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MASTER

FROM
IOWA STATE COMMERCE COMMISSION
STATE HOUSE
DES MOINES, IOWA 50319

I-SAVE CONSERVATION PROGRAM

IMPLEMENTING

TITLE II OF NECPA

RESIDENTIAL CONSERVATION SERVICE

FINAL DRAFT 5-30-80

FC01-77RG08117

DISCLAIMER

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CHAPTER 27

IOWA-SAVES AMERICA'S VITAL ENERGY

The I-SAVE (Iowa Saves America's Vital Energy) conservation plan was developed pursuant to Title II, Part I of the National Energy Conservation Policy Act (NECPA) of November 1978 and satisfies the requirements of a Residential Conservation Service Plan as outlined in the Federal Register of November 7, 1979. This plan is designed to provide comprehensive energy conservation information and services to residential consumers in Iowa who are served by large investor owned electric and gas utilities and participating home heating suppliers.

The Iowa state commerce commission, designated lead agency by governor Robert D. Ray on November 30, 1979, is charged with overall responsibility for development and implementation of the I-SAVE plan. In this regard, the ISCC identified approximately 20 individual groups who would be affected by the plan and invited them to participate directly in the formulation of specific plan provisions. These groups represented other state agencies, private contracting and building groups, financial institutions and associations, public and private utility associations and public interest groups. Subcommittees were formed and given a deadline of March 15, 1980, for the submission of all comments and plan proposals. On April 3, 1980, an executive committee was appointed and assigned the task of final review of the subcommittee work and consolidation of the input into plan form.

Public hearings were held on the draft plan at five locations throughout the state from April 24 to May 13, 1980. At the conclusion of the hearing process, all testimony and comments received were summarized, carefully reviewed and incorporated into the plan as necessary.

The overall objective of the I-SAVE plan is to conserve energy by facilitating cost effective retrofit of existing housing and promoting more efficient energy use. The ultimate benefit available to the customer under the I-SAVE plan--reduction in energy use--is dependent upon the action he or she takes as a result of the program audit. Benefits to the utility and the ratepayers as a whole, however, will accrue only upon widespread customer acceptance and utilization of program services. This degree of program acceptance and the resulting benefits to ratepayers can be attained only through an aggressive educational and promotional effort by the covered utilities.

This Commission, therefore, strongly encourages covered utilities to adopt aggressive promotional strategies for the I-SAVE plan.

250--27.1(476) <u>Scope and coverage.</u>

All electric and gas utilities which have sales, other than resale, exceeding 750 million kilowatt hours of electricity or 10 billion cubic feet of gas and participating home heating suppliers, shall provide a program announcement and shall offer conservation services to their customers who occupy a residential building containing at least one, but not more than four units, in a manner as provided by these rules.

The following electric and gas utilities have been identified as having sales in excess of the minimum sales listed above.

Covered Utilities

Interstate Power Company
100 Main Street
Dubuque, Iowa 52001

Iowa Electric Light & Power Company
P. O. Box 351
Cedar Rapids, Iowa 52406

Iowa-Illinois Gas & Electric Co.
206 E. 2nd Street
Davenport, Iowa 52808

Iowa Power & Light Company
P. O. Box 657
Des Moines, Iowa 50303

Iowa Public Service Company
P. O. Box 778
Sioux City, Iowa 51102

Iowa Southern Utilities Company
300 Sheridan Road
Centerville, Iowa 52544

Minnegasco
733 Marquette Avenue
Minneapolis, Minnesota 55402

Peoples Natural Gas Division
2223 Dodge Street
Omaha, Nebraska 68102

North Central Public Service Co.
1080 Montreal Avenue
St. Paul, Minnesota 55102

Union Electric Co.
P. O. Box 487
Keokuk, Iowa 52632

Covered Non-Regulated

Omaha Public Power District
1625 Harney Street
Omaha, Nebraska 68102

250--27.2(476) Definitions.

1. Assistant secretary. The term "assistant secretary" means the assistant secretary for conservation and solar energy of the U. S. Department of Energy.

2. Commission/lead agency/ISCC. ISCC means the Iowa state commerce commission.

3. Governor. The term "governor" means the governor of Iowa or his designee.

4. Secretary. The term "secretary" means the secretary of energy.

5. State. The term "state" means the state of Iowa.

6. Class B energy audit. The term "class B energy audit" means an energy audit in which the estimates of costs and savings associated with the installation of program or state measures are based on information collected by an eligible customer about his or her residential building and sent to a covered utility or participating home heating supplier for analysis.

7. Covered utility. The term "covered utility" means in

any calendar year a public utility which during the second preceding calendar year had either:

a. Sales of natural gas for purposes other than resale which exceeded 10 billion cubic feet, or

b. Sales of electric energy for purposes other than resale which exceeded 750 million kilowatt-hours.

8. Eligible customer. The term "eligible customer" means a person who:

a. Owns or occupies a residential building; and

b. Receives a fuel bill from a covered utility or participating home heating supplier for fuel used in such residential building.

9. Energy conservation measures. The term "energy conservation measures" means the following measures in a residential building:

a. Caulking. The term "caulking" means pliable materials used to reduce the passage of air and moisture by filling small gaps including:

(1) At fixed joints on a building;

(2) Underneath baseboards inside a building;

(3) In exterior walls at electrical outlets;

(4) Around pipes and wires entering a building; and

(5) Around dryer vents and exhaust fans in exterior walls.

Caulking includes, but is not limited to, materials commonly known as "sealants", "putty", and "glazing compounds".

b. Weatherstripping. The term "weatherstripping" means narrow strips of material placed over or in movable joints of windows and doors to reduce the passage of air and moisture.

c. Furnace efficiency modifications. The term "furnace efficiency modifications" means:

(1) Replacement furnaces or boilers. The term "replacement furnaces or boilers" means a furnace or boiler, including a heat pump, which replaces an existing furance or boiler of the same fuel type and which reduces the amount of fuel consumed due to an increase in combustion efficiency, improved heat generation or reduced heat losses.

(2) Furnace replacement burner (oil). The term "furnace replacement burner (oil)" means a furnace or boiler, including a device which atomized the fuel oil, mixes it with air, and ignites the fuel-air mixture, and is an integral part of an oil-fired furnace or boiler including the combustion chamber, and which because of its design, achieves a reduction in the oil used from that used by the device which it replaces.

(3) Flue opening modification. The term "flue opening modification" means an automatically operated damper installed in a gas-fired furnace (often called a vent damper) which:

(a) Is installed downstream from the drafthood, and

(b) Conserves energy by substantially reducing the flow of heated air through the chimney when the furnace is not in operation.

(4) Electrical or mechanical ignition system. The term "electrical or mechanical ignition system" means a device which, when installed in a gas-fired furnace or boiler,

automatically ignites the gas-burner and replaces a gas pilot light.

d. Replacement central air conditioner. The term "replacement central air conditioner" means a central air conditioner which replaces an existing central air conditioner of the same fuel type and which reduces the amount of fuel consumed due to an increase in efficiency.

e. Ceiling insulation. The term "ceiling insulation" means a material primarily designed to resist heat flow which is installed between the conditioned area of a building and an unconditioned attic. Where the conditioned area of a building extends to the roofs, the term "ceiling insulation" also applies to such material used between the underside and upperside of the roof.

f. Wall insulation. The term "wall insulation" means a material primarily designed to resist heat flow which is installed within or on the walls between conditioned areas of a building and unconditioned areas of a building or the outside.

g. Floor insulation. The term "floor insulation" means a material primarily designed to resist heat flow which is installed between the first level conditioned area of a building and an unconditioned basement, a crawl space or the outside beneath it. Where the first level conditioned area of a building is on a ground level concrete slab, the term "floor insulation" also means such material installed around the perimeter of or on the slab. In the case of mobile homes, the term "floor insulation" also means skirting to enclose the space between the building and the ground.

h. Duct insulation. The term "duct insulation" means a material primarily designed to resist heat flow which is installed on a heating or cooling duct in an unconditioned area of a building.

i. Pipe insulation. The term "pipe insulation" means a material primarily designed to resist heat flow which is installed on a heating or cooling pipe in an unconditioned area of a building.

j. Water heater insulation. The term "water heater insulation" means a material primarily designed to resist heat flow which is suitable for wrapping around the exterior surface of the water heater casing.

k. Storm window. The term "storm window" means a window or glazing material placed outside or inside an ordinary or prime window, creating an air space, to provide greater resistance to heat flow than the prime windows alone.

l. Thermal window. The term "thermal window" means a window unit with improved thermal performance through the use of two or more sheets of glazing material affixed to a window frame to create one or more insulated air spaces. It may also have an insulating frame and sash.

m. Storm or thermal door. The term "storm or thermal door" means:

(1) A second door, installed outside or inside a prime door, creating an insulating air space;

(2) A door with enhanced resistance to heat flow through the glass area by affixing two or more sheets of glazing material; or

(3) A prime exterior door with an R-value of at least 2.

n. Heat reflective and heat absorbing window or door material. The term "heat reflective and heat absorbing window or door material" means a window or door glazing material with exceptional heat-absorbing or heat-reflecting properties; or reflective or absorptive films and coatings applied to an existing window or door which thereby result in exceptional heat-absorbing or heat-reflecting properties.

o. Devices associated with electric load management techniques. The term "devices associated with electric load mangement techniques" means customer-owner or leased devices that reduce the maximum kilowatt demand on an electric utility and which are either:

(1) Part of a radio, ripple or other utility controlled load switching system on the customer's premises;

(2) Clock-controlled load switching devices;

(3) Interlocks, and other load-actuated, load-limiting devices, or

(4) Energy storage devices with control systems.

p. Clock thermostat. The term "clock thermostat" means a device which is designed to reduce energy consumption by regulating the demand on the heating or cooling system in which it is installed, and uses:

(1) A temperature control device for interior spaces

incorporating more than one temperature control level; and

(2) A clock or other automatic mechanism for switching from one control level to another.

10. Energy conserving practices. The term "energy conserving practices" means:

a. Furnace efficiency maintenance and adjustments, which means cleaning and combustion efficiency adjustment of gas or oil furnaces, periodic cleaning or replacement of air filers on forced-air heating or cooling systems, lowering the bonnet or plenum thermostats to 80° F. on a gas or oil forced-air furnace, and turning off the pilot light on a gas furnace during the summer;

b. Nighttime temperature setback, which means manually lowering the thermostat control setting for the furnace during the heating season to a maximum of 55° F. during sleeping hours;

c. Reducing thermostat settings in winter, which means limiting the maximum thermostat control setting for the furnace to 68° F. during the heating season;

d. Raising thermostat settings in summer, which means setting the thermostat control for an air conditioner to 78° F. or higher during the cooling season;

e. Water flow reduction in showers and faucets, which means placing a device in a shower head or faucet to limit the maximum flow to three gallons per minute, or replacing existing shower heads or faucets with those having built-in provisions for limiting the maximum flow to three gallons per minute;

f. Reducing hot water temperatures, which means manually setting back the water heater thermostat setting to 120° F., and reducing the use of heated water for clothes washing;

g. Reducing energy use when a home is unoccupied, which means reducing the thermostat setting to 55° F. when a home is empty for four hours or longer in the heating season, turning an air conditioner off in the cooling season when no one is home, and turning a water heater off when a home is vacant for two days or longer;

h. Plugging leaks in attics, basements, fireplaces, switch plates and wall plates which means:

(1) Installing scrap insulation or other pliable materials in gaps around pipes, ducts, fans, or other items which enter the attic or basement from a heated space;

(2) Installing fireproof material to plug any holes around any damper in a fireplace;

(3) Installing rubber gaskets or similar material around switch plates and wall plates; and

(4) Adding insulation to an attic or basement door.

i. Sealing leaks in pipes and ducts, which means installing caulking in any leak in a heating or cooling duct, tightening or plugging any leaking joints in hot water or steam pipes, and replacement of washers in leaking water valves;

j. Efficient use of shading, which means using shades or drapes, to block sunlight from entering a building in the cooling season, to allow sunlight to enter during the heating season, and to cover windows tightly at night during the heating season; and

k. Such other low or no cost practices designated by the governor and approved by the assistant secretary in a state plan which save energy, do not require the installation of energy conservation or renewable resource measures; and do not adversely impact the RCS program.

11. Home heating supplier. The term "home heating supplier" means a person who sells or supplies home heating fuel (including no. 2 heating oil, kerosene, butane, and propane) to an eligible customer for consumption in a residential building.

12. Participating home heating supplier. The term "participating home heating supplier" means a home heating supplier that has elected to participate in a state residential conservation service plan which includes home heating suppliers.

13. Program audit. The term "program audit" means an energy audit in which the estimates of costs and on an on-site inspection of the residence of an eligible customer by an auditor qualified according to a state or non-regulated utility plan.

14. Program measures. The term "program measures" means those energy conservation or renewable resource measures which the assistant secretary has by rule determined to be appropriate by climatic region and building category.

15. Public utility. The term "public utility" means any person, state agency, or federal agency which is engaged in the business of selling natural gas or electric energy, or

both, to residential customers for use in a residential building.

16. Renewable resource measure. The term "renewable resource measure" means the following measures in or with respect to a residential building:

a. Solar domestic hot water systems. The term "solar domestic hot water systems" means equipment designed to absorb the sun's energy and to use this energy to heat water for use in a residential building other than for space heating, including thermosiphon hot water heaters.

b. Active solar space heating systems. The term "active solar space heating systems" means equipment designed to absorb the sun's energy and to use this energy to heat living space by the use of mechanically forced energy transfer, such as fans or pumps.

c. Combined active solar space heating and solar domestic hot water system. The term "combined active solar space heating and solar domestic hot water system" means equipment designed to perform both of the functions described in paragraphs a and b.

d. Passive solar space heating and cooling systems. The term "passive solar space heating and cooling systems" means systems that make most efficient use of, or enhance the use of, natural forces--including solar insulation, winds, night time coolness and opportunity to lose heat by radiation to the night sky--to heat or cool living space by the use of conductive, convective or radiant energy transfer. Passive solar systems include only:

(1) Direct gain glazing systems. The term "direct gain glazing systems" means the use of south-facing (+ or -45° of true south) panels of insulated glass, fiberglass, or other similar transparent substances that admit the sun's rays into the living space where the heat is retained. Glazing is either double-paned, or single-paned equipped with movable insulation.

(2) Indirect gain systems. The term "indirect gain systems" means the use of panels of insulated glass, fiber glass or other transparent substances that direct the sun's rays onto specially constructed thermal walls, ceilings, rockbeds, or containers of water or other fluids where heat is stored and radiated.

(3) Solaria/sunspace systems. The "solaria/sunspace systems" means a structure of glass, fiberglass or similar transparent material which is attached to the south-facing (+ or -45° of true south) wall of a structure which allows for air circulation to bring heat into the residence, and which is able to be closed off from the residential structure during periods of low solar insolation.

(4) Window heat gain retardants. The term "window heat gain retardants" means those mechanisms which significantly reduce summer heat gain through south-facing (+ or -45° of true south) windows by use of devices such as awnings, insulated rollup shades (external or internal), metal or plastic solar screens, or moveable rigid insulation.

(5) Wind energy devices. The term "wind energy devices" means equipment that uses wind energy to produce energy in any form for personal residential purposes.

(6) Replacement solar swimming pool heaters. The term "replacement solar swimming pool heaters" means devices which are used solely for the purpose of using the sun's energy to heat swimming pool water and which replace a swimming pool heater using electricity, gas and other fossil fuel.

17. New customer. The term "new customer" means a person who becomes eligible after initial distribution of the conditioned program announcement, but before January 1, 1985.

18. Measures warranty. The term "measures warranty" means a manufacturer's or contractor's warranty which satisifies the requirements contained in 10 CFR 456.105(j).

19. Program announcement. The term "program announcement" means residential conservation service program information and offer of services that are required to be mailed or delivered by a covered utility to each eligible customer by section 27.6.

20. Residential building. The term "residential building" means any building used for residential occupancy which:

a. Is not a new building,

b. Has a system for heating, cooling, or both heating and cooling, living spaces, and

c. Contains at least one, but not more than four, dwelling units. Townhouses and rowhouses in rows of more than four separate houses are included in this definition, but garden apartment complexes which contain clusters of four apartment units or less are not.

21. Substantial interest. The term "substantial interest" means a direct or indirect ownership interest of 10% or more of a company selling or installing or manufacturing a program measure.

22. Program activity. The term "program activity" means any conservation program which a covered utility provides to its consumers.

250--27.3(476) Temporary programs.

None of the listed utilities have applied for a temporary program. Applications for temporary program status must conform to the requirements in 10 CFR 456.407.

250--27.4(476) Procedures for program monitoring and enforcing compliance with the state plan.

Every covered utility within Iowa is required to comply with the I-SAVE conservation plan. The Iowa state commerce commission, pursuant to its authority prescribed in chapter 476.1, Code of Iowa and in accordance with rules promulgated in chapter 27, section 250 (commerce commission) of the Code, will monitor and enforce compliance of covered utilities with the I-SAVE conservation plan.

27.4(1) Monitoring. The ISCC will be responsible for ensuring that all utilities:

a. Distribute program announcements to all eligible customers in accordance with provisions in the state plan. All covered utilities will inform the ISCC of their schedule for distribution of announcements and will notify the ISCC when actual distribution occurs. ISCC will determine utility compliance with the time schedule for distribution of the program announcement.

b. Follow all calculating and auditing procedures established by the ISCC to provide customers with accurate audit information. As directed by the ISCC, covered utilities and participating home heating suppliers will submit data and calculations on a randomly selected audit for verification of accuracy. The ISCC may supplement the review with random spot checking of auditors by a state designated auditor.

c. Perform the arranging of service function in accordance with I-SAVE conservation plan. This function shall be monitored by a periodic review of completed installation, consumer complaints, and the utilities annual I-SAVE program results report.

d. Perform the post installation inspection in accordance with I-SAVE plan requirements. The ISCC will periodically review inspections that have resulted from audits and arrangement of services to ensure that all program requirements are being satisfied.

e. Comply with the reporting and recordkeeping requirements established in the I-SAVE conservation plan. The submittal to the ISCC of the annual I-SAVE program results report, and subsequent review, will determine utility compliance in this area.

f. Comply with the accounting procedures and payment of costs as directed by the ISCC. The review of the annual results report submitted by each utility will determine compliance. In accordance with existing state law, the ISCC may institute formal investigations of accounting and auditing procedures.

27.4(2) Enforcement.

a. Covered utilities.

(1) The ISCC will be responsible for enforcing compliance with the I-SAVE conservation plan for covered-regulated and non-regulated utilities. The attorney general will be responsible for enforcing compliance of participating home heating suppliers pursuant to the consumer credit code, (section 537, Code of Iowa).

(2) Upon determination of noncompliance of a covered-regulated utility, the ISCC will direct the utility to comply within thirty (30) days.

(3) If the ISCC determines that the covered utility remains in noncompliance at the conclusion of the thirty (30) day period, or if the utility contests the basis on which the directive was issued, the ISCC will convene a hearing for a determination of the issues.

b. Home heating suppliers. When a violation is found to exist, the ISCC will notify the attorney general's office for action.

c. Conflicts of laws.

(1) Each covered utility shall petition the assistant secretary, in accordance with section 456.102 of the RCS final rule, when:

(a) The utility believes it is prohibited by Iowa state or local law or regulation from taking any action under NECPA or any rule or state plan promulgated pursuant to NECPA; or

(b) The utility believes it is required or permitted by Iowa state or local law or regulation to take any action prohibited by NECPA or any rule or state plan promulgated pursuant to NECPA.

(2) The petition should be filed with:

Assistant Secretary for Conservation & Solar Energy
U.S. Department of Energy
Forrestal Building, Room GH-068
1000 Independence Avenue, S.W.
Washington, D.C. 20585

(3) The petition must contain: A description of the action that the utility believes it is prohibited from taking, or the action that the utility believes it is required to take under state or local law or regulation.

(4) Three copies of the petition must be sent to:

Executive Secretary
Iowa State Commerce Commission
State Capitol
Des Moines, Iowa 50319

27.4(3) Exemptions and waivers for utility supply, installation and financing.

a. Each covered utility and participating home heating supplier which supplies, installs or finances any energy conservation or renewable resource measure shall be listed as a supplier, installer, a lender, as appropriated pursuant to section 27.9 (listing) of the plan, in the same manner and subject to the same requirements as any other supplier, installer or lender.

b. Covered utilities and participating home heating suppliers which supply, install or finance the sale or installation of energy conservation or renewable resource measures pursuant to 10 CFR 456.503 through 456.506 shall:

(1) Charge fair and reasonable prices and interest rates.

(2) Not discriminate unfairly among eligible customers.

(3) When financing energy conservation or renewable resource measures, not discriminate unfairly among suppliers, among contractors, or among measures.

c. Utility exemptions. Five covered utilities have applied for an exemption from the prohibition on utility supply installation and financing of measures. These programs were either operational as of November 9, 1978, or substantial planning and preparation for the programs had taken place as of that date.

27.4 (4) Procedure to ensure nondiscrimination.

a. Each covered utility that supplies, installs or finances energy conservation and renewable resource measures (pursuant to section 456.503-505 of the RCS final rule) shall submit to the ISCC by February 1 for the preceding year a status report on each program for which an exemption or waiver was obtained. Such report shall be in addition to the program results report described in section 27.16(3)(c) (reporting) and shall contain:

(1) Measures supplied, installed or financed,

(2) Prices and interest rates charged for supply, installation and financing of measures,

(3) A list of all suppliers and contractors who supply or install in conjunction with the utility, and

(4) A description of the criteria for eligible customers and criteria for participating in utility supply, installation or financing activities.

b. The ISCC shall monitor and evaluate this information to ensure compliance of section 27.4(3)b(1),(2) and (3).

250--27.5(476) <u>Scope of benefits.</u>

27.5(1) Eligibility. Customers' eligibility for program benefits under the I-SAVE conservation plan will be determined by the degree of participation in the plan by the individual customer. In order to obtain program benefits, the customer must, at a minimum, utilize at least one of the following services:

a. Utility arranges installation for an eligible customer according to the procedures contained in section 27.10 (arranging installation) of the I-SAVE program;

b. Utility arranges financing for an eligible customer according to the procedures contained in section 27.11

(arranging financing) of the I-SAVE program; or

c. A customer purchases a program measure from an I-SAVE listed supplier who verifies in writing to the customer that the measure meets applicable program material standards and is covered by the program measures warranty.

27.5(2) Program benefits. A customer who utilizes the installation arranging service according to procedures outlined in the section 27.10 (arranging installation), is entitled to the following benefits:

a. A measure warranty for each program measure installed, except caulking and weatherstripping;

b. Installation of program measures that meet all applicable RCS material standards;

c. Installation of program measures that meet all applicable RCS installation standards;

d. A mandatory post-installation inspection, if applicable, or inclusion in the pool of customers from which random inspections will be made according to procedures outlined in section 27.12 (post installation inspections) of the I-SAVE plan;

e. Access to customers' complaint proceedings, according to procedures in section 27.13 (consumer grievance procedure) of the I-SAVE plan; and

f. for listed suppliers, contractors or lenders, adherence to the listing requirements as outlined in section 27.9 (listing requirements) ofn the I-SAVE plan.

27.5(3) A customer who arranges financing of program measures through the utility according to procedures in section 27.11 (arranging financing) of the I-SAVE plan, is entitled to benefits (e) and (f) above.

27.5(4) A customer who purchases program measures from a listed supplier is eligible for benefits (a), (e) and (f) above.

27.5(5) When requesting benefits from the utility, customers who purchase their own measures from a listed supplier must provide a copy of the supplier's document which identifies the program measures purchased.

250--27.6(476) Program announcements.

a. Each covered utility and participating home heating supplier shall send to each eligible customer a program announcement within six (6) months after approval of the state plan by the department of energy.

b. This program announcement shall be sent out every two years after the initial distribution of the conditional announcements until January 1, 1985.

c. Each new customer, a person who becomes an eligible customer after the initial distribution of the program announcement, shall receive a program announcement within sixty (60) days of becoming a new customer, and every two years thereafter until January 1, 1985.

d. The content of the program announcement shall contain the following elements, as a minimum:

(1) A list of all program and state measures with an

estimate of savings in energy costs, which are likely to be produced in one year, expressed in ranges of dollars or percentages, and a statement to the effect that the total energy savings may be less than the sum of the cost savings projected for the individual measures;

(2) A list of all energy conserving practices, a statement that they are of low or no cost, and an estimate of savings in energy costs, which are likely to be produced in one year. expressed in ranges of dollars or percentages.

(3) An offer an description of the:

(a) Program audit;

(b) Installation arrangement service;

(c) Financing arrangement service; and

(d) Contractor, lender and supplier lists.

The description of each service shall include information on how a customer may obtain each service, the direct cost, if any, and the scope of benefits included in that service, The direct cost to the requesting consumer for the program audit and related services shall not exceed $15.00.

(4) Inclusion of the following disclosure or its equivalent: "Energy savings depend on many factors. The estimates contained in the announcement are based on estimates for typical houses. Your costs and savings will be different if your house is a different size or type, if your family is a different size or if your energy using habits are different from those we assumed. The energy audit which we offer will provide more specific estimates for your house."

(5) A brief explanation of the benefits of the federal and state energy credits; and

(6) A brief description of the benefits of the weatherization assistance program for low income persons, 10 CFR Part 440, and a brief description of who is eligible for such assistance.

e. No advertising for sale, installation, or financing by any supplier, contractor or lender of any energy conservation measure, renewable resource measure, state measure or energy conserving practice maybe included in the program announcement. If a covered utility finances the sale or installation of such measures or practices, the program announcement may so state.

f. No information regarding any product which is not an energy conservation measure, a renewable resource measure, state measure or any energy conservation practice may be included in the program announcement.

g. All program announcements must be submitted for approval to the Iowa state commerce commission prior to distribution.

h. The energy audits may be offered to customers on a conditional nondiscriminatory basis. All customers who receive a conditional offer of any audit must receive an unconditional offer of an audit within two years. The utilities will submit their plans for distributing the unconditional announcements and scheduling the audits to the Iowa state commerce commission prior to implementation.

i. The calculation procedures for the cost and savings estimates contained in the program announcement will be approved by the Iowa state commerce commission. This will assure that all program announcements in the state will be consistent. (see appendix)

j. All estimates in the program announcement will be based on recent prices and appropriate climatological data for the state.

k. The announcement may contain a statement similar to the following: "This offer to perform an energy audit and to provide related benefits is in compliance with the residential conservation service program pursuant to Part 1 of Title II of the national energy conservation policy act. Every 'covered utility' and 'participating home heating supplier' is required to provide each customer with a program announcement. If you receive service from more than one covered utility, you will receive more than one announcement, you may request an audit from either utility. A request for a second audit will be performed at actual cost."

250--27.7(476) <u>Program audits.</u>

27.7(1) Timing and preconditions.

a. Each covered utility and participating home heating supplier shall provide a program audit to an eligible customer within thirty (30) days of the request of an unconditional offer of an audit. Requests for waiver of the thirty (30) day requirement will be considered when audit requests substantially exceed the utilities capability to perform the audits in the required time.

b. Each covered utility and participating home heating supplier shall inform and provide to each new customer, upon request, a copy of the last program audit performed on the customers residence. If the new customer requests an additional audit and the previous audit had been performed within the previous two year period, such audit will be performed at actual cost to the new customer.

c. Covered utilities and participating home heating suppliers are prohibited from preconditioning a program audit in any manner.

d. Covered utilities and participating home heating suppliers shall not discriminate unfairly among eligible customers in providing program audits.

27.7(2) Content of program audit.

a. General. Each covered utility and a participating home heating supplier shall, at a minimum, provide to each eligible customer a comprehensive program audit which addresses all energy conserving practices, energy conservation measures and renewable resource measures upon request by an eligible customer. In each program audit, the auditor shall determine which of the energy conserving practices would save energy in the residence, explain and emphasize the importance of such practices and recommend that they be performed before the installation of any measure. The auditor shall then determine the applicability of each program measure in that residence. If a program measure is not applicable, then the requirements of this section to provide estimates of the cost and savings of installation in such residence do not apply.

b. Energy conserving practices. The following are defined as energy conserving practices for the purpose of this plan:

(1) Furnace efficiency maintenance and adjustments;

(2) Nighttime temperature setback;

(3) Reducing winter thermostat setting;

(4) Raising summer thermostat setting;

(5) Water flow reduction in showers/faucets;

(6) Reducing hot water temperatures;

(7) Reducing energy use when a home is unoccupied;

(8) Plugging leaks in attics, basements, crawl spaces, fireplaces, switch plates and wall plates;

(9) Sealing leaks in pipes and ducts; and

(10) Efficient use of shading.

c. Applicability of program measures.

(1) A program measure is applicable if installation of the measure is not in violation of federal, state or local laws and ordinances.

(2) Specific program measures listed below are applicable if the corresponding condition is met:

Measure	Applicability Criteria
Replacement furnaces or boilers	The furnace is five years or older.

Vent opening modification	The furnace combustion air is taken from a conditioned space.
Replacement central air conditioner	The building has a central air conditioner that is five years or older.
Ceiling insulation	The difference between R existing and R program = eleven or more, and the building is not a mobile home.
Wall insulation	There is no insulation in a substantial portion of the exterior walls and the building is not a mobile home.
Floor insulation	There is no insulation in the floor over an unconditioned space.
Rim joist insulation	The rim joist is accessible.
Foundation insulation	There is no insulation on the foundation walls above grade.
Water heater insulation	The remaining useful life of the heater appears to be three years or greater and space is available around the water heater to install insulation.
Thermal windows	The auditor judges that the prime window needs replacement.
Storm windows	Always applicable.
Heat-reflective and heat-absorbing window or door material	The residence has an existing room or central air conditioner.
Electric load management devices	Such systems are available through the electric utility.
Clock thermostat	The residence has a thermostat or the existing furnace or central air conditioner is compatible with a clock thermostat.

Passive solar space heating and cooling systems: (i) passive solar direct or indirect gain glazing systems	The living space of the residence has either a south-facing (+ or -45° of true south) wall or an integral south-facing (+ or -45° of true south) roof which is free of major obstruction to solar radiation.
(ii) Passive solar solaria/ sunspace systems	The living space of the residence has a south-facing ground level wall, which is free of major obstruction to solar radiation.
(iii) Passive solar window heat gain retardants	The living space of the residence has a south-facing (+ or -45° of true south) window that is not shaded from summer sunshine.
Wind energy systems	The lot is larger than .75 acres, there are no major wind obstructions and a tower can be sited at least fifty feet from a property line or right-of-way for electrical transmission or distribution lines.
Caulking & weatherstripping	Always applicable.
Duct and pipe insulation	If ducts and pipes are located in an unconditioned area.
Electrical or mechanical gas ignition system	Always applicable.
Oil furnace replacement burner	Always applicable.

d. Cost estimates. Estimates of energy cost savings and of installation costs provided as a result of a program audit shall be performed in the following manner:

(1) Actual measurements or inspections of the building shell and of the space heating, space cooling, and water heating equipment, shall be performed on-site by the auditor;

(2) Economic calculations shall be based on typical recent local electric rates, typical recent local fuel prices, typical recent local prices for materials and installation of program measures and typical recent local climate data for the eligible customer's location;

(3) A solar domestic hot water system's cost shall be based on the calculation procedures contained in the current HUD intermediate minimum property standards supplement, solar heating and domestic hot water systems 4930.2, 1977 edition, U.S. department of housing and urban development or equivalent procedure approved by the state; and

(4) Any cost and savings estimate for any applicable furnace efficiency modification to a gas or oil furnace or boiler shall be based on an evaluation of the seasonal efficiency of such furnace or boiler. This seasonal efficiency shall be based on an estimated peak (tuned-up) steady state efficiency corrected for cycling losses. Steady state efficiency shall be derived either from manufacturer's design data and observation of furnace components or by calculation of the combustion efficiency of the furnace or boiler. Where visual observation by the auditor shows poor operation, calculation of combustion efficiency shall be made.

e. Procedure to assure the validity of the program audit. The state shall approve all procedures of a covered utility and participating home heating suppliers governing the measurements or inspections that an auditor must make in an eligible customer's residence and the calculations which must be performed in making energy cost savings estimates. Such procedures shall be submitted to the state at least sixty (60) days prior to initial distribution of program announcements. The state shall approve or disapprove such procedures within sixty (60) days of submittal. The model calculation procedure contained in the I-SAVE plan may be used by the utilities without further validation. Should a utility desire to use procedures different from those specified, such procedures must be submitted to the ISCC for validation.

Each covered utility and participating home heating supplier shall provide the state a quarterly update of typical recent local electricity rates, typical recent local fuel prices, typical recent local prices for materials and installation of program measures and typical recent local climate data. Such information will be used by the ISCC to update and modify the calculation procedures.

f. Results of program audit. Upon completion of a program audit, the auditor shall provide the following information on-site, in writing to each eligible customer who receives a program audit;

(1) An estimate of the total cost (materials and labor), expressed in dollars or a range of dollars of installation by a contractor of each applicable program measure addressed in the program audit;

(2) An estimate of the total cost, expressed in dollars

or a range of dollars, of installation by the customer of each applicable program measure, other than replacement central air conditioners and wall insulation, addressed in the program audit. A covered utility or participating home heating supplier shall not provide any estimate to any eligible customer of the cost to purchase furnace efficiency modifications, devices associated with load management techniques, or wind energy devices for installation by the eligible customer;

(3) An estimate of the savings in energy costs, expressed in dollars or a range of dollars, which would occur during the first year from installation of each applicable program addressed by the program audit. In addition, a separate estimate which reflects savings over the expected life of the recommended measure (life cycle costing analysis) will be presented for each applicable program measure;

(4) A clear indication to the eligible customer, through sample calculation or disclosure, that the total energy cost savings from the installation of more than one program measure may be less than the sum of energy cost savings of each measure installed individually;

(5) The following disclosure: "The procedure used to make these estimates has been evaluated by the ISCC for accuracy. However, the actual installation costs you incur and energy savings you realize from installing these measures may be different from the estimates contained in this audit report. Although the estimates are based on observations or

measurements of your house, they are also based on assumptions which may not be totally correct for your household.";

(6) An estimate of the annual normal maintenance costs, if any, of each applicable program measure;

(7) The possible economic benefits to the eligible customer of existing federal and state tax incentives with, at a minimum, one sample of the effect of the tax benefit on the cost to the customer of installing one applicable energy conservation program measure and one applicable renewable resource program measure;

(8) A program audit addressing an applicable solar domestic hot water system shall include a description of the solar system assumed by the auditor in preparing energy savings estimates and shall include the following information:

(a) The square feet of the collector;

(b) The collector characteristics, including glazing materials and other collector materials;

(c) Any storage system needed, including the capacity of storage;

(d) Any freeze protection needed;

(e) The estimated percent of the water heating load to be met by solar energy;

(f) Any physical connections needed with existing heating systems;

(g) Any site preparation needed; and

(h) If the results are based on a simulation, the following disclosure or its equivalent:

"The energy cost savings estimates you receive are based on systems which may be different from the ones you purchase. Also, these estimates were not determined using actual conditions but using simulated measurements. Therefore, the cost savings we have estimated may be different from the savings which actually occur."

(9) A program audit addressing an applicable passive solar space heating and cooling system shall include:

(a) The generic description and a pictoral description of the particular system considered by the auditor;

(b) The estimated percent the heating load of the residence to be met by such a system;

(c) The approximate dimensions of the system;

(d) The characteristics of storage, including the recommended heat capacity; and

(e) The disclosure provided in paragraph 1.3(8)(h) of this subsection.

(10) A program audit addressing an applicable wind energy device shall include:

(a) Installation cost estimates, based on the kilowatt rating of a commercially available wind device appropriate to the level of electricity consumed in the customer's residence;

(b) Estimates of energy cost savings, based on average yearly wind speeds and the specification of the selected wind device;

(c) The auditor's best estimate of the average wind speed at the residence based on data available at the nearest wind measurement station; and

(d) The specifications of the wind device under consideration.

If an eligible customer is not present or otherwise declines in-person presentation, the auditor is relieved of any obligation to deliver the results in person.

g. Program audit of furnaces. An eligible customer must sign a release form provided by the auditor to allow an auditor of a covered utility or participating home heating supplier to provide costs and savings estimates for furnace efficiency modifications on a furnace which uses as its primary source of energy any fuel or source of energy other than the fuel source sold by that covered utility or participating home heating suppliers. The release shall include the following statement:

"If your home is heated by a source of fuel other than (identify the type of fuel supplied by the covered utility or participating home heating supplier), only the supplier of the other fuel may audit your furnace unless you specifically request us to audit your furnace. If you want us to audit your furnace (although we do not supply the fuel for it) please sign below in ink."

Any recommendation related to fuel-switching is prohibited.

h. Additional information to be provided during an audit. The auditor shall present the following information as a minimum to the eligible customer during, or upon completion of, the program audit:

(1) An explanation of the benefits and services listed in the state plan and a brief description of how the eligible

customer can qualify for such benefits and services.

(2) The lists of contractors, suppliers and lenders developed pursuant to the state plan for the applicable program measures.

(3) An explanation of the benefits of the weatherization assistance program for low income person, 10 CFR Part 440, and a brief description of who is eligible for such assistance.

i. Prohibitions and disclosure required for program audits. The auditor shall comply with the following:

(1) The auditor is prohibited from estimating, as part of any program audit provided pursuant to the state plan, the costs or energy cost savings of installing any product which is not an energy conserving practice or a program measure.

(2) The auditor is prohibited from recommending any supplier, contractor or lender who supplies, installs, or finances the sale or installation of any program measure, if such recommendation would unfairly discriminate among such suppliers, contractors or lenders. If a covered utility or participating home heating supplier, which arranged the audit, supplies, installs or finances the sale or installation of program measures, the auditor may so state.

(3) Any unfair discrimination among program measures is prohibited.

(4) Each energy auditor shall provide the eligible customer with a written statement of any substantial interest which the person or the person's employer has, directly or indirectly, in the sale or installation of any program measure.

j. Preaudit informational questionnaire. A covered utility or a participating home heating supplier may request an eligible customer who has requested a program audit to submit information in the form of a questionnaire provided such questionnaire is not a precondition of a program audit and the questionnaire is approved by the state. Such information may be obtained by mail or telephone.

k. Class B audits. A covered utility or a participating home heating supplier may offer Class B audits in conjunction with the RCS program provided that:

(1) Class B energy audits address all energy conserving practices and all program measures;

(2) Class B energy audits explain the energy conserving practices, emphasize the importance of these practices, and recommend that they be performed before installation of any measure;

(3) Class B energy audits meet the requirements for program audits contained elsewhere in this plan and contain procedures to assure the validity of the audit as provided for elsewhere in this plan with respect to program audits. However, all references to measurements and inspections by the auditor shall be treated as references to measurements and inspections by the customer;

(4) The Class B audit provides to the eligible customer the same information required as part of a program audit described elsewhere in this plan;

(5) The Class B audit provides to the eligible customer the additional information required as part of a program audit described elsewhere in this plan;

(6) The Class B audit offers the lists of contractors, suppliers and lenders developed pursuant to the plan;

(7) The Class B audit contains the same prohibitions required elsewhere in this plan, except that references to the program audit shall be deemed to refer to the Class B audit and references to the auditor shall refer to the entity providing the Class B audit; and

(8) The utility or participating home heating supplier providing the Class B audit attempts to contact the eligible customer by telephone or otherwise, if the information sent by such customer is incomplete or internally inconsistent this contact attempt to correct or make complete the information.

250--27.8(476) <u>Program auditors, installers & inspectors.</u>

27.8(1) Qualification of auditors. Each person who performs a program audit pursuant to this plan shall:

a. Be qualified according to the applicable procedures in 27.8(2) (minimum auditor qualification requirements) of the state plan.

b. Be under contract or subcontract to, be an employee of, or be an employee of a contractor or subcontractor to, a covered utility or participating home heating supplier.

27.8(2) Minimum auditor qualification requirements. In order to be a qualified program auditor under this plan, an individual shall meet the following requirements:

a. Complete a state-approved training course that provides the following:

(1) General understanding of the three types of heat transfer and the effects of termperature and humidity on heat transfer.

(2) General understanding of residential construction terminology and components.

(3) General knowledge of the operation of the heating and cooling systems used in the residential building.

(4) General knowledge of the different types of each applicable program measure; of the advantages, disadvantages, and applications of each; and of any installation standards prescribed for the RCS program.

(5) Capacity to conduct the audit according to the procedures described in section 27.7 (program audits) including: Familiarity with energy conserving practices prescribed in the state plan; capability of determining applicable program measures, and proficiency in audit procedures for each applicable program measure.

(6) Where a furnace efficiency modification is an applicable program measure, and the source of fuel for the existing furnace or boiler is either gas or oil, a working ability to calculate the steady state efficiency of the furnace or boiler as required by section 27.7(d)(4)(cost estimate).

(7) Where a renewable resource measure, other than wind

energy devices, is an applicable program measure, an understanding of the nature of solar energy and its residential applications, including: insolation, shading, heat capture and transport, heat transfer for hot water.

(8) Where a wind energy device is an applicable program measure, an understanding of the nature of wind energy and its residential applications, including: wind availability, effects of obstructions, wind capture, power generation, interfaces with residential and utility power lines.

b. Successfully demonstrate his/her qualifications in appropriate written or practical examinations to be administered by the training organization selected by each covered utility and participating home heating supplier and approved by the state.

Upon successful completion of the training and examination requirements, the candidate shall be provided with a certificate of qualification by the state which shall be valid for two years. Recertification shall be in accordance with this section.

The state shall approve or conduct the training and testing programs for auditors. Covered utilities and participating home heating suppliers shall submit proposed programs within thirty (30) days after adoption of the state plan. The state shall review and approve or disapprove the proposed program within thirty (30) days after submission. If the program is disapproved, the utilities and participating home heating suppliers will have thirty (30) days within which to amend and resubmit the proposed program.

The state shall, upon adoption of the state plan, place a notice in newspapers of general circulation outlining the state's qualification procedures and application procedures.

The state shall regularly publish announcements regarding the state training courses and examinations. The state shall publish a schedule within forty-five (45) days of plan adoption.

Auditor training and testing program shall be initiated sixty (60) days prior to the issuance of the program announcement and the first offer of an unconditional audit.

27.8(3) Qualifications of inspectors and installers.

a. Individuals who perform quality control inspections under the I-SAVE program shall be energy auditors certified according to section 27.8(4) a, b, c, and d, (assuring individual qualifications) and shall be knowledgeable of all state and federal installation and material standards applicable to the program measures installed.

b. Individuals who install program measures shall be knowledgeable of all applicable state and federal installation and materials standards.

27.8(4) Assuring individual qualifications. The state shall approve:

a. Training designed to instruct the individuals in the proper performance of their function(s).

b. Test designed to assess and certify the individuals' qualifications to perform their functions. Such tests may include either written or practical tests as determined necessary to meet the requirements of this section.

c. The state may certify utility auditors without additional training or testing if the utility's existing training procedure adequately satisfies the requirements of this section.

d. The state may certify the content of energy auditor training course provided by private industry as meeting the requirement for training auditors.

27.8(5) Additional requirements with respect to qualifying procedures. In order to participate in a state training program or testing procedure, a candidate shall be required to register at least two weeks prior to the offering of a class or test. Late registrants will be accepted into the class subject to space availability.

Each covered utility and participating home heating supplier shall provide a schedule of training programs and testing to the state for approval forty-five (45) days after plan adoption, demonstrating that there will be a sufficient number of trained auditors for initiation and completion of the RCS program.

27.8(6) Reciprocity of auditors. Auditors certified in states with a DOE-approved state plan may be authorized to conduct program audits in Iowa provided the auditor has a certificate from the auditor's home state. Such a certificate shall be issued if the candidate successfully demonstrates his/her qualifications in appropriate written or practical examinations administered by the state.

250--27.9(476) <u>Listing requirements.</u>

27.9(1) Responsibility for listing. The Iowa state commerce commission is the listing agency and shall be responsible for the preparation of maintenance of the master record. Utilities, home heating suppliers and other state agencies shall be used for obtaining information used to prepare complete lists. No person who serves as a supplier, contractor or lender shall be assigned duties incident to the compilation of the master records.

a. Public notice. The listing agency shall use the following methods of public notice to provide interested suppliers, contractors and lenders the opportunity to apply for inclusion in the master record.

(1) Publication in newspapers of general circulation in the state; and

(2) Direct notification of appropriate trade organizations with a request for active participation in distributing information and application forms.

b. Criteria for inclusion. The listing agency assures that all persons who agree to comply with the following requirements (unless the governor (or his designee) determines that such person's agreement is not adequate assurance of compliance with the requirement section) and only such persons are included in the initial master record, and thereafter in the existing master record within a reasonable time after applying for inclusion.

All installation contractors included in the master record shall:

(1) Comply with any materials and installation standards as contained in 10 CFR 456, subparts g, h, and i, and any applicable federal, state or local standards pertaining to the program measure installed;

(2) Install only measures which carries a measures warranty. (No measures warranty is necessary for caulking and weather-stripping);

(3) Furnish the customer with a written contract detailing the job to be performed and its cost and certifying that any applicable requirements for installation and material standards will be complied with;

(4) Assure that all individuals who are employed or otherwise retained by the contractor to install flue opening modifications, electrical or mechanical ignition systems, or wind energy devices have been qualified pursuant to section 27.8(3) (qualifications of inspectors and installers);

(5) Include in every contract a guarantee that the contractor will correct any violation of any installation standards without cost to the customer;

(6) At the contractor's choice, possess either a surety bond in the amount of $25,000 or a payment and performance bond, for each contract, in an amount sufficient to indemnify himself against possible liability resulting from installation of program measures;

(7) Comply with all applicable federal, state and local laws and regulations; and

(8) Agree to participate in good faith in the conciliation proceedings when there is a complaint by an eligible customer against such person.

c. All suppliers included in the master record shall:

(1) Supply program measures that carry the measures warranty as defined above;

(2) Supply program measures that are labeled as complying with DOE standards;

(3) Comply with all applicable federal, state and local laws and regulations;

(4) Have a method for informing customers of those products supplied that are program measures and that have a measures warranty (except for caulking and weatherstripping) and that meet any applicable RCS standards; and

(5) Agree to participate in good faith in the conciliation proceedings when there is a complaint by an eligible customer against such person.

d. All lenders included in the master record shall:

(1) Not take security in real property that is used as a principal residence of the eligible customer, unless the eligible customer acknowledges in writing that he or she is aware of the consequences of default on the loan;

(2) Permit a rebate of unearned finance charges if an eligible customer prepays a loan (either voluntarily or as a result of default). Where prepayment is the result of

default, the rebate shall be computed from the day of acceleration;

(3) Comply with all applicable federal, state and local laws and regulations; and

(4) Agree to participate in good faith in the conciliation proceedings when there is a complaint by an eligible customer against such person.

e. Criteria for removal from master record of suppliers, contractors and lenders.

The listing agency shall ensure that all persons in the master record who fail to comply with the requirements for inclusion are removed from the master record. Removal procedures shall ensure that:

(1) Each person proposed for such removal shall have:

(a) Written notice of the proposed removal and the grounds for such removal at least thirty (30) days before the actual removal;

(b) An opportunity to respond in writing to the allegations; and

(c) With respect to installers, access to the records of the listing agency regarding the inspections of the work of such installer.

(2) Each person removed from the master record shall have an opportunity to file a complaint through and participate in redress proceedings and civil action for the purpose of contesting such removal.

(3) Any person(s) included on the master record may be removed for the following reasons:

(a) Any supplier, contractor or lender accepted for inclusion on the master record may be removed for violations of any provision cited in section 27.9(1)b (criteria for inclusion);

(b) A customer complaint through the conciliation process may lead to removal from the master record. The supplier, contractor or lender shall have thirty (30) days to correct the violation as determined at the end of the conciliation process. If the violation is not corrected during the thirty (30) day period, delisting shall be automatic;

(c) A post-installation inspection which reveals a violation may lead to removal from the master record. The contractor shall have thirty (30) days after written notification to correct the violation the inspector reports. If no response is made during the thirty (30) days, delisting shall be automatic; and

(d) Any violation which results in a hazard to health shall be corrected within three (3) days of notification to the contractor. If no correction is made in that time period, delisting shall be automatic.

f. Criteria for reinstatement on master record of suppliers, contractors and lenders. Any person(s) removed from the master record shall have the opportunity to be reinstated, if the following conditions are fulfilled:

(1) Violation(s) leading to removal from the master record satisfactorily corrected; and

(2) All conditions of the conciliation process and the decision reached through that process have been met.

27.9(2) Contents of lists. The master record and lists produced from that record shall contain the following information in a fair, open and nondiscriminatory manner:

a. The name and address of each supplier, contractor and lender;

b. An indication of which program measures each supplier, contractor or lender will supply, install or finance. The inclusion of brand names will not be permitted. If lists include information regarding types of program measures for one type of a program measure, then it shall include such information for all types of such measures;

c. A statement that the persons listed have agreed to comply with any applicable DOE standards and state plan procedures for the sale, installation or financing of program measures;

d. A description of the complaint processing procedures, including an explanation of who may have access to such procedures and how to gain access to such procedures; and

e. An invitation to all supplier, contractors and lenders not included on the lists to apply for inclusion.

27.9(3) Distribution of lists. The state plan requires that every covered utility and participating home heating supplier provide, upon request to every eligible customer, lists of all suppliers, contractors and lenders included in the master record who sell, install or finance program measures in their service area or such other reasonable area required by the state plan.

27.9(4) Procedures for updating lists. The updating of the master record shall be the responsibility of the Iowa state commerce commission. Utilities and home heating suppliers shall provide such information as necessary concerning their respective service areas. Additions and deletions to the master record shall be issued every thirty (30) days with new lists to be published every six months.

250--27.10(476) Arranging installation.

27.10(1) Each covered utility will arrange installation of any program measure upon request by any eligible customer.

27.10(2) These arrangement services will be as follows:

a. Distribute lists of contractors and suppliers from the master record to all customers requesting it;

b. Assist the customer in obtaining answers to his questions regarding installation;

c. Advise low income, elderly, and handicapped customers of existing special programs available to meet their needs in the area of installation of program measures;

d. Provide materials and program measures specifications sheet for those recommended program measures as determined by the auditor. The specification sheet will serve as a bid specification stating the exact need and the applicable standards to facilitate comparative bids. When soliciting bids from listed contractors, the eligible customer must present an RCS bid specification to the contractor, on which the contractor may make the appropriate notations. (see appendix); and

e. Offer to obtain bids from listed contractors. In providing this service, the eligible customer will select three listed contractors, and the covered utility or participating home heating supplier will solicit bids from those contractors.

27.10(3) Each covered utility will provide such arrangement service within thirty (30) days from receipt of a request for such service.

27.10(4) Each covered utility and participating home energy supplier, when arranging installation of program measures, shall not recommend, select or provide information regarding any supplier or contractor if such recommendation, selection or information would unfairly discriminate among suppliers and contractors of program measures. Covered utilities that supply or install program measures may so inform the customers.

27.10(5) Each covered utility and participating home heating supplier, when arranging installation of program measures, is prohibited from discriminating unfairly among eligible customers, among suppliers, among contractors or among suggested measures.

27.10(6) Each covered utility and participating home heating supplier shall not arrange installation with any person not on the master record.

27.10(7) Each covered utility and participating home heating supplier shall not arrange, in conjunction with the I-SAVE program, the installation of any measure that is not a program measure.

250--27.11(476) Arranging financing.

27.11(1) Each covered utility and participating home energy supplier will arrange financing for the supply or installation of any applicable program measure upon request by any eligible customer.

27.11(2) These arrangement services will be as follows:

a. Distribute lists of lenders from the master record to all eligible customers requesting it;

b. Upon request assist the eligible customer in obtaining answers to his questions regarding financing;

c. Advise low income, elderly and handicapped eligible customers of existing special programs available to meet their needs in the area of financing of program measures; and

d. Provide common credit application form and assist in preparation of said form when requested. (see appendix)

27.11(3) Each covered utility and participating home heating supplier will provide such arrangement service thirty (30) days from receipt of a request for such service.

27.11(4) Each covered utility and participating home heating supplier when arranging financing for the purchase or installation of program measures, will not recommend, select or provide information regarding any lender if such recommendation, selection or information would unfairly discriminate among those that finance the purchase or installation of program measures. Covered utilities and participating home heating suppliers that finance program measures may so inform the customers.

27.11(5) Each covered utility and participating home heating supplier when arranging financing of program measures, is prohibited from discriminating unfairly among eligible customers, among suppliers, among contractors or among program measures.

27.11(6) Each covered utility and participating home heating supplier shall not arrange financing for supply or installation of program measures with any lenders not in the master record.

27.11(7) Each covered utility and participating home heating supplier shall not arrange financing, in conjunction with the I-SAVE plan for the supply or installation of any measure that is not a program measure.

250--27.12(476) Post-installation inspection.

27.12(1) Assignment of responsibility. The ISCC, as lead agency, will monitor the performance of post-installation inspections. The utility that performs the energy audit has primary responsibility for ensuring that post-installation inspection requirements are met. In this regard, the utilities must utilize RCS certified inspectors. These inspectors may be utility employees, independent inspectors under contract, or governmental building code inspectors.

27.12(2) Presentation of post-installation results/mandatory and random inspections.

a. A certificate of inspection will be sent to:

(1) The customer, within ten (10) working days of the inspection;

(2) The installer, within ten (10) days of the inspection;

(3) The lead agency, within ten (10) working days of the inspection; and

(4) The covered utility or participating home heating supplier, within ten (10) working days of the inspection.

b. A "certificate of inspection" will be filled out by the inspector indicating all required information. A standard certificate shall be developed by the entity responsible for administering the post-installation inspection.

c. Any violations will be immediately reported to those entities designated in 27.12(2)a.(1), (2), (3), and (4).

d. The certificate of inspection will certify that the inspected measures conform to applicable RCS material standards and installation standards. However, the certificate of inspection does not address nor insure against consequences of the use of materials or their installation. Such consequences remain the responsibility of the manufacturer or installer.

27.12(3) Mandatory inspections. All flue opening modifications, electrical or mechanical ignition systems and wind energy devices installed by an RCS listed installer will be subject to a mandatory post-installation inspection to determine compliance with applicable installation standards.

At a minimum, each installation will be inspected:

(1) Within seven (7) working days of receipt by the ISCC of written verification of completions; and

(2) By a qualified inspector who meets the applicable qualifications and has no financial interest in the installer of the measure unless such installer is a covered utility.

27.12(4) Random inspections.

a. Within a reasonable time after receipt of written verification of completion, random inspections of program measures with installation standards which are installed by RCS listed installers shall be conducted on:

(1) Four of the first ten installations by each installer of ceiling insulation, floor insulation, wall insulation and active solar water heating.

(2) Ten percent of all remaining installations by each installer of the above measures. The initial four inspections will be counted toward this ten percent as will inspections resulting from consumer complaints.

(3) Every installer with whom the utility arranges installation over the life of the program. Each utility will determine whether all listed installers have been inspected at least once. Each utility will verify inspections on an annual basis.

(4) Inspections conducted (if applicable) as a follow-up to consumer complaints will be arranged by the customer complaints office and the inspector. The inspector will forward a copy of the inspection certificate to those entities listed in 27.12(2)a (1), (2), (3) and (4).

b. At a minimum, the inspection will be conducted by a qualified inspector who will investigate whether the installation was done in accordance with RCS materials and installation standards.

250--27.13(476) <u>Consumer grievance procedures.</u>

27.13(1) Conciliation conference.

a. A conciliation conference shall be available for the purpose of resolving complaints by eligible customers against persons who sell, install or finance the sale or installation of program measures covered by this plan and shall also be available to address all other questions and complaints resulting from the operation of the plan.

b. Conciliation conference procedures are available to all eligible customers and shall insure that:

(1) Participation is free of cost and easily accessible to the eligible customer making the complaints:

(2) Participation by the eligible customer is voluntary; and

(3) Conciliation conference will be conducted by an impartial conciliator designated by the Iowa state commerce commission.

27.13(2) Conciliation conference process.

a. Any eligible customer having a complaint against persons that sell, install or finance program measures may contact the Iowa state commerce commission. A toll free number to the ISCC will be provided for this purpose.

b. Upon receipt of the complaint, the conciliator will have the authority to:

(1) Arrange the conciliation conference; and

(2) If deemed necessary at any time during the conciliation conference process, require the (covered utility or participating home heating supplier) to conduct a post-installation inspection of the job in question.

c. The conciliator will determine the method of conducting the conciliation conference. Acceptable methods include:

(1) In person; and

(2) Telephone.

d. Should a mutually acceptable resolution of the complaint not be reached through the conciliation conference, the parties shall have access to the redress procedure as described in section 27.13(3) (redress procedure).

e. If a violation of materials or installation standards is confirmed through a post-installation inspection, section 27.8 (delisting) shall apply.

27.13(3) Redress procedures.

a. A redress proceeding shall be available to all persons alleging injury arising from an activity carried out under the I-SAVE program.

(1) The party alleging harm or injury shall be responsible for initiating a claim in:

(a) Small claims court, if the amount in controversy does not exceed $1,000.00 (chapter 602, C79);

(b) District court, if the amount in controversy exceeds $1,000.00 (chapter 602, C79).

(2) This procedure satisfies the criteria set out in 10 CFR 456.315.

(3) Arbitration. Upon customer request, the complaint may be referred to the better business bureau for resolution by arbitration.

27.13(4) Civil action.

a. The party alleging harm or injury shall be responsible for initiating action in:

(1) Small claims court, if the amount in controversy does not exceed $1,000.00 (chapter 602, C79);

(2) District court, if the amount in controversy exceeds $1,000.00 (chapter 602, C79).

250--27.14(476) Customer billing, repayment of loans, and termination of service.

27.14(1) When billing a customer for costs associated with RCS program services, each utility shall:

a. Identify the charges and list them separately on the customers utility bill or other periodic bill.

b. Itemize the direct charges, if any, to a customer for the program audit, arrangement of services or post installation inspection.

c. If the customer and listed lending institution mutually agree to loan repayment through the utility, all associated loan costs will be listed separately from other RCS costs.

d. Allow the customer to include all RCS related costs in the payment for utility or fuel service. All payments received shall first be charges to pay for the purchase of utility or fuel service and only the excess shall be credited to charges for other costs or repayments, unless the customer requests an alternative distribution of payments.

27.14(2) In the case of any loan made by a covered utility or participating home heating supplier under the Iowa RCS program, the covered utility or participating home heating supplier shall permit the eligible customer to include repayment of that loan in the payment of his periodic utility or fuel bill for a period of not less than three years, unless the customer chooses a shorter repayment period. A covered utility or participating home heating supplier shall not be required to provide for monthly payments of less than five dollars.

27.14(3) A listed lending institution may require a lump sum payment of outstanding principal and interest upon default by the eligible customer.

27.14(4) No penalty shall be imposed by the lender for payment of all or any portion of the outstanding loan amount prior to the date such payment would otherwise be due.

27.14(5) No covered utility or participating home heating supplier shall terminate or otherwise restrict utility or fuel service to any customer for any default by such customer for payments due for any services under the Iowa RCS program.

250--27.15(476) Accounting.

27.15(1) General procedures. All costs and revenues directly attributable to the Iowa state conservation program as implemented by the Iowa state commerce commission shall be accounted for on the books and records of a covered utility separately from all amounts attributable to activities other than the implemented conservation program. The utilities may account for other conservation efforts (i.e., efforts outside those specified in the implemented program) separately but must, at a minimum, retain the ability to segregate the costs and revenues specifically attributable to the implemented program.

27.15(2) Uniform system of accounts.

a. Covered utilities subject to the jurisdiction of the federal energy regulatory commission (FERC) shall utilize the uniform system of accounts as prescribed in Title 18, CFR Parts 101, 104, 201 and 204.

b. Covered rural electric cooperatives shall utilize the uniform system of accounts as prescribed by the rural electrification administration (REA) in Title 7, CFR Part 1701, Appendix A.

c. Other covered or participating utilities shall adopt accounts within their existing accounting system with the attributes of the appropriate accounts prescribed herein.

27.15(3) Program expenses.

a. All amounts expended by a covered utility for the implemented conservation programs shall be charged to the accounts specifically identified for such use by FERC or REA. If no such account is so specified, the applicable expenses shall be charged to unique subaccounts within account 908, customer assistance expenses, or its successor.

b. Appropriate records shall be maintained under this account to permit ready identification of costs that are required to support the reporting requirements specified in section 27.16 (reporting). This will, at a minimum, allow ready identification of costs attributable to:

(1) Program information; and

(2) Program audits (by type).

c. Costs may include:

(1) All amounts expended by a covered utility for the program announcement and all public education and program promotion directly related to providing information about a utility's program;

(2) All amounts expended by a covered utility for labor and materials in connection with the purchase or installation of any energy conservation or renewable resource measure;

(3) All amounts expended by a covered utility to perform administrative and general duties directly related to the conservation program including those associated with program audits, list distribution, customer billing services and "arranging." These administrative costs may include any costs the utility incurs if it conducts post-installation inspections required by section 27.12 (post-installation inspection) and conciliation conferences required by section 27.13 (consumer grievance procedures); and

(4) All amounts expended by a utility to perform project manager duties directly related to the conservation program

including areas such as:

(a) Program audits;

(b) Arranging for a lender to make a loan to an eligible customer to finance the purchase and installation costs of energy conservation and renewable resource measures, including the costs of arranging repayment of the principal and interest of a loan as part of the periodic bill; and

(c) Arranging to have the program measures installed.

27.15(4) Program revenues.

a. All revenues or billed income, received by a covered utility, attributable to the implemented conservation program shall be charged to the accounts specifically identified by FERC or REA. If no such account is so specified, the applicable revenues shall be charged to unique subaccounts within account 456, other electric revenue (for electric utilities) or account 495, other gas revenues (for gas utilities) or their successors.

b. The revenues so collected shall support the reporting requirements specified in section 27.16 (reporting). This will, at a minimum, allow ready identification of revenues resulting from program audits and the direct sale or installation of any energy conservation or renewable resource measure covered by this program.

27.15(5) Alternative methods. To the extent that a utility considers these accounting requirements cause an unreasonable hardship or expense, that utility may petition the Iowa state commerce commission for approval of an alternative method that accomplishes similar goals.

250--27.16(476) Reporting.

27.16(1) General reporting guidelines. The purpose of the reporting guidelines is to ensure that sufficient information is collected and submitted to the Iowa state commerce commission to permit a full analysis of the conservation program. There shall be two separate reports, each filed annually. One report shall define the utility's conservation plan and include goals and targets for the various program efforts, defined in measurable terms for all non-educational conservation activities. The second report shall define the results of the conservation program. The ISCC may require interim reporting on a quarterly basis.

27.16(2) Conservation program plan report.

a. Each utility shall submit a conservation program plan annually. The date by which the initial plan is to be submitted will be specified by the commission. The plan shall normally cover a calendar year.

b. Each utility shall identify the overall energy savings goals that are anticipated from the conservation program for the following year and over a five year time frame.

c. The utility shall describe its plan to achieve these savings with the program activities described individually (where program activities are the different conservation efforts that compose the total program). Each program activity description shall include:

(1) Discussion of what the activity is, what residential end use it addresses, and what practices, measures or techniques it promotes;

(2) Identification of the energy savings anticipated (if applicable) from non-educational conservation activities.

(3) Discussion of the effect on peak demand and load shape.

(4) Estimated penetration of the measure, practice or technique as a result of this effort (if applicable); and

(5) Estimated cost to the utility of implementing this effort.

d. Discussion of the program activities shall include, but not be limited to, the promotion of the specific program measures specified in the RCS program.

e. The Iowa state commerce commission is responsible for approving the utility RCS programs. If a program is not approved, the Iowa state commerce commission will specifically identify those areas that are deficient.

f. To the extent that a utility considers that these reporting guidelines cause an unreasonable hardship or expense, that utility may petition the Iowa state commerce commission for approval of an alternative method with which it can reasonably comply. The specific information to be supplied under an alternative method should be identified. As much information as possible should be provided.

27.16(3) Data collection and analysis.

a. Data collection. In order to ensure a consistent reporting format, the commerce commission shall determine an appropriate method for identifying representative sample size for each utility from the total number of customers utilizing a particular activity. The commission shall provide standardized forms for use by the utility in recording responses from customers in the sample group.

Each utility shall collect data relating to the effectiveness of their non-educational program activities. This data will identify the following:

(1) Identification of those customers in the sample size who installed or implemented a specific program measure, technique or practice promoted by the activity;

(2) Identification of the fuel used for spaceheating and the type of heating/cooling plant in the residence;

(3) The amount of fuel purchased (electricity and/or natural gas) each month for a twelve (12) month period before and after the audit; and

(4) The monthly post audit energy savings in BTUs.

b. Data analysis. The utility shall submit the data outlined in section 27.16(3)(a) (data collection) as part of its conservation program results report to the commission. The commission shall utilize the data to determine for each utility:

(1) The relationship between the level of retrofit (number of measures, practices or techniques installed or implemented) and energy savings.

(2) The relative effectiveness of specific conservation measures, practices or techniques and energy savings.

(3) The penetration (utilization) of practices, measures or techniques.

(4) An estimate of the total savings resulting from the program activity.

27.16(4) Conservation program results report.

a. Each utility shall submit annually a report documenting the results of its non-educational conservation program activities for the previous year. Educational activities shall be included in the report but may be identified and described with respect to market penetration and overall effectiveness only. This report shall be submitted annually on the date specified by the commission. The results report should cover the same time period that the program plan report covers and shall be considered a report on the achievements of the plan.

b. Each results report shall contain, at a minimum the following:

(1) The data generated in 27.16(3)(a) (data collection) for each non-educational conservation program activity;

(2) Description of the utility's educational program activities, and a discussion of the overall effectiveness of each;

(3) Identification of the cost to the utility to provide the program and each program activity; and

(4) Identification of the costs incurred by the utility to provide a service under this program that are passed on to the specific consumers requesting that service and the revenues resulting from those charges.

For those instances in which the utility is not the provider of the energy used for space conditioning and/or water heating and the provider of that energy has not supplied the utility with savings estimates, the utility may, for those program activities pertaining to the reduction of space conditioning and/or water heating energy use, supply estimates of the numbers of residences effected in lieu of the actual savings estimates.

c. In a separate section, each utility shall identify the following, even if the topic has been discussed elsewhere in the report:

(1) A discussion of the degree to which the utility is engaged in supplying, installing, or financing energy conservation or renewable resource measures pursuant to sections 27.4(3) (exceptions for existing supply, installation and financing) or which are engaged in supplying, or installing, of renewable resource measures pursuant to a waiver granted under section 27.4 (waivers), or which are petitioning for such a waiver. A brief description with respect to the nature of the exempted activity in which it is engaged should be included.

(2) The approximate number of eligible customers and, if available, the percentage of those customers for whom the utility is the primary heating fuel supplier.

(3) A copy of the program announcement distributed to eligible customers.

(4) The number of eligible customers who have requested each service and the number of requests the utility has fulfilled, including the number of program audits performed;

the number of installations arranged by the utility; the number of loans arranged by the utility, the number of customers, if any, who are using the utility's billing service of repayment of loans; the number of installations, if any, of program measures which the utility supplied, installed, or financed.

(5) The number and function of people assigned to the utility's program, including part-time employees.

(6) The costs incurred by the utility or home heating supplier in providing each service under the residential conservation service program including separately those costs paid by individual customers for services received and those costs paid by all ratepayers.

(7) The number and results of post-installation inspections conducted according to section 27.12 (post-installation inspection).

(8) Identification of problems in finding or training qualified auditors and potential resolutions to those problems.

d. The Iowa state commerce commission, in its role as the lead agency, shall be responsible for collecting the following information:

(1) The conservation program characteristics for each utility as described in 27.16 (3) (data collection and analysis). The analysis of these program characteristics will be provided to the utilities in written form.

(2) A brief description of the status of activities carried out pursuant to section 27.8(1) (qualification procedures for auditors, installers and inspectors) including whether sufficient, qualified personnel are available for program needs, the reasons for any shortages and the proposed resolution of any such shortage problem on a statewide basis.

(3) The number and nature of complaints by eligible customers against suppliers, contractors and lenders which have been handled through the conciliation conference established under section 27.13(2) (conciliation conference procedures).

(4) The number of persons seeking redress through the procedures described in section 27.13(3) (redress procedures) and the nature of their allegations.

(5) The number of persons added to or removed from the master record established according to section 27.9 (listing) and the reasons for removal of persons.

(6) The number and function of state employees assigned to the residential conservation service program, including part-time employees.

(7) The cost to the state of developing and implementing the state plan.

(8) A citation to and brief description of any state or local law or regulation relevant to the state plan and the status of any proposed state or local legislation or regulation relevant to the state plan.

Further, the commission is responsible for filing of any DOE required reports.

e. The Iowa state commerce commission may require interim reporting of program results on a quarterly or semi-annual basis. These interim reports are intended to identify the level of activity in each program area and to highlight specific problem areas and are not to be considered a complete reporting of results.

f. To the extent that a utility considers that these reporting guidelines cause an unreasonable hardship or expense, that utility may petition the Iowa state commerce commission for approval of an alternative method that accomplishes similar purposes.

250--27.17(476) Recordkeeping.

27.17(1) Responsibility. Each utility shall be responsible for maintaining records sufficient to support the reporting requirements identified above or as otherwise approved by the Iowa state commerce commission.

27.17(2) Other specific requirements. Further, the following records shall be maintained for the periods indicated. These records shall be made available to the Iowa state commerce commission or other designated personnel upon request:

a. The name and address of each eligible customer who receives a program audit, which shall be kept for five years from the date of such program audit.

b. A copy of the data collected during the audit, and a copy of the estimates of costs and savings presented to the customer, which shall be kept for five years from the date of such program audit.

c. A copy of all requests furnished by eligible customers for furnace audits pursuant to section 27.7(1)(g) (furnace audits) which shall be kept for five years from the date of such request.

d. The name and address of each eligible customer for whom a utility arranged installation or financing of a program measure, which shall be kept for five years from the date of such arrangements.

e. The amount and cost of fuel purchased each month or other billing period for the twelve months prior to and the twelve months following each program audit for each eligible customer, which shall be kept two years from the date of such program audit.

f. The names of the individuals who have met the qualification criteria described in section 27.8(1) (qualification procedures for auditors, installers and inspectors). These records shall be:

(1) Updated within a reasonable period of time following each implementation of the qualification procedures; and

(2) Maintained separately for installers and inspectors of flue opening modifications, electrical or mechanical ignition devices and wind energy devices.

27.17(3) Alternative recordkeeping guidelines. To the extent that a utility considers these recordkeeping requirements cause an unreasonable hardship or expense, that utility may petition the Iowa state commerce commission for approval of an alternative method with which it can reasonably comply. The specific information to be supplied under an alternative method should be identified. As much information as possible should be provided.

250--27.18(476) Coordination.

27.18(1) In order to minimize duplication of statewide energy conservation services and programs, the Iowa state commerce commission, as designated lead agency for development and implementation of the RCS plan for the state of Iowa, will coordinate with the following programs:

a. Federal energy extension service. The state agency responsible for implementation of the EES program and the Iowa state commerce commission will ensure that where necessary, the following components of the EES plan are coordinated with the I-SAVE program:

(1) Home audit program;

(2) Hot line data bank; and

(3) Media spots--public issues.

b. State energy conservation program. The following components of the basic SECP will be coordinated with the RCS plan:

(1) Community betterment projects;

(2) Voluntary thermal upgrading of residence; and

(3) Comprehensive solar plan.

c. Supplemental state energy conservation plan. The following components of the supplemental state energy conservation plan will be coordinated with the I-SAVE plan:

(1) Public education program--all phases;

(2) Energy audit program/auditor training; and

(3) Consumer protection program.

d. Weatherization assistance program for low income consumers. The federal weatherization assistance program for Iowa is administered by the Iowa office for planning and programming. The ISCC will coordinate with OPP in the area of energy audits, which is a requirement under both programs. This coordination will ensure that adequate communication is maintained between the programs in order to identify those people who are eligible for weatherization assistance and to minimize the number of duplicate audits.

27.18(2) Energy suppliers. Coordination among energy suppliers is encouraged in all phases of the program. Those energy suppliers wishing to coordinate I-SAVE and related conservation program elements will submit a plan to the ISCC, detailing the objective, advantages and cost justification of joint operation of program responsibilities.

250--27.19(476) <u>Home heating suppliers.</u>

27.19(1) Home heating suppliers are included, by directions of the governor, in the I-SAVE plan.

27.19(2) Voluntary participation. Home heating suppliers are voluntary participants in the I-SAVE plan and upon completion of an application any home heating supplier may participate.

27.19(3) Petition for waiver of requirements. Upon application by the home heating supplier, the ISCC may waive, for the participating home heating supplier any requirement of the I-SAVE plan except:

a. Enforcement and investigation procedures;

b. The scope of benefits provisions for the consumer of home heating suppliers;

c. The calculations procedures established for program announcements;

d. The qualification requirements for auditors;

e. Any provision relating to anticompetitive activites or unfair discrimination provisions; and

f. Reporting and recordkeeping requirements except that accounting of costs may be waived.

27.19(4) Withdrawal. Any participating home heating supplier who has been voluntarily participating in the I-SAVE plan may withdraw subject to the following provisions:

a. Submit a notice of withdrawal stating the date (current or future) withdrawal is effective;

b. State that customers who have requested audits, and who have requested the arranging services will continue to receive those accrued plan benefits, including conciliation;

c. State that customers who have requested audits will be assured of receiving an audit from a covered utility or another participating home heating supplier; and

d. State that notification of withdrawal from I-SAVE will be provided to the home heating suppliers customers.

250--27.20(476) State measures.

27.20(1) Heat pump water heater systems shall be included in the I-SAVE program for all categories of residential buildings and all HUD/MPS regions in the state of Iowa.

APPENDIX 1

CALCULATION PROCEDURES

CALCULATION PROCEDURE VALIDATION

In accordance with section 456.307 of the RCS rules, the ISCC submits the following calculation procedures and validation process as part of the I-SAVE RCS plan.

VALIDATION PROCESS

The following calculation procedures were developed for the I-SAVE plan by the independent consulting firm Ernst & Whinney (Washington Utilities Group). In developing these procedures, Ernst & Whinney first contacted the RCS division of DOE for all available information pertaining to applicable program measures and practices. Further information was obtained from Scientific Applications Corporation (currently under contract to DOE) and the Department of Housing and Urban Development, which provided data concerning the methodologies employed in evaluating existing housing and conservation standards. Additional information necessary for the analysis was obtained from the ASHRAE handbook and other references outlined in the bibliography.

METHODOLOGY FOR THE COST-EFFECTIVENESS EVALUATION OF ENERGY CONSERVATION TECHNIQUES

INTRODUCTION

Background

In developing an effective energy conservation program, the cost effectiveness of the energy conservation techniques (ECT's) must be taken into account for two main reasons. First, cost effectiveness may be one criterion for including in, or excluding from, the conservation program any technique or group of techniques. Second, the cost effectiveness of measures included in a program will influence user acceptance and adoption of the technique. If, for example, users believe that a particular action is economically advantageous to them, such users may be more easily encouraged to adopt such a measure. On the other hand, if users feel that a particular measure will cost them more than they will save, additional incentives may be needed to encourage adoption of such techniques. Thus, it is important to consider the cost-effectiveness question, both from the perspective of the overall scope of the project (statewide, regionwide, etc.) and from the point of view of the individual energy user.

The purpose of this paper is to develop an approach to evaluate the cost effectiveness of various ECT's. Specifically, we will address two methods that can be used: (1) discounted cash flow analysis, and (2) breakeven analysis. Both of these analysis techniques require the determination of costs and savings before the analytical comparisons can be made. An overview of the basic steps to be followed in performing the cost-effectiveness evaluation is presented in this section, followed by a brief discussion of the limitations of the approach used. The remainder of this paper addresses each of these steps in detail. Also included are a bibliography and an appendix which describes how to adjust published degree day measures for different base temperatures and solar radiation.

Overview of Cost-Effectiveness Evaluation Steps

The basic steps we followed in performing the cost-effectiveness evaluation consist of the following:

- Determination of energy savings--The energy use avoided as a result of the adoption of the ECT must be quantified. Hence, the first step is to establish a model of residential energy requirements for space heating, space cooling, and hot water utilization based on heat gain and heat loss principles. Since actual total energy requirements and, accordingly, actual savings estimates will vary depending on a number of characteristics of the specific house to be retrofitted, an example set of housing characteristics will be chosen and the associated parameter values will be established. A general approach for using the model to develop appropriate equations to estimate savings from implementation of various ECT's will then be presented. Next, given the approach, a series of applications will be provided and the appropriate savings equations will be developed for a selected list of ECT's. Then, utilizing the parameters of the prototype house, a sample calculation of specific energy savings will be performed. Since these sample calculations are intended to serve as examples only, warnings and considerations for utilizing the specific savings figures outside of the context of this discussion will be outlined.

- Determination of dollar savings--Having determined the energy savings, relevant factors for selection of the appropriate energy price for converting Btu savings to dollar savings as well as other savings (e.g., avoidance of operation and maintenance costs) must be identified. Sample calculations will then be made.

- Determination of costs--The cost of the ECT's (e.g., initial material and investment cost, additional operating or maintenance costs, etc.) must be developed. Specific figures for selected items will be presented.

- Analytical comparisons--Given the cost and savings, the discounted cash flow or breakeven analysis can then be performed. The specifics of each approach will be defined and discussed and, based on the calculations and figures of previous examples, sample cost-effectiveness computations will be made. Finally, expansions and additional applications of the methodology will be presented.

Limitations

Certain limitations of the general approach and specific data used in this analysis should be noted. The savings from simultaneous implementation of several ECT's will generally not equal the sum of the savings from the single implementation of each individual technique. In addition, great care must be exercised in attempting to use the energy savings calculated in the examples outside of the context of this discussion. These points are expanded on when appropriate throughout the remaining sections of this paper.

DETERMINATION OF ENERGY SAVINGS

There are two basic approaches to developing an estimate of the energy savings realized by adoption of any given ECT. One approach utilizes actual savings measured through field testing of the technique in question. Generally, the method involves measuring the energy utilization of both a house without the technique and of an identical house in which the technique has been implemented; the energy savings is the difference in measured energy utilization. The second approach involves the use of analytical equations which conceptually depict the energy requirements of the house. These equations are used to calculate the energy utilization of the house, both with and without the ECT. The energy savings is the difference between the two calculated levels of energy utilization.

We believe that the second alternative (analytical approach) is more appropriate to the analysis at hand for a number of reasons. Since it is not feasible to field test the techniques being considered as a part of this study, it would be necessary to locate studies which previously tested the techniques which closely duplicate the same situation; for the energy savings figures to be consistent, all techniques would have had to be tested under the same conditions. Inasmuch as such savings will vary with, among other factors, climate, housing construction, energy-using equipment, and level or number of other ECT's in place, it would, at best, be extremely difficult to find such consistent conditions for all requisite techniques. Second, using actual performance data may provide little flexibility to evaluate savings under different conditions. If, for example, one is interested in the savings from a certain technique with an "in place" level of conservation techniques different from that in the original study, it may well be necessary to perform a new field test. Alternatively, if the savings were determined in a climate different from that of Iowa, there may be no way to adjust the results to obtain more relevant figures.

Use of the analytical equations eliminates these problems. A set of parameters which are representative of conditions in Iowa can be defined and used with the equations to obtain savings estimates for all techniques under the same conditions. If it is desirable to obtain savings estimates for ECT's under a range of conditions at any one point in time or under changing conditions over time, the parameters can be changed accordingly and the savings can be recalculated. Thus, the use of analytical equations to calculate energy savings enhances both the consistency of the estimates and the ability of the estimates to reflect changes over time.

Household Energy Usage: Space Conditioning and Hot Water Heating

The two main types of household energy usage to be considered in this discussion are space conditioning and hot water heating.

Space Conditioning.

Total annual space conditioning energy requirements are determined by four basic factors: cold weather heat loss, warm weather heat gain, efficiency of heating equipment, and the efficiency of the cooling equipment. More specifically:

$$E_{sc} = HL/e_h + HG/e_c, \qquad (1)$$

where,

E_{sc} = Total annual energy requirement for space conditioning;

HL = Annual cold weather heat loss of the house;

HG = Annual warm weather heat gain of the house;

e_h = Efficiency of the heating equipment;

e_c = Efficiency of the cooling equipment.

The total annual heat loss, HL, and total annual heat gain, HG, can be further decomposed as follows:

$$HL = HL_w + HL_c + HL_f + HL_d + HL_g + I_h, \quad (2a)$$

$$HG = HG_w + HG_c + HG_d + HG_g + I_c, \quad (2b)$$

where,

I_h = Annual heat loss through infiltration;

I_c = Annual heat gain through infiltration;

HL_j = Annual heat loss through structural component j, with subscripts as follows:

w = Walls

c = Ceiling

f = Floor

d = Doors

g = Windows

HG_j = Annual heat gain through structural component j, with subscripts defined as above.

In turn, each of the heat loss or heat gain components is basically determined by four factors: (1) the heat conductance or transmissivity of the specific surface, (2) the total area of the surface, (3) the temperature differential between the outside and inside of the surface, and (4) the time period over which the temperature differential exists. Additionally, windows have a second heat gain component due to solar radiation. Infiltration, on the other hand, is primarily determined by the rate of air change, the volume of air being changed, the temperature differential of the air changing, and the time period over which the differential exists. Thus, the components of heat loss and heat gain equations (2a) and (2b) can be further expanded as follows:

$$HL_w = U_{hw} \cdot A_w \cdot \Delta T_{hw} \cdot HRS_{hw}; \quad (3a.1)$$

$$HL_c = U_{hc} \cdot A_c \cdot \Delta T_{hc} \cdot HRS_{hc}; \quad (3a.2)$$

$$HL_f = U_{hf} \cdot A_f \cdot \Delta T_{hf} \cdot HRS_{hf}; \quad (3a.3)$$

$$HL_d = U_{hd} \cdot A_d \cdot \Delta T_{hd} \cdot HRS_{hd}; \quad (3a.4)$$

$$HL_g = U_{hg} \cdot A_g \cdot \Delta T_{hg} \cdot HRS_{hg} + SHG_{hg} \cdot A_g; \quad (3a.5)$$

$$I_h = .018 \cdot R_h \cdot V \cdot \Delta T_{hi} \cdot HRS_{hi}; \quad (3a.6)$$

$$HG_w = U_{cw} \cdot A_w \cdot \Delta T_{cw} \cdot HRS_{cw}; \quad (3b.1)$$

$$HG_c = U_{cc} \cdot A_c \cdot \Delta T_{cc} \cdot HRS_{cc}; \quad (3b.2)$$

$$HG_d = U_{cd} \cdot A_d \cdot \Delta T_{cd} \cdot HRS_{cd}; \quad (3b.3)$$

$$HG_g = U_{cg} \cdot A_g \cdot \Delta T_{cg} \cdot HRS_{cg} + SHG_{cg} \cdot A_g; \quad (3b.4)$$

$$I_c = .018 \cdot R_c \cdot V \cdot \Delta T_{ci} \cdot HRS_{ci}; \quad (3b.5)$$

where,

U_{hj} = Conductance of component j during the winter, in Btu/hr - ft^2 - ^{o}F;

U_{cj} = Conductance of component j during the summer, in Btu/hr - ft^2 - ^{o}F;

A_j = Area of component j, in square feet;

ΔT_{hj} = Heat loss temperature differential between the the outside and inside surfaces of component j, in degrees F;

ΔT_{cj} = Heat gain temperature differential between the the outside and inside surfaces of component j, in degrees F;

HRS_{hj} = Time period over which ΔT_{hj} exists, in hours;

HRS_{cj} = Time period over which ΔT_{cj} exists, in hours;

SHG_{hg} = Solar heat gain through windows in winter, in Btu/ft^2;

SHG_{cg} = Solar heat gain through windows in summer, in Btu/ft^2;

R_h = Rate of air change during winter, in Btu/hr - ft^3 - ^oF;

R_c = Rate of air change during summer, in Btu/hr - ft^3 - ^oF;

V = Volume of space being conditioned, in cubic feet,

with all subscripts j as follows:

i = infiltration load;

all others as defined previously.

Over the course of the year, the conductance of the components (U_{hj}, U_{cj}) and the areas of the components (A_j) will remain constant. However, the temperature differentials (ΔT_{hj}, ΔT_{cj}) as well as the associated time periods (HRS_{hj}, HRS_{cj}) will vary as both the outdoor and indoor temperatures vary. Thus, for any annual period, the value of ($\Delta T_j \cdot HRS_j$) is actually the sum of all prevailing ΔT_j's times the associated HRS_j, or

$$\sum_{k=1}^{n} \Delta T_{jk} HRS_{jk}$$

for both of the heating and cooling seasons. If the variable HRS_{jk} is constant for all ΔT_{jk}'s, then this sum can be expressed as

$$HRS_j \sum_{k=1}^{n} \Delta T_{jk}.$$

This latter formulation is easily adapted to the degree day concept; the term $\sum_{k=1}^{n} \Delta T_{jk}$ is representative of total heating or cooling degree days, assuming a base (indoor) temperature of 65^o F., and, since each ΔT_j is effective for one day, HRS_j is equal to 24. Thus, the term $\Delta T_{hj} \cdot HRS_{hj}$ can, in all cases except for heat loss through the floor (j = f) and ceiling (j = c), be replaced by:

$$24 \cdot DD_{HB}$$

where,

DD_{HB} = annual heating degree days for base temperature B,

and the term $\Delta T_{cj} \cdot HRS_{cj}$ can be replaced by:

$24 \cdot DD_{CB}$,

where,

DD_{CB} = annual cooling degree days for base temperature B.

Procedures for calculating degree days for base temperatures other than 65° F. and for adjusting cooling degree days to account for solar radiation effects on outside surface temperatures are detailed in Appendix A.

In the case of heat loss through the floor (j = f), however, the temperature differential is not between inside and outside; rather, it is the differential between the base inside temperature and the basement temperature. This latter temperature can be calculated as the weighted average of the base inside temperature and the ground temperature, where the weights are the proportional heat transfer per hour through adjacent components:

$$t_b = \frac{\left(A_f \cdot U_{hf}\right) \cdot B + \left(A_{bw} \cdot U_{bw} + A_{bf} \cdot U_{bf}\right) \cdot t_g}{A_f \cdot U_{hf} + A_{bw} \cdot U_{bw} + A_{bf} \cdot U_{bf}}$$

where,

t_b = Basement temperature;

t_g = Ground temperature;

subscripts,

bw = Basement walls;

bf = Basement floor;

and all other variables are as defined previously.

Thus,

$$\Delta T_{hf} = B_h - t_b$$

$$= B_h - \left[\frac{A_f \cdot U_{hf}}{A_f \cdot U_{hf} + w_{hf}}\right] \cdot B_h$$

$$- \left[\frac{w_{hf}}{A_f \cdot U_{hf} + w_{hf}}\right] \cdot t_g$$

$$= \left[\frac{w_{hf}}{A_f \cdot U_{hf} + w_{hf}}\right] \cdot \left(B - t_g\right)$$

where,

$$w_{hf} = A_{bw} \cdot U_{bw} + A_{bf} \cdot U_{bf}.$$

Given that the substantial proportion of the heating degree days occurs during October through April, the corresponding number of hours, HRS_{hf}, becomes 212 days x 24, or 5088.

Similarly, the appropriate temperature differential for heat loss through the ceiling is the differential between the base inside temperature and the attic temperature. This attic temperature can be calculated as the weighted average of the base inside temperature and the outside temperature, where the weights are again the proportional heat transfer per hour through the adjacent components:

$$t_{ha} = \frac{\left(A_c \cdot U_{hc}\right) \cdot B + \left(A_r \cdot U_{hr} + A_{aw} \cdot U_{haw}\right) \cdot t_o}{A_c \cdot U_{hc} + A_r \cdot U_{hr} + A_{aw} \cdot U_{haw}};$$

and,

$$t_{ca} = \frac{\left(A_c \cdot U_{cc}\right) \cdot B + \left(A_r \cdot U_{hr} + A_{aw} \cdot U_{caw}\right) \cdot t_o}{A_c \cdot U_{cc} + A_r \cdot U_{hr} + A_{aw} \cdot U_{caw}};$$

where,

t_{ha} = Heating season attic temperature;

t_{ca} = Cooling season attic temperature;

subscripts:

r = Roof;

aw = Attic walls;

hr = Roof during the heating season;

cr = Roof during the cooling season;

haw = Attic walls during the heating season; and,

caw = Attic walls during the cooling season.

Thus,

$$\Delta T_{hc} = B_h - t_{ha}$$

$$= B_h - \left[\frac{A_c \cdot U_{hc}}{A_c \cdot U_{hc} + w_{hc}}\right] \cdot B_h - \left[\frac{w_{hc}}{A_c \cdot U_{hc} + w_{hc}}\right] \cdot t_o$$

$$= \left[\frac{w_{hc}}{A_c \cdot U_{hc} + w_{hc}}\right] \cdot \left(B_h - t_o\right) \text{ ; and,}$$

$$\Delta T_{cc} = B_c - t_{ca}$$

$$= B_c - \left[\frac{A_c \cdot U_{cc}}{A_c \cdot U_{cc} + w_{cc}}\right] \cdot B - \left[\frac{w_{cc}}{A_c \cdot U_{cc} + w_{cc}}\right] \cdot t_o$$

$$= \left[\frac{w_{cc}}{A_c \cdot U_{cc} + w_{cc}}\right] \cdot \left(B_c - t_o\right) ;$$

where,

$$w_{hc} = A_r \cdot U_{hr} + A_{aw} \cdot U_{haw} \text{ ; and}$$

$$w_{cc} = A_r \cdot U_{cr} + A_{aw} \cdot U_{caw} .$$

Combining these values with the degree day concept developed above, the term $\Delta T_{hc} \cdot HRS_{hc}$ becomes:

$$\left[\frac{w_{hc}}{A_c \cdot U_{hc} + w_{hc}}\right] \cdot DD_{HB} \cdot 24;$$

and the term $T_{cc} \cdot HRS_{cc}$ can be replaced by:

$$\left[\frac{w_{cc}}{A_c \cdot U_{cc} + w_{cc}}\right] \cdot DD_{CB} \cdot 24$$

Using these formulations for the floor and ceiling temperature differentials, and the degree day measures calculated in Appendix A, Equations (3a.1) - (3a.6) and (3b.1) - (3b.5) become:

$$HL_w = U_{hw} \cdot A_w \cdot DD_{HB} \cdot 24; \tag{4a.1}$$

$$HL_c = U_{hc} \cdot A_c \cdot \left[\frac{w_{hc}}{A_c \cdot U_{hc} + w_{hc}}\right] \cdot DD_{HB} \cdot 24; \tag{4a.2}$$

$$HL_f = U_{hf} \cdot A_f \cdot \left[\frac{w_{hf}}{A_f \cdot U_{hf} + w_{hf}}\right] \cdot B - t_g \cdot 5088; \tag{4a.3}$$

$$HL_d = U_{hd} \cdot A_d \cdot DD_{HB} \cdot 24; \tag{4a.4}$$

$$HL_g = U_{hg} \cdot A_g \cdot DD_{HB} \cdot 24 - SHG_{hg} \cdot A_g; \tag{4a.5}$$

$$I_h = .018 \cdot R_h \cdot V \cdot DD_{HB} \cdot 24; \tag{4a.6}$$

$$HG_w = U_{cw} \cdot A_w \cdot DD_{CB} \cdot 24; \tag{4b.1}$$

$$HG_c = U_{cc} \cdot A_c \cdot \left[\frac{w_{cc}}{A_c \cdot U_{cc} + w_{cc}}\right] \cdot DD_{CB} \cdot 24; \tag{4b.2}$$

$$HG_d = U_{cd} \cdot A_d \cdot DD_{CB} \cdot 24; \tag{4b.3}$$

$$HG_g = U_{cg} \cdot A_g \cdot DD_{CB} \cdot 24 + SHG_{cg} \cdot A_g; \tag{4b.4}$$

$$I_c = .018 \cdot R_c \cdot V \cdot DD_{CB} \cdot 24; \tag{4b.5}$$

where,

DD_{HB} = Total annual degree days to heat to temperature B;

DD_{CB} = Total annual degree days to cool to temperature B, adjusted for solar radiation.

Knowing the values of all variables in Equations (4a.1) to (4a.6) and (4b.1) to (4b.5) as well as the equipment efficiencies e_h and e_c from Equation (1), the total space conditioning energy requirement can be calculated.

Hot Water Heating. Total annual hot water heating energy requirements are determined by three basic factors: water heating need, hot water tank heat loss, and efficiency of water heating equipment. More specifically:

$$E_w = (WH + TL)/e_w; \quad (5)$$

where,

E_w = Total annual energy requirement for water heating,

WH = Annual water heating energy needs of the household;

TL = Annual heat loss from the hot water heater; and,

e_w = Efficiency of the hot water heater.

Annual water heating needs are primarily determined by the volume of hot water required annually and by the extent to which the temperature of the water must be raised, as follows:

$$WH = W_{HD} \cdot (T - T_c) \cdot 364 \cdot 8.34; \quad (6a)$$

where,

W_{HD} = Average daily hot water use of the household, in gallons;

T = Desired temperature of hot water, in degrees F;

T_c = Temperature of cold water coming into the tank, in degrees F;

8.34 = Number of Btu's required to raise the temperature of one gallon of water one degree F, in Btu/gal-^oF.

Additionally, heat loss of the tank can be decomposed to:

$$TL = U_t \cdot SA_t \cdot (T - T_R) \cdot 24 \cdot 365; \qquad (6b)$$

where,

U_t = Heat conductance of transmissivity of hot water tank, in Btu/hr-ft^2-^{o}F;

SA_t = Surface area of hot water tank, in square feet;

T = Desired temperature of hot water, in degrees F; and,

T_R = Temperature of area where tank is located, in degrees F.

Again, note that by knowing the values of all variables in Equations (6a) and (6b), it is possible to calculate the total household energy requirement for hot water heating.

Prototype House

For both space conditioning and hot water heating, all variables can be classified into two groups:

- Those which depict the basic structure and characteristics of the house, and will remain constant throughout this analysis
- Those which represent factors that can be changed by the implementation of conservation techniques.

This section presents the adopted values of the constant parameters and the initial levels for those factors that are alterable with conservation.

House Shell. The prototype house to be used in the analysis is a single level structure with a full basement and an attic, both of which are unconditioned. The overall dimensions of the house are 30 feet by 40 feet, the ceilings are 8 feet high, and the roof angle is 40°; also, the building has a wood exterior finish. It is assumed that the house has a front and a back door, each 3 feet by 7 feet, and that windows cover 15 percent of the exterior wall area. Further, 80 percent of the house is carpeted, and the remaining 20 percent of the floor area is covered with tile. There is currently no insulation in the home.

Given this information, the area and volumetric parameters for the conditioned space become:

- Volume (V) = 30 x 40 x 8 = 9600 cubic feet
- Ceiling Area (A_c) = 30 x 40 = 1200 square feet
- Roof Area (A_r) = 2 x (15/cos 40°) x 40 = 1566 square feet
- Total Floor Area (A_f) = 30 x 40 = 1200 square feet
- Total Basement Floor Area (A_{bf}) = 30 x 40 = 1200 square feet
- Door Area (A_d) = 2 x 3 x 7 = 42 square feet
- Window Area (A_g) = .15[2(30 + 40) ·8] = 168 square feet
- Wall Area (A_w) = [2(30 + 40)·8] - 168 - 42 = 910 square feet
- Basement Wall Area (A_{bw}) = [2(30 + 40)·8] = 1120 square feet
- Attic Wall Area (A_{aw} = 2 x .5 x 30 x (15 x tan 40°) = 378 square feet.

Next, the winter and summer conductance U-values of each of the shell components must be calculated. Generally speaking, the conductance U of any substance is equal to the reciprocal of its resistance, R, as follows:

$$U = 1/R.$$

Further, the resistance of a layered set of substances is equal to the sum of the resistance of the N individual components:

$$R_T = R_1 + R_2 + \dots + R_N.$$

Thus, the conductance of the layered set becomes:

$$U = 1/R_T = 1/(R_1 + R_2 + \dots + R_N).$$

Therefore, it is necessary to know the composition of each of the shell components so the U-values may be computed.

Starting at the inside of the wall and moving toward the outside, the component layers of the exterior walls of the house are as follows:

1. Gypsum wallboard, 1/2" thick;
2. Studs, 2" x 4";
3. Sheathing, 1/2" thick; and,
4. Wood siding.

In computing the resistance and conductance, the air surface next to both the inside and outside of the wall must be considered. Since there is no insulation between the studs, the layer between the wallboard and the sheathing is most appropriately considered as an air space.

It is now possible to compute the conductances of the wall, U_{hw} and U_{cw}, as follows:

	Winter Resistance	Summer Resistance
Inside Air Film	.68	.68
Wallboard	.45	.45
Airspace	1.01	1.01
Sheathing	1.32	1.32
Wood Siding	.81	.81
Outside Air Film	.17	.25
Total Resistance	4.44	4.52
Conductance (1/R)	U_{hw} = .225	U_{cw} = .221.

It should be pointed out that the variation in the resistance of the air films is due to differences in wind speed; inside air R-values assume still air, winter outdoor values assume 15 mph wind, and summer values assume 7.5 mph wind speed.

The component layers of the attic walls would be identical to those of the walls of the conditioned space, with the exception of the wallboard; thus, the conductances U_{haw} and U_{caw} can be computed as follows:

	Winter Resistance	Summer Resistance
Inside Air Film	.68	.68
Sheathing	1.32	1.32
Wood Siding	.81	.81
Outside Air Film	.17	.25
Total Resistance	2.98	3.06
Conductance (1/R)	U_{haw} = .336	U_{caw} = .327

Starting at the inside of the ceiling and working up, the structural components are as follows:

1. Gypsum wallboard, ½" thick; and,

2. Ceiling joists, 2" x 8".

Again, air films will be included.

Given this information, the ceiling conductances U_{hc} and U_{cc} can now be computed:

	Winter/Summer Resistance
Inside Air Film	.62
Wallboard	.45
Attic Air Film	.62
Total Resistance	1.69
Conductance (1/R)	$U_{hc} = U_{cc} = .592$

Starting from the inside of the attic and working out, the structural components are:

1. Ceiling rafters, 2" x 4";

2. Plywood sheathing, 5/8";

3. Felt building membrane;

4. Asphalt shingle roofing.

Outside and inside air films will be included.

The roof conductances U_{hr} and U_{cr} can now be calculated:

	Winter Resistance	Summer Resistance
Inside Air Film	.62	.62
Sheathing	.78	.78
Felt	.06	.06
Roofing	.44	.44
Outside Air Film	.17	.25
Total Resistance	2.07	2.15
Conductance (1/R)	$U_{hr} = .483$	$U_{cr} = .465$

Starting from the basement and moving up, the structural components of the tiled portion of floor are:

1. Floor joist, 2" x 8";
2. Wood subfloor, 3/4" thick;
3. Plywood, 5/8" thick;

4a. Tile

For the carpeted portion, component (4a) becomes:

4b. Padding and carpet.

Air films are again considered.

The conductances U_{hf} and U_{cf} are calculated as follows:

	Tile: Winter Resistance	Carpet: Winter Resistance
Basement Air Film	.62	.62
Wood Subfloor	.94	.94
Plywood	.78	.78
Tile	.05	--
Padding and Carpet	--	2.08
Top Air Film	.62	.62
Total Resistance	3.01	5.04
Conductance	$H_{hft} = .332$	$U_{hfc} = .198$

To arrive at a composite U-value, each component is weighted by its proportion of total floor area:

$$U_{hf} = .2U_{hft} + .8U_{hfc}$$
$$= .2(.332) + .8(.198)$$
$$= .225.$$

The average conductance U_{bw} for the basement walls is .443, while the conductance U_{bf} for the basement floor is .022. Assuming 2-inch solid wood doors, the winter and summer conductances are U_{hd} = .43 and U_{cd} = .42. For windows that are 80 percent single pane glass and 20 percent wood sash, the appropriate conductance values are U_{hg} = .99 and U_{cg} = .936.

For this analysis, average rates of air change per hour will be established at R_h = 1.00, and R_c = .67, respectively. In addition, the indoor winter temperature will be set at 70° F., while the summer temperature will be set at 75° F.

Space Conditioning Equipment. The prototype house can have four types of heating equipment and one type of air conditioning. In all cases, the equipment is located outside of the conditioned space. The different equipment and associated efficiencies are:

	Efficiency
Gas Heat	.59 1/
Oil Heat	.63 2/
Electric Resistance Heat	1.00
Heat Pump	2.00
Electric Air Conditioning	2.00

1/ Stephen R. Petersen, Kimberly A. Hockenbery, Methodology and Technical Basis for the Economic Analysis of Suggested Energy Conservation Measures, U.S. Department of Commerce, National Bureau of Standards, 1974, p. 22; also, Michigan Public Service Commission, Case No. U-5451 (June 6, 1977), Exhibit No. A - (LMD-2).

2/ Stephen R. Petersen and Kimberly A. Hockenbery, p. 22; also D.W. Turner and R.E. Holmes, "Efficiency Factors for Domestic Oil Heating Units," Proceedings of the Conference on Improving Efficiency in HVAC Equipment and Components for Residential and Small Commercial Buildings, October 7-8, 1974, p. A-21.

Climate Factors. It will be assumed that this house is located in Des Moines, Iowa. This area has 6710 heating degree days, and 928 cooling degree days, both based on the standard 65^{o} F. Using the method in Appendix A, this translates into 8104 degree days to heat to 70^{o} F (DD_{HB}), and 1407 degree days to cool to 75^{o} F. for non-horizontal surfaces (DD_{CB}). During the months of May through September, the solar heat gain factor, SHG_{cg}, is 137,728 Btu/ft^2, while during October through April the solar heat gain factor, SHG_{hg}, is 160,654 Btu/ft^2. All parameters relative to space conditoning are summarized in Table #1.

Hot Water Utilization. This household has a 50 gallon hot water heater, located in the basement, which has a conductance U_t of .171 and a surface area SA_t of 30.2 square feet. Cold water comes in at 55^{o} F., and the desired hot water temperature is 140^{o} F. The household uses 80 gallons of hot water per day. All these hot water-related values are also summarized in Table 1.

TABLE 1

PARAMETER VALUES FOR PROTOTYPE HOUSE

Space Conditioning

Volume and Area:

A_w = 910	A_{bf} = 1200
A_{aw} = 378	A_{bw} = 1120
A_c = 1200	A_d = 42
A_r = 1566	A_g = 168
A_f = 1200	V = 9600

Conductance and Infiltration:

U_{hw} = .225	U_{cw} = .221
U_{haw} = .336	U_{caw} = .327
U_{hc} = .592	U_{cc} = .592
U_{hr} = .483	U_{cr} = .465
U_{hd} = .43	U_{cd} = .42
U_{hf} = .225	U_{bf} = .022
U_{hg} = .990	U_{cg} = .936
U_{bw} = .443	R_c = .67
R_h =1.0	

Indoor Temperatures:

Conditioned Space-Winter 70°
Conditioned Space-Summer 75°
Average Annual Basement Temperature 54.6°

TABLE 1 (Cont.)

Equipment Efficiency:

e_h (gas)	= .59	e_c	= 2.0
e_h (oil)	= .63	e_w (elec)	= 1.0
e_h (elec)	= 1.0	e_w (gas)	= .7
e_h (h. pump)	= 2.0		

Climate:

DD_{HB} = 8104	SHG_{hg} = 160,654
DD_{CB} = 1407	SHG_{cg} = 137,728
t_g = 45	

Hot Water:

U_t = .171	T = 140
SA_t = 30.2	T_c = 55
W_{HD} = 80	

Impact of Energy Conservation Techniques

Given the basic energy requirements, equations and the prototype house just described, it is possible to develop the equations and to calculate the savings to be realized by adoption of an ECT. In this section, the general approach for development of such savings equations will be presented; implementation of single techniques and simultaneous implementation of multiple techniques will both be discussed. Then, a number of ECT's will be considered. For each technique, a brief description will be provided where necessary, the variable(s) and portion(s) of the energy requirement equation affected by implementation will be identified, and a sample calculation will be performed. Table 2 lists the ECT's to be considered.

General Approach. To determine the savings for implementation of any single ECT from the energy requirements equations, four basic steps are required:

1. Determine which variable(s) of the energy requirements equations will be impacted by the adoption of the ECT;
2. Identify the component equation(s) in which these variables appear;
3. Subtract the equation(s) for energy requirements after implementation from such equation(s) for requirements before implementation; and,
4. Substitute appropriate values for the parameters into the resulting savings equation.

For simultaneous implementation of multiple techniques, however, it may not always be appropriate to determine total savings by summing the savings from the individual techniques. In general, the total savings will equal the sum of the individual savings only when no two of the ECT's

TABLE 2

ENERGY CONSERVATION TECHNIQUES TO BE CONSIDERED

Ceiling Insulation
Wall Insulation
Floor Insulation
Caulking/Weatherstripping
Storm Windows
Thermal Windows
Heat Reflecting Window Material
Heat Absorbing Window Material
Shading
Storm Doors
Nighttime Temperature Setback
Clock Thermostat
Reduce Thermostat in Winter
Raise Thermostat in Summer

Furnace Efficiency Maintenance and Adjustment

- Mechanical Ignition (Gas Furnace)
- Flue Opening Modification (Gas Furnace)
- Replace Oil Furnace
- Replace Oil Burner
- Replace Central Air Conditioner

Reduce Hot Water Temperature
Reduce Water Flow in Showers, Faucets
Water Heater Insulation
Solar Hot Water Heating

affect the same variable and when equipment efficiencies are not affected. In all cases, however, it is advised to calculate a new single savings equation using the steps just described and simultaneously changing all affected variables, and then substituting parameter values which take into account the multiple changes.

Use of Specific Savings Estimates Generated in Sample Calculations. Before considering the specific ECT's listed in Table 2, several words of caution are in order concerning specific savings figures to be calculated for the specific ECT's. Extreme care must be taken in using the energy savings calculated in the examples outside the context of this discussion. It must be remembered that the specific savings are dependent on the size, structure and orientation of the house, the initial in-place level of conservation, specific type of equipment and level of equipment efficiency, as well as all the other parameter values identified in Table 1 above. For example, a one-story home with 1,500 square feet will generally have greater savings and, thus, example estimates will understate the savings. Similarly, smaller homes will have relatively lower savings; thus, the estimates for the prototype house would tend to overstate savings. Generally speaking, two-story houses with 1,200 square feet will have a different savings configuration than the one-story prototype house due to the structural differences. Solar related factors (the adjustment to degree days to cool, solar heat gains) will vary substantially in relation to the direction each portion of the house is facing. (Average values for all directions have been used in the examples.) Equipment efficiencies will vary widely depending on type of equipment, appropriate sizing, and so on. Since the calculations used figures for gas heat and electric air conditioning, resulting estimates would not accurately reflect savings when other fuels are used. Similarly, efficiencies resulting from implementation will be even more diverse; for equipment-related ECT's, the literature generally cites a very wide range of values. While the specific figures used in the examples tend toward the middle of the range, it must be kept in mind that the resulting estimates are but a single point in a whole range of values. To reiterate, then, the appropriateness of all conditions established and parameter values assumed should be checked before adapting the estimates developed in the sample calculations to other purposes. Given these cautions, the discussion can proceed to the specific examples.

Ceiling Insulation. Ceiling or attic insulation essentially reduces the heat flow through the top of the conditioned space. Such insulation comes in various materials and forms: glass fiber, cellulose; blanket or batt, loose fill. In all cases, however, the degree of heat loss or heat gain prevention is measured by the R-value or resistance, which increases as the thickness of the insulation layer increases.

Adding ceiling insulation will reduce the conductance value U_{hc} and, therefore, will reduce the ceiling heat loss, HL_c, in Equation (4a.2) as follows:

$$HL_c^o = U_{hc}^o \cdot A_c \cdot \left[\frac{w_{hc}}{A_c \cdot U_{hc}^o + w_{hc}} \right] \cdot DD_{HB} \cdot 24 \qquad (7a)$$

$$HL_c^1 = U_{hc}^1 \cdot A_c \cdot \left[\frac{w_{hc}}{A_c \cdot U_{hc}^1 + w_{hc}} \right] \cdot DD_{HB} \cdot 24 \qquad (7b)$$

$$HL_c^o - HL_c^1 = \left[\frac{(U_{hc}^o \cdot w_{hc})}{(A_c \cdot U_{hc}^o + w_{hc})} - \frac{(U^1 \cdot w_{hc})}{(A_c \cdot U_{hc}^1 + w_{hc})} \right] \cdot A_c \cdot DD_{HB} \cdot 24 \qquad (8)$$

$$\Delta HL_c = \left[\frac{\Delta U_{hc} \cdot w_{hc}^2}{(A_c \cdot U_{hc}^o + w_{hc})(A_c U_{hc}^1 + w_{hc})} \right] \cdot A_c \cdot DD_{HB} \cdot 24 \qquad (8a)$$

where,

superscript o = Initial value of variable,

superscript 1 = Value of variable after implementation of ECT.

All other variables are as defined previously.

Similarly, the addition of ceiling insulation will reduce the conductance value U_{cc} and thus will also reduce the ceiling heat gain, HG_c, from Equation (4b.2) as follows:

$$HG_c^o = U_{cc}^o \cdot A_c \cdot \left[\frac{w_{cc}}{(A_c \cdot U_{cc}^o + w_{cc})} \right] \cdot DD_{CB} \cdot 24 \qquad (9a)$$

$$HG_c^1 = U_{cc}^1 \cdot A_c \cdot \left[\frac{w_{cc}}{(A_c \cdot U_{cc}^1 + w_{cc})} \right] \cdot DD_{CB} \cdot 24 \qquad (9b)$$

$$HG_c^o - HG_c^1 = \left[\frac{(U_{cc}^o \cdot w_{cc})}{(A_c \cdot U_{cc}^o + w_{cc})} - \frac{(U_{cc}^1 \cdot w_{cc})}{(A_c \cdot U_{cc}^1 + w_{cc})} \right] \cdot A_c \cdot DD_{CB} \cdot 24 \qquad (10)$$

$$\Delta HG_c = \left[\frac{\Delta U_{cc} \cdot w_{cc}^2}{(A_c \cdot U_{cc}^o + w_{cc})(A_c \cdot U_{cc}^1 + w_{cc})} \right] \cdot A_c \cdot DD_{CB} \cdot 24 \qquad (10a)$$

Since all other components of heat loss, heat gain, and infiltration equations will not change, the total energy savings realized become, utilizing Equation (1):

$$E_{sc}^o - E_{sc}^1 = \frac{\Delta HL_c}{e_h} + \frac{\Delta HG_c}{e_c} \qquad (11)$$

$$= \left[\frac{(\Delta U_{hc} \cdot w_{hc}^2)/e_h}{(A_c \cdot U_{hc}^o + w_{hc})(A_c \cdot U_{hc}^1 + w_{hc})} \right] \cdot A_c \cdot DD_{CB} \cdot 24$$

$$+ \left[\frac{(\Delta U_{cc} \cdot w_{cc}^2)/e_c}{(A_c \cdot U_{cc}^o + w_{cc})(A_c \cdot U_{cc}^1 + w_{cc})} \right] \cdot A_c \cdot DD_{CB} \cdot 24$$

Example:

Assume that R-30 insulation is installed in the ceiling of the prototype house. To calculate the savings, it is first necessary to determine the new ceiling conductances. Again, a component-by-component analysis of resistance is necessary; all items will be the same except for the addition of the layer of insulation. New conductances, U_{hc} and U_{cc}, are:

	Winter/Summer
Total Previous Resistance of Ceiling	1.69
Gained Resistance of Insulation	30.00
Total New Resistance	31.69
New Conductance	0.032
Old Conductance	0.592
Change in Conductance	$0.560 = \Delta U_{hc} = \Delta U_{cc}$

Substituting these ΔU values, the efficiency for gas heat, and the other required parameter values from Table 1 into Equation (11) yields:

$$\Delta E_{sc} = \left[(.560)(883.4)^2/.59\right] \Big/ \left[(1200 \times .592 + 883.4)(1200 \times .032 + 883.4)\right](1200)(8104)(24)$$
$$+ \left[(.560)(851.8)^2/2.0\right] \Big/ \left[(1200 \times .592 + 851.8)(1200 \times .032 + 851.8)\right](1200)(1407)(24)$$
$$= 117{,}671{,}747 + 5{,}919{,}645$$
$$= 123{,}591{,}392$$

Thus, if R-30 insulation is added above the ceiling of the prototype house with gas heat and air conditioning, 123,591,392 Btu's of energy would be saved each year.

Wall Insulation. Wall insulation reduces the heat loss and heat gain through the sides of the conditioned space. Although blanket or batt insulation may be used in walls in new construction, loose fill, blown in through small holes, is the only form adaptable to retrofit. As with ceiling insulation, the degree of heat loss or heat gain is measured by the insulation R-value.

Addition of wall insulation will reduce the conductance value U_{hw} and, therefore, will reduce the wall heat loss component HL_w in Equation (4a.1) as follows:

$$HL_w^o = U_{hw}^o \cdot A_w \cdot DD_{HB} \cdot 24 \tag{12a}$$

$$HL_w^1 = U_{hw}^1 \cdot A_w \cdot DD_{HB} \cdot 24 \tag{12b}$$

$$HL_w^o - HL_w^1 = (U_{hw}^o - U_{hw}^1) \cdot A_w \cdot DD_{HB} \cdot 24 \tag{13}$$

$$\Delta HL_w = \Delta U_{hw} \cdot A_w \cdot DD_{HB} \cdot 24 \tag{13a}$$

Similarly, the addition of wall insulation will reduce the conductance value U_{cw} and, thus, will reduce the heat gain HG_w in Equation (4b.1) as follows:

$$HG_w^o = U_{cw}^o \cdot A_w \cdot DD_{CB} \cdot 24 \tag{14a}$$

$$HG_w^1 = U_{cw}^1 \cdot A_w \cdot DD_{CB} \cdot 24 \tag{14b}$$

$$HG_w^o - HG_w^1 = (U_{cw}^o - U_{cw}^1) \cdot A_w \cdot DD_{CB} \cdot 24 \tag{15}$$

$$\Delta HG_w = \Delta U_{cw} \cdot A_w \cdot DD_{CB} \cdot 24 \tag{15a}$$

Since all other components of heat loss, heat gain, and infiltration equations will not be affected by the addition of wall insulation, the total energy savings realized becomes, utilizing Equation (1):

$$E_{sc}^{o} - E_{sc}^{1} = \frac{\Delta HL_w}{e_h} + \frac{\Delta HG_w}{e_c} \qquad (16)$$

$$= \Delta U_{hw}/e_h \cdot A_w \cdot DD_{HB} \cdot 24$$

$$+ \Delta U_{cw}/e_c \cdot A_w \cdot DD_{CB} \cdot 24$$

Example:

Assume that R-7 insulation is installed in the walls of the prototype house. To calculate the savings, it is again necessary to determine the new wall conductances. In the component-by-component analysis of the wall, all items will be the same as before except that the airspace between the studs will be replaced by the insulation. New conductances, U_{hw} and U_{cw} are:

	Winter	Summer
Total Previous Resistance of Wall	4.44	4.52
Lost Resistance of Airspace	-1.01	-1.01
Gained Resistance of Insulation	7.00	7.00
Total New Resistance	10.43	10.51
New Conductance	0.096	0.095
Old Conductance	0.225	0.221
Change in Conductance	$0.129 = \Delta U_{hw}$	$0.126 = \Delta U_{cw}$

Substituting these ΔU values, the efficiency of gas heat and the other required parameter values from Table 1 into Equation (16) yields:

$$\Delta E_{sc} = (.129/.59)(910)(8104)(24)$$

$$+ (.126/2.0)(910)(1407)(24)$$

$$= 38{,}698{,}111 + 1{,}935{,}919$$

$$= 40{,}634{,}030$$

Thus, if R-7 insulation is added to the exterior walls of the prototype house with gas heat and air conditioning, 40,634,030 Btu's of energy would be saved each year.

<u>Floor Insulation</u>. Floor insulation will reduce the heat loss through the bottom of the conditioned space. This type of insulation comes generally in blanket or batt form and has a resistance R-value.

Addition of insulation in a basement or crawl space will reduce the conductance value U_{hf} and, in turn, will reduce the heat loss component in Equation (4a.3) as follows:

$$HL_f^o = U_{hf}^o \cdot A_f \cdot \left[\frac{w_{hf}}{A_f \cdot U_{hf}^o + w_{hf}}\right] \cdot (B - t_g) \cdot 5088 \qquad (17a)$$

$$HL_f^1 = U_{hf}^1 \cdot A_f \cdot \left[\frac{w_{hf}}{A_f \cdot U_{hf}^1 + w_{hf}}\right] \cdot (B - t_g) \cdot 5088 \qquad (17b)$$

$$HL_f^o - HL_f^1 = \left[\frac{(U_{hf}^o \cdot w_{hf})}{(A_f \cdot U_{hf}^o + w_{hf})} - \frac{(U_{hf}^1 \cdot w_{hf})}{(A_f \cdot U_{hf}^1 \cdot w_{hf})}\right] \cdot A_f \cdot (B - t_g) \cdot 5088 \qquad (18)$$

$$\Delta HL_f = \left[\frac{(\Delta U_{hf} \cdot w_{hf}^2}{(A_f \cdot U_{hf}^o + w_{hf})(A_f \cdot U_{hf}^1 + w_{hf})}\right] \cdot A_f \cdot (B - t_g) \cdot 5088 \qquad (18a)$$

Since all other components of the heat loss, heat gain, and infiltration equations will not be affected by the installation of floor insulation, the total energy savings realized becomes, utilizing Equation (1):

$$E_{sc}^o - E_{sc}^1 = \Delta HL_f / e_h \qquad (19)$$

$$= \left[\frac{(\Delta U_{hf} \cdot w_{hf})/e_h}{(A_f \cdot U_{hf}^o + w_{hf})(A_f \cdot U_{hf}^1 + w_{hf})}\right] \cdot A_f \cdot (B - t_g) \cdot 5088$$

Example:

Assume that R-11 insulation is installed under the floor of the prototype house. The new floor conductance values will again be computed on a component-by-component basis. All items will be the same except that insulation will be added between the joists. New conductances for the tiled and carpeted sections are:

	Tile: Winter Resistance	Carpet: Winter Resistance
Total Previous Floor Resistance	3.01	5.04
Gained Resistance of Insulation	11.00	11.00
Total New Resistance	14.01	16.04
New Conductance	0.071	0.062
Old Conductance	0.332	0.198
Change in Conductance	$0.261 = \Delta U_{hft}$	$0.136 = \Delta U_{hfc}$

To arrive at the composite change in U-value, each component must be weighted by its proportion of the total floor area:

$$\Delta U_{hf} = (.2)(.261) + (.8)(.136) = .161.$$

Substituting this ΔU value, the efficiency of gas heat, and the other required parameters from Table 1 into Equation (19) yields:

$$\Delta E_{sc} = \left[(.161)(522.6)^2/.59\right] \Big/ \left[(1200 \times .225 + 522.6)(1200 \times .064 + 522.6)\right] (1200)(70 - 45)(5088)$$

$$= 23{,}944{,}746$$

Thus, if R-11 insulation is added below the floor of the prototype house with gas heat, 23,944,746 Btu's of energy will be saved each year.

Caulking/Weatherstripping. Caulking and weatherstripping are used to fill gaps and cracks in the shell of the conditioned space, particularly around doors and windows; by filling the crack, unconditioned air flow into the space is reduced. In addition, comfort is increased due to the reduction of drafts. Though caulking compound is generally all in the same form, weatherstripping is not; it can be found in widths varying from 1/2 inch to several inches, in thicknesses ranging from 1/8 inch to 1/2 inch, and a variety of materials including felt and foam.

Addition of caulking and/or weatherstripping will reduce the air change rate R_h and, thus, will reduce the infiltration I_h in Equation (4a.6) as follows:

$$I_h^o = .018 \cdot R_h^o \cdot V \cdot DD_{HB} \cdot 24 \qquad (20a)$$

$$I_h^1 = .018 \cdot R_h^1 \cdot V \cdot DD_{HB} \cdot 24 \qquad (20b)$$

$$I_h^o - I_h^1 = .018 \cdot (R_h^o - R_h^1) \cdot V \cdot DD_{HB} \cdot 24 \qquad (21)$$

$$\Delta I_h = .018 \cdot \Delta R_h \cdot V \cdot DD_{HB} \cdot 24 \qquad (21a)$$

Similarly, caulking and/or weatherstripping will reduce the air change rate R_c and, thus, will reduce the infiltration I_c in Equation (4b.5) as follows:

$$I_c^o = .018 \cdot R_c^o \cdot V \cdot DD_{CB} \cdot 24 \qquad (22a)$$

$$I_c^1 = .018 \cdot R_c^1 \cdot V \cdot DD_{CB} \cdot 24 \qquad (22b)$$

$$I_c^o - I_c^1 = .018 \cdot (R_c^o - R_c^1) \cdot V \cdot DD_{CB} \cdot 24 \qquad (23)$$

$$\Delta I_c = .018 \cdot \Delta R_c \cdot V \cdot DD_{CB} \cdot 24 \qquad (23a)$$

Since all components of the heat loss and heat gain equations remain unaffected, the total energy savings realized becomes, using Equation (1):

$$\begin{aligned} E_{sc}^o - E_{sc}^1 &= \Delta I_h/e_h + \Delta I_c/e_c \qquad (24) \\ &= .018 \cdot \Delta R_h/e_h \cdot V \cdot DD_{HB} \cdot 24 \\ &\quad + .018 \cdot \Delta R_c/e_c \cdot V \cdot DD_{CB} \cdot 24. \end{aligned}$$

Example:

Assume that all cracks in the conditioned space shell are caulked/weatherstripped. To calculate savings, the resulting change in the air change rates, R_h and R_c, must be determined. According to ASHRAE, the rate of air change with weatherstripping is two-thirds the nonweatherstripped rate. Thus,

$$\Delta R_h = R_h^o - R_h^1 = 1 - (2/3)\cdot 1 = 1/3$$

$$\Delta R_c = R_c^o - R_c^1 = 2/3 - 2/3(2/3) = 2/9$$

Substituting these ΔR values, the efficiencies for air conditioning and gas heat, and the required parameters from Table 1 into Equation (24) yields:

$$\begin{aligned}\overline{\Delta E}_{sc} &= .018(1/3/.59)(9600)(8104)(24) \\ &+ .018(2/9/2.0)(9600)(1407)(24) \\ &= 18,988,084 + 648,346 \\ &= 19,636,430.\end{aligned}$$

Thus, if caulking/weatherstripping is added to the prototype house with gas heat and air conditioning, 19,636,430 Btu's of energy would be saved each year.

Storm Windows. Storm windows reduce the heat loss from and air flow around the windows of the house. They come in two main types: wood frame storms, and aluminum triple-track windows.

Installation of storm windows reduces the conductance factor U_{hg} and, accordingly, reduces the window heat loss component HL_g in Equation (4a.5) as follows:

$$HL_g^o = U_{hg}^o \cdot A_g \cdot DD_{HB} \cdot 24 - SHG_{hg} \cdot A_g \qquad (25a)$$

$$HL_g^1 = U_{hg}^1 \cdot A_g \cdot DD_{HB} \cdot 24 - SHG_{hg} \cdot A_g \qquad (25b)$$

$$HL_g^o - HL_g^1 = (U_{hg}^o - U_{hg}^1) \cdot A_g \cdot DD_{HB} \cdot 24 \qquad (26)$$

$$\Delta HL_g = \Delta U_{hg} \cdot A_g \cdot DD_{HB} \cdot 24 \qquad (26a)$$

In addition, storm window installation reduces the air change rate R_h and, thus, reduces the infiltration in Equation (4a.6) as follows:

$$I_h^o = .018 \cdot R_h^o \cdot V \cdot DD_{HB} \cdot 24 \qquad (27a)$$

$$I_h^1 = .018 \cdot R_h^1 \cdot V \cdot DD_{HB} \cdot 24 \qquad (27b)$$

$$I_h^o = I_h^1 = .018 \cdot (R_h^o - R_h^1) \cdot V \cdot DD_{HB} \cdot 24 \qquad (28)$$

$$\Delta I_h = .018 \cdot \Delta R_h \cdot V \cdot DD_{HB} \cdot 24 \qquad (28a)$$

Since all other components of the heat loss and infiltration and all heat gain components remain unchanged, total energy savings becomes, using Equation (1):

$$E_{sc}^o - E_{sc}^1 = (\Delta HL_g + \Delta I_h)/e_h \qquad (29)$$

$$= \Delta U_{hg}/e_h \cdot A_g \cdot DD_{HB} \cdot 24$$

$$+ .018 \cdot \Delta R_h/e_h \cdot V \cdot DD_{HB} \cdot 24$$

Example:

Assume storm windows of 80 percent glass with a metal sash are installed in the prototype house. To calculate savings, the change in conductance and air change rates must be determined. Since the conductance with storms is .50,

$$\Delta U_{hg} = .99 - .50 = .49$$

The air change rate with storms is the same as that with caulking/weather-stripping, thus:

$$\Delta R_h = 1 - 2/3(1) = 1/3.$$

Substituting these values for ΔU_{hg} and ΔR_h, the efficiency for gas heat, and the required parameters from Table 1 into Equation (29) yields:

$$\Delta E_{sc} = (.49/.59)(168)(8104)(24) + .018(^1/_3\ /.59)(9600)(8104)(24)$$
$$= 27,137,137 + 18,988,084$$
$$= 46,125,221$$

Thus, by installing storm windows in the prototype house with gas heat, 46,125,221 Btu's can be saved each year.

Thermal Windows. While standard windows have a single pane of glass set in the frame, thermal windows have multiple panes, separated by small air spaces, set in the single frame. The additional layers of glass reduce the heat flow through the windows.

Replacing the standard windows with double or triple pane thermal windows changes both the conductance U_{hg} and the solar heat gain SHG_{hg} and, therefore, changes the heat loss component in Equation (4b.4), as follows:

$$HG_g^o = U_{cg}^o \cdot A_g \cdot DD_{CB} \cdot 24 + SHG_{cg}^o \cdot A_g \qquad (32a)$$

$$HG_g^1 = U_{cg}^1 \cdot A_g \cdot DD_{CB} \cdot 24 + SHG_{cg}^1 \cdot A_g \qquad (32b)$$

$$HG_g^o - HG_g^1 = (U_{cg}^o - U_{cg}^1) \cdot A_g \cdot DD_{CB} \cdot 24 + (SHG_{cg}^o - SHG_{cg}^1) \cdot A_g \qquad (33)$$

$$\Delta HG_g = \Delta U_{cg} \cdot A_g \cdot DD_{CB} \cdot 24 + \Delta SHG_{cg} \cdot A_g \qquad (33a)$$

Since all other components of the heat loss, heat gain, and infiltration components remain unchanged, total energy savings becomes, using Equation (1):

$$E_{sc}^o - E_{sc}^1 = \Delta HL_g/e_h + \Delta HG_g/e_c$$
$$= \Delta U_{hg}/e_h \cdot A_g \cdot DD_{HB} \cdot 24 - \Delta SHG_{hg}/e_h \cdot A_g$$
$$+ \Delta U_{cg}/e_c \cdot A_g \cdot DD_{CB} \cdot 24 + \Delta SHG_{cg}/e_c \cdot A_g \qquad (34)$$

Example:

Assume that the standard, single pane windows are replaced by double pane thermal windows. To calculate the savings, the changes in conductance and solar heat gain must be determined. With a winter conductance for $^1/_8$ inch double pane thermal windows with a $^1/_2$ inch airspace of .466,

$$\Delta U_{hg} = .990 - .466 = .524$$

Similarly, with a summer conductance for such windows of .532

$$\Delta U_{cg} = .936 - .532 = .404$$

Additionally, the changes in the summer and winter solar heat gains are:

$$\Delta SHG_{hg} = 160{,}654 - .88(160{,}654) = 19{,}278$$

$$\Delta SHG_{cg} = 137{,}728 - .88(137{,}728) = 16{,}527$$

Substituting these ΔU and ΔSHG values, the efficiency for air conditioning and gas heat, and the required parameter values from Table 1 into Equation (34) yields:

$$\Delta E_{sc} = (.524/.59)(168)(8104)(24) - (19{,}278/.59)(168)$$

$$+ (.404/2.0)(168)(1407)(24) + (16{,}527/2.0)(168)$$

$$= 29{,}020{,}122 - 5{,}489{,}329 + 1{,}145{,}951 + 1{,}388{,}268$$

$$= 26{,}065{,}012$$

Replacing standard windows with thermal windows as described above will result in annual savings of 26,065,012 Btu's.

Heat Reflecting and Absorbing Window Materials. Several types of materials are on the market today which have special heat reflecting or heat absorbing properties. Some of these are different glasses or other glazing materials; others include a variety of films which are applied to more standard window glasses. Such materials are effective in increasing occupant comfort as well as in altering a building's energy requirements.

Use of any of these materials can alter the conductance, U_{hg}, the solar radiation factor, SHG_{hg}, or both and, thus, will change the heat loss component HL_g of Equation (4a.5) as follows:

$$HL_g^o = U_{hg}^o \cdot A_g \cdot DD_{HB} \cdot 24 - SHG_{hg}^o \cdot A_g \quad (35a)$$

$$HL_g^1 = U_{hg}^1 \cdot A_g \cdot DD_{HB} \cdot 24 - SHG_{hg}^1 \cdot A_g \quad (35b)$$

$$HL_g^o - HL_g^1 = (U_{hg}^o - U_{hg}^1) \cdot A_g \cdot DD_{HB} \cdot 24 - (SHG_{hg}^o - SHG_{hg}^1) \cdot A_g \quad (36)$$

$$\Delta HL_g = \Delta U_{hg} \cdot A_g \cdot DD_{HB} \cdot 24 - \Delta SHG_{hg} \cdot A_g \quad (36a)$$

Similarly, application of these materials will alter the conductance factor U_{cg} and solar radiation factor SHG_{cg} and, thus, will change the heat gain component HG_g in Equation (4b.4) as follows:

$$HG_g^o = U_{cg}^o \cdot A_g \cdot DD_{CB} \cdot 24 + SHG_{cg}^o \cdot A_g \quad (37a)$$

$$HG_g^1 = U_{cg}^1 \cdot A_g \cdot DD_{CB} \cdot 24 + SHG_{cg}^1 \cdot A_g \quad (37b)$$

$$HG_g^o - HG_g^1 = (U_{cg}^o - U_{cg}^1) \cdot A_g \cdot DD_{CB} \cdot 24 + (SHG_{cg}^o - SHG_{cg}^1) \cdot A_g \quad (38)$$

$$\Delta HG_g = \Delta U_{cg} \cdot A_g \cdot DD_{CB} \cdot 24 + \Delta SHG_{cg} \cdot A_g \quad (38a)$$

Since all other heat loss, heat gain, and infiltration components will remain unchanged, total energy savings from the use of reflective/absorptive materials for window surfaces becomes, using Equation (1):

$$E_{sc}^o - E_{sc}^1 = \Delta HL/e_h + \Delta HG/e_c \quad (39)$$

$$= \Delta U_{hg}/e_h \cdot A_g \cdot DD_{HB} \cdot 24 - \Delta SHG_{hg}/e_h \cdot A_g + \Delta U_{cg}/e_c \cdot A_g \cdot DD_{CB} \cdot 24 + \Delta SHG_{cg}/e_c \cdot A_g$$

Example:

Assume the $^1/_8$ inch standard glass panes are replaced by $^1/_8$ inch heat absorbing glass panes in the prototype house. In this case, the conductance values U_{hg} and U_{cg} are unaffected; thus,

$$\Delta U_{hg} = \Delta U_{cg} = 0.$$

The solar heat gain values, SHG_{hg} and SHG_{cg} are reduced to 83 percent of their original value; thus,

$$\Delta SHG_{hg} = 160,654 - .83(160,654) = 27,311$$

$$\Delta SHG_{cg} = 137,728 - .83(137,728) = 23,414$$

Substituting these values, the efficiencies of air conditioning and gas heat, and the required parameter values from Table 1 into Equation (39) yields:

$$\Delta E_{sc} = -(27,311)/.59(168) + (23,414)/(2.0)(168)$$

$$= -7,776,692 + 1,966,776$$

$$= -5,809,914$$

By using heat absorbing glass instead of standard glass in the prototype home equipped with gas heat and air conditioning can increase the energy requirement 5,809,914 Btu's per year.

Use of Shading. Use of shades, blinds, and draperies can alter both the heat transfer and solar heat gain properties of window openings. Such use has the advantage of being selective; that is, the shading devices can be used only when they positively affect energy usage.

Use of shades, blinds, or drapes can alter the winter conductance U_{hg} and solar heat gain SHG_{hg}, and, thus, impact the heat loss component HL_g in Equation (4a.5), as follows:

$$HL_g^o = U_{hg}^o \cdot A_g \cdot DD_{HB} \cdot 24 - SHG_{hg}^o \cdot A_g \quad (40a)$$

$$HL_g^1 = U_{hg}^1 \cdot A_g \cdot DD_{HB} \cdot 24 - SHG_{hg}^1 \cdot A_g \quad (40b)$$

$$HL_g^o - HL_g^1 = (U_{hg}^o - U_{hg}^1) \cdot A_g \cdot DD_{HB} \cdot 24 - (SHG_{hg}^o - SHG_{hg}^1) \cdot A_g \quad (41)$$

$$\Delta HL_g = \Delta U_{hg} \cdot A_g \cdot DD_{HB} \cdot 24 - \Delta SHG_{hg} \cdot A_g \quad (41a)$$

Similarly, summer values U_{cg} and SHG_{cg} can be altered to impact the heat gain component HG_g, as follows:

$$HG_g^o = U_{cg}^o \cdot A_g \cdot DD_{CB} \cdot 24 + SHG_{cg}^o \cdot A_g \quad (42a)$$

$$HG_g^1 = U_{cg}^1 \cdot A_g \cdot DD_{CB} \cdot 24 + SHG_{cg}^1 \cdot A_g \quad (42b)$$

$$HG_g^o - HG_g^1 = (U_{cg}^o - U_{cg}^1) \cdot A_g \cdot DD_{CB} \cdot 24 + (SHG_{cg}^o - SHG_{cg}^1) \cdot A_g \quad (43)$$

$$\Delta HG_g = \Delta U_{cg} \cdot A_g \cdot DD_{CB} \cdot 24 + \Delta SHG_{cg} \cdot A_g \quad (43a)$$

Since none of the other heat gain, heat loss, or infiltration components are affected, potential energy savings from utilization of shading devices, as derived from Equation (1), is as follows:

$$\begin{aligned} E_{sc}^o - E_{sc}^1 &= \Delta HL_g/e_h + \Delta HG_g/e_c \quad (44a) \\ &= \Delta U_{hg}/e_h \cdot A_g \cdot DD_{HB} \cdot 24 - \Delta SHG_h/e_h \cdot A_g \\ &+ \Delta U_{cg}/e_c \cdot A_g \cdot DD_{CB} \cdot 24 - \Delta SHG_{cg}/e_c \cdot A_g \end{aligned}$$

Alternatively, if the component ΔHL_g is negative, the shading can be used only in the summer and, thus:

$$\begin{aligned} E_{sc}^o - E_{sc}^1 &= \Delta HG_g/e_c \quad (44b) \\ &= \Delta U_{cg}/e_c \cdot A_g \cdot DD_{CB} \cdot 24 - \Delta SHG_{cg}/e_c \cdot A_g \end{aligned}$$

Example:

Assume white shades are installed in all windows of the prototype house. To calculate the savings, the change in conductances and solar heat gain must be determined:

$$\Delta U_{hg} = .99 - .747 = .243$$

$$\Delta U_{cg} = .936 - .729 = .207$$

$$\Delta SHG_{hg} = 160,654 - .25(160,654) = 120,490$$

$$\Delta SHG_{cg} = 137,728 - .25(137,728) = 103,296$$

Substituting these values, the efficiencies of air conditioning and gas heat, and the required parameters from Table 1 into Equation (44a) yields:

$$\begin{aligned}\Delta E_{sc} &= (.243/.59)(168)(8104)(24) - (120,490/.59)(168) \\ &\quad + (.207/2.0)(168)(1407)(24) + (103,296/2.0)(168) \\ &= 13,457,805 - 34,309,017 \\ &\quad + 587,158 + 8,676,864 \\ &= -20,851,212 + 9,264,022 \\ &= -11,587,190\end{aligned}$$

However, since the heat loss portion is negative, Equation (44b) will be used instead:

$$\begin{aligned}\Delta E_{sc} &= (.207/2.0)(168)(1407)(24) + (103,296/2.0)(168) \\ &= 587,158 + 8,676,864 \\ &= 9,264,022\end{aligned}$$

Thus, use of shades in the summer will result in savings of 9,264,022 Btu's per year.

<u>Storm Doors</u>. As with storm windows, storm doors reduce heat loss from a house. Such doors can have either aluminium or wood frames.

Utilization of storm doors reduces the conductance factor U_{hd} and thus, changes the heat loss component HL_d of Equation (4a.4) as follows:

$$HL_d^o = U_{hd}^o \cdot A_d \cdot DD_{HB} \cdot 24 \quad (45a)$$

$$HL_d^1 = U_{hd}^1 \cdot A_d \cdot DD_{HB} \cdot 24 \quad (45b)$$

$$HL_d^o - HL_d^1 = (U_{hd}^o - U_{hd}^1) \cdot A_d \cdot DD_{HB} \cdot 24 \quad (46)$$

$$\Delta HL_d = \Delta U_{hd} \cdot A_d \cdot DD_{HB} \cdot 24 \quad (46a)$$

Since all other heat loss, heat gain, and infiltration components will be unaffected by typical use of storm doors, total energy savings, as derived from Equation (1), is as follows:

$$E_{sc}^o - E_{sc}^1 = \Delta HL_d/e_h \quad (47)$$

$$= \Delta U_{hd}/e_h \cdot A_d \cdot DD_{HB} \cdot 24$$

Example:

Assume wooden storm doors are installed. To compute savings, the change in the door conductance U_{hd}:

$$\Delta U_{hd} = .43 - .24 = .19$$

Substituting this ΔU value, the efficiency for gas heat, and the required parameters from Table 1 into Equation (47) yields:

$$\Delta E_{sc} = (.19/.59)(42)(8104)(24)$$

$$= 2,630,641$$

Thus, use of storm doors in the winter in the prototype home with gas heat will save 2,630,641 Btu's a year.

Nighttime Temperature Setback. This ECT involves no physical changes to the home whatsoever; the family simply reduces the thermostat during winter sleeping hours. Since the desired temperature is lower, less heat is required.

Implementation of this basic measure affects the base temperature B for a portion of each day and therefore will also change the degree day measure DD_{HB}. Thus, heat loss for all components HL_w, HL_c, HL_f, HL_d, HL_g, and I_h in Equations (4a.1) to (4a.6) is changed, as follows:

$$HL_w^o = U_{hw} \cdot A_w \cdot DD_{HB}o \cdot 24 \quad (48a)$$

$$HL_w^1 = U_{hw} \cdot A_w \cdot DD_{HB}1 \cdot 24 \quad (48b)$$

$$HL_w^o - HL_w^1 = U_{hw} \cdot A_w \cdot (DD_{HB}o - DD_{HB}1) \cdot 24 \quad (49)$$

$$\Delta HL_w = U_{hw} \cdot A_w \cdot \Delta DD_{HB} \cdot 24 \quad (49a)$$

$$HL_c^o = U_{hc} \cdot A_c \cdot \left[\frac{w_{hc}}{A_c \cdot U_{hc} + w_{hc}}\right] \cdot DD_{HB}o \cdot 24 \quad (50a)$$

$$HL_c^1 = U_{hc} \cdot A_c \cdot \left[\frac{w_{hc}}{A_c \cdot U_{hc} + w_{hc}}\right] \cdot DD_{HB}1 \cdot 24 \quad (50b)$$

$$HL_c^o - HL_c^1 = U_{hc} \cdot A_c \cdot \left[\frac{w_{hc}}{A_c \cdot U_{hc} + w_{hc}}\right] \cdot DD_{HB}o - DD_{HB}1 \cdot 24 \quad (5$$

$$\Delta HL_c = U_{hc} \cdot A_c \cdot \left[\frac{w_{hc}}{A_c \cdot U_{hc} + w_{hc}}\right] \cdot \Delta DD_{HB} \cdot 24 \quad (5\ \ )$$

$$HL_f^o = U_{hf} \cdot A_f \cdot \left[\frac{w_{hf}}{A_f \cdot U_{hf} + w_{hf}}\right] \cdot (B^o - t_g) \cdot 5088 \cdot \quad (5\ \ )$$

$$HL_f^1 = U_{hf} \cdot A_f \cdot \left[\frac{w_{hf}}{A_f \cdot U_{hf} + w_{hf}}\right] \cdot (B^o - t_g) \cdot 5088 \cdot (1 - X)$$

$$+ U_{hf} \cdot A_f \cdot \left[\frac{w_{hf}}{A_f \cdot U_{hf} + w_{hf}}\right] \cdot (B^1 - t_g) \cdot 5088 \cdot X \quad (5\ \ )$$

$$HL_f^o - HL_f^1 = U_{hf} \cdot A_f \cdot \left[\frac{w_{hf}}{A_f \cdot U_{hf} + w_{hf}}\right] \cdot (B^o - t_g) - (B^1 - t_g)$$

$$\cdot 5088 \cdot X \quad (53)$$

$$\Delta HL_f = U_{hf} \cdot A_f \left[\frac{w_{hf}}{A_f \cdot U_{hf} + w_{hf}}\right] \cdot \Delta B \cdot 5088 \cdot X; \quad (53a)$$

where:

X = fraction of a day the base temperature B is reduced.

$$HL_d^o = U_{hd} \cdot A_d \cdot DD_{HB^o} \cdot 24 \quad (54a)$$

$$HL_d^1 = U_{hd} \cdot A_d \cdot DD_{HB^1} \cdot 24 \quad (54b)$$

$$HL_d^o - HL_d^1 = U_{hd} \cdot A_d \cdot (DD_{HB^o} - DD_{HB^1}) \cdot 24 \quad (55)$$

$$\Delta HL_d = U_{hd} \cdot A_d \cdot \Delta DD_{HB} \cdot 24 \quad (55a)$$

$$HL_g^o = U_{hg} \cdot A_g \cdot DD_{HB^o} \cdot 24 - SHG_{hg} \cdot A_g \quad (56a)$$

$$HL_g = U_{hg} \cdot A_g \cdot DD_{HB} \cdot 24 - SHG_{hg} \cdot A_g \quad (56b)$$

$$HL_g^o - HL_g^1 = U_{hg} \cdot A_g \cdot (DD_{HB^o} - DD_{HB^1}) \cdot 24 \quad (57)$$

$$\Delta HL_g = U_{hg} \cdot A_g \cdot \Delta DD_{HB} \cdot 24 \quad (57a)$$

$$I_h^o = .018 \cdot R_h \cdot V \cdot DD_{HB^o} \cdot 24 \quad (58a)$$

$$I_h^1 = .018 \cdot R_h \cdot V \cdot DD_{HB^1} \cdot 24 \quad (58b)$$

$$I_h^o - I_h^1 = .018 \cdot R_h \cdot V \cdot (DD_{HB^o} - DD_{HB^1}) \cdot 24 \quad (59)$$

$$\Delta I_h = .018 \cdot R_h \cdot V \cdot \Delta DD_{HB} \cdot 24 \quad (59a)$$

All heat gain components are unaffected by this heating season temperature change; thus, total energy savings as derived from Equation (1), is as follows:

$$E_{sc}^o - E_{sc}^1 = (\Delta HL_w + \Delta HL_c + \Delta HL_f + \Delta HL_d + \Delta HL_g + \Delta I_h)/e_h \quad (60)$$

$$= \left[U_{hw} \cdot A_w + U_{hc} \cdot A_c \cdot \left(\frac{w_{hc}}{A_c \cdot U_{hc} + w_{hc}}\right) + U_{hd} \cdot A_d + U_{hg} \cdot A_g + .018 \cdot R_h \cdot V\right] \cdot 24 \cdot \frac{\Delta DD_{HB}}{e_h} + U_{hf} \cdot A_f \cdot \left(\frac{w_{hf}}{A_f \cdot U_{hf} + w_{hf}}\right) \cdot (\Delta B \cdot X)/e_h \cdot 5088.$$

<u>Example</u>:

Assume the temperature of the house is set back to 65°F for 8 sleeping hours. Utilizing the algorithm of Appendix A, the degree day total for heating to 70°F in the day and 65°F at night has been calculated to be 7565, as shown in Table A-2. Thus, the change in degree days resulting from the setback is:

$$\Delta DD_{HB} = 8104 - 7698 = 406$$

Additionally,

$$\Delta B = 70 - 65 = 5;$$

$$X = 8/24 = 1/3$$

Substituting these values, the efficiency for gas heat, and the required parameters from Table 1 into Equation (60) yields:

$$\Delta E_{sc} = \Big[(.225)(910) + (.592)(1200)(883.4)/(1200 \times .592 + 883.4)$$
$$+ (.43)(42) + (.99)(168) + (.018)(1)(9600)\Big] \times 24$$
$$\times (406/.59)$$
$$+ \Big[(.225)(1200)(522.6)/(1200 \times .225 + 522.6)\Big]$$
$$\Big[(5)(1/3)/(.59)\Big] (5088)$$
$$= 15{,}783{,}387 + 2{,}558{,}721$$
$$= 18{,}342{,}108$$

Thus, by setting the nighttime temperature of the gas heated prototype house back to 65^{o}F from 70^{o}F, 18,342,108 Btu's can be saved.

<u>Clock Thermostat</u>. Clock thermostats, which can be set to automatically raise and lower the indoor temperature, can save energy in the same way as nighttime setback. They do, however, have the advantage of making the adjustment without intervention by any member of the household. Therefore, the base temperature and degree day changes resulting from installation of the clock thermostat will be identical to that for manual adjustment. Thus, the energy savings will be exactly as shown in Equation (60).

Example:

Assume the clock thermostat is set to reduce the temperature for 8 sleeping hours to 65° F. The energy savings calculation would then be identical to that for the nighttime setback described in the previous example, and total energy savings would be 18,342,108 Btu's per year.

Permanent Winter Thermostat Reduction. While reducing the thermostat during sleeping hours will save some energy, reducing the setting all the time will save even more. As with the clock thermostat, the variables and equations affected by such a permanent reduction will be identical to those affected by the nighttime setback, and total energy savings are represented by Equation (60).

Example:

Assume the temperature of the house is permanently reduced to 65°F during the heating season. Since this adjustment will reduce the degree day total to 6710, the change in degree days becomes:

$$\Delta DD_{HB} = 8104 - 6710 = 1394$$

Additionally,

$$\Delta B = 70 - 65 = 5$$

$$X = 1$$

Substituting these values, the efficiency for gas heat, and the required parameters from Table 1 into Equation (60) yields:

$$\Delta E_{sc} = \Big[(.225)(910) + (.592)(1200)(883.4)/(1200 \times .592 + 883.4)$$

$$+ (.43)(42) + (.99)(168) + (.018)(1)(9600)\Big] \times 24$$

$$\times (1394/.59)$$

$$+ \Big[(.225)(1200)(522.6)/(1200 \times .225 + 522.6)\Big]$$

$$\Big[(5)(1)/(.59)\Big] (5088)$$

$$= 54{,}192{,}222 + 7{,}676{,}163$$

$$= 61{,}868{,}385$$

Thus, by reducing the temperature of the prototype house with gas heat from 70° to 65° for the heating season, 61,868,385 Btu's can be saved annually.

Permanent Summer Thermostat Increase. Just as lowering the thermostat in winter reduces the heat loss that must be replaced, so does raising the thermostat in the summer reduce the heat gain that must be removed.

Implementation of this basic measure affects the base temperature B and, therefore, will affect the adjusted degree day measure DD_{CB}. Thus, the heat gain for all components HG_w, HG_c, HG_d, HG_g, and I_c in Equations (4b.1) to (4b.5) is as follows:

$$HG_w^o = U_{cw} \cdot A_w \cdot DD_{CB^o} \cdot 24 \qquad (61a)$$

$$HG_w^1 = U_{cw} \cdot A_w \cdot DD_{CB^1} \cdot 24 \qquad (61b)$$

$$HG_w^o - HG_w^1 = U_{cw} \cdot A_w \cdot (DD_{CB^o} - DD_{CB^1}) \cdot 24 \qquad (62)$$

$$\Delta HG_w = U_{cw} \cdot A_w \cdot \Delta DD_{CB} \cdot 24 \qquad (62a)$$

$$HG_c^o = U_{cc} \cdot A_c \cdot \left[\frac{w_{cc}}{A_c \cdot U_{cc} + w_{cc}} \right] \cdot DD_{CB^o} \cdot 24 \qquad (63a)$$

$$HG_c^1 = U_{cc} \cdot A_c \cdot \left[\frac{w_{cc}}{A_c \cdot U_{cc} + w_{cc}} \right] \cdot DD_{CB^o} \cdot 24 \qquad (63b)$$

$$HG_c^o - HG_c^1 = U_{cc} \cdot A_c \cdot \left[\frac{w_{cc}}{A_c \cdot U_{cc} + w_{cc}} \right] \cdot (DD_{CB^o} - DD_{CB^1}) \cdot 24 \qquad (64)$$

$$\Delta HG = U_{cc} \cdot A_c \cdot \left[\frac{w_{cc}}{A_c \cdot U_{cc} + w_{cc}} \right] \cdot \Delta DD_{CB} \cdot 24 \qquad (64a)$$

$$HG_d^o = U_{cd} \cdot A_d \cdot DD_{CBo} \cdot 24 \qquad (65a)$$

$$HG_d^1 = U_{cd} \cdot A_d \cdot DD_{CB1} \cdot 24 \qquad (65b)$$

$$HG_d^o - HG_d^1 = U_{cd} \cdot A_d \cdot (DD_{CBo} - DD_{CB1}) \cdot 24 \qquad (66)$$

$$\Delta HG_d = U_{cd} \cdot A_d \cdot \Delta DD_{CB} \cdot 24 \qquad (66a)$$

$$HG_g^o = U_{cg} \cdot A_g \cdot DD_{CBo} \cdot 24 + SHG_{cg} \cdot A_g \qquad (67a)$$

$$HG_g^1 = U_{cg} \cdot A_g \cdot DD_{CB1} \cdot 24 + SHG_{cg} \cdot A_g \qquad (67b)$$

$$HG_g^o - HG_g^1 = U_{cg} \cdot A_g \cdot (DD_{CBo} - DD_{CB1}) \cdot 24 \qquad (68)$$

$$\Delta HG_g = U_{cg} \cdot A_g \cdot \Delta DD_{CB} \cdot 24 \qquad (68a)$$

$$I_c^o = .018 \cdot R_c \cdot V \cdot DD_{CBo} \cdot 24 \qquad (69a)$$

$$I_c^1 = .018 \cdot R_c \cdot V \cdot DD_{CB1} \cdot 24 \qquad (69b)$$

$$I_c^o - I_c^1 = .018 \cdot R_c \cdot V \cdot (DD_{CBo} - DD_{CB1}) \cdot 24 \qquad (70)$$

$$\Delta I_c = .018 \cdot R_c \cdot V \cdot \Delta DD_{CB} \cdot 24 \qquad (70a)$$

All heat loss components are unaffected by this cooling season temperature change, thus, total energy savings, as derived from Equation (1), is as follows:

$$E_{sc}^o - E_{sc}^1 = (\Delta HG_w + \Delta HG_c + \Delta HG_d + \Delta HG_g + \Delta I_c)/e_c \qquad (71)$$

$$= \left[U_{cw} \cdot A_w + U_{cc} \cdot A_c \cdot \left(\frac{w_{cc}}{A_c \cdot U_{cc} + w_{cc}} \right) + U_{cd} \cdot A_d + U_{cg} \cdot A_g + .018 \cdot R_c \cdot V \right] \cdot \Delta DD_{CB} / e_c \cdot 24$$

Example:

Assume the temperature of the prototype house is permanently set up to 80° F. for the cooling season. Utilizing the algorithm of Appendix A, the degree day total shown in Table A-2 for cooling to 80° for non-horizontal solar radiation is 1016. Thus, the change in degree days resulting from the increase is:

$$\Delta DD_{CB} = 1407 - 1016 = 391$$

Substituting these values, the efficiency for air conditioning, and the required parameters from Table 1 into Equation (71) yields:

$$\Delta E_{sc} = \left[(.221)(910) + (.592)(1200)(851.8)/(1200 \text{ X } .592 + 851.8) + (.42)(42) + (.936)(168) + (.018)(.67)(9600) \right] (391/2.0)(24)$$

$$= 4{,}124{,}852$$

Thus, by raising the temperature of the prototype house from 75° to 80° for the cooling season, an annual energy savings of 4,124,852 Btu's can be realized.

Furnace Efficiency Maintenance and Adjustment. All the ECT's discussed so far have affected energy requirement through making changes in either the external shell of the conditioned space or the temperature of the conditioned space. It is also possible to save energy through alternations to the heating and cooling equipment. One method of doing this is to periodically check and adjust the furnace; this includes such things as cleaning filters, fine-tuning the air/fuel mix where appropriate, and so on. When this is done, the furnace can more efficiently convert input energy into the required heating.

Such adjustments do not affect any of the heat gain or heat loss components in Equations (2a) and (2b); they do, however, change the heating equipment efficiency e_h in Equation (1). Thus, energy savings becomes:

$$E^o_{sc} = HL/e^o_h + HG/e_c \tag{72a}$$

$$E^1_{sc} = HL/e^1_h + HG/e_c \tag{72b}$$

$$E^o_{sc} - E^1_{sc} = HL/e^o_h - HL/e^1_h = HL \cdot \left[\frac{e^1_h - e^o_h}{e^1_h \cdot e^o_h}\right] \tag{73}$$

<u>Example</u>:

Assume a gas furnace in the prototype home receives routine maintenance, and the efficiency of the furnace changes from .59 to .61. Substituting these values and the required parameters from Table 1 into Equation (73) yields:

$$\Delta E_{sc} = \Bigg(\Big[(.225)(910) + (.592)(1200)(883.4)/(1200 \times .592 + 883.4) + (.43)(42) + (.99)(168) + (.018)(1)(9600)\Big](8104)(24) + \Big[(.225)(1200)(522.6)/(1200 \times .225 + 522.6)\Big](70 - 45)(5088) - \Big[(160{,}654)(168)\Big]\Bigg)\left(\frac{.61 - .59}{(.61)(.59)}\right)$$

$$= (181{,}531{,}797)(.0475)$$

$$= 8{,}622{,}760.$$

Thus, by performing routine maintenance on a gas furnace in the prototype house, 8,622,760 Btu's may be saved annually.

Flue Opening Modification/Vent Damper. When a furnace is not in operation, heat is lost through the chimney. By reducing this heat loss, energy can be saved. While such modifications do not affect the heat gain or heat loss components in Equations (2a) and (2b), they do affect the efficiency e_h of gas furnaces. Thus, total energy savings from flue opening modification can be calculated as shown in Equation (73).

Example:

Assume a vent damper is installed for the gas furnace in the prototype home and, accordingly, the efficiency of the furnace is increased from .59 to .63. Substituting these values and the required parameters from Table 1 into Equation (73) yields:

$$\Delta E_{sc} = \Big(\Big[(.225)(910) + (.592)(1200)(883.4)/(1200 \times .592 + 883.4)$$

$$+ (.43)(42) + (.99)(168) + (.018)(i)(9600)\Big] (8104)(24)$$

$$+ \Big[(.225)(1200)(522.6)/(1200 \times .225 + 522.6)\Big] (70 - 45)(5088)$$

$$- \Big[(160,654)(168)\Big]\Big) \left(\frac{.65 - .59}{(.65)(.59)}\right)$$

$$= (181,531,797)(.156)$$

$$= 28,318,960$$

Thus, by installing a vent damper in the prototype house, 28,318,960 Btu's may be saved annually.

Electric/Mechanical Ignition. Conventional gas furnaces have a pilot light which burns continuously, whether or not the furnace is operating. By replacing the pilot with an electric ignition, much of the energy consumed by the pilot light when the furnace is not operating can be saved.

Given that the average pilot light consumes about 800 Btu per hour, the average consumption per day is 800 x 24, or 19,200 Btu. Thus, for the months of May through September, pilot consumption would be:

$$19{,}200 \text{ Btu/day} \times 153 \text{ days} = 2{,}937{,}600 \text{ Btu} \qquad (74a)$$

This analysis assumes that the equipment unit is located in an unconditioned part of the house. If the unit is located in an area that is cooled, installation of the electric ignition would eliminate the need to remove the heat gain resulting from the pilot. In this case, the savings becomes:

$$\Delta E = \text{Energy Consumed by Pilot} + \text{Cooling Eliminated} \qquad (74b)$$

$$= 2{,}937{,}600 + 2{,}937{,}600/e_c = 2{,}937{,}600[1+1/e_c].$$

Example:

In the case of the prototype house, the gas furnace is located in the basement and, thus, is not in the conditioned space. Thus, Equation (74a) is appropriate, and 2,937,600 Btu's could be saved annually.

Replace Oil Burner/Oil Furnace. By replacing the oil burner or entire furnace with a newer, perhaps better sized or more updated unit, it is possible to increase the efficiency of the heating system. While such replacements do not affect the heat gain or heat loss components in Equations (2a) or (2b), they do affect the afficiency e_h of oil fueled heating equipment. Thus, the energy savings formula is identical to that identified in Equation (73).

Example:

Assume, for the moment, that the prototype house is heated with oil; assume further that the burner of the unit is replaced and, thus, the efficiency of the unit is increased from .63 to .67. Substituting these values and the required parameters from Table 1 into Equation (73) yields:

$$\Delta E_{sc} = \Bigg(\Big[(.225)(910) + (.592)(1200)(883.4)/(1200 \times .592 + 883.4) + (.43)(.42) + (.99)(168) + (.018)(1)(9600)\Big](8104)(24) + \Big[(.225)(1200)(522.6)/(1200 \times .225 + 522.6)\Big](70 - 45)(5088) - \Big[(160,654)(168)\Big]\Bigg)\left(\frac{.67 - .63}{(.67)(.63)}\right)$$

$$= (181,531,797)(.095)$$

$$= 17,245,521$$

Thus, by replacing the burner in the oil furnace in the prototype home with an optimal unit, 17,245,521 Btu's of energy can be saved.

Replace Central Air Conditioners. At any point in time, it has been possible to purchase central air conditioners of varying efficiencies; over time, the maximum available level of efficiency of the unit has increased. Thus, replacing a current air conditioning unit with one of a higher efficiency will result in energy savings.

Again, the heat loss and heat gain components in Equation (2a) and (2b) will be unaffected by air conditioner replacement; only the cooling efficiency measure e_c will be changed. Thus, total energy savings, developed from Equation (1), is as follows:

$$E^o_{sc} = HL/e_h + HG/e^o_c \tag{75a}$$

$$E^1_{sc} = HL/e_h + HG/e^1_c \tag{75b}$$

$$E^o_{sc} - E^1_{sc} = HG/e^o_c - HG/e^1_c$$

$$= HG \cdot \left[\frac{e^1_c - e^o_c}{e^o_c \cdot e^1_c}\right]$$

Example:

Assume the central air conditioner in the prototype home is replaced with a high efficiency unit; this replacement increases the efficiency from 2.0 to 2.6. Substituting these values and the required parameters from Equation (76) yields:

$$\Delta E_{sc} = \Bigg(\Big[(.221)(910) + (.592)(1200)(851.8)/(1200 \times .592 + 851.8) + (.42)(42) + (.936)(168) + (.018)(.67)(9600)\Big](1407)(24) + \Big[(137,728)(168)\Big]\Bigg)\left(\frac{2.6 - 2.0}{(2.0)(2.6)}\right)$$

$$= (52,824,575)(.115)$$

$$= 6,074,826$$

By replacing the air conditioner in the prototype home with a high efficiency unit, 6,074,826 Btu's can be saved annually.

Reduce Hot Water Temperature. Most households maintain a hot water temperature of 140^{o}F, however, they use water at the somewhat cooler temperature of $110^{o} - 120^{o}$F. By reducing the hot water temperature from 140^{o} to the use temperature range, the household avoids the heating and recooling of the water.

Reducing the hot water temperature impacts the water temperature variable T and, thus, affects both the water heating component WH and the tank loss component TL of Equations (6a) and (6b), as follows:

$$WH^{o} = W_{HD} \; (T^{o}-T_{c}) \cdot 365 \cdot 8.34 \qquad (77a)$$

$$WH^{1} = W_{HD} \; (T^{1}-T_{c}) \cdot 365 \cdot 8.34 \qquad (77b)$$

$$WH^{o} - WH^{1} = W_{HD} \left[(T^{o}-T_{c})-(T^{1}-T_{c})\right] \cdot 365 \cdot 8.34 \qquad (78)$$

$$\Delta WH = W_{HD} \cdot \Delta T \cdot 365 \cdot 8.34 \qquad (78a)$$

$$TL^{o} = U_{t} \cdot SA_{t} \cdot (T^{o}-T_{R}) \cdot 24 \cdot 365 \qquad (79a)$$

$$TL^{1} = U_{t} \cdot SA_{t} \cdot (T^{1}-T_{R}) \cdot 24 \cdot 365 \qquad (79b)$$

$$TL_{o} - TL_{1} = U_{t} \cdot SA_{t} \cdot \left[(T^{o}-T_{R})-(T^{1}-T_{R})\right] \cdot 24 \cdot 365 \qquad (80)$$

$$\Delta TL = U_{t} \cdot SA_{t} \cdot \Delta T \cdot 24 \cdot 365 \qquad (80a)$$

Thus, total energy savings, derived from Equation (5), is as follows:

$$E_w^o - E_w^1 = (\Delta WH + \Delta TL)/e_w \quad (81a)$$
$$= W_{HD} \cdot 365 \cdot 8.34 \cdot \Delta T/e_w$$
$$+ U_t \cdot SA_t \cdot 24 \cdot 365 \cdot \Delta T/e_w$$

The savings calculation in Equation (81a) assumes that the hot water use W_{HD} remains unchanged; this implies that the final demand is for a certain volume of water regardless of temperature. However, if the final demand is for a final volume of water at an unchanged temperature, then the savings ΔWH will be exactly offset by a change in W_{HD}. In the latter case, Equation (81a) becomes:

$$E_w^o - E_w^1 = (\Delta WH + \Delta TL)/e_w \quad (81b)$$
$$= 0 + U_t \cdot SA_t \cdot 24 \cdot 365 \cdot \Delta T/e_w.$$

<u>Example</u>:

Assume the desired hot water temperature in an electric hot water heater is reduced from 140°F to 120°F. Thus,

$$\Delta T = 140 - 120 = 20$$

Substituting this temperature change as well as the required parameters from Table 1 into Equation (81a) yields:

$$\Delta E_{sc} = (80)(365)(8.34)(20)/1.0$$
$$+ (.171)(30.2)(24)(365)(20)/1.0$$
$$= 4,870,560 + 904,768$$
$$= 5,775,328$$

If, on the other hand, Equation (81b) is used:

$$\Delta E_{sc} = (.171)(30.2)(24)(365)(20)/1.0$$
$$= 904,768$$

Thus, by reducing the setting on an electric hot water heater to 120°F instead of 140°F, 904,768 to 5,775,328 Btu's can be saved.

Reduce Water Flow in Showers, Faucets. There are certain instances (taking a shower, for example) when the total water used and, thus, hot water used, is more dependent on the amount of time that the water is running than on the need for a specific volume of water. In these cases, installing a restrictor to limit the flow rate of the water will reduce the usage of hot water and, thus, save energy.

Reducing the flow will reduce W_{HD} and, thus, will affect the water heating component WH of Equation (6a) as follows:

$$WH^1 = W^o_{HD} \cdot (T-T_c) \cdot 365 \cdot 8.34 \tag{82a}$$

$$WH^1 = W^1_{HD} \cdot (T-T_c) \cdot 365 \cdot 8.34 \tag{82b}$$

$$WH^o - WH^1 = (W^o_{HD}-W^1_{HD}) \cdot (T-T_c) \cdot 365 \cdot 8.34 \tag{83}$$

$$\Delta WH = \Delta W_{HD} \cdot (T-T_c) \cdot 365 \cdot 8.34 \tag{83a}$$

The variable W_{HD} can be expanded to show its flow - and nonflow - related components:

$$W_{HD} = F_{HD} \cdot M + NF_{HD} \; ; \tag{84}$$

where:

F_{HD} = Flow rate of hot water

M = Length of time, in minutes, that water is running; and

NF_{HD} = Nonflow related hot water use.

The change in W_{HD} resulting from the installation of restrictors can then be shown to be:

$$W^{o}_{HD} = F^{o}_{HD} \cdot M + NF_{HD} \quad (85a)$$

$$W^{1}_{HD} = F^{1}_{HD} \cdot M + NF_{HD} \quad (85b)$$

$$W^{o}_{HD} - W^{1}_{HD} = (F^{o}_{HD} - F^{1}_{HD}) \cdot M \quad (86)$$

$$\Delta W_{HD} = \Delta F_{HD} \cdot M \quad (86a)$$

Substituting (86a) into (83a) yields:

$$\Delta WH = \Delta F_{HD} \cdot M \cdot (T - T_c) \cdot 365 - 8.34 \quad (87)$$

Since the tank loss component TL remains unchanged, total energy savings, derived from Equation (5), becomes:

$$E^{o}_{w} - E^{1}_{w} = \Delta WH/e_w \quad (88)$$

$$= \Delta F_{HD} \cdot M/e_w \cdot (T - T_c) \cdot 365 \cdot 8.34$$

Example:

Assume low flow shower heads are installed which reduce the hot water flow rate from 4.2 to 2.45 gallons per minute and, further, that family members spend a total of 12 minutes a day, on average, in the shower. Thus, the flow rate reduction is:

$$\Delta E_{sc} = (1.75)(12)/(1.0)(140 - 55)(365)(8.34)$$

$$= 5{,}433{,}719.$$

Thus, installing low flow shower heads in the prototype home with an electric hot water heater and the above utilization can result in annual savings of 5,433,719 Btu's.

Hot Water Heater Insulation. Just as insulating the ceiling, walls, or floors reduces heat loss from the conditioned space, so does hot water heater insulation reduce heat loss from the hot water tank.

Water heater insulation reduces the conductance value of the tank U_t and thus reduces the tank loss component TL of Equation (6b) as follows:

$$TL^o = U_t^o \cdot SA_t \cdot (T - T_R) \cdot 24 \cdot 365 \quad (89a)$$

$$TL^1 = U_t^1 \cdot SA_t \cdot (T - T_R) \cdot 24 \cdot 365 \quad (89b)$$

$$TL^o - TL^1 = (U_t^o - U_t^1) \cdot SA_t \cdot (T - T_R) \cdot 24 \cdot 365 \quad (90)$$

$$\Delta TL = \Delta U_t \cdot SA_t \cdot (T - T_R) \cdot 24 \cdot 365 \quad (90a)$$

Since the water heating component WH is not affected by the addition of insulation, total energy savings, as derived from Equation (5), are as follows:

$$E_w^o - E_w^1 = \Delta TL/e_w \quad (91)$$

$$= \Delta U_t/e_w \cdot SA_t \cdot (T - T_R) \cdot 24 \cdot 365$$

Example:

Assume one inch of R-3.2 insulation is applied to an electric hot water tank in the basement. This changes the conductance U_t from .171 to a new value of:

$$U_t^1 = \frac{1}{(1/.171 + 3.2)} = \frac{1}{(5.85 + 3.2)}$$

$$= .110$$

Thus,

$$\Delta U_t = .171 - .110 = .061.$$

Substituting this value for ΔU_t as well as the required parameters from Table 1 into Equation (91) yields savings of:

$$\Delta E_{sc} = (.061)/(1.0)(30.2)(140 - 54.6)(24)(365)$$

$$= 1{,}378{,}157$$

Thus, by adding one inch of insulation to an electric hot water tank in the prototype house, 1,378,157 Btu's can be saved annually.

Solar Domestic Hot Water. For all the ECT's discussed thus far, implementation resulted in energy savings due to a reduction in the energy requirements of the house. It is also possible to save gas, oil, or electricity by deriving part of the required load from renewable energy resources like solar or wind energy. In the case of the solar domestic hot water, all or part of the hot water heating requirements are provided by solar energy.

For renewable energy resources, calculation of savings requires a slightly different approach than has been utilized thus far. First, some type of feasible or optimal system must be developed for the specific house. In the case of solar, this system would primarily be dependent on the amount of solar radiation available in a specific location, the maximum feasible area for the collector, and the energy requirements of the household. Once the collector area of the system has been determined, the energy provided (i.e., conventional fuel not required) can be calculated, on a monthly basis, as follows:

$$E_m^P = H_{\bar{T},m} \cdot A_{col} \tag{92}$$

where

E_m^P = Energy, in Btu's, provided in month m by the system;

$H_{\bar{T},m}$ = Average solar energy available for the location, in Btu's per square foot, in month m; and,

A_{col} = Area of the solar collector, in square feet.

Monthly savings are then determined as follows:

$$E_m^S = E_m^P \quad \text{if } E_m^P \leq E_m^R \tag{93a}$$

$$E_m^S = E_m^R \quad \text{if } E_m^P > E_m^R \tag{93b}$$

where

E_m^S = Energy saved, in Btu's, in month m

E_m^R = Energy required, in Btu's, in month m

Annual savings then become:

$$E^S = \Sigma E_m^S \quad (94)$$

where

E^S = Total annual savings

<u>Example</u>:

Assume a solar hot water heating system with 700 square feet of solar collector is installed on the roof of the prototype house. Assume further that, for the Iowa location, monthly solar availability, $H_{\overline{T},m}$, is as follows:

Jan	1272	May	1662	Sep	1617
Feb	1540	June	1762	Oct	1576
Mar	1562	July	1784	Nov	1269
Apr	1560	Aug	1709	Dec	1119

Using Equation (92), monthly energy provided by the 700 square feet of collector, E_m^P, in thousand Btu's, is as follows:

Jan	890.4	May	1163.4	Sep	1131.9
Feb	1078.0	June	1233.4	Oct.	1103.2
Mar	1093.4	July	1248.8	Nov	888.3
Apr	1092.0	Aug	1196.3	Dec	783.3

Converting Equations (5a) and (5b) to a monthly requirement and using the parameters in Table 1 and the efficiency of an electric hot water heater, monthly usage, in thousand Btu's, for the prototype home is:

Jan	2086.2	May	2086.2	Sep	2018.9
Feb	1884.3	June	2018.9	Oct	2086.2
Mar	2086.2	July	2086.2	Nov	2018.9
Apr	2018.9	Aug	2086.2	Dec	2086.2

In all cases, energy required exceeds energy provided; thus, total energy saved, as calculated with Equation (94), becomes:

$$E^S = 890.4 + 1078 + 1093.4 + 1092 + 1163.4 + 1233.4$$
$$+ 1248.8 + 1196.3 + 1131.9 + 1103.2 + 888.3 + 783.3$$
$$= 12,902.4$$

By installing a solar domestic hot water system with 700 square feet of collector in the prototype home with an electric hot water heater, 12,902,400 Btu's can be saved annually.

Summary. The basic information for all techniques discussed is summarized in Table 3. For each ECT, the table identifies:

1. The variable(s) affected by implementation of the ECT;
2. The reference number(s) for the heat load/energy requirement equations in which the affected variables appear; and,
3. The reference number for the appropriate savings equation.

TABLE 3

SUMMARY OF IMPACT OF SAVINGS CALCULATIONS
AND ENERGY CONSERVATION TECHNIQUES

Energy Conservation Technique	Variables Affected	Equations Affected	Savings Equation
Ceiling Insulation	U_{hc}, U_{cc}	(4a.2), (4b.2)	(11)
Wall Insulation	U_{hw}, U_{cw}	(4a.1), (4b.1)	(16)
Floor Insulation	U_{hf}	(4a.3)	(19)
Caulking/Weatherstripping	R_h, R_c	(4a.6), (4b.5)	(24)
Storm Windows	U_{hg}, R_h	(4a.5), (4a.6)	(29)
Thermal Windows	U_{hg}, SHG_g	(4a.5)	(34)
	U_{cg}, SHG_c	(4b.4)	
Heat Reflecting/Absorbing Materials	U_{hg}, SHG_{hg}	(4a.5)	(39)
	U_{cg}, SHG_{cg}	(4b.4)	
Use of Shading	U_{hg}, SHG_{hg}	(4a.5)	(44a), (44b)
	U_{cg}, SHG_{cg}	(4b.4)	
Storm Doors	U_{hd}	(4a.4)	(47)
Nighttime Temperature Setback	DD_{HB}, B	(4a.1)-(4a.6)	(60)
Clock Thermostat	DD_{HB}, B	(4a.1)-(4a.6) 1/	(60) 1/
Winter Thermostat Reduction	DD_{HB}, B	(4a.1)-(4a.6)	(60)
Summer Thermostat Increase	DD_{CB}	(4b.1)-(4b.5)	(71)
Furnace Efficiency Maintenance and Adjustment	e_h	(1)	(73)
Flue Opening Modification/Vent Damper	e_h 2/	(1)	(73)
Electric/Mechanical Ignition	e_h 2/	(1)	(74a), (74b)

TABLE 3 (Cont.)

Energy Conservation Technique	Variables Affected	Equations Affected	Savings Equation
Replace Oil Burner	e_h 3/	(1)	(73)
Replace Oil Furnace	e_h 3/	(1)	(73)
Replace Central Air Conditioner	e_c	(1)	(76)
Reduce Hot Water Temperature	T, [W_{HD}] 4/	[(6a)], 4/ (66)	(81a),(81b)
Reduce Water Flow in Showers, Faucets	W_{HD}	(6a)	(88)
Water Heater Insulation	U_t	(6b)	(91)
Solar Domestic Hot Water	-	-	(94)

1/ Calculations and savings assume clock thermostat used for nighttime temperature setback.

2/ Gas heat only.

3/ Oil heat only.

4/ Depends on extent to which volume of water demanded depends on water temperature.

DETERMINATION OF DOLLAR SAVINGS

Given the approach for calculating the energy savings from the implementation of energy conservation techniques, it is now possible to focus on the broader task of determining the dollar savings and, ultimately, the cost effectiveness of the ECT's.

Selection of the Appropriate Fuel Cost

The next step is selection of the appropriate fuel cost for converting the Btu savings to dollar savings. The level of the analysis will play an important role in determining which price measure should be used. For example, if the calculations are being made to evaluate the areawide cost effectiveness, then, logically, some statewide average price for gas, oil, and electricity would be appropriate. Alternatively, if the analysis takes the perspective of the individual user, then it would be more appropriate to use the actual prices charged by the relevant individual utilities. Additionally, the selection of the actual price which is most appropriate will depend on the utility's overall rate structure; it may be appropriate to use the price of the fuel in the customer's tail rate block. For example, assume that the customer under consideration uses gas heat and that the local utility has a declining block structure. Any energy savings would reduce gas consumption in the higher usage blocks, that is, the blocks with lower rates. Since the average price for the residential use would include the effects of the higher-priced blocks, use of an average figure may tend to overstate the savings, relative to the actual savings resulting from reduced consumption in the lower priced block. Alternatively, if the utility has an increasing block structure, use of some average price may tend to understate savings, relative to the actual savings resulting from reduced consumption in the higher priced block.

Calculation of the Dollar Savings

Once the relevant factors have been considered and the appropriate fuel price has been selected, it is a relatively straightforward matter to compute the dollar savings as follows:

$$SVGS_{i,j} = \Delta E_j \cdot UCOST_i \cdot CONV_i \qquad (95)$$

where

$SVG_{i,j}$ = Annual dollar savings when fuel i is utilized and conservation technique j is implemented;

ΔE_j = Btu's of energy saved when ECT j is implemented;

$UCOST_i$ = Unit cost of fuel type i; and

$CONV_i$ = Conversion factor which translates units of fuel into Btu's[1/].

Example:

In the sample calculation for ceiling insulation, it was determined that 117,671,747 Btu's could be saved during the heating season in the prototype house with gas heat, and 5,919,645 Btu's could be saved during the cooling season. Assuming a statewide price of natural gas of \$3.64 per Mcf, a gas conversion factor of 1,020,000 Btu's per Mcf, a price of electricity of 5.3¢ per kWh, and an electric conversion factor of 3,412 Btu per kWh, the total annual savings becomes, using Equation (95):

$$\begin{aligned} SVGS &= 117{,}671{,}747 \times \$3.64/1{,}020{,}000 + 5{,}919{,}645 \times \$.053/3{,}412 \\ &= \$419.93 + \$91.95 \\ &= \$511.88 \end{aligned}$$

1/ Conversion factors for gas, oil, and electricity are as follows:

1 Mcf (gas) = 1,020,000 Btu's

1 kWh (electricity) = 3412 Btu's

1 gal (distillate oil) = 138,690 Btu's.

Thus, by installing ceiling insulation in the prototype house with air conditioning and gas heat, \$511.88 can be saved annually.

Alternatively, assume that this home is located in the service area of electric and gas utilities where both have declining block structures. Assume further that the customer is paying a tail block rate of 3.56¢ per kWh for electricity and \$2.75 per Mcf for gas, respectively. Under this scenario, the annual savings calculated with Equation (95) would be:

$$\begin{aligned} SVGS &= 117{,}671{,}747 \times \$2.75/1{,}020{,}000 + 5{,}919{,}645 \times \$.0356/3{,}412 \\ &= \$317.25 + \$61.76 \\ &= \$379.01 \end{aligned}$$

Using the tail block rates for electric and gas in the individual's service area yields annual savings of \$379.01 , compared with the \$511.88 calculated on the average statewide rates.

DETERMINATION OF COSTS

Once the savings have been determined, it is necessary to establish the cost of the various ECT's. In some instances, as with temperature adjustments and caulking/weatherstripping, little or no cost is incurred; in others, such as with insulation installation or solar hot water systems, a substantially larger expenditure is required. Unlike the savings-related fuel costs, for which a single rate schedule exists within each service area, cost figures for energy conservation techniques tend to be much more diverse. Within a given area variation will exist due to differences in the composition and quality of materials as well as because of diversity in contractor installation charges.

While occasionally figures will appear in the related literature, published cost information for implementation of the ECT's generally does not exist. Thus, to obtain cost information it is necessary to survey contractors and/or material suppliers in the relevant geographic area. Such a survey was taken for several of the techniques under consideration for eight locations in Iowa. Both the range of quoted costs and average values of such costs for the state are summarized in Table 4.

TABLE 4

SUMMARY OF IOWA SURVEY OF COSTS OF VARIOUS ENERGY CONSERVATION TECHNIQUES

Energy Conservation Technique	Range of Values: Material Cost	Range of Values: Installation Cost	Mean Value: Material Cost	Mean Value: Installation Cost
Wall Insulation (per sq. ft.)				
Batts & Rolls --				
R-7	.06	--	.06	--
R-11	.08-.18	.04-.20	.145	.109
Loose --				
R-7	.104	--	.104	--
R-11	.07-.50	.15-.365	.155	.225
Ceiling Insulation (per sq. ft.)				
Batts & Rolls --				
R-11	.08-.18	.04-.20	.145	.113
R-19	.16-.32	.07-.117	.212	.087
R-30	.26-.48	.06-.11	.378	.096
R-38	.33-.62	.062-.12	.458	.101
Loose --				
R-11	.07-.50	.09-.20	.165	.145
R-19	.138-.80	.118-.30	.241	.200
R-30	.25-.65	.172-.28	.314	.214
R-38	.33-1.60	.055-.30	.480	.190
Storm Windows	17.50-64.00	2.00-25.00	30.11	8.94
Storm Door	49.00-232.00	10.00-35.00	91.47	18.08
Clock Thermostat	11.00-120.00	10.00-100.00	59.98	23.63
Low Flow Shower Heads	2.00-38.00	9.50-30.00	14.53	20.35
Gas Furnaces --				
Vent Damper	40.00-200.00	15.00-85.00	95.60	37.11
Electrical/Mechanical Ignition System	65.00-300.00	20.00-150.00	122.77	52.17

ANALYTICAL COMPARISON OF COSTS AND SAVINGS

Once the annual costs and savings have been established, the analytical comparisons can be undertaken. As mentioned previously, the specific type of analysis performed will depend on the perspective: for areawide evaluation, a discounted cash flow (DCF) analysis over the life of the ECT would be appropriate while, for an individual consumer evaluation, DCF analysis over a somewhat shorter time frame or a break-even analysis would be more relevant.

Discounted Cash Flow Analysis

Under DCF analysis, annual costs and annual savings for each year in the time period chosen would be discounted to present value and summed, as follows:

$$SVGS^{PV} = \sum_{t=0}^{T} \frac{SVGS_t}{(1+r)^t} \tag{96}$$

$$COSTS^{PV} = \sum_{t=0}^{T} \frac{COSTS_t}{(1+r)^t} \tag{97}$$

where,

$SVGS^{PV}$ = Total discounted savings;

$COSTS^{PV}$ = Total discounted costs;

$SVGS_t$ = Annual savings in year t; and

$COSTS_t$ = Annual costs in year t.

Total discounted savings are then compared with total discounted costs:

- If total discounted savings, $SVGS^{PV}$, are greater than total discounted costs, $COSTS^{PV}$, then the ECT is considered cost-effective.

- If, on the other hand, total discounted costs, $COSTS^{PV}$, exceeds total discounted savings, the ECT is considered not to be cost-effective.

Calculation of Annual Savings. For this analysis, the annual energy savings will remain constant over time; however, the dollar value of such savings will fluctuate as the price of the fuel fluctuates. Thus, it will be necessary to establish a fuel price for each year considered in the analysis. Once this is done, Equation (95) can be used to calculate the stream of expected annual savings from the ECT.

Determination of Annual Costs. Beyond the initial investment (i.e., the costs for t=0), the only annual costs would be any operation and maintenance expense for the technique. For the bulk of the ECT's under consideration there are, for all practical purposes, no additonal costs beyond the initial outlay; thus, annual costs for $t \neq 0$ would be zero.

Selection of Time Frame. The approximate time frame for the DCF calculation will depend on the perspective of the analysis. In considering the overall cost effectiveness of the ECT for an area, all costs and all savings for the life of the technique should be considered. In the relevant literature, life-cycle frames of 10- to 30-year periods have been used for ECT's, with 20 years generally being selected.

Individuals, on the other hand, may not be interested in the overall cost effectiveness of a measure. They would more likely consider only that portion of the costs and savings that impact them directly. For example, a homeowner considering the purchase of storm windows would not be interested in the total savings if he would sell his home before all the savings were realized; he would only be interested in that portion of the savings that would result before the sale. In this context, then, a more appropriate measure might be the cost effectiveness over a somewhat shorter period of time, perhaps five or seven years.

Selection of the Discount Rate. The appropriate discount rate for the analysis of an investment decision is often characterized as the rate which can be earned by the investor in an alternative investment of comparable risk. Although the current attention devoted to the overall energy picture and energy conservation issues may lead one to believe that investment in ECT's serves purposes other than realization of a return, it is not reasonable to expect consumers to enter arrangements that are not economically advantageous. Conceptually then, a discount rate that represents all consumers should be used in the analyses. However, given the differing investment alternatives available to various groups of consumers (passbook savings accounts versus Treasury bills, for example), it is very difficult, if not impossible, to select a single representative discount rate for all consumers. Consequently, use of a range of rates may be appropriate for gaining an understanding of the potential effects of an investment action. Depending on the purpose of the analyses, the range of effects determined may provide the necessary information, or further refinements within that range may be necessary. For example, using a range of values may show that, under any reasonable discount rate, investment in an ECT is cost effective. Conversely, the use of a range of rates may show that at one end of the range an investment should be made while at the other end, it should not. In this instance, a refinement of the actual rate expected or a determination of the internal rate of return of the investment (i.e., the discount rate at which the present value of the savings equals the present value of the costs) might provide a clearer input to the decision process from the analyses.

Example Calculation. Continuing on with the example of the installation of R-30 ceiling insulation in the prototype house with air conditioning and gas heat, the cost effectiveness of the ECT on a statewide basis will be calculated. In a previous example, it has been determined that the first-year heating season savings will be $419.93, and first-year cooling season savings will be $91.95. Assume that gas and electric prices will escalate at the following annual real rates (i.e., increase over and above inflation rate):

	Gas[1/]	Electric[1/]
1980-85	6.9%	1.2%
1985-90	4.3%	-0.2%
1990-95	4.1%	1.8%
1995-2000	0.0%	0.0%

Applying these escalation rates to first-year savings yields annual savings for the next 19 years, as follows:

1/ Ted Kornreich and M. Duvall, Evaluation of Solar and Wind Energy Measures for the Residential Conservation Service Program, Science Applications, Inc., Technical Note 382-00-9, October, 1979, p. 21.

	Annual Heating Season Savings	Annual Cooling Season Savings	Total Annual Savings
1980	$419.93	$91.95	$511.88
1981	448.91	93.05	541.96
1982	479.88	94.17	574.05
1983	512.99	95.30	608.29
1984	548.39	96.44	644.83
1985	586.23	97.60	683.83
1986	611.44	97.40	708.84
1987	637.73	97.21	734.94
1988	665.15	97.02	762.17
1989	693.75	96.82	790.57
1990	723.59	96.63	820.22
1991	753.26	98.37	851.63
1992	784.14	100.14	884.28
1993	816.29	101.94	918.23
1994	849.76	103.78	953.54
1995	884.60	105.65	990.25
1996-1999	884.60	105.65	990.25

If the real discount rate is set at 0 percent (which has the effect of setting the discount rate equal to the rate of inflation), total present value savings for the 20-year life-cycle period become simply the total of the annual savings, or $15,940.51. If the real discount rate is, instead, set at -5.0 percent (which is the same as setting the rate at a level of 5 percentage points below the inflation rate), discounted savings total $30,151.32. Alternately, if the real discount rate is set at +5 percent (or 5 percentage points higher than the inflation rate), discounted savings total $9,376.14. Using the average cost per square foot for materials and installation of R-30 batt insulation in Table 4 of $0.475, the investment cost of the 1,200 square feet becomes $570. Quite clearly, the discounted savings over 20 years will exceed the investment cost at all three rates; thus, the ceiling insulation is a cost-effective technique over the range tested.

Breakeven Analysis

As mentioned earlier, the individual homeowner may be interested in the number of years it will take him to recover his initial investment, or the "breakeven point." Under breakeven analysis, net annual savings are discounted to present value:

$$NSVGS_t^{PV} = \frac{(SVGS - COSTS_t)}{(1 + r)^t} \qquad (98)$$

$NSVGS_t^{PV}$ = Discounted net annual savings for period t;

$SVGS_t$ = Annual savings in period t;

$COSTS_t$ = Annual costs in period t; and

r = Annual discount rate.

Discounted net annual savings are then totalled until the sum equals the initial investment cost. The number of years' savings included in the total determines the breakeven point.

Calculation of Annual Savings, Determination of Annual Costs, Selection of Discount Rate. The same general factors considered in the discussion of these items for the DCF cost effectiveness analysis are applicable here.

Example Calculation. Still continuing with the example of the installation of R-30 ceiling insulation in the prototype house with air conditioning and gas heat, the breakeven point for the ECT for the individual in Des Moines will be determined. Using Des Moines-specific averages for the materials and installation cost per square foot, the initial investment required for the 1,200 square feet of R-30 batt insulation is $.458 X 1,200, or $549.60. In a previous example, it was determined that the first-year heating season savings will be $317.25 and first-year cooling savings will be $61.76, for a total of $379.01. Applying the same escalation factors as were used in the DCF analysis example and Equation (95) yields annual savings for 1980-85 of:

	Annual Heating Season Savings	Annual Cooling Season Savings	Total Annual Savings
1980	$317.25	$61.76	$379.01
1981	339.14	62.50	401.64
1982	362.54	63.25	426.19
1983	387.56	64.01	451.57
1984	414.30	64.78	479.08
1985	442.88	65.56	508.44

Since there are no annual operating and maintenance expenses, net annual savings will equal total annual savings; using a real discount rate of zero, discounted net annual savings will equal total annual savings.

At the end of the first two years, total discounted net annual savings at a zero real rate equals $379.01 plus $401.64, or $780.65. At the -5 percent real rate, such savings will equal $398.96 plus $445.03, or $843.99. Alternately, at a +5 percent real rate, the two-year savings will equal $360.96 plus $364.30, or $725.26. Since all these values exceed the initial investment cost of $549.60, the homeowner will recover his initial investment in two years for the range of rates examined.

FINAL COMMENTS

The general discussion presented considers the basics of the approach. It is possible to expand these basics to consider other factors. On an individual user level, for example, cost considerations can be expanded to include current taxation effects as well as to evaluate the potential effectiveness of proposed tax adjustments. On an areawide basis, individual costs and savings can be aggregated, and conservation program costs can be introduced into the analysis. Portions of the methodology can also be used in other phases of the development and evaluation of a conservation program. Given adequate data on housing stock and current levels of in-place conservation, the basic approach to energy savings estimation can be of assistance in evaluating program targets. Generally speaking, such information can be used to determine how much energy could be saved by a given response to the program; alternately, the same basic material can be used to determine what response may be necessary to realize a given level of energy savings.

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APPENDIX A

ADJUSTING PUBLISHED DEGREE DAY MEASURES FOR DIFFERENT BASE TEMPERATURES AND SOLAR RADIATION

Given monthly data on average daily high and low temperatures, it is possible to adjust published degree day measures for base temperatures other than 65° F. First, hourly temperatures are calculated for each month, as follows:

$$T_{i,j} = T_{max,j} - PCT_i(T_{max,j} - T_{min,j})$$

where,

$T_{i,j}$ = Temperature for hour i in month j;

$T_{max,j}$ = Average daily high temperature for month j;

$T_{min,j}$ = Average daily low temperature for month j; and

PCT_i = Values as listed in Table A-1.

Using this calculated hourly data, the heating degree day adjustment factors are computed with the following procedures:

1. Calculate hourly temperature differentials

$$\Delta T^{HB}_{i,j} = B^H_{i,j} - T_{i,j}$$

where,

$\Delta T^{HB}_{i,j}$ = Difference between base heating temperature $B^H_{i,j}$ and the temperature in hour i of month j; and,

$B^H_{i,j}$ = Base heating temperature in hour i for month j;

for $B^H_{i,j}$ = 65 for all months and hours.

2. For each month j, sum all <u>positive</u> $\Delta T_{i,j}^{H65}$, and divide the sum by 24 to obtain average daily temperature differential ΔTAV_j^{H65}.

3. Calculate

$$DD^{H65} = \sum_{j=1}^{12} (\Delta TAV_j^{H65} \cdot D_j)$$

where,

DD^{H65} = Calculated heating degree days for 65° F base; and,

D_j = Number of days in month j.

4. Repeat steps 1 to 3, using B = new desired base temperature instead of B = 65, and compute DD^{HB}, the calculated degree days for base B.

5. Calculate the adjustment factor

$$ADJ_B^H = \frac{DD^{HB}}{DD^{H65}} .$$

Once the adjustment factor ADJ_B^H has been computed, the adjusted degree day measure can be calculated:

$$DD_{HB} = (ADJ_B^H) \times (HDD)$$

where,

HDD = Published heating degree day measure.

This method has been used to adjust the published heating degree day data for a constant 70° F. indoor temperature and for a 70° F. daytime temperature with a setback to 65° F. from 10 P.M. to 6 A.M. for Burlington, Des Moines, and Waterloo, Iowa. Results are shown in Table A-2; supporting data and calculated values are detailed in Tables A-3 to A-5.

Similarly, the cooling degree day adjustment factors can be computed:

1. Calculate

$$\Delta T^{CB}_{i,j,1} = B^{C}_{i,j} - T_{i,j,1}$$

where,

$T_{i,j,1}$ = Temperature for hour i in month j, as calculated above;

$\Delta T^{CB}_{i,j,1}$ = Difference between base cooling temperature $B^{C}_{i,j}$ and the outside temperature in hour i of month j; and,

$B^{C}_{i,j}$ = Base cooling temperature in hour i for month j;

for $B^{C}_{i,j}$ = 65 for all months and hours.

2. For each month j, sum all <u>positive</u> $\Delta T^{C65}_{i,j,1}$, and divide the sum by 24 to obtain the average daily temperature differential $\Delta TAV^{C65}_{j,1}$.

3. Calculate

$$T_{i,j,2} = 90 - PCT_i (T_{max,j} - T_{min,j})$$

where,

$T_{i,j,2}$ = Hourly temperature in hour i for month j with a daily high temperature of 90° and the same monthly temperature range as above.

4. Calculate

$$\Delta T^{CB}_{i,j,2} = T_{i,j,2} - B^{C}_{i,j}$$

where,

$\Delta T^{CB}_{i,j,2}$ = Temperature differential for hour i in month j, based on $T_{i,j,2}$

for all $B^{C}_{i,j}$ = 65° F.

5. For each month j, sum all <u>positive</u> $\Delta T^{C65}_{i,j,2}$, and divide the sum by 24 to obtain the average daily temperature differential $\Delta TAV^{C65}_{j,2}$.

6. Calculate

$$DD^{C65} = \sum_{j=1}^{12} [(\Delta TAV^{C65}_{j,1})(D_j - D_{90,j}) + (\Delta TAV^{C65}_{j,2})(D_{90,j})]$$

where,

DD^{C65} = Calculated cooling degree days for 65° F. base; and,

$D_{90,j}$ = Number of days in month j where temperature exceeds 90° F.

7. For the months in which ΔTAV^{C65}_j is greater than zero, adjust the hourly temperatures $T_{i,j,1}$ and $T_{i,j,2}$ for solar radiation effects.

$$T^{SOL}_{i,j,1} = T_{i,j,1} + SOL_i;$$

$$T^{SOL}_{i,j,2} = T_{i,j,2} + SOL_i;$$

where,

$T^{SOL}_{i,j,1}$ = Outside temperature in hour i of month j, adjusted for solar radiation;

$T^{SOL}_{i,j,2}$ = Outside temperature in hour i of month j on days where the temperature exceeds 90° F, adjusted for solar radiation; and,

SOL_i = Solar adjustment differential in hour i, with values as shown in Table A-6.

8. For these same months, calculate

$$\Delta T^{SOL/B}_{i,j,1} = T^{SOL}_{i,j,1} - B^C_{i,j};$$

$$\Delta T^{SOL/B}_{i,j,2} = T^{SOL}_{i,j,2} - B^C_{i,j};$$

where,

$\Delta T^{SOL/B}_{i,j,1}$ = Difference between base cooling temperature $B^C_{i,j}$ and the outside solar adjusted temperature in hour i for month j; and,

$\Delta T^{SOL/B}_{i,j,2}$ = Difference between base cooling temperature $B^{C}_{i,j}$ and the outside solar-adjusted temperature in hour i for month j on days where the temperature exceeds 90^{o}.

9. For each month, sum all positive $\Delta T^{SOL/B}_{i,j,1}$ and divide the sum by 24 to obtain the average daily solar-adjusted temperature differential

Δ $\Delta TAV^{SOL/B}_{j,1}$; repeat for $\Delta T^{SOL/B}_{j,2}$.

10. Calculate

$$DD^{SOL/B} = \sum_{j=1}^{12} [(\Delta TAV^{SOL/B}_{j,1})(D_j - D_{j,90}) + (\Delta TAV^{SOL/B}_{j,2})(D_{j,90})]$$

where,

$DD^{SOL/B}$ = Calculated solar-adjusted cooling degree days for base B.

11. Calculate the adjustment factor

$$ADJ^{SOL}_{B} = \frac{DD^{SOL/B}}{DD^{C65}}$$

Once the adjustment factor ADJ^{SOL}_{B} has been computed, the adjusted degree day measure can be calculated:

$$DD_{CB} = (ADJ^{SOL}_{B}) \times (CDD);$$

where,

CDD = Published cooling degree day measures.

This method has been used to adjust published cooling degree day data for 75^{o} F. and 80^{o} F. bases and solar radiation effects for the Burlington, Des Moines, and Waterloo, Iowa, locations. Results are shown in Table A-2, supporting data and calculated values are detailed in Tables A-3 to A-5.

TABLE A-1

PERCENTAGES FOR CALCULATING HOURLY TEMPERATURES

1 a.m.	87
2	92
3	96
4	99
5	100
6	98
7	93
8	84
9	71
10	56
11	39
12 p.m.	23
1 p.m.	11
2	3
3	0
4	3
5	10
6	21
7	34
8	47
9	58
10	68
11	76
12 a.m.	82

Source: <u>ASHRAE Fundamentals Handbook</u>, 1977, p. 25.4.

TABLE A-2

ADJUSTED DEGREE DAY MEASURES FOR HEATING, COOLING TO VARIOUS TEMPERATURES

	Burlington	Des Moines	Waterloo
Heating:			
70°	7507	8104	8834
70° day/65° night	6959	7698	8267
Cooling:			
75°	1418	1407	1256
80°	1034	1016	820

TABLE A-3

CLIMATE DATA USED TO CALCULATE
DEGREE DAY MEASURES FOR BURLINGTON, IOWA

Raw Data:

Month	Avg. Daily Maximum ($T_{max,i}$)	Avg. Daily Minimum ($T_{min,i}$)	Days Temperature Exceeds 90° ($D_{90,i}$)	Heating Degree Days (HDD_i)	Cooling Degree Days (CDD_i)
January	31.7°	14.1°	0	1,305	0
February	36.2	18.4	0	1,056	0
March	46.6	27.1	0	871	0
April	62.1	40.5	0	416	5
May	72.7	50.9	1	172	73
June	81.9	60.9	7	16	208
July	86.1	64.6	11	0	322
August	84.6	63.1	8	8	284
September	76.7	54.1	3	70	82
October	66.7	43.9	0	320	20
November	49.2	30.3	0	756	0
December	35.9	19.3	0	1,159	0

Calculated Values:

$DD^{H65} = 6474$ $\qquad$ $DD^{65} = 994$

$DD^{H70} = 7904$ $\qquad$ $DD^{SOL/75} = 1418$

$DD^{H70/65} = 7327$ $\qquad$ $DD^{SOL/80} = 1034$

Raw Data Source: "Climate of Iowa", Climatography of the U.S., No. 60, National Oceanic and Atmospheric Administration, Environmental Protection Data Service; Asheville, N.C. (12/76)

TABLE A-4

CLIMATE DATA USED TO CALCULATE
DEGREE DAY MEASURES FOR DES MOINES, IOWA

Raw Data:

Month	Avg. Daily Maximum ($T_{max,i}$)	Avg. Daily Minimum ($T_{min,i}$)	Days Temperature Exceeds 90° ($D_{90,i}$)	Heating Degree Days (HDD_i)	Cooling Degree Days (CDD_i)
January	27.5°	11.3°	0	1,414	0
February	32.5	15.8	0	1,142	0
March	42.5	25.2	0	964	0
April	59.7	39.2	0	465	0
May	70.9	50.9	1	186	59
June	79.8	61.1	4	26	191
July	84.9	65.3	9	0	317
August	83.2	63.4	6	13	270
September	74.6	54.0	1	94	73
October	69.4	43.6	0	350	18
November	46.4	29.2	0	816	0
December	32.8	17.2	0	1,240	0

Calculated Values:

$DD^{H65} = 6985$ $\qquad$ $DD^{C65} = 913$

$DD^{H70} = 8436$ $\qquad$ $DD^{SOL/75} = 1384$

$DD^{H70/65} = 8013$ $\qquad$ $DD^{SOL/80} = 1000$

Raw Data Source: "Climate of Iowa", Climatography of U.S. No., 60, National Oceanic and Atmospheric Administration, Environmental Data Service: Ashville, N.C. (12/76)

TABLE A-5

CLIMATE DATA USED TO CALCULATE DEGREE DAY MEASURES FOR WATERLOO, IOWA

Raw Data:

Month	Avg. Daily Maximum ($T_{max,i}$)	Avg. Daily Minimum ($T_{min,i}$)	Days Temperature Exceeds 90° ($D_{90,i}$)	Heating Degree Days (HDD_i)	Cooling Degree Days (CDD_i)
January	25.7°	6.9°	0	1,510	0
February	30.2	11.3	0	1,238	0
March	40.6	22.3	0	1,039	0
April	58.5	36.3	0	528	0
May	70.0	47.5	1	229	37
June	79.4	57.6	4	39	144
July	83.6	61.5	5	7	243
August	82.1	59.5	4	26	206
September	73.3	49.8	1	137	35
October	63.5	39.7	0	426	10
November	44.6	25.6	0	897	0
December	30.6	12.9	0	1,339	0

Calculated Values:

$DD^{H65} = 7851$ $\qquad$ $DD^{C65} = 710$

$DD^{H70} = 9353$ $\qquad$ $DD^{SOL/75} = 1321$

$DD^{H70/65} = 8753$ $\qquad$ $DD^{SOL/80} = 863$

Raw Data Source: "Climate of Iowa", Climatography of the U.S., No. 60, National Oceanic and Atmospheric Administraiton, Environmental Data Center: Asheville, N.C. (12/76)

TABLE A-6

ADJUSTMENT FOR SOLAR RADIATION EFFECTS

1 a.m.	0
2	0
3	0
4	0
5	0
6	8.5
7	19.8
8	23.3
9	22.3
10	20.7
11	18.3
12 p.m.	16.8
1 p.m.	18.3
2	20.8
3	22.3
4	21.7
5	20.0
6	13.2
7	0
8	0
9	0
10	0
11	0
12 .m.	0

Source: Average of light and dark surfaces for all directions given in <u>ASHRAE Fundamentals Handbook</u>, 1977, p. 25.5.

APPENDIX 2

EXEMPTION PETITIONS

The following utilities have applied for an exemption from the prohibition on utility supply, installation and financing of program measures.

(1) Iowa Public Service.

Iowa Public Service has the following conservation and renewable resource program in progress:

a. Employee home improvement weatherization program.

b. Energy efficient products (offered to employees only).

(2) Union Electric.

Union Electric is engaged in the following programs:

a. Union electric employee purchase plan.

b. Residential electric space heating conservation program.

c. Residential insulation program for existing homes.

(3) Minnegasco.

Minnegasco supplies, installs and finances many program measurers for its customers, including caulking and weather-stripping, furnace efficiency modifications, replacement of central air conditioners, all types of insulation, storm windows and doors, flow restrictors and clock thermostats.

(4) North Central Public Service Company.

North Central Public Service Company is engaged in the sale, installation and financing of furnaces, air conditioners and loose fill type insulation.

(5) Peoples Natural Gas.

Peoples Natural Gas is engaged in the sale, installation and financing to both employees and customers of the following conservation measures:

a. Ceiling and wall insulation

b. Day/night setback devices

c. Intermittant ignition devices and vent dampers

APPENDIX 3

FORMS

(Closed end, unsecured/secured credit)

CREDIT APPLICATION

IMPORTANT: Read these Directions before completing this Application

Check Appropriate Box

☐ If you are applying for individual credit in your own name and are relying on your own income or assets and not the income or assets of another person as the basis for repayment of this credit request, complete only Sections A and D. If the requested credit is to be secured, also complete the first part of Section C and Section E.

☐ If you are applying for joint credit with another person, complete all Sections except E, providing information in B about joint applicant. If the requested credit is to be secured, then complete Section E.

☐ If you are applying for individual credit, but are relying on income from alimony, child support, or separate maintenance or on the income or assets of another person as the basis for repayment of the credit requested, complete all Sections except E to the extent possible, providing information in B about the person on whose alimony, child support, or maintenance payments or income or assets you are relying. If the requested credit is to be secured, then complete Section E.

Date of Note____/____/____ Maturity____/____/____

NET PROCEEDS .... $________

Doc. Fee .... $________

Interest .... $________

Credit Life .... $________

A/H .... $________

Reserve .... $________

ANNUAL PERCENTAGE RATE .... ________

Dealer Rate______ Amount of Note $________

______Pmts. @______and______@______

Pmts. Due.................... 5-10-15-20-25-30

DISBURSEMENT OF PROCEEDS

Credit to Acct. No.................... $________

Cashiers Check to.................... $________

Pay-off Loan No.................... $________

Cash .... $________

(This total should equal Net Proceeds Above)..... $________

Amount Requested $________ Payment Date Desired________ Proceeds of Credit To Be Used For________

SECTION A—INFORMATION REGARDING APPLICANT

Full Name (Last, First, Middle):________ Birthdate ___/___/___

Present Street Address:________ Years there:______

City:________ State:______ Zip:______ Phone:______

Social Security No.: ________ Driver's License No.: ________

Previous Address:________ Zip:______ Years there:______

Present Employer and Address:________ Phone:______ Zip:______

Position or title:______ Name of supervisor:________ Years there:______

Previous Employer and Address:________ Years there:______

Present net salary or commission:$______ per______. No. Dependents:______ Ages:______

Alimony, child support, or separate maintenance income need not be revealed if you do not wish to have it considered as a basis for repaying this obligation. Alimony, child support, separate maintenance received under: ☐ court order ☐ written agreement ☐ oral understanding

Other income: $______ per______. Source(s) of other income: ________

Is any income listed in this Section likely to be reduced before the credit requested is paid off? ☐ Yes (Explain in detail on separate sheet.) ☐ No

Have you ever received credit from us?______ When?______ Office______

Checking Account No.: ______ Institution and Branch: ________

Savings Account No.: ______ Institution and Branch: ________

Name of nearest relative not living with you:________ Relationship:______ Phone:______

Address:________ Zip:______

SECTION B — INFORMATION REGARDING JOINT APPLICANT OR OTHER PARTY (Use separate sheets if necessary)

Full Name (Last, First, Middle): ________ Birthdate: ___/___/___

Relationship to Applicant (if any):______ Address:________ Phone:______

City:________ State:______ Zip:______ Years there:______

Social Security No.:________ Driver's License No.: ________

Present Employer and Address:________ Phone:______ Zip:______

Position or title: ______ Name of supervisor:________ Years there:______

Previous Employer and Address:________ Years there:______

Present net salary or commission: $______ per______. No. Dependents:______ Ages:______

Alimony, child support, or separate maintenance income need not be revealed if you do not wish to have it considered as a basis for repaying this obligation. Alimony, child support, separate maintenance received under: ☐ court order ☐ written agreement ☐ oral understanding

Other income: $______ per______. Source(s) of other income: ________

Is any income listed in this Section likely to be reduced before the credit requested is paid off? ☐ Yes (Explain in detail on separate sheet.) ☐ No

Checking Account No.: ______ Institution and Branch: ________

Savings Account No.: ______ Institution and Branch: ________

Name of nearest relative not living with Joint Applicant or Other Party:________ Relationship:______ Phone:______

Address:________ Zip:______

FR App. — Maynard Printing, Inc., Des Moines, Iowa 50309 — 7/79

SECTION C—MARITAL STATUS
(Do not complete if this is an application for individual unsecured credit.)

Applicant: ☐ Married ☐ Separated ☐ Unmarried (including single, divorced, and widowed)

Other Party: ☐ Married ☐ Separated ☐ Unmarried (including single, divorced, and widowed)

SECTION D—ASSETS AND DEBT INFORMATION
(If Section B has been completed, this Section should be completed giving information about both the Applicant and Joint Applicant or Other Person. Please mark Applicant-related information with an "A." If Section B was not completed, only give information about the Applicant in this Section.)

ASSETS OWNED (Use separate sheet if necessary.)

Description of Assets	Value	Subject to Debt? Yes/No	Name(s) of Owner(s)
Cash—Bank (if any), etc.	$		
Automobiles (Make, Model, Year)			
Cash Value of Life Insurance (Issuer, Face Value)			
Real Estate (Location, Date Acquired)			
Marketable Securities (Issuer, Type, No. of Shares)			
Other (List)			
TOTAL ASSETS	$		

OUTSTANDING DEBTS (Include charge accounts, installment contracts, credit cards, rent, mortgages, etc. Use separate sheet if necessary.)

Creditor	Type of Debt or Acct. No.	Name in Which Acct. Carried	Original Debt	Present Balance	Monthly Payments	Past Due? Yes/No
1. (Landlord or Mortgage Holder)	☐ Rent Payment ☐ Mortgage		$ (Omit rent)	$ (Omit rent)	$	
2.						
3.						
TOTAL DEBTS			$	$	$	

CREDIT REFERENCES: Name and Address

1.	2.

Are you a co-maker, endorser, or guarantor on any loan or contract? Yes ☐ No ☐ If "Yes," for Whom? To Whom?

Are there any unsatisfied judgments against you? Yes ☐ No ☐ Amount $ If "Yes," to whom owed?

Have you been declared bankrupted in the last 14 years? Yes ☐ No ☐ If "Yes," where? Year

Other obligations—(E.g., liability to pay alimony, child support, separate maintenance. Use separate sheet if necessary.) ______

SECTION E—(Complete only if credit is to be secured.) Briefly describe the property to be given as security: ______

and list names and addresses of all co-owners of the property:

Name Address

If security is real estate, give the full name of your spouse (if any): ______

Everything that I have stated in this application is correct to the best of my knowledge. I understand that you will retain this application whether or not it is approved. You are authorized to check my credit and employment history and to answer questions about your credit experience with me.

Applicant's Signature ______ Date ______ Other Signature (Where Applicable) ______ Date ______

IOWA RCS BID SPECIFICATION FORM

AUDITOR				CONTRACTOR		
Measures	Recommendations	Estimated Cost[1]	Estimated Life Cycle Savings	Name	Bid	Specifications[2]
		$			$	
		$			$	
		$			$	
		$			$	
	Totals	$			$	

[1]These figures are subject to change due to price increases, changing fuel prices, etc.

[2]Contractor specifications should indicate the R value to be installed over and above any existing R value, area in square feet, type of material to be used, thickness, weight, amount, etc.
Customers should review the specifications and bid prior to and after installation to ensure that they receive the quantity and quality of materials or supplies promised.

Dear Sir:

On ______________, Iowa's public utilities will be announcing the Residential Conservation Service (RCS) (______________) program to their customers. The program will make an energy audit available to their customers. This audit may recommend certain measures which could save energy for the customer. If the customer wishes, the utility will then supply them with a list of qualified suppliers, installers, and lenders and assist the customer in arranging for these services.

It is the responsibility of the Iowa State Commerce Commission to generate and maintain these lists of installers, suppliers, and lenders. We are inviting you to apply for inclusion on the list.

We have enclosed a fact sheet about the RCS program, which summarizes the benefits and responsibilities you would assume should you choose to participate in the Program. If you choose not to participate, you need do nothing. If, however, you would like to be included in the Program and named on the list which the utilities will be supplying to their customers, you should fill out the enclosed application and mail it to:

____

____

____

____

For further information about the application form or the RCS program, please contact ______________________________.

Very truly yours,

APPLICATION FOR LISTING TO INSTALL ENERGY CONSERVATION MEASURES OF THE RCS PROGRAM

1. Your company name: ______________________________

2. Your company address: ______________________________

____

3. Your company telephone number: (   ) ______________________________

4. Name of individual in your company who should be contacted if a complaint is lodged against your company about a product which your company installed: ______________________________

5. Please list any State or local licenses your firm holds and what the license numbers are:

License	License Number

6. Please check which of the following types of installations your company will make under the RCS Program: a check indicates that your company will be listed as being an installer of these measures to RCS customers in your service area.

Energy Conservation Measures:

_____ Replacement furnaces or boilers

_____ Furnace replacement burners (oil)

_____ Flue opening modifications

_____ Electrical or mechanical ignition systems

_____ Replacement central air conditioners

_____ Ceiling insulation

_____ Wall insulation

_____ Floor insulation

_____ Duct insulation

_____ Pipe insulation

_____ Water heater insulation

_____ Storm windows

_____ Thermal windows

_____ Storm or thermal doors

_____ Heat reflective or heat absorbing window or door material

_____ Devices associated with electric load management techniques

_____ Clock thermostats

<u>Renewable Resource Measures:</u>

_____ Solar domestic hot water systems

_____ Active solar space heating systems

_____ Combined active solar space heating and solar domestic hot water

_____ Direct gain glazing systems

_____ Indirect gain systems

_____ Solaria/sunspace systems

_____ Window heat gain retardants

_____ Wind energy devices

_____ Replacement solar swimming pool heaters

7. Indicate the geographic area your company will serve by county or city.

_________________________ _________________________

_________________________ _________________________

_________________________ _________________________

_________________________ _________________________

_________________________ _________________________

8. Indicate the amount of the bond your company holds. ($10,000 minimum, and copy must be enclosed.

____

I wish to have our firm included on the Master List of RCS installers. I certify that this firm will comply with the requirements of the RCS Program, and that the information supplied in this application is accurate.

Your signature: ______________________________

Title: ______________________________

Date of signature: ______________________________

APPLICATION FOR LISTING TO SUPPLY
ENERGY CONSERVATION MEASURES
OF THE RCS PROGRAM

1. Your company name: ______________________________

2. Your company address: ______________________________

____

3. Your company telephone number: (   ) ______________________________

4. Name of individual in your company who should be notified if a complaint is lodged against your company about a product which your company supplied:

____

5. Please check which of the following energy conservation and renewable resource measures your company will supply under the RCS Program. A check indicates that your company will be listed as supplying those measures to RCS customers in your service area.

Energy Conservation Measures:

_____ Replacement furnaces or boilers

_____ Furnace replacement burners (oil)

_____ Flue opening modifications

_____ Electrical or mechanical ignition systems

_____ Replacement central air conditioners

_____ Ceiling insulation

_____ Wall insulation

_____ Floor insulation

_____ Duct insulation

_____ Pipe insulation

_____ Water heater insulation

_____ Storm windows

_____ Thermal windows

_____ Storm or thermal doors

______ Heat reflective or heat absorbing window or door material

______ Devices associated with electric load management techniques

______ Clock thermostats

Renewable Resource Measures:

______ Solar domestic hot water systems

______ Active solar space heating systems

______ Combined active solar space heating and solar domestic hot water

______ Direct gain glazing systems

______ Indirect gain systems

______ Solaria/sunspace systems

______ Window heat gain retardants

______ Wind energy devices

______ Replacement solar swimming pool heaters

I wish to have our firm listed on the Master List of Suppliers of the RCS Program. I certify that this firm will comply with the requirements of the RCS Program, and that the information supplied in this application is accurate.

Your signature: ______________________________

Title: ______________________________

Date of signature: ______________________________

APPLICATION FOR LISTING TO LEND ON ENERGY CONSERVATION MEASURES OF THE RCS PROGRAM

1. Your company name: ______________________________

2. Your company address: ______________________________

   ____

3. Your company headquarters telephone number: ( ) ______________

4. The name and title of the individual in your company headquarters who should be contacted about Program company involvement in general:

   ____

5. The name of the individual in your company headquarters who should be notified if a customer lodges a complaint against your firm:

   ____

6. What areas of the state are you willing to loan in?

County or City Served	Location of Your Branch or Office

7. Please check which types of loans and indicate the dollary amount of loans your company will consider furnishing to RCS Program residential customers to enable them to make home energy conservation improvements:

	Any Amount	Dollar Minimum	Dollar Maximum
Personal loans - unsecured			
Junior liens/second mortgages secured by subject property residence			
Home improvement loans secured by collateral other than residential property			
Unsecured home improvement loans			

8. Please check which types of home improvements you would consider making loans for:

_____ Minor conservation improvements (under $100 each)

_____ Insulation

_____ Replacement furnaces and water heaters

_____ Active solar space heating system

_____ Solar hot water heater systems

_____ Solar swimming pool heat systems

_____ Home remodeling for passive solar heating

I wish to have our company included on the Master List of RCS lenders. I certify that our company will comply with the requirements of the RCS Program, and that the information supplied in this application is accurate.

Your signature: ______________________________

Title: ______________________________

Date of signature: ______________________________

APPENDIX 4

NEWSPAPERS WITH GENERAL CIRCULATION

AND

TRADE ORGANIZATIONS

NEWSPAPERS WITH GENERAL CIRCULATION

Des Moines Register & Tribune
715 Locust
Des Moines, Iowa 50309

Quad City Times
News Department
City Desk
Davenport, Iowa 52801

Press Citizen
Iowa City, Iowa 52240

Iowa Desk - Omaha World Herald
World - Herald Square
Omaha, Nebraska 68102

Cedar Rapids Gazette
City Desk
500 3rd Avenue, S.E.
Cedar Rapids, Iowa 52406

TRADE ORGANIZATIONS

Iowa Savings & Loan League
306 Savings and Loan Building
Des Moines, Iowa 50309

Iowa Bankers Associations
430 Liberty Building
Des Moines, Iowa 50309

Iowa Association of Plumbing, Heating
and Cooling Contractors
506½ East Army Post Road
Des Moines, Iowa 50315

Home Builders Associations of Iowa
979 Oakridge Drive
Des Moines, Iowa 50314

Professional Insulation Contractors of America