematical equations and computer programming specifications have been developed and verified with a case study; 4) using a case study, reporting formats were developed for the Hospital Energy Control System (HECS), measuring any corrective action against established baselines; 5) an "incentive" energy control chart score board was recommended at each hospital using the HECS; 6) all equipment, procedures, operational policies and building items identified in Stages 1 and 2 as high energy consumption factors were included in detailed self-evaluating check lists; instructions for determining the status of and recommendations for reducing energy consumption for each of 16 critical items were developed; 7) immediate education and implementation of the computerized HECS are essential to motivate significant energy conservation at the 171 U.S. V.A. hospitals.

Reynolds, Smith and Hills, Architects-Engineers-Planners, Inc. Energy Conservation Study of Veterans Administration Hospital: Summary. Jacksonville, Florida: Reynolds, Smith and Hills, Inc; 1974 July; AE&P file no. 73330; 19 p. Prepared for Veterans Administration Hospitals, Washington, D.C.

This brief report is a summary of the three volume study on how to reduce energy consumption in the existing 171 V.A. hospitals. Each variable factor was isolated and analyzed in terms of it's effect on energy consumption, with the hospital complex visualized as a "black box" with physical and information flows. Using data gathered from a new form, "Energy Conservation Survey," Stage 1 detailed a comprehensive investigation of 80 "energy associated" variables. Then Reynolds, Smith, and Hills inspected the three hospitals to develop specific recommendations for energy conservation. The significant energy variables were statistically analyzed and combined to establish a single "management of energy usage" index. The initial baseline survey (Stage 1) of the three selected hospital complexes at Lake City, Florida, at San Diego, California, and at Buffalo, New York, was completed and published in February 1974. The field work was completed in March 1974, and a report was published (Stage 2) indicating the conservation actions that can be taken at these other hospitals. Guided by Stage 1 and 2 findings, Stage 3 provided the design for an energy data reporting system. In conjunction with this computerized reporting system, a self-evaluating energy check list was provided for hospitals' use.

Ross and Baruzzini, Inc. Energy Conservation at Barnes Hospital, Phase I: Final Report. St. Louis, Mo.: Ross and Baruzzini, Inc., Consulting Engineers, 7912 Bonhomme Avenue, St. Louis, Missouri 63105, 314-725-2242.

At Barnes Hospital (total area 1,155,400 sq. ft.) energy conservation opportunities (ECOs) were identified with the potential savings of approximately $214,000/year (13% of the total energy costs). These opportunities were identified through in depth evaluation of energy use, interconnection, and interaction among the various utilities; as well as consultation with the hospital employees. Annual savings of over $100,000/year have already been effected, primarily from decreases in lighting levels, switching off of lights when not needed, and reductions in heating, ventilation, and air conditioning. Using data obtained from Phase I work, the next phase has been planned, documenting additional ECOs, some of which will require capital expenditures with suitable payback.

Richard G. Stein and Partners. Hospital Energy Conservation Study at Peekskill Community Hospital, Peekskill, New York. New York: Richard G. Stein and Partners; 1978 August; 216 p. Available from Richard G. Stein and Partners, 588 Fifth Avenue, New York, New York.

This study of the 114 bed Peekskill Community Hospital was made for the purpose of reducing the energy use in the hospital and examining how the information gained could be put to use in other hospitals of mid-range size (75-200 beds). The energy use systems analyzed were: lighting, air conditioning fans, exhaust fans, fan coil units, chiller, cooling tower, miscellaneous equipment, building losses, outside air, humidification, reheat, domestic hot water, incinerator, and generator. The energy savings is given in terms of electricity, oil, total energy, dollar cost and dollar savings. The energy saving alternatives verify the the need for and development of a plan for updating the present energy monitoring and control system (EMCS). Alternative energy sources were evaluated to determine the feasibility of their providing necessary future energy requirements. Recommendations involving modifications to the mechanical systems included: 12 specific energy conserving modifications to the heating, ventilation, and air conditioning systems; installing a supplementary cooling system for the Neo-Natal area so the large central chillers will not have to operate in order to satisfy this small area during intermediate seasons; expanding energy management function to include shutting off various systems when not in use; investigating modifications to elevator controls. Recommendations for the present electrical system include reducing lighting levels in certain areas and using more energy efficient lamps, as well as providing additional switching in mechanical rooms and other areas. It was recommended as a plumbing modification, to install a reverse osmosis and deionization system in place of the original distilled water system. It was also recommended to install a new computer-based automatic EMCS; including optimizing and energy management programs, and all hardware and software for energy conservation modifications and operation of steam plant. To replace the existing manual system in the area of alternative energy sources, it was recommended to install a new oil/gas-fired steam boiler plant adjacent to the building, and convert the major portion of the electrical heating and domestic hot water. The following alternatives are not economically sound <u>at this time</u>: 1) on-site generation of all or some of the electrical requirements; 2) heat storage by use of ice-forming heat pumps; 3) heat pump heat reclamation system; 4) solar energy systems for environmental heating and cooling. This report contains analysis of savings and implementation costs as well as detailed descriptions of the development of the engineering and economic factors involved in recommendations.

Ziedan, R.F. "Four-Phase Assault on Energy Loss Includes High-Performance Windows." <u>Building Operating Management</u> 1977; 24(7):70.

St. Mary's Hospital in Rochester, Minnesota (1030 beds) embarked on an energy conservation program which included educating staff, ascertaining efficiency of the physical plant, installing permanent storm windows and developing information and a statistical data base. Tests on existing windows showed an air infiltration rate averaging 4.0 cu ft/min/lineal foot of each crack, an estimated loss of 2.5×10^6 Btu's per year through each of the 3200 windows in the hospital. The installation of the initial order of 600 specially designed windows were specified to reduce that loss to 0.5 cu ft/min/lineal foot; but on testing, some had infiltration rates of only 0.18 cu ft/min/lineal foot, resulting in an estimated loss through each window of 12.7×10^4 Btu's per year, approximately 1/20th of present windows. Savings based on current fuel prices are estimated to be $7.24/window/year, as well as an additional $7.20/window/year resulting from the lowered U-value of each window due to the dual glazing provided. It is predicted that the payback will be 6 to 7 years.

INSTRUCTIONAL MATERIALS

Blue Cross of Greater Philadelphia. Practical Energy Management in Health Care Institutions. Philadelphia, Pa.: Blue Cross of Greater Philadelphia; 1977; 66 p. Available from Blue Cross of Greater Philadelphia, 1333 Chestnut Street, Philadelphia, PA 19107.

This manual is based on a University City Science Center program to help six hospitals in the Philadelphia area manage energy. Special attention is given to executive overview of energy management (stressing the need for top management leadership and the organization of an energy management, data collection and analysis, building and equipment surveys, energy saving ideas, and implementation of energy saving programs). The energy use systems discussed include environmental control (HVAC uses 40-65% of hospital energy), food services (5-10%), medical equipment (3-5%), and sterilization and incineration (2%). The energy saving opportunities discussed in detail involve: system shutdown during unoccupied hours, addition of return air, use of enthalpy control, automatic temperature controls, modifications of terminal re-heat systems, room air conditioners, energy efficiency tests for chillers, energy saving opportunities for chilled water plants, prevention of steam waste, control of radiator systems, piping insulation, domestic hot water, laundries, motor shutdown, demand control/centralized monitoring and computer systems, lighting, power factor improvement, elevators, window and door leakage, window modifications, and shading control for windows. Some of the actual results of the energy saving steps taken at the six hospitals are discussed in detail (e.g., installation of time clocks, reduction of hot water temperatures, etc.).

Boyle, D.D. Applying Life-cycle Budgeting to Energy Problems: Life-cycle Cost Analysis of Energy Options. Boston: Department of Health, Education and Welfare; 1978; NP 23196; 18 p.

Life-cycle costing provides a useful vehicle for evaluation of energy-supply options. The state-of-the art is examined in this report. Ultimately, the consideration of options must address and compare costs, and not just capital costs. Examples are: the mid- and long-term cost sacrifice in operational disruption and disadvantage caused by deferring action for a period of years; the obvious comparison of options in fuel types; initial, replacement, and operational costs of plant and equipment; variations in the mix of purchased and generated utilities such as steam, hot water, chilled water, and electricity; and options in the ownership and management concepts for the utility systems. An approach to the evaluation of building options in a life-cycle cost analysis over 20 years is followed in a test case--that of adding surgical capacity to a large regional medical center.

Department of Energy. Energy Audit Workbook for Hospitals. Washington, D.C.: Department of Energy; 1978 September; NTIS PC A05/MF A01; 99 p.

This workbook describes some simple methods by which the administrator or maintenance director of a hospital can analyze energy uses, determine areas in which energy savings can be made, and estimate the magnitude of cost savings in accordance with U.S. Department of Energy procedures described as class C information audits. It provides a do-it-yourself, fill-in-the-blanks approach to an energy-conservation program for hospitals that do not have full-time engineering personnel. Of necessity, it is a generalized approach which cannot be as detailed as an energy audit conducted by an engineering team.

Department of Health, Education and Welfare. Energy Management in Health Care Institutions. Washington, D.C.: Department of Commerce; 1975; DHEW Publication No. (HRA) 76-619; 8 p.

Health care institutions in the U.S. can make an important contribution to the National Energy Conservation Program and, at the same time, cut operating costs. An energy management campaign is outlined in the booklet. Commitment of top management, appointing a director, developing the program, and motivating employees are important steps that can be taken to initiate the program. A review of the monthly utility bills will indicate energy usage over a period, and data from the bills can be used to calculate the number of Btu's consumed per square foot of floor space. Then, areas where reductions in energy use may result can be cited. Some recommendations are given for buildings, grounds, and vehicles to evaluate operation efficiency.

Department of H.E.W. Energy Strategies for Health Care Institutions. 1976 April; DHEW Publication No. (HRA) 76-620; 48 p. Available from U.S. Department of Health, Education, and Welfare, Public Health Service, Health Resources Administration.

This report, drawn from materials presented at four conferences sponsored by the Health Resources Administration (HRA) of HEW and by the American Hospital Association, is an orientation to the energy issue as well as a source of specific answers to problems of energy conservation. It begins with an overview of the energy situation and then proceeds to a discussion of the impact of energy on health care institutions. An agenda for health care administrators is sketched with suggestions for an energy audit, energy sharing (by institutions), energy monitoring life-cycle costing, and professional help. Energy conservation in existing institutions is discussed with the suggestion of creating a "shopping list" to describe each proposed change, its total cost, the

Btu and dollar savings, the environmental effect on building operation, and effect on hospital operation and patient care. Environmental conditioning equipment is singled out as the area with largest potential savings (for example, through night thermostat setback in non-patient areas). Other areas discussed are heat recovery, maintenance procedures, and modifications to lighting systems (e.g., use of energy efficient lamps, more use of natural lighting). Numerous suggestions are made for energy saving measures that can be incorporated into new building design; these deal with the building envelope itself, windows, equipment, electrical subsystems, and mechanical systems. Finally, energy strategies for future action are given, detailing HRA's program to provide information, guidance, and technical assistance to health facility administrators, to accumulate a data base on hospital resource use, to review and possibly update the Hill-Burton program and regulations, and to provide leadership (through the Public Health Service) for the application of solar energy to hospital needs.

Dubin, F.S., Mindell, H.L. and Bloome S. How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings: An Energy Conservation Manual. Park Ridge, N.J.: Noyes Data Corporation; 1976; 735 p.

Buildings consume for heating, air conditioning, lighting, and power more than 33% of all energy used in the United States, the equivalent of 10 million barrels of oil per day at a time when oil imports are approximately six million barrels per day. Energy conservation programs that have been undertaken within the past three years in existing commercial, institutional, and residential buildings have already resulted in a reduction of their annual fuel and electricity consumption by 20 to 50% and indicate the range of potential savings for almost all buildings now in use. This book is based on reports prepared for the Federal Energy Administration by Dubin-Mindell-Bloome Associates. Part I of this energy conservation manual (ECM-1) is directed primarily to owners, occupants, and operators of buildings. It includes a wide range of opportunities and options to save energy and operating costs through proper operation and maintenance. It also includes minor modifications to the building and mechanical and electrical systems which can be implemented promptly with minimum investment. The measures contained in ECM-1 would result in energy and operating cost savings of 15 to 30% based on present fuel costs. Part 2 of this manual (ECM-2) is intended for engineers, architects, and skilled building operators who are responsible for analyzing, devising, and implementing comprehensive energy conservation programs which involve additional and more complex measures than those included in ECM-1. ECM-2 includes many energy conservation measures which can result in further energy savings of 15 to 25% with an investment cost that can be recovered within 10 years through lower operating expense.

Love, W. Energy Management Assistance Workbook. Sacramento: California Energy Commission; 408 p. Available from the Publications Unit, California Energy Commission, 1111 Howe Avenue, MS #50, Sacramento, California 95825.

Facility managers and maintenance personnel learn how to reduce waste in the energy used to light, heat, ventilate, and cool their buildings. They are provided with random energy conservation surveys completed by the Energy Management Assistance Team (EMAT). They are shown simple, inexpensive ways of testing equipment, adjusting or modifying buildings and equipment, and using preventive maintenance to save energy dollars. This workbook is used by the Energy Management Assistance Team in putting on workshops for the commercial/industrial sector as well as for state and local government assistance. Its purpose is to help those in charge obtain the best energy efficiency available from their buildings and equipment.

Enviro-management and Research, Inc. of Washington, D.C., with the Veterans Administration, the National Electric Manufacturers Association, and the National Electrical Contractors Association. Total Energy Management for Hospitals. Rockville, Maryland: U.S. Department of Health, Education and Welfare; 1977; DHEW Publication No. (HRA) 77-613; 78 p. Available form the U.S. Department of Health, Education and Welfare, Public Health Service, Health Resources Administration, Energy Action Staff, 5600 Fishers Lane, Room 10A-41, Rockville, Maryland 20857.

This handbook proposes to effect energy savings by making the buildings' systems as efficient as possible. In this scheme, a review of past energy consumption leads to the development of an energy utilization index (how much energy the building consumes per gross conditioned sq. ft.); then review of possible conservation procedures leading to the formulation of the initial energy conservation goal. Other factors (e.g., time and budget) are considered to establish the priorities for producing actual savings. Then comes an action plan which is implemented and monitored. The Total Energy Management (TEM) system eliminates energy waste, expands areas of investigation, and promotes conservation without adversely affecting the building environment. In the case of buildings not previously subject to other conservation efforts, there have been energy savings of 15 to 20% more in the first year of TEM application. This manual includes energy conservation guidelines for ventilation and exhaust, infiltration, heating and cooling, transmission, lighting, service facilities, domestic hot and cold water, elevators and escalators, electric power, interior space utilization, and advanced technologies.

Federal Energy Administration, Office of Energy Conservation and Environment. Guidelines for Saving Energy in Existing Buildings, Owners and Operators Manual (ECM 1) and Engineers, Architects and Operators Manual (ECM 2). Washington, D.C.: Federal Energy Administration; 1975 June; 748 p. See: Dubin, Mindell, Bloome, How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings: An Energy Conservation Manual.

Federal Energy Administration, Office of Energy Conservation and Environment. Identifying Retrofit Projects for Buildings. Washington, D.C.: Federal Energy Administration; 1976 September, FEA/D-76/467.

A method for identifying and evaluating retrofit options for buildings is presented which involves collecting energy use data; categorizing the building by size, function, and climate; identifying retrofit options; and performing economic calculations. The options discussed are in the categories of heating, ventilating, lighting, cooling, water heating, and miscellaneous. Checklists of options, blank data forms, and a glossary of options are included.

Naramore, Bain, Brady and Johnson. Life-cycle Budgeting and Costing as an Aid in Decision Making: Volume II, Energy Handbook. Seattle, Washington: Naramore, Bain, Brady and Johnson; 1976 June, NTIS PC A09/MF A01; 186 p.

Techniques and procedures for assessing alternatives in terms of energy use, conservation, and related monetary costs or fiscal resources are presented in a handbook directed to those who make planning decisions concerning the construction or renovation of health care facilities. This handbook is one of a series documenting the life-cycle costing procedure for evaluating the initial and long-term cost implications of a decision before the decision is made.

The energy handbook opens with an overview of the application of life-cycle costing to energy-related decisions. The basic concepts involved in evaluating energy/cost/operational tradeoffs are explained. Specific decision making steps are described relative to the energy source level (utility, solar, onsite generated, or geothermal energy); facility programming; system and system component level (e.g., heating, ventilating, and air conditioning subsystems); operations level; and annual energy density criteria (all levels). Reference charts and tables and lists of additional references are provided. Application of the costing techniques and procedures to a medium-sized general hospital is described.

Pacific Gas and Electric Company. Energy Utilization Audit Manual. 1977, 136 p.

An Energy Utilization Audit (EUA) is an on-site survey and analysis of a PG&E customer's building or plant, and equipment, with a written report recommending specific energy conserving actions. This manual contains chapters on the elements of an effective EUA (including an exmple of transmittal letter), conducting the EUA, completing and processing the data summary forms, a minimum audit "checklist", conservation "rules of thumb", conservation estimating techniques, literature, and examples of EUAs and callbacks. The "checklist" includes a number of recommendations in auditing a building's lighting, heating, ventilation and air conditioning, the building itself, electrical systems and equipment, and refrigeration systems. The rules of thumb should be useful for estimating conservation where specific measurements cannot be made or are unknown; thus, for example, the manual says that fluorescent ballast losses represent 5 to 7% of lamp rating, each 1^{o} lower thermostat setting (heating) will reduce gas consumption by 3%; and boiler turbulators (in fire tube boilers) can save 10% heat loss.

Price, S.G. Air Conditioning for Building Engineers and Managers. New York: Industrial Press Inc.; 1970; 142 p.

This handbook was prepared for building engineers, superintendents, and property managers concerned with the operation and maintenance of air conditioning equipment in large apartment and commercial buildings and public institutions. Information is included on: refrigeration theory, self-contained units, central chilled-water refrigeration plants, cooling towers, water treatment, air supply systems, filters, maintenance, economical operation, safety, and operation and control for energy conservation.

Reynolds, Smith and Hills. Life-cycle Costing Emphasizing Energy Conservation: Guidelines of Investment Analysis. Jacksonville, Florida: Reynolds, Smith and Hills: NTIS PC A07/MF A01; Report. No. ERCA--76/130; 1977 May; 177 p.

Life-cycle costing is a method of expenditure that recognizes the sum total of all costs associated with the expenditure during the time it is in use; it is an input for decision making. The purpose of this guidebook is to provide applicable study parameters for capital expenditures emphasizing energy conservation. These parameters quantify such features as discount rates, energy escalation rates, study of period, salvage value, and Btu measurements. By using these analysis concepts, budget requests for energy conservation programs will be standardized and result in a common measurement basis. The format and measurement statistics requested allow a comparable ranking of budget contenders, thus assuring maximum benefit for the funds expended. The guidebook also serves to allow the magnitude and complexity of each individual project to dictate the level of analysis required. Finally, this document is designed to serve as a working desk guide. Its overriding message is to balance accuracy with simplicity. The methodology is geared towards ease of calculation; it is anticipated that the techniques described herein will be adequate to handle over 90% of the economic analysis situations confronting facility engineers. Life-cycle costing is a tool which synthesizes data and contributes to making a logical decision, but it is not an end in itself.

Spielvogel, L.B. "How to Make an Energy Audit." Electrical World 1977; 187(114-115).

Two types of energy audits are available for determining the energy budget of a specific building: a walk-through audit in which recommendations are based on educated guesses regarding energy consumption, and a detailed audit in which traditional manual engineering techniques or more complex computer methods are used to calculate energy usage. Both types produce alternative measures for saving energy that must be studied in relation to management, operations, and cost requirements for the building. Two basic questions that must be asked during an energy audit are whether the heating-cooling systems are being used as originally intended, and whether the original design is the most efficient.

Spielvogel, L.G. "Energy Audits." Heating, Piping & Air Conditioning 1977; 67-73.

The process of conducting an energy audit is discussed. Two purposes of an energy audit are to determine how much energy is going where and how to save energy. An energy budget is described as the Btu in fuel bought plus the Btu in electricity bought, divided by the building square footage. Energy audits are characterized in two classes: specific audits for a particular building the way it is being used, and generalized audits developed by government organizations and associations. Specific audits are further subdivided into walk through audits and detailed audits. These are discussed in some detail. Audit techniques are reviewed including the factors of system operation, controls, equipment performance, unoccupied conditions, load versus energy, energy load factor and utility information. Generalized audits are briefly discussed along with audit comparison and evaluation. The factor of life cycle costs is also reviewed.

Stein, R.J. and Partners. Low Energy Utilization School, Energy Conservation Operation Manual, Phase 2: Report. New York: Richard J. Stein and Partners; 1977 March; NTIS PC A05/MF A01; Report No. PB--268555.

This manual consolidates maintenance and operational steps which will result in the lowest energy use consistent with a school's educational program. It covers guidelines for maintenance and operating procedures for energy efficiency in the plant, a revised set of standards based on extensive research, and methods of scheduling and controlling the use of the equipment to provide services only when the spaces are occupied and only to the extent required by physical conditions and types of activity. The basic discussion concerns procedures that are the custodian's responsibility.

Stroeh, H. and Woods, J. "Development of a Hospital Energy Management Index." ASHRAE Transactions 1978; 84(2).

This paper presents the Hospital Energy Management Index (HEMI) as a management instrument by which the energy performance of a hospital can be quantified. The HEMI combines the factors of size, outdoor temperature, patient load, and energy consumption in a simple linear relationship, allowing comparisons to be made within a hospital (annual analysis) or between hospitals. Three hospitals of different sizes but similar occupancy loads are evaluated by the HEMI and shown to have nearly identical energy consumption characteristics. With the data from these hospitals as a reference, two other hospitals are evaluated by the HEMI and are shown to have significantly different performances. One, with a substantially reduced occupancy load, was characterized as energy excessive; the other, supplied by a district heating system, was shown to be energy efficient. Other less reliable methods of evaluating the effectiveness of energy management programs are investigated in this paper, including the energy utilization index, degree-day methods, and the management of energy use method.

Total Energy Management for Nursing Homes and Other Long-Term Care Institutions. 1977. Available from Department of Health, Education and Welfare, Rockville, Maryland 20857.

The purpose of this publication is to provide the basic instruction needed to implement the most effective form of energy conservation--Total Energy Management (TEM). In long-term care facilities, the effort required is worthwhile for many different reasons. TEM is self-paying and promotes energy conservation without negative impact on health care services. Chapters are titled "Understanding Energy Consumption", "Initiating A Total Energy Management Program", "Developing Energy Consumption Data", "Conducting The Facility Survey", "Developing and Implementing The Basic Plan", "Communication and Motivation", "Monitoring Your Program And Keeping It Effective", and "Guidelines For Energy Conservation". Two appendixes furnish information on building information for TEM and sources of information for energy management.

U.S. Government. *The Potential for Energy Conservation: Staff Study. Final Report.* Washington, D.C.: Office of Emergency Preparedness, U.S. Government Documents; 1972 October; Report No. PB-213722; 247 p.

The following is a list of energy conservation measures for health care facilities. It includes only a partial list of actions for energy savings, those pertaining to heating, ventilating, and air conditioning:

- Reduce heat loss in winter and heat gain in summer through addition of storm windows, caulking, humidifiers, fans, and so on.
- Improve efficiency of furnaces and air conditioning units.
- Provide a single large efficient air conditioning-heating plant to serve entire hospital complex.
- Reduce heat added in air handling system by minimizing reheat for humidity control, intake of outside air, and duct velocities.
- Recover and utilize heat rejected by furnaces, water heaters, and condensers of air conditioning units and in air exhausted from building.
- Use total energy concept more widely.
- Reduce energy required for hot water heaters by offering more efficient designs (no continuous gas pilot, thicker shell insulation, and so on).
- Provide devices to keep heat exchange surfaces clean.
- Reduce energy required for lighting by favoring fluorescent lamps, reducing levels, and promoting use of more natural light.
- Reduce energy consumption of all appliances and equipment.
- Limit hot water consumption of washing machines and dishwashers.
- Reduce energy required for cooking.
- Redesign range burners so that more heat enters and less is lost to the air.
- Require thicker insulation in oven walls.
- Reduce energy consumption of refrigerators by being conservative about opening the door.
- Smooth out daily demand cycle by shifting heavy loads to off-peak hours.

Veterans Administration. Energy Conservation in the V.A. Washington, D.C.: Veterans Administration; 1979 January; 50 p.

This V.A. manual details "Energy Management Tasks" for use at all V.A. health care facilities. These tasks are applicable to typical heating, ventilating and air conditioning systems, lighting, electrical equipment, boiler plant, plumbing, building envelope, and laundries. Each energy management task is organized to 1) define the task; 2) determine where the task is applicable; 3) describe how implementation can be accomplished; 4) establish methods for calculating energy and cost savings; 5) provide a guide to costs; and 6) illustrate, by example, the cost-effectiveness of each task. The energy management tasks included in this initial printing are primarily operational and maintenance activities that require low investment and provide immediate energy savings. Additional tasks of this type, as well as cost-effective retrofit tasks (these are identified in the contents) will be sent in later mailings.

Wood, Q.E. "How to Conduct a Hospital Energy Audit." Hospital Engineering Newletter 1971; 19:2-3.

One of the best ways for a hospital to know where it stands in relation to energy use and anticipated shortages is to conduct an energy audit. The four phases essential to an orderly approach to an energy audit are 1) collection of data and facts; 2) evaluation of the collected data; 3) formulation of action plans; and 4) formulation of contingency plans.

MISCELLANEOUS DOCUMENTS

Baird, G. "Air Change and Air Transfer in a Hospital Ward Unit." *Building Science* 1969 January; 3(3):113-24.

This paper describes an investigation of the factors which affected the air change rates in patient rooms, the air transfer between these rooms and the air transfer between these rooms at a hospital ward unit designed on the "race-track" principle. Tests were conducted on a fully air conditioned ward having partially natural ventilation. The main factors were isolated, and prediction equations for the transfer from room to room are given in terms of these factors. The implications of these equations and their possible use in the design of hospital ward ventilation schemes are discussed.

Banner, M.T. "Hospitals Cope with the Crunch." *Journal of the American Hospital Association* 1975; 47(21):37-42.

Taking political changes and uncertainties into account, the energy situation for hospitals during the 1975-76 winter looked more confusing than the previous winter. This article examines and evaluates what hospitals have done to conserve and manage energy. Some hospital spokesmen are going beyond the conventional energy conservation suggestions to point out the need for an engineering approach to energy management. The Veterans Administration has begun an energy conservation program, involving its 171 hospitals, which could save each health facility from 10 to 50% of the energy it consumes. The Federal Energy Administration and the Blue Cross are financing a program which provides for energy audits of six Philadelphia-area hospitals, which is designed to develop practical conservation guidelines. In addition to energy savings programs to reduce energy use, some hospitals have implemented heat recovery programs to use wasted energy, including one program which uses recovery of heat generated by burning solid wastes. Solar energy utilization has also been considered by hospitals for such end uses as hot water heating and space heating. The Public Health Service has launched a program to demonstrate how solar energy can be used in health faclities. Recommendations are made for hospitals to cope with their urgent energy problems: 1) to organize a united effort to affect legislation and energy policy; 2) plan to convert to non-fossil energy sources or to use supplementary non-fossil fuels; 3) implement energy management programs; and 4) prepare for short-term disruptions of fuels.

Building Environment Division of National Bureau of Standards. Technical Guidelines for Energy Conservation. Washington, D.C.: National Bureau of Standards, Department of Commerce; 1977 June; AFCEC-TR-77-12; 400 p.

This report provides detailed technical material on various energy conservation actions for existing Air Force facilities and utility systems. It is specifically tailored to serve as a working document for base engineers and technical personnel. The report covers energy conservation for Air Force facilities, including the equipment for providing hot water, space heating and cooling, lighting, and humidification. It also covers central plant systems and underground distribution systems (hot water, steam, and chilled water). It does not cover energy conservation measures for tactical or mission-related equipment such as ground vehicles or fighter aircraft.

Crall, G., Christopher, P. and Cuba, J.F. Bibliography on Available Computer Programs in the General Areas of Heating, Refrigeration, Air Conditioning, and Ventilation. Battelle Columbus Labs, Ohio; 1975 October; NSF 75-10436.

The descriptions of computer programs included in this bibliography inform potential users of what the programs do and who to contact for more information. The computer programs described are arranged alphabetically by sections according to the type of computation being performed: 1) heating and/or cooling load calculation programs containing the calculation of heating and/or cooling loads for a building or zone; 2) energy analysis programs concerning the estimating of the annual energy consumption of buildings; 3) duct design programs used to assist in the area of duct sizing, cost estimating, and sound analysis; 4) piping design programs classified either as pipe sizing programs or as pipe flexibility programs; 5) equipment selection programs that include collector area and performance characteristics, storage capacity, building load, and weather data to predict the performance of the solar heating and/or cooling system.

Cummings, R. Solar Energy for Health Care Institutions. U.S. Department of Health, Education and Welfare: 1976 January; DHEW Publication No. (HRA) 77-618; 12 p. Available from U.S. Department of Health, Education and Welfare, Public Health Service, Health Resources Administration.

This booklet is designed to help health care administrators prepare to use solar energy in order to achieve savings and stabilize rising energy costs. There are discussions of solar collector function and applications, including solar water heating, space heating, and air conditioning; solar costs, with examples of the savings that can be achieved over time; getting ready for solar, with advice on obtaining expert help, projecting needs, and inspecting buildings and building plans; buying solar; and proper steps, with advice on making sure your site is applicable, design is adequate, and the firm you are dealing with is reliable.

Design Guidelines for Energy-conserving Systems. Washington, D.C.: Veterans Administration; 1977; NP-22647.

Guidelines for the design of new Veterans Administration Facilities are presented. The information given is applicable, in whole or in part to the following: solar energy systems, total energy systems, continuous-duty standby systems, engine-driven chillers/heat pump systems, and solid-waste boiler systems. The guidelines provide uniformity of design for new VA facilities and supplement established VA standards and policy.

Department of Health, Education and Welfare. The Marketability of Integrated Energy/Utility Systems. Department of Health, Education and Welfare, Washington, D.C.: DHEW, Office of Facilities, Engineering and Property Management; 1976; PB-266042; 45 p.

This marketing guide acquaints the prospective marketplace with the potential and underlying logic of the generic integrated utility system (IUS) concept. A sizeable number of educational and medical facilities may well be compatible with the IUS concept, and appropriate implementation of an IUS would bring about the realization of substantial annual dollar savings for the institution along with impressive energy savings.

Downey, G.W. "Solar Energy for Health Care." Modern Health Care 1975 October; 4:18-23.

The potential of solar energy as an inexpensive, pollution-free source of energy for the health field is explored. The general concepts and development of solar energy are reviewed, and predictions concerning availability of other energy sources are outlined. It is suggested that health facilities able to install carefully planned, well constructed solar energy systems may be spared the worst hardships of fossil fuel scarcity. The nation's first solar system in an acute care setting is being installed at the South County Hospital, Wakefield, Rhode Island. Those involved in this installation are preparing a manual to help health care managers determine the feasibility of solar energy for their institutions. Highlights of that manual are presented concerning the use of solar energy for heating water, heating space, cooling buildings, and generating electricity. Currently, solar energy can help health care institutions solve three major problems: dealing with emergency power failures, coping with energy starvation, and reducing operating costs. It is noted that solar energy can be stored for short-term emergencies for periods of one day to one week. It is recommended that new health facilities be designed for conversion to solar equipment in the future. Solar compatibility has three basic requirements: a place for pumps, storage tanks, and heat exchangers. The relatively high cost to date of solar installations is pointed out. The heat reclamation system at Children's Hospital of Philadelphia and the installation of a solar system in a Georgia nursing home are described. Photographs and drawings accompany the text.

Dressler Corporation. Cost Containment in Hospitals Through Energy Conservation. HEW Publication; HRA 79-14511. Available from Bob Rawles, Division of Energy Programs and Policies, 3700 East-West Highway, Rm. 1022, Hyattsville, MD 20782.

This report records the results of energy conservation efforts in various medical facilities and is based on a national survey of 21 select hospitals. The survey was designed to outline, using a hospital's own words, case histories of cost containment through energy conservation. The survey was not a contest. It was, rather, a means to outline various managerial and technical approaches to save energy in medical facilities. It is hoped that the case histories provide both motivation and guidance for continued and expanded energy conservation programs. The various case histories should prove especially useful to Governing Boards, Administrators, and Top Managements in medical facilities. The various case histories are from a wide variety of facilities: small, medium, and large facilites; teaching centers; VA facilities; and centralized service facilities. The case histories also cover all major climate zones in the nation.

Dubin, F.S. A Study of Air Conditioning, Heating and Ventilation Design for Veterans Administration Hospital Kitchens and Laundries. West Hartford, Conn.: Fred S. Dubin Associates, 1970 February.

The objective of this study was to develop criteria for providing acceptable environmental conditions in kitchens and laundries within economical cost limits. The build-up of heat and humidity in both kitchens and laundries has had a detrimental effect on the comfort of employees, their work output, and morale. The many pieces of heat, moisture, and grease producing equipment included in modern VA kitchens and laundries require special air conditioning systems which are more complex than those used for comfort air conditioning in other types of spaces. The report develops temperature, humidity, and ventilation criteria; and provides sketches, details, and comparative costs for alternative equipment and systems to satisfy these criteria.

Dubin-Mindell-Bloome Associates, Consulting Engineers. A Study of Design Criteria and Systems for Air Conditioning in Existing Veterans Administration Hospitals: Research Study Report. New York, New York: Dubin-Mindell-Bloome Associates; 1971 March; 223 p. Prepared for Research Staff, Office of Construction, Veterans Administration, Washington, D.C., 20420.

This report gives reasons for considering alternative systems to central chilled water systems for air conditioning used in existing VA hospital buildings, especially, but not solely, when the life expectancy of the hospital is less than 20 years. Reasons for some of the high costs of HVAC systems in hospitals are given, e.g., the widespread requirement for 100% fresh air, and the practice of assigning areas in VA hospitals without regard to the special environmental control they require. This report also details procedures for analysis of economic data in regard to selecting HVAC systems. It is recommended that the VA should request the Bureau of Budget to make a single policy concerning air conditioning of both new and existing buildings. There are 21 recommendations given for revision of VA construction standards for HVAC systems; e.g., establish optimum standards for room conditioning in existing hospitals with 1-20 year life expectancies, and permit partial recirculation of air with proper filtration in all areas which currently call for 100% fresh air. There are also recommendations for pre-design procedures for each proposed air conditioning installation in an existing hospital; e.g., the need to determine phasing of construction prior to design. There are 14 recommendations for reducing initial costs, including select equipment that can be amortized within the life expectancy of the building, reduce percentage of outside air and increase recirculation, group areas in the hospital with similar environmental control needs, reduce pipe insulation thickness, install heat recovery equipment in fresh air exhaust air, etc. Full consideration of kitchens and laundries are given in a separate study, "A Study of Air Conditioning, Heating, and Ventilating Design for Veterans Administration Hospital Kitchens and Laundries".

Egelston, N.B. "Energy-saving Tips." Hospital Engineering 1974; 19(4):10.

Hospitals should give more thought to Btu losses through ventilation systems. Long range plans should include heat exchangers to reuse the energy in heated air in the winter and chilled air in the summer. Short range plans should consider installing programmed timers on air conditioning units and exhaust fans to shut them down in unoccupied areas. There will be very little change in temperature over a 12 hour shutdown period. Fans can also be slowed 25-35% without making a noticeable difference in comfort. The various measures can result in significant energy and cost savings.

Ellis, B. "Energy Management: It's Dollars and Sense." Hospitals 1977 March; 51:159.

A total energy management program was instituted at Lutheran General Hospital, Park Ridge, Ill. Top consideration was given to areas of highest energy usage. Heating, ventilation, and cooling systems consume about 45-50% of all energy in most institutions; therefore, the biggest potential savings are in this area. Forced air ventilation was shut down during non-use periods in kitchen and administrative areas along with some recirculation of air to the equipment control room for cooling. Water temperature was lowered two degrees throughout the hospital except in the kitchen which is now separately supplied. A continuous program for monitoring boiler efficiency was established; a load-shedding plan was instituted during peak demand period. Planning for a new addition has included specially designed windows and a solar energy unit for water heating. The addition has also been carefully zoned for maximum efficiency of the heating-ventilation-cooling system. The program is planned to extend to all hospital personnel and include end-use restrictions such as turning down thermostats and shutting off lights. It is stressed that these measures should not be used in place of a total energy management approach. Figures for gas and electrical consumption are cited. General recommendations are given for implementing such a program. If energy consumption becomes regulated, savings from conservation can also be invested in more patient care services.

Ellis, B. "Energy Management: The Only Game in Town." Hospitals 1976; 50(24):67-70.

The U.S. hopes for independence from foreign oil imports by 1985, but there are still many uncertainties. Oil and natural gas currently supply hospitals with 75% of their energy needs. R.E. Griffiths, energy management specialist of Health Resources Administration at the meeting of the Curtailment Strategies Technical Advisory Committee, stated that although there is enough natural gas for hospital needs, alternative fuels such as coal or oil are also obtainable. Experts agree that a change to other energy sources in the next ten years is inevitable. Solar energy units are operating at Royal Elaine Nursing Home in Georgia and South County Hospital in Rhode Island, while Lutheran General Hospital and Boston Children's Hospital are building solar hot water systems. The Indian Health Service at Shiprock, New Mexico, will have a solar system capable of heating and cooling the building. A "Solar Energy Demonstration Program for Health Institutions" will fund approximately 60 facilities from 1976 to 1980. Another program operated by HEW, "Integrated Utilities System" hopes to reduce institutions energy requirements by 42%. The project is sponsored by the Experimental Technology Incentive Program of the National Bureau of Standards. A Boston health-care facility and educational facilities have banded together to build their own electrical power plant. The system will provide electricity, steam, chilled water and solid waste incineration to the Medical Area Service Corps. Another similar project is being built in New England for the Catholic Medical Center. Beginning in 1977, a series of conferences on energy management in health care institutions will be held in conjunction with various national health organizations.

"Energy Management: Computerized." Building Design & Construction 1978 June; 52-5.

A discussion is given of computerized building automation for energy conservation. Systems are currently available for control of heating, ventilation, air conditioning, lighting systems, and monitoring plant production activity. A hospital system and a commercial building system are cited as examples.

"Energy Recovery Solves Hospital's Problem." Heating, Piping & Air Conditioning 1977 August; 49(8):53-56.

A heat recovery system for a hospital heating-ventilation-air conditioning installation is described. The system design allows for recovery of energy in the laundry exhaust air, distribution of supply air to the patient care wing, easy access for servicing, and economic feasibility. A rotary energy recovery wheel was selected as the energy recovery device because of its performance and economical advantages. The unit worked continuously without difficulty during the severe winter of 1976.

Eotvos Lorand, Tudomanyegyetem. Grid Connected Integrated Community Energy System. Phase II: Final State 2 Report. Preliminary Design Waste Management and Institutional Analysis. Budapest: Eotvos Lorand Tudomanyegyetem; 1970 March; NTIS PC A06/MF A01; 124 p.

The preliminary design of a regional, centralized solid waste management system for the Twin Cities Metropolitan Region (TCMR) in Minnesota is presented. The concept has been developed for sound environmental and safe disposal of solid waste generated from its health care industry, although some additional waste supplements are included as economic assistance in order to approach a competitive alternative to current health care solid waste disposal costs. The system design focuses on a 132 tons per day high-temperature, slagging pyrolysis system manufactured by Andco Incorporated (Andco-Torrax Division design criteria are given). A collection and transportation system (CTS) has been planned for the movements of a ten mile solid waste-shed zone, for municipal solid waste from a local transfer station currently processing municipal solid waste, and for pyrolysis residue to final disposal. Each of these facilities is now considered as a service contract operation. Approximately 15 vehicle trips per day are estimated as vehicle traffic delivering the refuse to the pyrolysis facility. Cost estimates for the CTS have been determined in conjunction with current municipal refuse haulers in the TCMR, and are valued at the following: (HHC/SSW) at 20.00 $/T; municipal transfer at 4.00 to be paid the pyrolysis system as a drop charge. Special box-bag containers are to be required in handling the HHC/SSW at a cost of 30.19 $/T estimate, the total operating cost for the pyrolysis system has been estimated to be 13.73 $/T, with a steam credit of 11.70 $/T, to yield a net cost of 2.03 $/T. Capital cost has been estimated to be 7,700,800 dollars, 1978. A back-up facility capital investment of 163,000 dollars (1978) has been estimated, which should be applied to the existing University of Minnesota incinerator.

Gish, R.W. "A Plan for Energy Savings." American Institute of Astronautics and Aeronautics 1973 August; 60:30-37.

The 150-bed hospital was designed with energy savings in mind: it is predicted that 9.34 billion Btu's will be saved yearly, a 20 to 30% total energy reduction for the life of the hospital. Design features implemented include the building orientation and perimeter wall area; the use of heat reflecting glass; and the reuse of waste energy. The heat exchanger installed operates at 66% efficiency for saving waste energy from exhaust air, does not freeze at design conditions eliminating the need for a preheating coil system, and carries a filter rating efficiency of 35 to 50% by NBS dust stop rating. It supplies/removes humidity in the incoming air stream and uses lithium chloride to purify the incoming supply air and eliminate atmospheric pollution from the exhaust air. Top floor heat gain/loss was eliminated by using that space as the building mechanical space. The hot water system was completely changed. Existing direct-fired gas storage type heaters were removed as were four inefficient fire gas fired heaters. They were replaced by a semi-instantaneous type steam-to-water heat exchanger requiring no appreciable storage; making maximum use of available steam and giving a continuous flow of constant temperature water.

Gore, E. and Qureshi, A.S. "Design Guidelines for Solar Energy Systems." Heating, Piping & Air Conditioning 1977 July; 49(7):43-53.

A comprehensive study was prepared (commissioned by the Veteran's Administration) to establish design guidelines and limitations for the selection, evaluation, and design of the energy-conserving systems to be used in future VA hospitals. The guidelines are applicable for a wide range of projects. This article deals with solar energy systems. These guidelines are to be used in conjunction with other standards (ASHRAE standard 93-77, methods of testing solar collectors; ASHRAE standard 94-97, methods of testing thermal storage devices; etc.). Specifically presented are: HVAC systems, solar collectors, maintenance, materials and surface coatings, solar collector efficiency, freeze and corrosion protection, heat storage systems, backup systems, controls and monitoring systems, typical control diagrams, solar energy design, and an economic analysis.

Gore, E. and Qureshi, A.S. "Design Guidelines for Total and Selective Energy Systems." Heating, Piping & Air Conditioning 1977 September; 44(9):57-64.

A comprehensive study was made to establish design guidelines and limitations for the selection, evaluation, and design of the energy conserving systems to be used in future Veteran's Administration Hospitals. The study sets forth considerations that must be taken into account by the designer in the early stages of a project to determine what types of energy-saving systems are feasible for that project. It establishes design procedures. While the study was prepared for hospitals, the considerations involved are virtually the same for a wide range of projects.

Hayet, L. and Maxwell, T.H. "Heat Recovery Wheel." Actual Specifying Engineer 1975 May; 33(5):54-56.

Engineers specified modular air-to-air total energy recovery exchangers to air condition the new Boca Raton Community Hospital in Florida. Major components in the factory-packaged rotary air-to-air total energy recovery wheel are intake and exhaust, a chilled water spray and coil section, supply-air filter section, plenums, exhaust-air filter section, control panel and structural base. The ability of the total energy recovery wheel to absorb and transfer moisture (latent heat) as well as temperature (sensible heat) is the result of using a desiccant finely dispersed throughout the microstructure of the wheel surfaces. The desiccant absorbs moisture from the humid airstream and gives it up to the dry airstream because of the difference in vapor pressure between the desiccant and each airstream. The recovery efficiency of the wheel ranges from 60 to 90% in the recommended operating range. The most economical operating efficiency for optimum installed cost and operating cost is near 75%.

Hayet, L. "New HVAC Concept Reduces Costs and Conserves Energy." Consulting Engineer 1977 September; 49(3):117-119.

A prepackaged unit concept was developed by combining the heat recovery wheel with conventional air handling and temperature control devices which makes it possible to provide the air conditioning effect in a routine manner for almost all hospital functional areas, with similar component assembly providing the air input. The basic system components are: the supply air fan, the return air fan, the heat recovery wheel, spray section, cooling coil, supply and return rough filters, supply final filters, terminal reheat at the duct outlets, plus controls to coordinate their operation.

Health Education Authority of Louisiana. HEAL G-C ICES, Phase II: Detailed Feasibility Analysis and Preliminary Design. New Orleans, LA: Health Education Authority of Louisiana; 1978 March; NTIS PC-A09/MF A01; 183 p.

In this preliminary report for Phase II of the Health Education Authority of Louisiana's (HEAL) Integrated Community Energy Systems Program (ICES), specific elements of the basic institutional issues were readdressed, as requested by the U.S. Department of Energy. The draft environmental assessment was reassessed and updated. Thermal energy demand profiles for the major community sectors, i.e., the five institutions comprising the HEAL complex, were refined on a month-by-month basis and resulted in establishing ICES plant systems design capacities of 121,500 pounds per hour demand and 418,175,000 pounds per year for steam; 10,000 tons demand and 38,885,000 ton-hours per year for cooling. From these values the concept of the plant was developed. The Phase I capital cost estimate was updated. The capital cost is now indicated as $29,960,500. The Phase I operating cost estimate was updated, with that figure now $8,468,479. The Phase I financial analysis was updated, producing an estimated annual revenue level of $9,907,062.

"HEW Program for Conservation in Hospitals." Heating, Piping & Air Conditioning 1977 July; 49(7).

The Health Resources Administration says that the nation could cut as much as $532 million a year from hospital and nursing home costs by the end of 1980, if basic energy conservation were adopted. Two manuals are discussed which explain these measures. They are distributed by HEW's Energy Action staff. Techniques examined include load shedding, monitoring heat plant efficiency and making proper adjustments, improving insulation, recycling air, and reducing water temperatures. Operating costs are discussed along with reductions in energy consumption and expenses.

Hittman Associates, Inc. Energy Efficient Water Use in Hospitals: Final Summary Report. 1979 March; 120 p. Available from Lawrence Berkeley Laboratory, University of California, 1 Cyclotron Road, Bldg. 90, Room 3058G, Berkeley, CA 94720.

The Energy Efficient Water Use in Hospitals study is primarily directed towards identifying and evaluating water heating energy conservation measures that are either proposed or can be currently implemented by hospitals without adversely affecting the quality of patient care, and are operational within existing sanitation standards and health codes. Also identified are conservation measures which require modification and areas requiring further research. The majority of the conclusions and recommendations researched are based on a detailed water heating energy usage and the related operational practices of hospital staff. The bases for federal, state, and local sanitation standards were researched, and inconsistencies in these standards as applied to hospital laundries and diet kitchens are reported.

The target audience for this study are hospital administrators, organizations chartered to provide operational guidelines for health care facilities, and government officials responsible for enforcing health care facility standards and codes at the federal, state, and local level.

Hoppenworth, G.L. and Mead, T.R. "Energy Conservation and Good Plant Operations Go Hand in Hand." Hospitals 1975; 49:43-46.

The Swedish American Hospital in Rockford, Illinois, has demonstrated that good plant engineering techniques can result in significant savings in fuel costs. Considerable energy conservation was started through the up-grading of procedures and facilities. Steam traps were overhauled, boiler alarms were installed, and the treatment of the boiler water was changed from liquid to dry chemicals. Piping was replaced, insulated, and the condensate was again returned to the system instead of routing to a drain. The heating units in the fresh air handling system were designed to temper the fresh air being introduced into patient rooms, and controls were set higher in summer and lower in winter, which resulted in a better temperature balance in the distribution system.

Although the area in use had increased by approximately 19% in 6 years, the energy consumption had dropped more than 25%, with a savings of $76,800, which would have been enough to heat the plant for about 1 1/2 years.

"Hospital Gets Zoned Fire Control System as Its Size Doubles." Building Design & Construction 1978 April; 19(4):54-9.

Life safety and the cost and availability of energy sources were given top priority in a project to renovate Samaritan Hospital in Ashland, Ohio. Smoke and ionization detectors were used in a fire control system based on designated zones. The two oldest buildings were demolished in order to meet new building codes. A two-phase building program enabled the hospital to continue functioning during the construction stage. A combination of natural gas, fuel, oil, and electricity was used. Steam is produced by boilers burning either oil or gas. Heat exchangers provide the hospital's heating and hot water needs, while electric reciprocating water chillers and multiple compressors provide air conditioning. The electrical system is planned for future expansion and voltage change without requiring equipment replacement. A fully insulated brick veneer wall and double-glazed windows give the wall a 0.73 U value. Other energy conserving features include heat recovery coils and the fire and smoke control built into the ventilating system.

"How Old Hospital Invested $20,000 to Save $8,000 a Year in Heating Costs." Modern Hospital 1966 September; 107(3):160.

Trafalgar Hospital in New York had obsolescent noneconomical utilities which are described in this article. All contractors contacted, except one, made the same recommendations. The dissenters' recommendations were accepted, however, in spite of a cost projection five to eight times the planned expenditure. These recommendations are listed. The changed system proved to work quite well. The old system had been costing $3,000 for coal, $6,200 for oil, $720 for management, and $10,000 for labor. The $20,000 investment reduced the annual $20,000 operating cost to $12,000 annually ($7,200 for oil and $4,800 for gas). It was found, with the addition of a combination steam and electric sterilizer ($1,000) for the operating room, that the high-pressure boiler could be shut down for a daily period, thereby increasing the savings.

"Hospitals Take Energy Conservation Steps." Hospital Progress 1974 January; 55:20-20a.

An 11-point energy conservation program is cited from St. Francis Hospital, Wichita. Directives include lowering temperatures in non-patient areas, shutting all windows, shutting off fluorescent lights when not in use for more than an hour, shutting off incandescent lights and appliances when not in use, elimination of portable heaters when possible, walking instead of using the elevators, observing speed limits and forming car pools, and better utilization of linen for hot water conservation.

St. John's Hospital, Santa Monica, California, turned off air conditioning to certain areas during non-use times at an estimated savings of 300,000 kilowatt hours per year. Some fluorescent bulbs were removed from multiple fixtures at an estimated savings of 2,800 watts per day. Initial expense for replacement of other lights will be made up in savings of over 100,000 watts per year. Other steps include water temperature reductions, equipment maintenance for maximum efficiency, and employee education.

"How to Live with Energy: 52 Ways to Conserve Fuel and Power (And Lower the Utility Bill, Too)." Modern Hospital 1974 January; 222:59-61.

There are a variety of ways that hospitals can conserve energy and reduce their utility bills. This article has compiled a list of energy saving ideas for hospitals from documents issued by the American Hospital Association, and through reporting by the staff of Modern Hospital and other McGraw Hill reporters. This list is divided into general conservation measures, heating, air conditioning, and lighting.

"Investor Owned Hospitals Cooperate in Energy Conservation." Investor-Owned Hospital Review 1974 February/March; 7:10.

Investor-owned hospitals are complying with energy crisis guidelines and apparently are experiencing little difficulty in fulfilling their health care delivery commitments. Investor owned hospitals are following energy conservation guidelines to save fuel, electricity, and gasoline. A few examples are given. Medicorps 196 bed hospital near Philadelphia has reduced its heating system from five to three hot water heaters. Water temperatures are reduced from 180 to 160 degrees without losing heat in the building. Other hospitals are lowering the thermostats, reducing unnecessary lighting, offering incentives to car pools, and are even purchasing extra blankets to meet an emergency.

Irwin, W.T. "Piping Insulations Thickness: Lower Losses, High Gains." Specifying Engineer 1977 November; 38(5):98-99.

The new Children's Hospital National Medical Center in Washington, D.C., which opened June, 1977, could claim to be one of the largest facilities (1.6 million sq. ft. of enclosed space) yet completed to incorporate substantial energy-saving mechanical and architectural designs. The system consists of an exterior weatherproof glass wall, sloping to provide natural shading and reduce heat gain with no thermal components, and an interior drywall partition with glass as required. The space between walls, varying from 2 to 5 ft., is conditioned with filtered air maintained with 10°F of room temperature. As a result, all hospital rooms can be treated as interior space, permitting the use of smaller, less sophisticated air handling units to reduce energy requirements. Mechanically, substantial energy savings can be expected from the use of significantly thicker pipe insulation, with resulting lower piping losses. High-pressure steam lines (125 lb.), for example, would normally call for 2-in. insulation thickness on 8-in. pipe. Children's Hospital's schedule, on the other hand, specified 4 1/2-in. insulation thickness pipe. This increase in insulation thickness is a deviation from past practices, since it is the usual practice to decrease the size of pipe insulation, not only for high-pressure steam, but for medium and low-pressure steam, condensate lines, hot water heating runs and domestic hot water piping as well. It seems certain that the cost of the additional insulation will be defrayed by the savings in fuel cost within the hospital's first year of operation.

Jain, A. Procedure for Estimating the Energy Requirements of a Hospital Under Planning. Austin, Texas: Texas University; 1974 January; 167 p. Available from University Microfilms International, 300 N. Zeeb Road, Ann Arbor, Michigan 48106.

Procedures are described for estimating the energy requirements of a planned hospital. The energy situation in the United States is reviewed, and four measures are identified which will contribute to the conservation of energy: 1) improved insulation in houses and buildings; 2) adoption of more efficient air conditioning systems; 3) shifting intercity freight from highway to rail, intercity passengers from air to ground travel, and urban passengers from automobiles to mass transit; 4) introduction of more efficient industrial processes and equipment. The use of electrical energy by hospitals is discussed in terms of energy resources and health facility planning. Energy consumption in a 100-bed hospital is examined for the following systems: medical equipment and instruments; heating, ventilation, and air conditioning; laundry and kitchen equipment; lighting; and elevators. Procedures for estimating the amount of energy consumed by each of these systems are detailed. Computer programs are described that were developed to implement energy consumption and forecasting techniques.

Kaelin, J.J. "How One Hospital Converted to Total Energy System." Modern Hospital 1968 April; 110(4).

By installing a "total energy" power plant, the 106-bed Jenkins Kentucky Clinic Hospital has cut its monthly electric bill in half, while collecting a bonus of free heat and hot water. A two diesel engine system was installed along with a third completely independent stand-by engine. Water from the engine cooling system is passed through a heat exchanger to provide heat for the hospital heating system and hot water supply. In the first month of operation, fuel cost was $440 compared with the previous electric bill of $900 to $1,200 per month. On a kilowatt-hour basis, purchased power cost about 1.5 cents including demand charge, while the new system produced electricity for about 0.7 cents to 0.8 cents (0.5 to 0.6 cents for fuel plus 0.2 cents for routine maintenance and provision for overhaul).

Katz, E.G. "Electricity Conservation: There's More Than One Way To Save." Journal of the American Hospital Association 1975 November.

A well-managed electricity conservation program can reduce a hospital's electricity bill by at least 10%. The engineering criteria used to design the mechanical systems in existing hospitals did not take into account increased costs and shortages of energy. Significant savings are possible by correcting situations in which energy is being overused or wasted. Rather than randomly applying conservation concepts, a systematic electricity savings program should include tabulating, charting, and monitoring of electric power consumption and costs; learning the details of electrical rate schedules and using them to the hospital's advantage; making an electricity use inventory of all the equipment that uses electric power; formulating a list of practical electricity conservation actions; and developing implementation priorities for these actions in the order of the amount of time needed for the savings to pay off the capital costs of the action.

Kuns, K.K. "Energy Conservation, Santa Barbara, California." Hospital Engineering Newsletter 1974 March/April; 19:6-7.

The director of engineering and maintenance at the Santa Barbara Cottage Hospital reports estimated savings of $2,500 to $3,000 monthly (486,480 watts), plus the energy that will be conserved when the power factor correction is made, or an estimated 51 barrels of oil per day. There have been no steps taken which jeopardize the health or safety of patients and the success of the program is attributed to the cooperation of the employees. The program includes reduced corridor lighting, more appropriate operation of air conditioning equipment, reduced interior and exterior decorative lighting and water fountain operation, shut-down of some elevators at night and the planned installation of capacitors to correct the power factor from 77 to 98%.

Lehrfeld, D. "Practicality Study of Stirling Total Energy Systems." Proceedings of the 12th Intersociety Energy Conversion Engineering Conference: Vol. II; 1977; Washington, D.C.; La Grange Park, Illinois: American Nuclear Society, Inc.; 1977; 1504-1511.

Under U.S. ERDA contract, Philips Laboratories has investigated the application of Stirling cycle prime movers to total energy power generation systems. Electrical, heating, and cooling demand profiles for a typical residential complex, hospital, and office building were studied, and alternative Stirling total energy systems were conceptualized for each site. These were analyzed in detail and contrasted with purchased-power systems for these sites to determine fuel-energy savings and investment attractiveness. The residential complex and hospital would be excellent candidates for total energy systems, and prime movers in the 1000 kW output range would be required. Stirling engines with so large an output have not been built to date. The principle advantage of a Stirling prime mover in this application, in view of national concern over present and future dependence on oil, is that it would utilize low grade liquid fuels and coal.

Lentz, C. "Initial vs. Life-cycle Cost: The Economics of Conservation." Consulting Engineer 1976 October; 47(4):84-89.

The author, a professional staff member of Arthur D. Little, Inc., explains the pros and cons of four procedures for ranking energy conservation investment proposals.

Michaud, Cooley, Hallburg, Erickson and Associates. Evaluation of Computerized Energy Programs for the Calculation of Energy Use in New and Existing Buildings: Final Report. Minneapolis, Minnesota: Michaud, Cooley, Hallburg, Erickson and Associates; NTIS PC A01; 1975 October; 152 p.

This report contains an evaluation of a number of existing HVAC LOAD and ENERGY computer programs with relation to the accuracy of the programs, and the complexity of programs implementation and the utilization cost of the programs, in order to determine whether any of the programs could be endorsed for use in meeting existing or promulgated state building codes for the design of new buildings and retrofit of existing buildings.

Miller, J.F. "Solar Energy and Economic Conderations." ASHRAE Journal 1977 November; 19(11):40-42.

Economic considerations affecting selection of solar energy systems for buildings are briefly discussed. Comparative economic analyses of several candidate solar energy system configurations are tabulated for representative cases of hospital, school, and office buildings in three regions of the U.S. Systems cost, return on investment, and projected payback period are used for economic comparison. The economic impact of using solar energy for supplemental domestic water heating is evaluated. Rules of thumb normally used for collector area and thermal storage optimization are concluded to be generally invalid.

Minnesota Energy Agency. Energy Conservation Measures That Can Be Implemented Immediately in Office Buildings. St. Paul: Minnesota Energy Agency; 1977 January.

Several energy-saving measures applicable to large buildings can also be implemented in the hospital setting. Employees should walk up one floor and down two to use all revolving doors. Tempratures should be checked and maintained. Administrators should consider reducing fresh air intake under winter conditions and operate ventilation units fewer hours during the day cycle. Lights should be turned off, drapes closed at night, and ballasts disconnected from fluorescent fixtures where tubes have been removed. The building superintendent and maintenance engineer sould survey each floor. These measures should be implemented as quickly and completely as possible.

Minnesota University. Grid-Connected Intergrated Community Energy System (ICES). Minneapolis: Minnesota University; 1978 March; NTIS, PC A05/MF A01; 78p.

The University of Minnesota GRID-ICES was divided into four identifiable programs in order to study the feasibility of each of the parts of the ICES independently. The total program involves cogeneration, fuel coversion, fuel substitution, and energy conservation by system change. This Phase II report substantiates the theory that the basic GRID ICES is not only energy-effective, but it will become most effective as unit operating costs adjust to supply demand in the 1980's. The basic program involves the cogeneration of steam and electricity. The University of Minnesota has been following an orderly process of converging its central heating plant from gas-oil to 100% coal since 1973. The first step in the transition is complete. The University is presently using 100% coal, and will begin the second step, the test burning of low Btu western coal during the spring, summer, and fall, and high Btu eastern coal during high thermal winter period. The final step to 100% western coal is planned to be completed by 1980. In conjunction with the final step, a retired northern states power generating plant has been purchased and is in the process of being retrofitted for topping the existing plant steam output during the winter months. The basic plan of ICES involves the add-on work and expense of installing additional boiler capacity at southeast steam and non-condensing electric generating capability. This will permit the simultaneous generation of electricity and heat, dependent upon the thermal requirements of the heating and cooling system in university buildings. This volume presents an overview of the community and the ICES.

Moran, A.D. "Energy Conservation Program Saves $89,000." Hospital Progress 1977 May; 58(5):50-57.

Estimates indicate that hospitals can reduce their energy consumption as much as 30% by instituting energy conservation measures. DePaul Hospital, Norfolk, VA, developed such an energy conservation program. This article outlines the approach taken by the plant and maintenance department to which the task of developing and implementing the program was delegated. In undertaking the program, DePaul utilized a step-by-step model consisting of six phases for assessing previous energy consumption and evaluating recommendations for change. Descriptions of each phase are included: the 13 recommendations selected for implementation saved 279,000 gallons of fuel oil and $89,000 in the program's first year of operation.

Morgan, R.H. "Energy Conservation." Hospital Engineeering (Sevenage) 1976 June; 30:8-9,11-13.

Various precautions are required to ensure that the use and conservation of fuel is carried out to the maximum advantage. The technique of intermittent heating has been used for many years on heating and boiler installations. The most common method used today uses the compensation control incorporated in an "on/off" heating system. A new method showing considerable savings when compared with conventional methods, calculates the optimum start time for heating and boiler installations and automatically switches on or off the heating or air conditioning systems. This system is outlined. Methods of obtaining maximum boiler efficiency are considered. A relatively inexpensive optimizer control has been designed to provide optimum processing efficency by acting as a trimming control for a plants main process controllers. The economic viability of the system becomes immediately apparent through the optimization of fuel consumption and the minimization of pollution. The functioning of the control is also described.

Moyers, J.C. and Hise, E.C. "Annual Cycle Energy System and Application." International Conference on Energy Use Management; 1977 October; Tucson, Arizona; Elmsford, New York: Pergamon Press Inc.; 1977:231-238.

The Annual Cycle Energy System (ACES), under development at ERDA's Oak Ridge National Laboratory, promises to provide space heating, air conditioning, and water heating at a significantly lower expenditure of energy than conventional space conditioning and water-heating systems. The ACES embodies heat pumping, thermal storage and, where climate dictates, solar assistance. The concept is described, along with variations in design that permit flexibility to maximize energy conservation or to provide load management capabilities. Installations that exist or are under construction are described, and variations that are incorporated to meet specific objectives are discussed.

Murnane, T. "California Hospital Sees 15-month Payback in Control Unit." Energy User News 1978 June; 3(26):7.

A California hospital expects its new energy management system to reduce energy costs by 19% a year and a have a 15-month payback. The system was designed expecially for health care facilities that require a different management approach due to their 24-hour operation, and their inability to regularly cycle equipment. Following analysis of the hospital's energy use, suitable computerized electronic equipment was selected to control the operating schedules of equipment. The biggest savings have resulted from computerized air handlers.

Naecke, O.K.E. "Central Laundries and the Energy Issue." Hospital Administration in Canada 1967 March; 16:65-6.

With emergence of the energy problem, much more must be evaluated in central laundries than the services provided. Two aspects of the problem involve energy shortages and energy costs. One of the most important energy conservation measures under consideration is that of waste heat reclamation. Heat sources include waste water, exhaust gas, condensate system, and exhaust air. Performance of air handling systems in respect to heating and make-up air requirements should be thoroughly investigated. Evaluation of new equipment including price, operating costs, history of maintenance and repairs, and energy savings features are important. Eight other general conservation measures are suggested. Factors to consider in planning central laundry facilities include overall plant efficiency, use of only one fuel, new and better concepts in building construction and services, and thorough evaluation of process equipment. Centralization of services and use of industrial and process engineering in planning of central laundry and linen services can lead to better and more efficient use.

Noakes, E.H. "Total Energy." hospitals 1970 September; 44(17):73-76.

Total energy is defined as a central plant which supplies energy needs for power, e.g., heating and cooling as one system, while simultaneously meeting all of the necessary requirements. It means the on-site generation of electrical power, coupled with a heating and chilling plant designed to make use of recent developments in heat recovery from exhaust gases and from the cooling-jacket water of the engine driving the generator. Recovered steam provides space heating and cooling, hot water, and steam for other purposes. Total energy, which is already used in some 450 large buildings in the United States, is especially suitable for hospitals because they are open 24 hours a day, need large amounts of hot water, air conditioning and steam, and have good electricity/steam balance. So far, nine U.S. hospitals have installed total energy systems. Any hospital considering total energy sould first carry out a feasibility study: this paper sets out the main factors which must be taken into account and the calculations which must be made.

Pennsylvania State University. What Can Penntap Do for Your Organization? University Park, Pennsylvania: Penntap; EES-1664; 2 p.

The Pennsylvania Technical Assistance Program (PENNTAP) of the Pennsylvania Energy Extension Service provides cost-free assistance to local governments, school districts, hospitals, business, and industry in helping to analyze their energy needs and developing energy conservation programs. Penntap can help identify energy problems and establish priorities for solving them. Penntap suggests ways to conduct an energy audit if one is necessary, and their specialists will stay until the problems are solved. To request assistance with an organization's energy problems and programs, the telephone number and address of the Penntap office are given.

Philips Laboratories. System Analysis Design and Proof-of-Concept Experiment of a Total Energy System: Quarterly Progress Report, 15 May 1976--15 August 1976. Briarcliff Manor, New York: Philips Labs; 1976; NTIS PC A03/MF A02; 36p.

The activities of Philips Laboratories on Task I, Stirling system conceptual design during this reporting period include: 1) typifying the three sites to be studied by extracting data from the raw information supplied; 2) establishing typical performance characteristics for fossil-fueled Philips Stirling prime movers; and 3) enlisting (via subcontract) the expertise of a firm in the power generation, heating, ventilating, and air conditioning fields to assist in accomplishing the conceptualization effort of Task I in a timely fashion. The three sites selected for study were a residential complex in Jersey City, New Jersey; a military hospital in Fairfield, California; and a federal office building in Anchorage, Alaska. For each site, typical heating, cooling and electrical profiles were selected for a full day during each season of the year. These demand profiles were to be used to characterize the sites for the remainder of the study.

Proceedings of the Conference on Improving Efficiency and Performance of HVAC Equipment and Systems for Commercial and Industrial Buildings: Volume I. 1976 April; Lafayette, Indiana; West Lafayette Indiana: Purdue Research Foundation; 1976; 292 p.

Abstracts were prepared for 47 of the 48 papers (in volumes) presented at the conference; one paper was processed previously. In volume I, abstracts were prepared for 33 of the 47 papers, with abstracts prepared for the remaining papers appearing in volume II. Two citations are announced with abstracts only.

Pulley, F.L. "Small Hospital Big on Comfort and Economy." Heating, Piping & Air Conditioning 1965 March; 37:91-5.

A new 44-bed hospital with area heating/cooling zones is described. The area containing the laundry and kitchen facilities requires winter heating with adequate positive ventilation and ventilation rates of 8 cfm/ft^2 for the kitchen and laundry, with 2-speed fans in the kitchen for operational economy. More critical control is maintained over the area containing OR and delivery rooms, nursery lab, etc. Recirculation in these areas is permitted during non-occupied periods; while during occupied periods 100% outside air is used and exhausted. Assuming that the room lights indicate occupancy of the OR, a relay activates the controls to place it on 100% outside air. The administrative areas provide for the occupants' comfort and sufficient exhaust to allow for occupancy and some smoking. The bedroom wing is supplied with 50 cfm to a 2-bed room. The central heating plant consists of 2 scotch-type boilers operating at 100 psi with pressure reducing stations as needed. Each boiler is rated at 6150 MBtuh at 100% firing and provides 2750 MBtuh at full load by the absorption water chilling machine. When gas and electric costs were compared, it was found the absorption unit offers a savings of $1368. The total annual and operating costs amount to a $1143 savings due to the use of the absorption unit.

"Recovery of Heat From Waste: A Burning Issue." Processing 1977 September; 23(9):81.

The energy conservation aspects of heat recovery systems for use with solid waste incinerators are described with examples of the waste heat recovered from burning industrial, municipal, and hospital wastes.

Satterfield, T.F. "Financial Managers Play Important Role in Control of Energy Cost and Use." Hospital Financial Management 1976 October; 30:50-2.

There are two basic methods for conserving energy. The first is simply not to use it; but, this is not practical with ill patients. The answer must be the superior monitoring of its use. This author lists 19 steps for conserving energy as it relates to HVAC. The following were included: 1) consider package units to serve small areas that need around the clock service permitting major systems to be shut down; 2) reduce the environmental requirements as much as possible; 3) consider selective switching of air handlers to shut off unnecessary units; 4) use exhaust air to precondition incoming air; and 5) install vestibules at entrances to reduce unnecessary loss of conditioned air. This article also discussed electricity and lighting in regards to energy conservation.

Smith, L.T., Matula, R.A. and Tsou, F. "Solid Waste Incineration Energy Recovery in Hospitals." Journal of Environmental Systems 1976; 6(4):303-320.

Small-scale, on-site incineration is examined as one practical method for disposing of hospital solid waste. On-site incineration-energy recovery systems are reviewed, and potential annual savings of conventional fuel cost are computed as a function of bed capacity and fuel costs. Potential savings in a 500 bed hospital, for example, are found to range from 19,000 to 57,000 dollars per year for a fuel price range of one to three dollars per million Btu. A market survey of 492 hospitals in Pennsylvania, New Jersey, and Delaware, indicates a strong potential interest in on-site incineration-energy recovery systems. Extrapolation of the survey results to the Northeast and Middle Atlantic regions shows a potential market of 500 to 600 small-scale units. Potential blockages to the hospital market, such as particulate emissions and auxiliary fuel requirements, are discussed.

Spielvogel, L.G. Critical Analysis of FEA Office Lighting Study: HVAC Energy Relationships. Wyncote, PA: Lawrence G. Spielvogel, Inc.; 1975 October; PB-246555; 37 p.

The purpose of this report is to present a critical analysis of heating and cooling energy relationships and conclusions in the Ross and Baruzzini study for FEA entitled "Energy Conservation Applied to Office Lighting", dated April 15, 1976. This report should be obtained with the Ross and Baruzzini study (NTIS PB-244154/1WB; PC $8.75/MF $2.25) since frequent references are made to it in order to avoid duplication of material. Numerous errors and inconsistencies are identified and the computer energy analyses are critiqued.

Spielvogel, L.G. "Designer's Need for Research Information." Proceedings of an EPRI Workshop on Technologies for Conservation and Efficient Utilization of Electric Energy. Volume I. Executive Summary; Volume II. Work Papers. 1976 July; San Diego, CA; 1976; EPRI-EM-313-SR: 5.78-5.82 (vol. II).

The type of information needed by designers to improve energy conservation in buildings and the ways in which research programs will provide such information are discussed. Research on design methods for heating-ventilating and air conditioning systems, and for predicting the energy needs of buildings are recommended.

Spielvogel, L.G. "Energy Management: Technology, Engineering and People." ASHRAE Journal 1976 June; 18(6):39-40.

The ability to manage energy use in buildings requires a combination of technology and the application of engineering "know-how" to the building for use by its occupants. Traditional concern has been placed on the design capacity of building systems and the performance of the equipment and systems at these conditions. An alternative to this system would be to design a building so that its varied energy needs can be met only to the necessary extent during the hours when the system is needed. While the more efficient equipment being utilized in building design is superior, an even higher degree of superiority could be achieved by the use of a proper initial concept. In order to attain the most desirable result: technology, engineering, and people must be considered jointly if a higher level of energy-efficient building is to be realized.

Swann, L.E. "Energy Conservation Is the Rule." Hospital Engineering November/December 1976; 2:3-4.

Many routine changes to conserve energy were implemented in an Alabama hospital, but the most dramatic change occured after a conversion from a double duct air conditioning system to a variable-volume system. This was accomplished by removing the rod between the two dampers on the mixing box and closing the hot deck damper serving all interior zones. Total dollar reduction was $3000 a month. After opening a new 28,000 sauare foot addition, the facility was still using less energy than before the change was made.

Swan, L.H. "Energy Conservation Practices in Georgia Hospital." Hospital Engineering 1976; 21(5):2-3.

St. Mary's Hospital, Athens, GA, has taken positive steps to contain costs by reducing purchases of gas and electricity. The following measures and estimated annual savings were included: 1) addition of a 125 ton chiller to carry light loads when the 450 ton unit is not needed - $7,136.99. 2) changing from 23 500-watt incandescent lights to 28 150-watt sodium lights - $1,047.55. 3) shutting down at night the air handling system in the business office, data processing, and medical records - $2,055.97. 4) removing two elevators from service at night $1,175.30. 5) changing of burners on boilers from nonmodulating to modulating - $1,175.30. 6) reduction of incinerator operating time from eight hours to four hours - $2,555. These are just a few energy saving ideas that can be incorporated in a hospital plan. Net savings annually are approximately $21,154.

Thermal Storage Ideal for All-electric Economy. Electric Light Power (Boston) 1976 October; 54(10):38.

A review of different techniques for saving both the customer and the utility money indicated that the energy storing concept had the greatest potential. The off-peak electric thermal storage system at the Catholic Medical Center in Machester, New Hampshire is described. The hospital will use electricity only at night and will store it as heat energy in the 126,000-gallon underground heat sink. The practice will save the hospital about $40,000 the first year.

"Total Energy Provides Total Solution." Modern Hospital 1969 May; 112(5):154+.

Franklin Foundation Hospital has installed a total energy system. Two main factors led to the decision to install this system; 1) the hospital's location in a hurricane belt prompting need for minimum disruption of power and 2) the ready availability of gas. Experience with one engine-generator set indicated that half-time operation cut the electric bill from $1,150 per month to $515, while increasing average gas cost only $117. Expanding these figures to full-time generation, total energy would increase the monthly gas bill only by $235 while eliminating electric costs for a savings of about $12,000 annually. Projecting this figure to the facility upon completion of construction, estimated annual savings would be about $36,000. The system and operation is described. Heat is recovered to operate building air conditioning, hot water converters, and water heaters. Maintenance of the system is discussed.

The complete on-site energy plant costs about $120,000 to install; net investment is calculated at $100,000, based on alternative cost of $10,000 for incoming electric service and $10,000 for a standby engine-generator for set. Annual depreciation, insurance premium, interest, and fuel cost figures are given along with estimated comparison costs of purchased power. Taking into account all of these elements, the owners and engineers project a system payback period of less than five years.

Transaction Systems, Inc. Evaluation of Energy Conservation within Health Facilities: Final Report. Atlanta, Georgia: Transaction Systems, Inc.; 1976 September, PB-256006; 63 p.

Four regional energy conferences were staged by the Health Resources Administration (HRA) to increase the awareness of health care facility administrators and engineers concerning the impact of energy shortages on the facility's ability to operate. The conferences were also designed to suggest various strategies to conserve energy or otherwise minimize the impact of rapidly rising fuel costs. A handbook on energy conservation was produced by HRA for use by small facility hospitals engineers. Recommendations for further HRA initiatives in the field of energy include: additional conferences, a national blueprint, and a high level policy conference. Appendixes contain evaluation forms, conference rosters, and a brochure advertising the conferences.

Ultrasystems, Inc. A Market Study of Energy-Related Equipment for the Commercial Buildings Sector: Decision-makers, Buying Process, and Marketing Strategies. Final Report. Newport, California: Ulrasystems, Inc.; 1976 September; 155 p.

Detailed information is given on the market for conservation practices in the commercial buildings sector that may be stimulated or supported by federal government actions and initiatives. The commercial building sector, both existing and projected through 1980, is described, and levels of energy consumption in each segment of the commercial buildings sector is listed. Key decision-makers involved in the buying and adaptation processes used for energy-related equipment, both new and retrofit, are discussed. Existing market approaches, decision processes, areas of concentration for energy conservation, and recommendations for federal strategies to encourage energy conservation practices are covered.

Ward, H.O. "Energy Recovery in Commercial Buildings." Environmental Science and Technology 1977; 20(6):9-11.

Examples of heat recovery equipment, i.e., heat wheels and exhaust air heat exchangers in operation in office buildings, hospitals, and industrial plants for metals and food processing are presented. The energy or fuel conservation potential of using heat recovery equipment is discussed.

Wareham, III., E.A. "Intricacies of Illumination." Consulting Engineer 1977 September; 49(3):120-4.

Considerations in the lighting of health care facilities that are different from the lighting of other installations discussed include: the importance of color in certain areas; the special footcandle levels and their distribution depending upon the task and where it occurs; the selection of fixtures to perform the specific lighting task; and the impact of other electrical systems on the lighting system.

Weibel, W.A. "Update on LPS." Light Design & Application 1977 November; 7(11):46-50.

Recent applications of low-pressure sodium lamps indicate rapidly increasing acceptance despite the color rendition problem. The LPS lamps are characterized by: high light output, long life, high efficiency, low energy use and low energy cost. The present, highly developed LPS lamp is available in five wattages: 35 (4800 lumens of output), 55 (8000), 90 (13500), 125 (22500) and 180 (33000); there is little or no decrease in light output during its life. The efficacies of these lamps (lumens of light output per watt of power input) are, respectively, 137, 145, 150, 167, and 183. In comparison, efficacies for other sources range from 18-23 for incandescent, 42-63 for mercury, 68-86 for fluorescent, 84-115 for metal halide and 95-140 for high-pressure sodium.

Whyte, J.J. "An All-electric Hospital." Hospitals 1971 November; 45:98.

The new Provident Hospital (273 beds), Baltimore, is an all-electric hospital. Services and techniques made available by this system are listed. Patient rooms are autonomous with individual controls. Economic installation was a prime consideration in the selection of the all-electric system. The particular needs of individual areas were easily met from the wide range of available electrical equipment, and installation time and labor costs were less than those for other systems, since equipment was economically installed where heat was needed. Also, because the system requires few moving parts that wear out or break down, operation is nearly maintenance free. Another economical facet is heat generation at the point of use, instead of a central source which requires a transmission and its attendant heat dissipation. The power, mechanical, and waste handling systems are described in detail; also the central control console and its operation. Seven air-to-air rotary heat exchangers are employed in the air-conditioning system and their operation is described. There is no air recirculation within the building and comparisons of power usage are made with and without the heat exchangers. A one time saving was realized attributable to the reduction in sizing of equipment, electrical distribution system, and smaller chilled water piping and pumps. Based on a negotiated rate of 1.016 cents per kilowatt-hour, projected savings are made of one-time savings of $496,000 for the all-electric system over a gas system and $521,000 over an oil system. The projected all-electric annual cost savings over the gas or oil systems are $75,439 and $68,549 respectively.

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TABLES

These tables are provided for the purpose of cross referencing each of the abstracted reports found in this bibliography. They list a number of subject areas which should prove interesting to an energy auditor. Tables I-III correspond to the three major divisions of this bibliography: audits, instructional materials, and miscellaneous documents.

Table I. See: Hospital Energy Audit Reports, pp. 3-10.

Sources of Audit Materials	Heating	Ventilation	Air Conditioning	Laundry	Kitchen	Incineration	Bldg. Envelope	Windows	Electrical Systems (including lighting)	Operation & Maintenance	Solar	Heat Recovery	Total Energy	Steam	Monitoring System	Domestic Hot & Cold Water	Economic Analysis	Computer Simulation	Administrative Guidance	Energy Type
ANCO	●	●	●		●				●									●		Elect./gas
Cummings									●		●					●				Elect./gas
Energy Management Services	●	●	●	●	●				●	●								●	●	Elect./gas/oil
Gard, Inc.	●	●	●						●	●		●		●	●		●			Elect./steam
Minnesota	●	●	●	●			●		●							●		●		
Philips	●		●						●			●	●							Gas/coal/Low-grade liquid fuels
Pope	●	●	●			●	●		●	●		●		●	●	●		●		Steam/elect./gas
Reynolds	●	●	●	●			●	●	●	●				●	●					Fuel oil/elect./steam
Ross & Baruzzini	●	●	●	●	●				●	●						●				Gas/elect./steam
Spot Survey																	●			Gas/fuel oil/elect.
Stein	●	●	●		●	●	●	●	●							●				Fuel oil/elect.
Van Zelm	●	●	●						●		●				●				●	Elect./oil/gas
Ziedan									●											Fuel oil

Table IIa. See: Instructional Materials, pp. 13-17.

Sources of Instructional Materials \ Instructional Materials	Heating	Ventilation	Air Conditioning	Laundry	Kitchen	Incineration	Bldg. Envelope	Windows	Electrical Systems (including lighting)	Operation & Maintenance	Solar	Heat Recovery	Total Energy	Steam	Monitoring System	Domestic Hot & Cold Water	Economic Analysis	Computer Simulation	Administrative Guidance
Blue Cross	●	●	●	●	●	●	●	●	●	●				●		●			●
Boyle			●						●					●		●	●		
DOE																			●
DHEW (76-619)																			●
DHEW (76-620)	●	●	●					●	●		●	●							●
Dubin	●		●						●	●									
Energy Management	●	●	●						●	●									●
Enviro-Management	●	●	●				●		●				●			●			●
Federal Energy Administration	●	●	●						●	●	●	●	●			●	●	●	●
Narramore	●	●	●						●								●		●

Table IIb. See: Instructional Materials, pp. 18-23.

Sources of Instructional Materials	Heating	Ventilation	Air Conditioning	Laundry	Kitchen	Incineration	Bldg. Envelope	Windows	Electrical Systems (including lighting)	Operation & Maintenance	Solar	Heat Recovery	Total Energy	Steam	Monitoring System	Domestic Hot & Cold Water	Economic Analysis	Computer Simulation	Administrative Guidance
Pacific Gas	●	●	●				●		●										
Price			●														●		
Spielvogel (how to)	●		●														●		●
Spielvogel (Energy Audits)																	●		
Stein										●									
Stroeh																			●
Total Energy													●						
U.S. Government	●	●	●		●			●	●			●				●			
Veterans Administration	●	●	●	●	●		●		●							●			
Wood																			●

Table IIIa. See: Miscellaneous Documents, pp. 27-34.

Sources of Other Materials	Heating	Ventilation	Air Conditioning	Laundry	Kitchen	Incineration	Bldg. Envelope	Windows	Electrical Systems (including lighting)	Operation & Maintenance	Solar	Heat Recovery	Total Energy	Steam	Monitoring System	Domestic Hot & Cold Water	Economic Analysis	Computer Simulation	Administrative Guidance
Baird		●	●																
Banner						●					●	●							
Building	●		●						●					●		●			
Christopher	●	●	●								●							●	
Cummings	●		●								●								●
Design	●		●			●					●		●						
DHEW	●		●										●				●		
Downey	●	●	●						●		●					●			
Dressler																	●		●
Dubin	●	●	●	●	●												●		
Dubin-Mindell	●	●	●									●					●		
Egelston	●	●	●									●							
Ellis (1977)	●	●	●		●			●	●	●	●		●						
Ellis (1976)	●	●	●			●			●		●			●					
Energy Management	●	●	●						●						●				
Energy Recovery	●	●	●									●							
Eotvos						●													

Table IIIb. See: Miscellaneous Documents, pp. 35-42.

Sources of Other Materials	Heating	Ventilation	Air Conditioning	Laundry	Kitchen	Incineration	Bldg. Envelope	Windows	Electrical Systems (including lighting)	Operation & Maintenance	Solar	Heat Recovery	Total Energy	Steam	Monitoring System	Domestic Hot & Cold Water	Economic Analysis	Computer Simulation	Administrative Guidance
Gish	●	●						●				●		●					
Gore (Solar)	●	●	●								●				●		●		
Gore(Total)	●									●		●	●				●	●	
Hayet (Heat Recovery)	●		●									●							
Hayet (New HVAC)	●	●	●																
Health Education			●											●			●		
HEW Program	●	●					●								●				
Hittman	●			●	●														●
Hoppenworth	●	●	●							●				●					
Hospital gets zoned	●	●	●				●	●	●					●		●			
How old hospital	●								●					●					
Hospitals take energy	●		●					●	●	●									
How to live	●		●						●	●									
Investor owned	●								●	●									
Irwin	●	●	●				●	●						●		●			
Jain	●	●	●	●	●		●		●									●	
Kaelin	●		●							●		●	●			●			

Table IIIc. See: Miscellaneous Documents, pp. 42-48.

Other Materials

Sources of Other Materials	Heating	Ventilation	Air Conditioning	Laundry	Kitchen	Incineration	Bldg. Envelope	Windows	Electrical Systems (including lighting)	Operation & Maintenance	Solar	Heat Recovery	Total Energy	Steam	Monitoring System	Domestic Hot & Cold Water	Economic Analysis	Computer Simulation	Administrative Guidance
Katz									●										
Kuhns			●						●	●									
Lehrfeld	●	●	●						●				●						
Lentz	●	●	●														●		
Michaud																		●	
Miller	●		●								●					●	●		
Minnesota Energy Agency	●	●	●						●	●									
Minnesota University	●								●					●					
Moran										●									
Morgan	●									●									
Moyers	●		●																
Murnane	●	●								●									
Naecke	●	●	●	●								●							
Noakes	●	●	●						●			●		●		●			
Pennsylvania State Univ.																			●
Philips	●	●	●						●										
Proceedings	●	●	●																

Table IIId. See: Miscellaneous Documents, pp. 49-55.

Sources of Other Materials	Heating	Ventilation	Air Conditioning	Laundry	Kitchen	Incineration	Bldg. Envelope	Windows	Electrical Systems (including lighting)	Operation & Maintenance	Solar	Heat Recovery	Total Energy	Steam	Monitoring System	Domestic Hot & Cold Water	Economic Analysis	Computer Simulation	Administrative Guidance
Pulley	●	●	●	●	●				●										
Recovery						●						●					●		
Satterfield	●	●	●						●										●
Smith						●						●							
Spielvogel (critical)	●	●	●						●										
Spielvogel (designer's)	●	●	●																
Spielvogel (energy)			●					●											●
Swann			●																
Thermal									●										
Total	●	●	●								●	●					●		
Transaction																			●
Ultrasystems	●	●	●						●								●		
Ward												●							
Wareham									●										
Weibel									●										
Whyte			●						●			●			●				

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