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A DESCRIPTION OF THE HOUSEHOLD ENERGY GAME:
ITS PURPOSE, CONSTRUCTION AND SOURCES OF INFORMATION

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Introduction

This technical report has been prepared to provide users of The Household Energy Game (hereafter abbreviated Hh.E.G.), with a more complete description of the purposes of the game as well as our method of construction, and to list the sources of information used in the game. It is expected that this paper may be of interest to those concerned either with simulation/gaming or with household energy use.

The paper consists of a narrative description followed by an annotated copy of the game. The footnotes explain the calculations employed and the line of reasoning followed and give the sources of data for all quantities portrayed. In putting the game together, the authors found it necessary to summarize data from varied sources into tables for their own use. A number of these tables are included with the thought that they might be of general interest to the reader, and also to aid in the explanation of the game.

Finally, several appendices are added to give further background and information on the game: A list of discussion questions which might be used by teachers or group leaders; a copy of the questionnaire used in evaluating the draft version of the game; a list of the "handy hints" booklets surveyed in preparing the energy savings section of the game; and a comparison of the average household energy budget outlined in the game with several other average budgets which have been published. This comparison was made to convince the authors that they really weren't out in Left Field with their figures, and to show the range of estimates used by others.

Description of the Household Energy Game

Why a Household Energy Game

Given the present controversy over electric power generation, anyone attending a public meeting or public regulatory hearing on power plant or transmission line siting is sure to hear this argument; "If we just didn't use so much electricity, we wouldn't need this facility." And it's an undeniable argument.

The Household Energy Game was developed to address some of the difficulties involved in using less. Household energy use was chosen for two reasons: 1) it accounts for fully one-third of the energy used in the United States; and 2) it is something that people are directly familiar with, therefore providing a concrete way of introducing various concepts of energy use and facts about energy.

The Household Energy Game is designed to be totally self-contained, so that it may be played at home by an individual or a family. It could also be used in a classroom, with this "technical paper" serving as a teacher's guide, and providing some extra information and background for the teacher. For this purpose, suggested discussion questions are provided in Appendix A.

The Household Energy Game is part of a larger University of Wisconsin-Marine Studies Center project on power plant siting. The other outputs of the project will include technical reports as well as some more elaborate gamed simulations. It is intended that the Household Energy Game be used as preparatory exercise for those engaged in these larger gamed simulations.

Other suggestions have been considered as to the use of the Hh.E.G. For instance, it might be useful as a survey instrument. We would be interested in participating in such a use, and would also be happy to receive further suggestions as to its modification and use.

The Hh.E.G. is copyrighted to give us some control over its distribution, but permission for reprinting will be freely granted.

Defining the Game

The question arises, "Is this exercise in household energy use actually a game?" In fact, this is one of the criticisms we encountered in testing the Hh.E.G. -- that it wasn't a game.

Definitions are sometimes tedious, but they can be justified as serving purposes other than establishment of the writer's expertise. This is especially true in a field such as simulation/gaming, where diverse terminology abounds, because not enough time has yet elapsed to develop a common language. So, almost every game, and every paper on gaming, starts with a definition.

The three elements commonly agreed on as necessary to a game (Armstrong and Hebson) are: 1) a model -- an abstract representation of some part of the real world; 2) a set of rules; and 3) a method of scorekeeping. These elements are all present in the Hh.E.G. The model is the representation of energy use in the household. This is clearly an abstraction of all of the variables available. The realm which has been selected is the household and within this realm, energy use (in fact only direct energy use) has been chosen for representation in the game. You will notice that the game says nothing about the size, shape, color, convenience or durability of any of the appliances -- only about their direct energy use. While all these other elements may be important in any household decision, they cannot all be included -- so a choice was made.

The rules in any game serve to regulate the behavior of the players and restrict the means of attaining a score. In this case, the rules state how points are attributed to any appliance or use and how points may be saved. To violate the rules -- to take credit for savings not achieved, or to deliberately underestimate or ignore some uses -- is cheating, as in any game.

The scorekeeping, which is done on the tally sheet or the playing grid, is like scoring in any game. In this case, the score is tied to actual energy use in the household. Competition, which is usually related to score keeping, can be viewed in several ways, and this is left up to the participant. An average household is specified in the game for 1975, and one could compete with this energy picture. A competition based on this game could also be set up between households. Or a competition could be seen within a household; where the object was to reduce energy use by a specified amount or toward some external goal. For this purpose, the 1955 average household use for the U.S. is specified, as is the energy use for various other countries.

The definition of a game is satisfied, though the lack of physical playing pieces and the relative seriousness of the subject matter may make this game a little less fun than others. It does have its rewards though, in increased energy savings and understanding of energy use.

Constructing the Game

Several objectives were set for the game in terms of information content and style. These are outlined below.

Content Objectives

1. To provide a total picture of direct energy use in the household.
2. To provide an understandable approach to energy use.
3. To provide a quantification of the various possible savings measures.
4. To provide supplementary information which would answer questions as they arose and explain the minimum concepts necessary to an understanding of household energy use.

Format Objectives:

1. The game should be self-contained, not requiring any external instructions or information.
2. The game should be interest catching, and should hold attention throughout play.
3. The game should be satisfying, and should provide some reward for play.

— Content Objectives —

1) A total picture of household energy first requires that personal transportation be included, something which is not ordinarily done. Then, all uses within the home must be quantified, and all fuels converted to a common unit. In this case, it was decided to convert to British Thermal Units (BTU). This meant, assuming an average heat rate, or efficiency, for electric production and then computing the energy use of various electric appliances in terms of the energy input to the generating station.

For most appliances and devices portrayed in the game, the energy use figure is taken from national statistics, which are available from several sources. These averages are the product of average power ratings and average hours of use; e.g., a toaster, which draws 1,000 watts and is used 10 minutes a day, will use 272 Killowatt hours per year or 23×10^5 BTU per year. The exceptions to this use of averages are automobiles and home heat, where average figures simply could not be used and maintain the desired standards of accuracy. A quick glance at the chart inside the front cover of the game will convince you that the margin for error with any appliance is large compared to the margin for home heat or transportation.

Auto use is computed as a function of observed mileage (mpg) and miles driven per year. Home heat is computed using a heat loss approach, along with an assumed furnace efficiency which is based, again, on averages.

2) To make the game understandable, some method of quantifying and portraying energy use, other than strict physical units, had to be developed. Previous experience has shown us that people have a good deal of difficulty understanding energy use, and that most energy units are meaningless to the average individual. For example, a questionnaire administered by students, as a part of an energy course, showed that those tested had no consistent knowledge of how much energy they used or how they used it. Furthermore, responses which were obtained could not be correlated with any socio-economic or educational indicators.

A slightly abstract unit of measure, then, seemed desirable in that it could be tailored to a recognizable size, one that a householder would have some feel for. Our search for this measure took us to the "average household use" divided by 100. Average household use seemed like a concept within the grasp of everyone, and 1% of this turned out to be a reasonable level of accuracy for most energy uses, while maintaining a moderate level of detail.

It would be easy to imagine dividing the average household energy use into 1000 parts in order to zero in on the smaller electric appliances, i.e., the electric typewriter used to put this paper together falls in at about this level. But this level of detail also soon becomes overwhelming in the sheer number of variables that have to be considered. And it is also totally inappropriate to the larger items such as hot water and home heat, which may not be represented in the game at an accuracy of more than ± 10%.

An energy unit which equals 1% of average household use also provides a <u>rough</u> guide for percent savings, which is a common way of expressing energy conservation requirements, though it must be remembered that each square represents one percent of the average household, not necessarily of each actual household. For instance, a household which uses 150 squares worth of energy will require a 15 square reduction to achieve a 10% savings.

The average household as pictured inside the front cover of the game may or may not exist. We have little statistical information to determine the shape of the distribution of energy use per household. Presumably, it is something of a bell-shaped curve, though whether the curve is flat or peaked is not known. The studies available show appliance use somewhat correlated with income (Berman & Hammer) and total use (Hannon), while heating energy, at least for newer homes, clearly varies with house size and therefore with income. These indicators point toward a more or less normal distribution of energy use. The exception which presumably proves the rule, then, is the Princeton study (Fox) which shows energy use in identical townhouses, with identical appliance packages and presumably similar occupants; varying by more than a factor of two.

So, while we have just argued that the spread may be wide, the average is at least within actual reach of everyone and therefore within easy imagining.

3) Quantification of the various possible energy savings measures seemed absolutely necessary. Most of the articles, pamphlets, etc., which we surveyed (App. C) did not provide any measure of the actual quantity of energy which could be saved by any individual measure, nor any relative weighting of these measures.

To provide this, we divided the game into two parts, so that the participant would first calculate his actual household energy use and then calculate savings. This approach was necessary because in many instances the savings which could be achieved could not be quantified in absence of a starting point. Home heat is a good example since it is impossible to say anything quantitatively about the effect of weather-stripping or additional insulation on home heat without knowing the size of the home and the present level of weatherstripping or insulation. The same is true of the autumobile; a tune-up may increase gas mileage, but it is impossible to calculate the savings without knowing the mileage before and after the tune-up. Many other uses, such as air-conditioning and hot-water, also fall into this category.

Those savings measures which were then adopted were quantified as accurately as possible. Details of these calculations are given in the footnotes for each savings measure in the annotated version of the Household Energy Game which follows this introduction. The general approach was to calculate power savings for those measures which increased efficiency or savings in hours of operation for those methods which would decrease use. These measures were then translated from BTU's or Kwhr's into squares, for comparison with the rest of the game. A large number of proposed energy savings measures were rejected as being technically incorrect or trivial. And for those which we thought it necessary to include, but did not have reliable figures on, we simply estimated.

4) To provide supplementary information which would answer questions as they arose and explain the minimum concepts necessary to the understanding of the game, a series of "boxes" was developed. This is something of a standard technique now in explanatory writing, where information which is deemed desirable by the author but not necessary to the flow of the text, is put into encircled paragraphs and separated from the body of text. These boxes are equivalent to long footnotes, but are more visually attractive and therefore more likely to be read. Material placed in these boxes includes an explanation of the concept of peaking, or load duration, as applied to the electric utility industry and indirect use of energy, as in the manufacture of appliances. These are concepts which do not fit into the game as structured, but are very important to

an overall understanding of energy use. Other boxes include explanations of concepts relied on in the game, such as simple efficiency of appliances and heat loss from a dwelling. Finally, the boxes are used to introduce supplementary information, such as energy use in the U.S. in 1955 or world energy use in 1974.

Two of these "boxes" deserve special attention because they were designed to make up for major weaknesses in the game.

Cumulative energy use (BTU's per year) is fine for expressing fuel burned, but it does not reflect the size of the facility needed to burn this fuel; that is, it does not reflect demand. This is an important distinction, because many facilities and devices are sized according to demand. Perhaps the main one that we would think of is an electric generating station, where the boilers and turbines need to be able to handle the maximum Kw load placed on the system at any one instant -- even though this load may continue for only a few percent of the day or year. Transmission lines must also be sized this way. And this sizing according to demand is responsible for many of the interactions over electric power generation. It would be a mistake to think that cutting down on overall electric use, while not cutting down on peak demand, would prevent another power plant from being built. An example of this from the game is air-conditioning, which shows up as 1% of average household use, but actually accounts for 12% of the peak demand on Wisconsin's electric generating system (WEP

Other apparatuses are also sized according to demand. Furnaces, must be able to heat a home on the coldest day and auto's must carry the family and its gear on vacation. To some extent this sizing according to demand contributes to decreased efficiency during off peak use. The family station wagon used for commuting or shopping with one person is an easily visible example. In any case, there didn't seem any reasonable way to work the concept of "demand" into the game, so it was put into a "box" and explained separately.

Indirect use of energy, is another important ingredient to the energy picture that was not included in the game. One of the reasons for this was the difficulty in drawing a line around indirect use. Some theories of the economy, for instance, operate on the principle that all production is either directly or indirectly in the service of the consumer. (The purpose of the government, for instance, is clearly to serve the individual, thus all use of energy by the government could be charged indirectly to the household.)

Another reason for not including the indirect use of energy is the difficulty in quantifying it and the difficulty in control by the householder. Energy use in aluminum cans is clearly greater than in glass bottles, and here the consumer has direct control. Many other products, however, might be subject to lower energy use through changes in the manufacturing process which the consumer really has no control over.

A box covering indirect use is provided to show the importance of the energy which goes into manufacturing various appliances. It should be noted that this box includes only manufacturing energy and not energy used in packaging, distributing and marketing that product — this energy may well be greater than the energy in manufacturing.

— Format Objectives —

1) To meet the objective of producing a game which would be self-contained (i.e. not requiring any outside instructions or coaching), a number of requirements were set.

(a) It had to be simple. This means that although energy is a product of two things -- power consumed and hours of use -- for most appliances the hours of use were assumed constant and equal to the average and the player was charged for his energy use according to the size of the appliance -- or its power rating. Hours of use are still a major variable, but without metering equipment, there was no way to incorporate this into the game. And appliance use is low enough part of the total that this simplification was not out of order. The major household uses, auto and home heat, were calculated in a more precise manner, though obviously there is a limit to the number of variables that can be included in something like home heat. For example, the number of children in the house, and how long they leave the door open when going in and out, is likely to be as great a variable in heat loss as the insulation in the walls. In some other cases, like cooking and hot water, the relationship to energy use was placed according to the number of people in the house. This seemed the simplest way to do this and the most accurate because the size of the hot water heater doesn't vary much, and it would be difficult again for the homeowner to measure hours of use.

(b) It had to be flexible and able to incorporate a large number of different lifestyles and energy use patterns.

To do this, the space which could be devoted to any one appliance or use, was limited, and therefore, the large number of charts and graphs that you see in the game was necessary. A prose description of each appliance was out of the question. And, some accuracy was certainly sacrificed in doing this because of the difficulty players will have in identifying the size of their appliance or characteristics of their house.

(c) It had to be cheaply reproducible since the intent of the game was wide distribution. Therefore, a pencil and paper format was chosen rather than some of the more complicated options requiring separate pieces -- playing boards, markers, etc. Even though these things are attractive to some and more closely associated with the word "game."

2) To make the game interest-catching, and entertaining, several things were necessary. Since we had not allowed ourselves the use of separate playing pieces, etc., good graphics and clean layout were thought essential. And the game was reworked many times to achieve a flow through the various segments. It must be admitted, however, that most of the interest in this game was externally generated. There would be no household energy game if there were no energy problems. We have tried to strengthen the relevance of this game, though, by providing some links back between energy use and every day economic concerns. These are shown in the introduction and a box which allows translation of energy squares into dollars.

3) The final objective, which needed to be met was that the game should have some reward built into it. This reward comes in two parts.

First of all there is the satisfaction gained through increased knowledge and understanding -- a non-trivial reward for those entering a new area of knowledge. Secondly there is the satisfaction of action, of actually being able to specify and accomplish a measurable energy savings. The game provides this by quantifying savings and allowing a deduction from the score sheet. This is an important feedback that is totally missed by the "handy hints" type pamphlets which tell you how to save energy but not how much you will save or how to measure this savings. Many of these things are too small to show up on the electric bill because there are several other variables affecting the electric bill (like weather and rate changes). Also, very few people keep accurate accounts of any of their energy purchases -- either gasoline or heating fuel or electricity. It is imperative that the game do this scorekeeping for them and provide them with instant reward, even though it is a symbolic reward.

Testing the Game

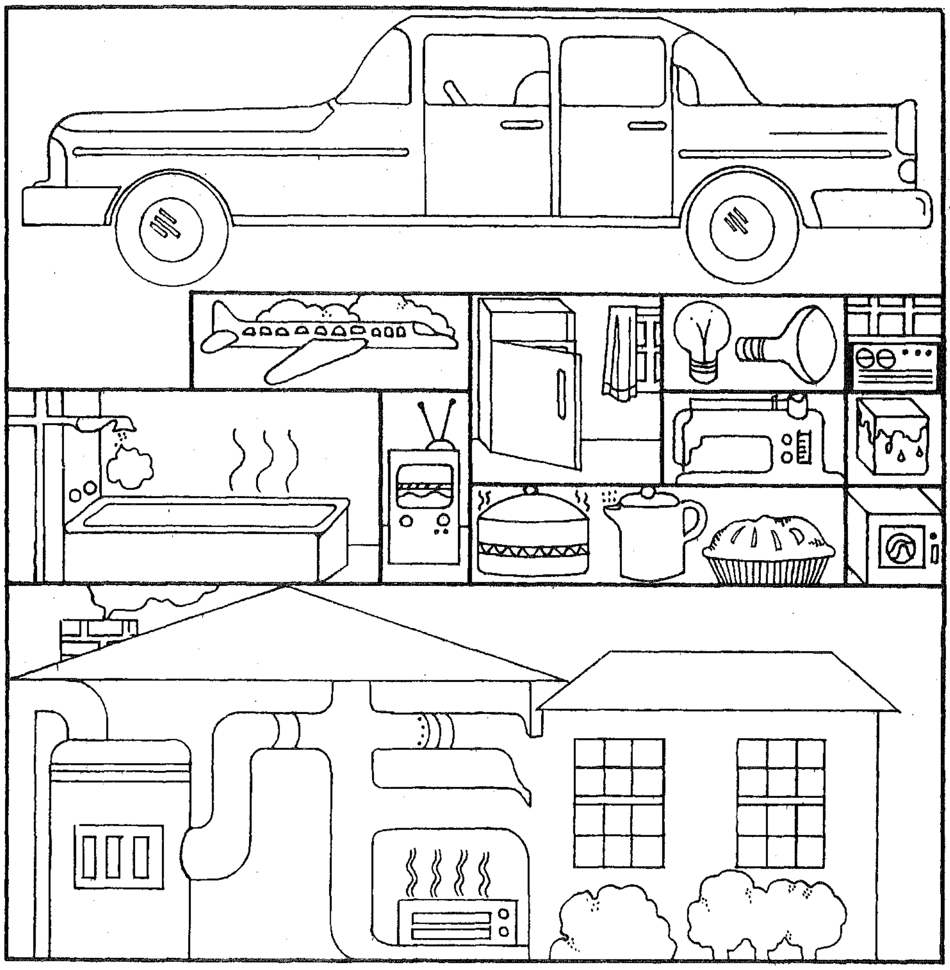
The Hh.E.G. has been run through several stages of development and testing and these might be worth a short mention since they have served to greatly increase the playability and clarity of the game. The basic concepts of the game and the units of measure were part of the original version. The method of scorekeeping and the specific rules and informational "boxes" were developed through several iterations of modification and testing. Informal pre-tests were conducted through a series of five draft versions of the game, with staff and friends. The major test was conducted using 300 copies of the game along with a one-page questionnaire (attached as appendix B). These copies were given to various adult, college and high school groups. The emphasis was on a subjective determination of how much trouble players had with the rules and where these troubles occurred. We were also interested in which of the informational boxes could be eliminated and if any new ones needed to be added. Objectively we wished to measure how much of the information in the game was transferred to the players. This was done partly to get an idea of the educational potential of the game and partly to check the subjective answers. (Clearly one who had not read the game carefully enough to answer the most elementary objective questions was in a poor position to comment on the subjective part.) The answers to the objective part were encouraging. As shown on the questionnaire in the appendix, a high percentage of those playing the game were able to answer the questions. This is a little hard to evaluate because we didn't do any control testing to evaluate knowledge prior to playing the game; but other testing we have done indicates that this is probably significantly better than a random sample would produce.

Further evaluation will be carried out with samples of the game in its final form, probably by mail questionnaire. This testing will be aimed primarily at measuring learning through before and after tests or through tests to control groups where such are easily available, such as in schools.

Format or content changes in the game will also be considered if the tests seem to indicate these. Anyone interested in testing the game as an educational device, or using it as a sampling device, is welcome to it and we will cooperate as best we can.

The next section of this paper is an annotated copy of the game with footnotes grouped at the end. The reasons for not footnoting the game itself should be clear, in that it would be quite cumbersome and would interfere with the flow of the game, as well as being of little interest to most users. Following these footnotes are the references, and a set of data tables which are often referred to in the footnotes. These tables contain their own justification where necessary, and are the basis for the numbers used in the game. The reader should note that these tables are in a lettered series A-D, while tables in the game itself are in a numbered series 1-3.

THE annotated HOUSEHOLD ENERGY GAME



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CONTENTS

ENERGY ON A BUDGET

Whether or not you believe that there is a real energy shortage in this country, you probably have noticed that your monthly heating oil bill has nearly doubled[1] and that gasoline is becoming more and more expensive.

You've probably also noticed that your local electric company has been raising its rates and is talking about further rate hikes.[2]

Taken together, these events mean that energy, which used to be only a minimal item in the family budget, is now becoming a considerable expense. In 1970, about five percent of an average family's income was used to buy energy;[3] today this amount has risen closer to ten percent.[4] And with energy demand constantly growing, this percentage will continue to rise.

Today, energy use per household in the United States is growing at about five to seven percent per year,[5] while income is only growing at about two to three percent per year.[6] As a result, even if prices stay the same, energy is bound to become a significant household expense in a few years. As it is, with energy prices rising, some estimate that by 1990, the average family will spend 20 percent of its income on gas, electricity, heating oil and gasoline—in short, one dollar in five will go for energy.[7]

More likely, we will see a lowering of energy use in the home as people begin to budget their use of energy more carefully, much as they now budget their finances.

The "Household Energy Game" has been developed to help with this task; to give you some idea of how much energy you use and how you can manage it.

The game is divided into two parts. In the first part, you can put together your own energy budget. This includes all those uses of energy over which you have some control—such things as transportation, home heating and cooling and the use of electrical appliances. It does not include such things as the amount of energy it takes to manufacture home appliances.

To help you draw up this budget, numbers have been assigned to all types of energy use to give them some relative weight. (see **What is a Square?**) This enables you to see how much energy your hot water heater uses, for example, as compared to your car or television set.

When you are finished making up your energy budget, you will have some idea of where your energy consumption stands in comparison to today's average American household.[8] If you're nostalgic, you can also look back to 1955 and see how much energy it took for the average family to get along 20 years ago.

The second part of the "Household Energy Game" is devoted to ways in which you can modify your budget to conserve energy—and save money in the process. Some of these measures are quite simple and yet the energy you save can have a considerable impact, both on your pocketbook and on the country's energy consumption, as a whole. After all, with one-third of the energy consumed in the United States now going to household uses, every bit of energy conservation will be important.[9]

1. SPENDING ENERGY

The rules for calculating your household energy use are quite straight-forward. Take a tally sheet and grid from the book. You will see the tally sheet divided into several categories: home heating, transportation, etc.—each of which is covered by a section in this booklet. In each section, you will find instructions for calculating your energy use—just follow these instructions and fill in the number of points most closely corresponding to your own use on your tally sheet.

In some cases, you will be offered several choices and will have to use your best judgment in picking the value closest to your own use. If you don't own an appliance, but do use one (i.e. a laundromat washing machine) you still must fill in the appropriate number indicated. If you own an appliance but don't think you use it, fill in the number anyway. For the purpose of the game, it is assumed that if you own it, you use it.[10] If you own more than one of any appliance, you must fill in the appropriate number for each appliance. Each number stands for so many points. Each point, in turn, represents one square in the game grid.

When you have completed your tally sheet, color in the appropriate number of squares (1 point = 1 square) for each use on the energy use grid. This will give you a good overall picture of your total energy use and how it compares with that of the average household.

WHAT IS A SQUARE?

Units of energy can be quite confusing—Horse power (Hp), British Thermal Units (BTU), Kilocalaries (Kcal.), Barrels of oil (Bbls), ergs, joules and short tons of coal are all common measures of energy. To avoid this confusion, and to offer a measure of energy which hopefully the reader will have some feeling for, all energy in this game is expressed in units equal to 1% of the average family's household energy use. This equals one point on the tally sheet or one square on your grid. Some equivalent measures are listed below.[11]

100 Squares = Average Household Energy Budget = 400,000,000 BTU

1 Square = 1% of Average Household Energy Budget = 4,000,000 BTU [12]

1 Square = 32 gallons of gasoline (the average car uses 25 squares worth of gasoline per year or roughly one tankful per week)

1 Square = 29 gallons of heating oil (the average house used 40 squares or 1,200 gal. of oil for heating

1 Square = 3,900 cubic feet of natural gas (the average house used 40 squares or 160,000 cu. ft. of gas for heating) gas for heating)

1 Square = 300 lbs of coal or 0.15 tons (the average house uses 40 squares or 6 tons of coal for heating)

1 Square = 380 Kwhr of electricity delivered (1,172 Kwhr produced; actually, you only get 1/3 of the energy that goes into electricity, but in the game you're charged for all of it)

Each square is worth roughly $10.00 which means a cost of $1,000/year for the total average household energy use. This is 10% of the average family income of $10,000. With present trends in price, this figure will rise to $2,500 by 1985.

Examples

Gasoline: 1 Square = 32 gal x .50/gal = $16.00
Heating Oil: 1 Square = 29 gal x .30/gal = $9.00
Natural Gas: 1 Square = 4,000 cf x .15/100 cf = $6.00
Electricity: 1 Square = 380 Kwh x .03/Kwh = $11.40

Without too much difficulty, you can translate energy squares into dollars. The above figures indicate how much fuel each square represents. Just multiply by the fuel's current cost to get the dollar value.

MILES PER GALLON \ MILES DRIVEN PER YEAR IN THOUSANDS	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
5	31	37	43	50	56	62	68	74	80	86	94	99	105	112	118	124	130
7	22	27	31	36	40	45	50	54	58	62	67	71	76	80	85	89	94
9	17	21	24	28	31	35	38	42	45	49	52	56	59	62	66	69	73
11	14	17	20	23	26	28	31	34	37	40	43	45	48	51	54	57	60
13	12	14	17	19	22	24	26	29	31	34	36	38	41	43	46	48	50
15	10	12	15	17	19	21	23	25	27	29	31	33	35	37	40	42	44
17	9	11	13	15	17	18	20	22	24	26	28	29	31	33	37	37	41
19	8	10	12	13	15	16	18	20	21	23	25	26	28	30	31	33	35
21	7	9	10	12	13	15	16	18	19	21	23	24	25	27	28	29	31
25	6	8	9	10	11	13	14	15	16	18	19	19	21	23	24	25	26
29	5	6	8	9	10	11	12	12	14	15	17	17	19	20	21	22	23
35	5	6	6	7	8	9	10	11	12	13	14	15	16	17	17	18	19
39	4	5	6	7	7	8	9	10	11	12	12	13	14	15	15	16	17

Table 1. Automobile Energy Consumption (14)

TRANSPORTATION

Transportation is the second largest household energy use, surpassed only by home heating. The instructions below tell you how to figure your energy consumption for each type of transportation you may have used last year. Determine the points for each of these types separately and record them on your tally sheet. (13)

Automobile

For each auto that you own, find the number of miles per gallon (mpg) it gets along the left side of **Table 1.** Then read across till you come to the number of miles you drove that car last year and record the number of points in the box where the two values intersect. For example, if you have a car which gets 11 mpg and you drive it 8,000 miles each year, then record 23 points on your tally sheet. If you don't know your mileage assume it to be the average—13 mpg. If you don't know how many miles you drove, assume you drove 10,000 miles.

Motorcycle

If you use your motorcycle for commuting, record 5 points on your tally sheet; if you only use it for sport, record 2 points. (15)

Air Travel

For each round trip which any member of the family took last year for purposes of personal business or pleasure, record 3 points. Record 2 points for each one-way trip on your tally sheet. (16)

Bus or Train

If the members of your family took more than 10 intercity round trips on the bus or train, record 1 point. (17)

Mass Transit

For every three months worth of commuting on the bus or train, record 1 point. (18) For a year's worth of commuting, then, you would record 4. Record 3 points for each student in your household commuting to school on the bus.

If you make one or two shopping trips per week by bus or train, record 1 for the year.

Taxi or Hitchhiking

Figure out how many miles you travel by either of these modes in a year and then look at the automobile energy table. Assume the vehicle you're riding in gets an average of 13 mpg, (19) and record the appropriate number of points on your tally sheet.

Motorhome or Camper

Same as automobile.

HEATING-HOT WATER AIR CONDITIONING

Home Heating

Several factors influence home heating needs: average outside temperature; house size; furnace type; insulation values of walls and ceilings; installation of storm windows or thermopane; weather stripping quality; and basement or slab foundation construction.[20] You may know some of these things about your home, others you will have to guess at, or use the average figures which are provided here. But you should take the trouble to find out how big your house is and what it is made of. Home heating is the largest household energy use in the northern latitudes and, as you will see, a small change in home heating practices can equal the energy used by a number of appliances.

To find your home heating needs, you will use **Table 2.** This is designed for Wisconsin temperatures but if you live outside Wisconsin, you can use **Table 2** and then correct for your areas (see **Home Heating Outside Wisconsin**).

To determine the basic number of points to record on your tally sheet, start with the left hand column of **Table 2** which shows gas or oil, and electric heat. If you have electric heat, go across to the column which indicates the size of your house or apartment and record the number of points indicated on your tally sheet.

If you have gas or oil heat, go to the next column, and pick the category which shows the type of insulation you have in your house. Then follow across to the column which gives your house size either according to the number of rooms, or more accurately, according to the number of square feet of floor area. If you don't know how much insulation you have, use the shaded row which indicates the average.

There are two corrections you can make on this figure:

1) If you don't have storms on all your windows, you use more heat and so must add the number of points indicated to your tally sheet according to your house size.

2) If you do have *good* weather stripping on all your windows and doors, subtract the number indicated on the table in the row marked "weather stripping."

					NUMBER OF ROOMS IN HOME					
					4	5	6	7	8	9
FURNACE TYPE	INSULATION TYPE	R VALUE*	APT.		FLOOR AREA IN SQUARE FEET					
			1 B.R.	2 B.R.	900	1200	1500	1800	2100	2400
OIL OR GAS	NONE: CEILING OR WALL	R-0	44	62	67	88	127	156	188	220
	2" FIBERGLASS CEILING 0" WALL	R-7 R-0	26	36	42	52	60	72	80	89
	3-1/2" FIBERGLASS CEILING 1" STYROFOAM WALL	R-11 R-7	20	28	32	40	50	56	63	72
	3-1/2" FIBERGLASS CEILING 3-1/2" FIBERGLASS WALL	R-11 R-11	15	27	31	38	42	54	61	69
	6" FIBERGLASS CEILING 3-1/2" FIBERGLASS WALL	R-19 R-11	14	25	28	35	42	49	56	64
	6" FIBERGLASS CEILING FULL FOAM OR FOAM/GLASS WALL	R-19 R-19	13	24	26	33	39	46	53	60
	HOUSES WITHOUT FULL STORMS ADD:		5	7	9	10	11	13	14	16
	HOUSES WITH EXCELLENT WEATHERSTRIP. SUBTRACT:		4	5	6	7	9	11	13	15
ELEC.	NOT. ELEC. MANUF. ASSOC. STD S (6" CEILING, 3-1/2" WALL, STORMS, 1/2 AIRCHANGE/HR)		20	40	44	56	66	76	78	98
					2 B.R.		3 B.R.		4 B.R.	

*** The R value of an insulation describes its insulating properties apart from its thickness and is included in the table, because insulation is often sold according to its R value.**

Table 2. Home Heating[21]

Hot Water

If you have a gas water heater, put 7 points on your tally sheet.[23] If you have an electric water heater, record 12.[24] These figures are appropriate for a household of two to four people. If you live alone, subtract 2 points. If there are five or more in your household, add 2 points.

Air Conditioning

Central air-conditioning: record the number of points equal to 10% (1/10) of the points recorded for home heat.[25]

For each room air-conditioner, record 1 point on the tally sheet.[26]

HOME HEATING OUTSIDE WISCONSIN [22]

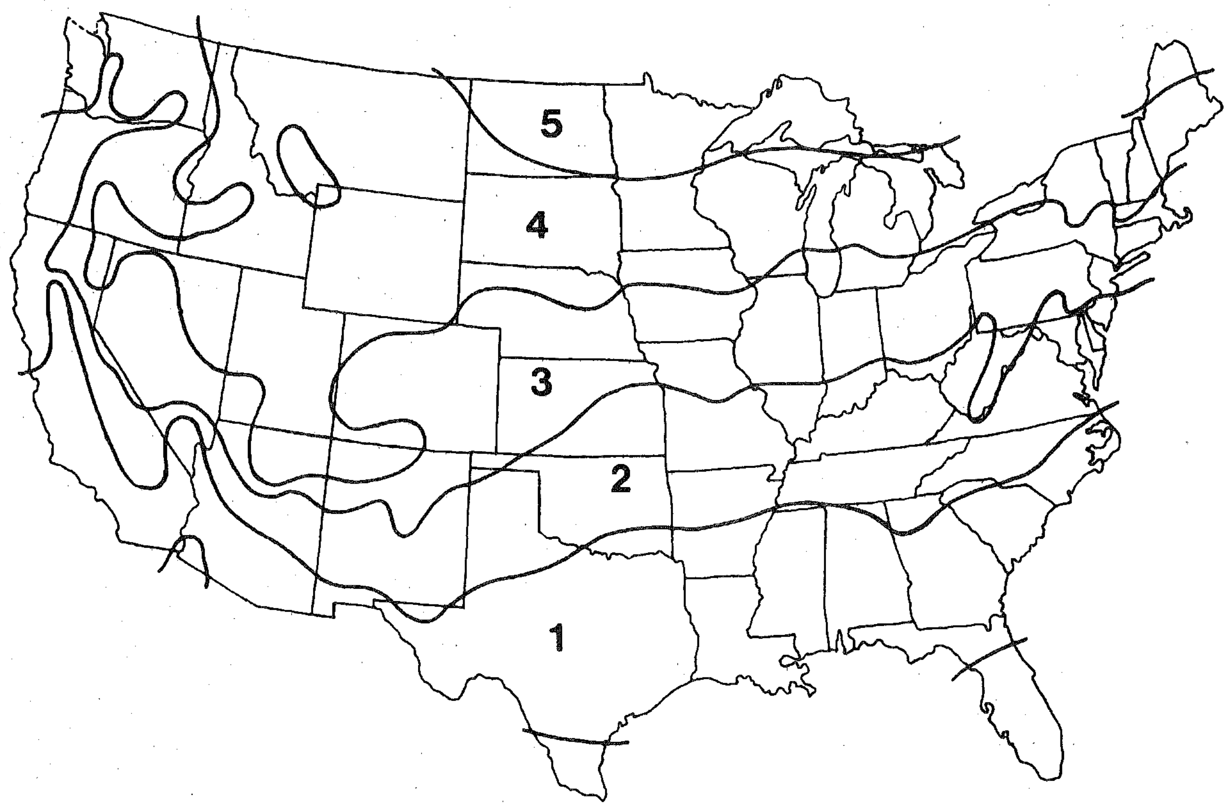


Table 2, used for home heating calculations, is based on Wisconsin's climate. To figure your home heating needs outside of Wisconsin, first calculate your heating needs according to Table 2, then find your zone on the map and use chart below to correct this figure for your climate.

If you live in zone:	Degree Days	Then multiply the points you've recorded by:
1	2,000	0.25 or 1/4
2	4,000	0.50 or 1/2
3	6,000	0.75 or 3/4
4	8,000	1.00 or 1/1
5	10,000	1.25 or 5/4

Example: Say the number of points indicated for heating your size home with the kind of fuel you use is 40 but you live in Memphis, Tennessee instead of Wisconsin. Memphis is in zone 2, so take 40 points, multiply times ½ and record 20 points on your tally sheet.

APPLIANCES

Appliances do not make up a major portion of household energy use; however, they have been a very fast growing area of use and offer potential for substantial energy savings.

MAJOR APPLIANCES (27)

Refrigerator

The things which affect energy use in your refrigerator are its size and the method of defrosting it. A frost-free refrigerator actually has heating coils built into the walls to provide for automatic defrosting.

To determine the number of points for your tally sheet, look under the description of your refrigerator in the chart below. If you have an older model "frost-free" in which only the refrigerator section defrosts automatically, you may subtract one point from the value given for your sized frost-free refrigerator.

	MANUAL DEFROST			
	COMPACT	APARTMENT SIZE	AVG. HOME SIZE	LARGE SIZE
SIZE (CU. FT.)	9	12	14	17
POINTS	1	2	3	4

	FROST-FREE			
	APARTMENT SIZE	AVG. HOME SIZE	LARGE SIZE	GIANT SIZE
SIZE (CU. FT.)	12	14	17	19
POINTS	3	4	6	7

Chart 1. Refrigerator

Freezers

Freezers come in a wide range of sizes from the 6 cubic foot "apartment size" model to the giant 31 cubic foot model. Fifteen cubic feet is about average. As with refrigerators, these may be either manual defrost or frost-free. The chart below gives you the number of points to record for each model.

	MANUAL DEFROST						FROST-FREE				
SIZE (CU. FT.)	7	12	15	17	22	31	12	15	19	22	31
POINTS	1	2	3	4	5	6	4	5	6	7	8

Chart 2. Freezer

Other Appliances

The chart below provides the number to be recorded for a variety of other large appliances found in the household.

APPLIANCE	POINTS
CLOTHES DRYER	3
T.V.–BLACK & WHITE	1
T.V. COLOR	2
DISHWASHER	1
WASHING MACHINE	(SEE MISC. APPLIANCES)

Chart 3. Other Major Appliances

Cooking

Calculating the energy used for cooking takes into account your stove and all table-top appliances such as frypans, toaster, coffee makers, and broilers. A family of two to four should record four points. If you live alone, subtract one. If there are five or more in your family, add one.[28]

Lighting

The amount of energy you use for lighting is mainly determined by the number of rooms in your house. To count rooms, include everything but hallways, bathrooms, closets and unfinished basements or attics. The chart below shows the number of points which corresponds to the number of rooms you have.

– If you have an electric porch or yard light which is left on at night, add one more point.

– If you have a gas post light, add five more points.

	HOUSE OR APARTMENT					
ROOMS	1–2	3–4	5–6	7–8	9–10	11–12
POINTS	1	2	3	4	5	6

Chart 4. Lighting

MISCELLANEOUS APPLIANCES (29)

Check off each appliance that you own, using additional check marks if you own more than one of any appliance. Be sure to include everything that you own—even if you don't use it very much. Then add up the check marks and put the total number in the box indicated. Look at the instructions under the box to see how many points they represent, then add the points up for all categories and record them under the "miscellaneous appliances" section of your tally sheet.

			Checks	Points
__dehumidifier	____attic fan	____lawn or garden tractor	☐	☐
__water pump	____sump pump	____engine heater		
	____snowmobile	____motor boat		

1 check = 1 point
2 checks = 2 points

			Checks	Points
__air cleaner	____window fan	____minibike	☐	☐
__humidifier	____portable heater	____all terrain vehicle		
	____stereo set	____water bed heater		

1 or 2 checks = 1 point
3 or 4 checks = 2 points

			Checks	Points
__elec. power mower	____washing machine	____iron	☐	☐
__gas power mower	____record player	____radio		
__roof or gutter heater	____elec. blanket	____sauna		
	____vaporizer			
	____ice cube maker			

2-4 checks = 1 point
5-7 checks = 2 points
8-10 checks = 3 points

			Checks	Points
__sno-blower	____vacuum	____trash compactor	☐	☐
__shredder	____wood lathe	____garbage disposal		
__roto-tiller	____jointer	____hair dryer		
__chain-saw	____grinder	____elec. floor polisher		
__elec. clock	____110V arc welder	____sewing machine		
__table fan		____garage door opener		
		____blender or mixer		

6-14 checks = 1 point
15-24 checks = 2 points

			Checks	Points
__elec. shaver	____elec. vibrator	____elec. knife sharpener	☐	☐
__elec. knife	____elec. toothbrush	____elec. hand drill		
__heating pad	____elec. typewriter	____elec. hand saw		
__projector	____elec. calculator	____soldering iron		
__elec. games & toys	____yogurt maker	____elec. hedge trimmer		
	____elec. lawn edger	____camping equip. (stoves, lanterns)		

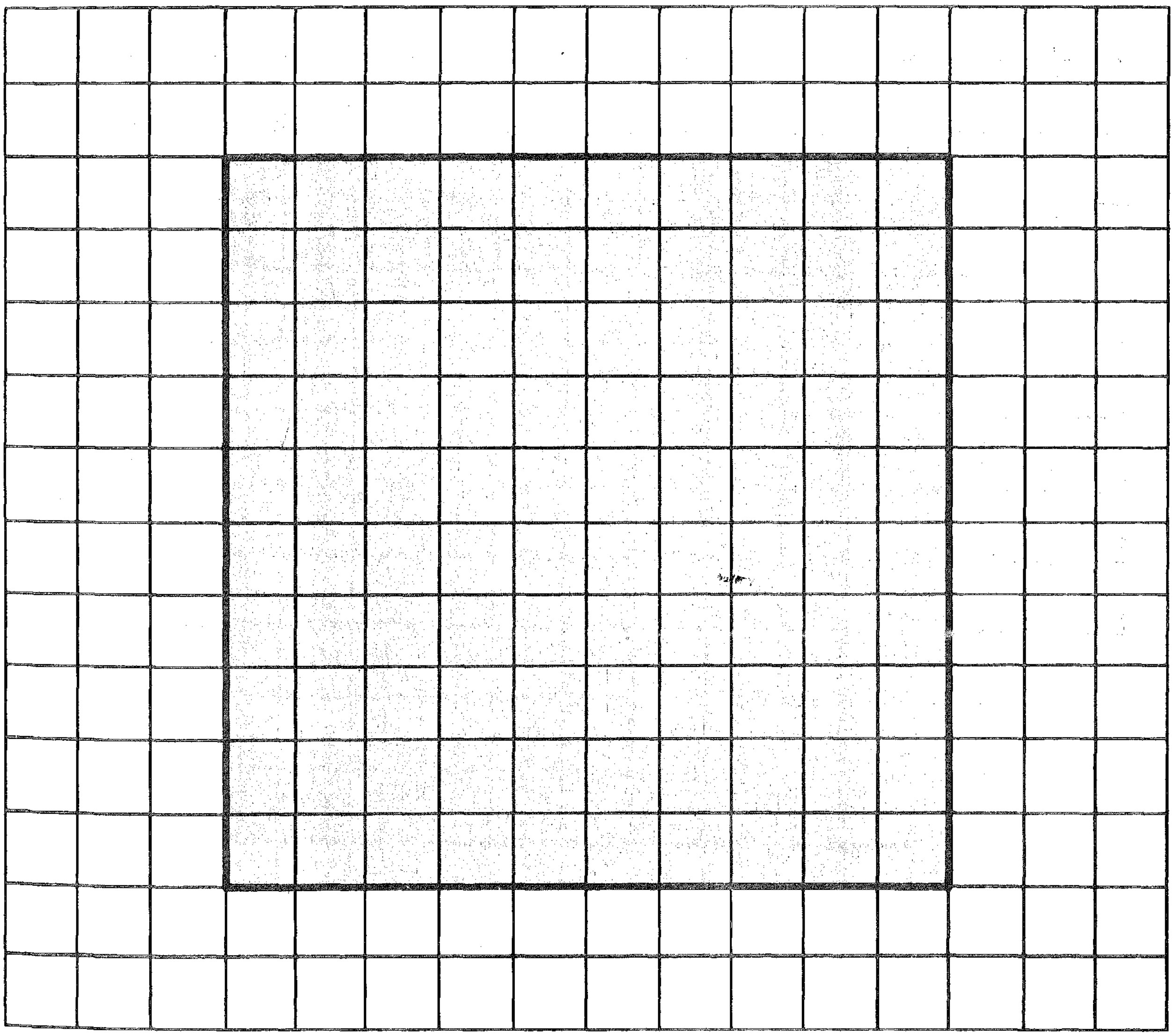
10-29 checks = 1 point
30-49 checks = 2 points

TOTAL POINTS ____________

TALLY SHEET

ENERGY USE CATEGORIES									TOTAL ENERGY USE	ENERGY SAVINGS	FINAL TALLY
TRANSPORTATION	CAR #1	CAR #2	MOTOR-CYCLE	AIR TRAVEL	BUS	MASS TRANSIT	TAXI OR HITCHHIKE				
HOME HEAT	BASIC ENERGY COST	STORM WINDOWS	WEATHER STRIPPING	CORRECTION FOR OUTSIDE WISCONSIN							
HOT WATER											
AIR CONDITIONING											
MAJOR APPLIANCES	#1 REFRIGERATOR	#2 REFRIGERATOR	FREEZER	WASHER	DRYER	#1 TV	#2 TV	#3 TV			
COOKING											
LIGHTING											
MISC. APPLIANCES											
								TOTAL			

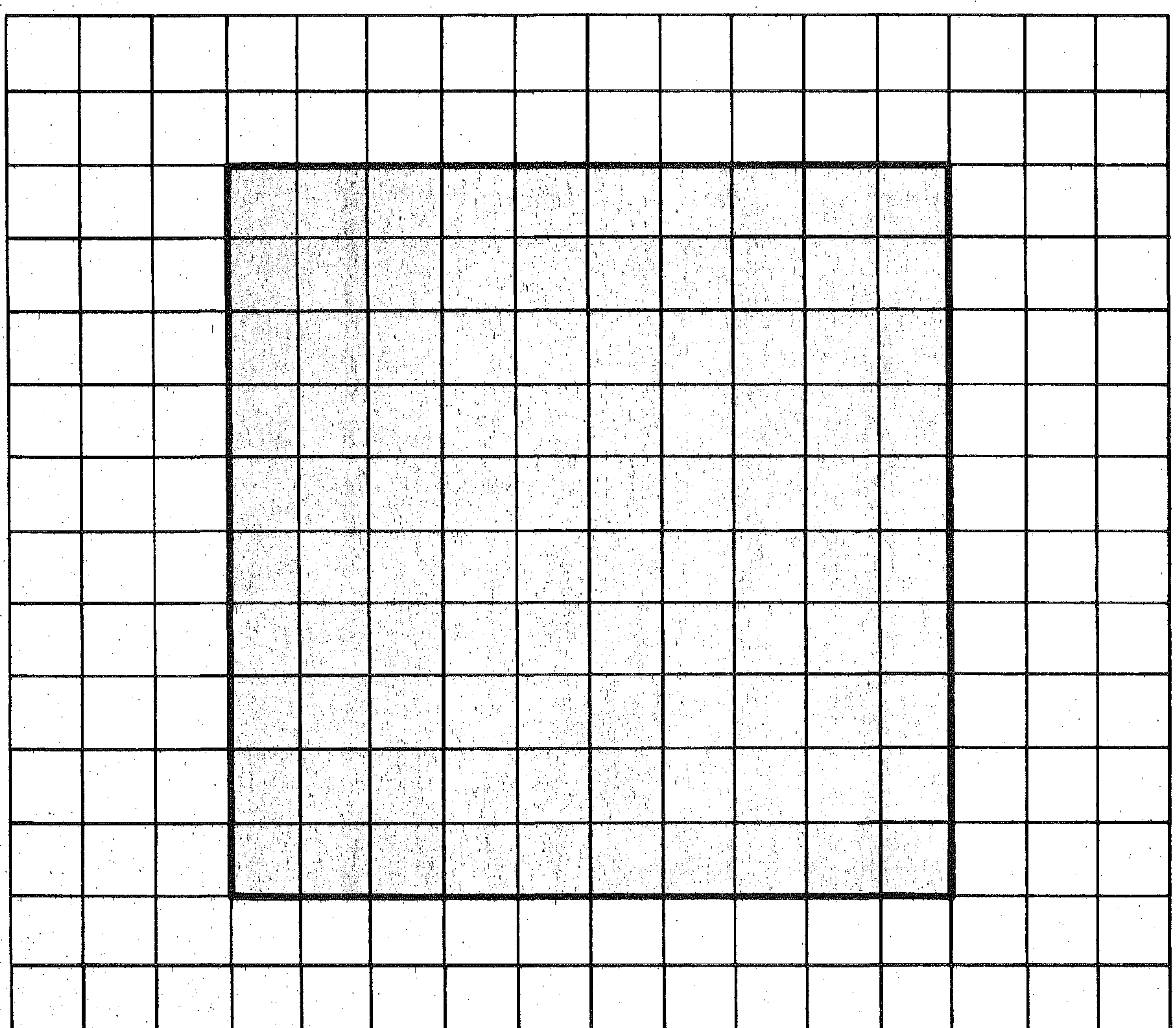
GAME GRID



TALLY SHEET

ENERGY USE CATEGORIES									TOTAL ENERGY USE	ENERGY SAVINGS	FINAL TALLY
	CAR #1	CAR #2	MOTOR-CYCLE	AIR TRAVEL	BUS	MASS TRANSIT	TAXI OR HITCHHIKE				
TRANSPORTATION											
	BASIC ENERGY COST	STORM WINDOWS	WEATHER STRIPPING	CORRECTION FOR OUTSIDE WISCONSIN							
HOME HEAT											
HOT WATER											
AIR CONDITIONING											
	#1 REFRIGERATOR	#2 REFRIGERATOR	FREEZER	WASHER	DRYER	#1 TV	#2 TV	#3 TV			
MAJOR APPLIANCES											
COOKING											
LIGHTING											
MISC. APPLIANCES											
								TOTAL			

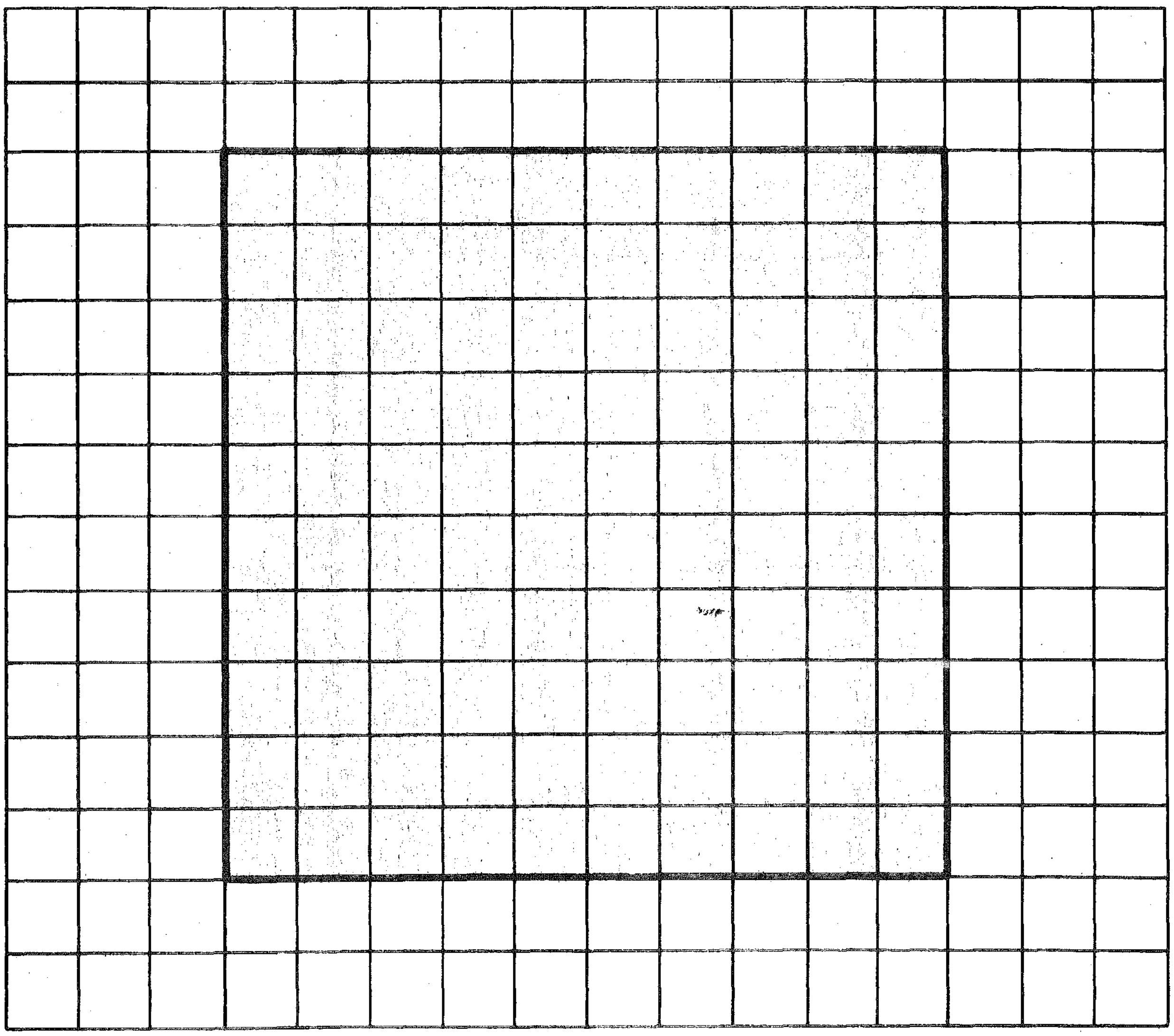
GAME GRID



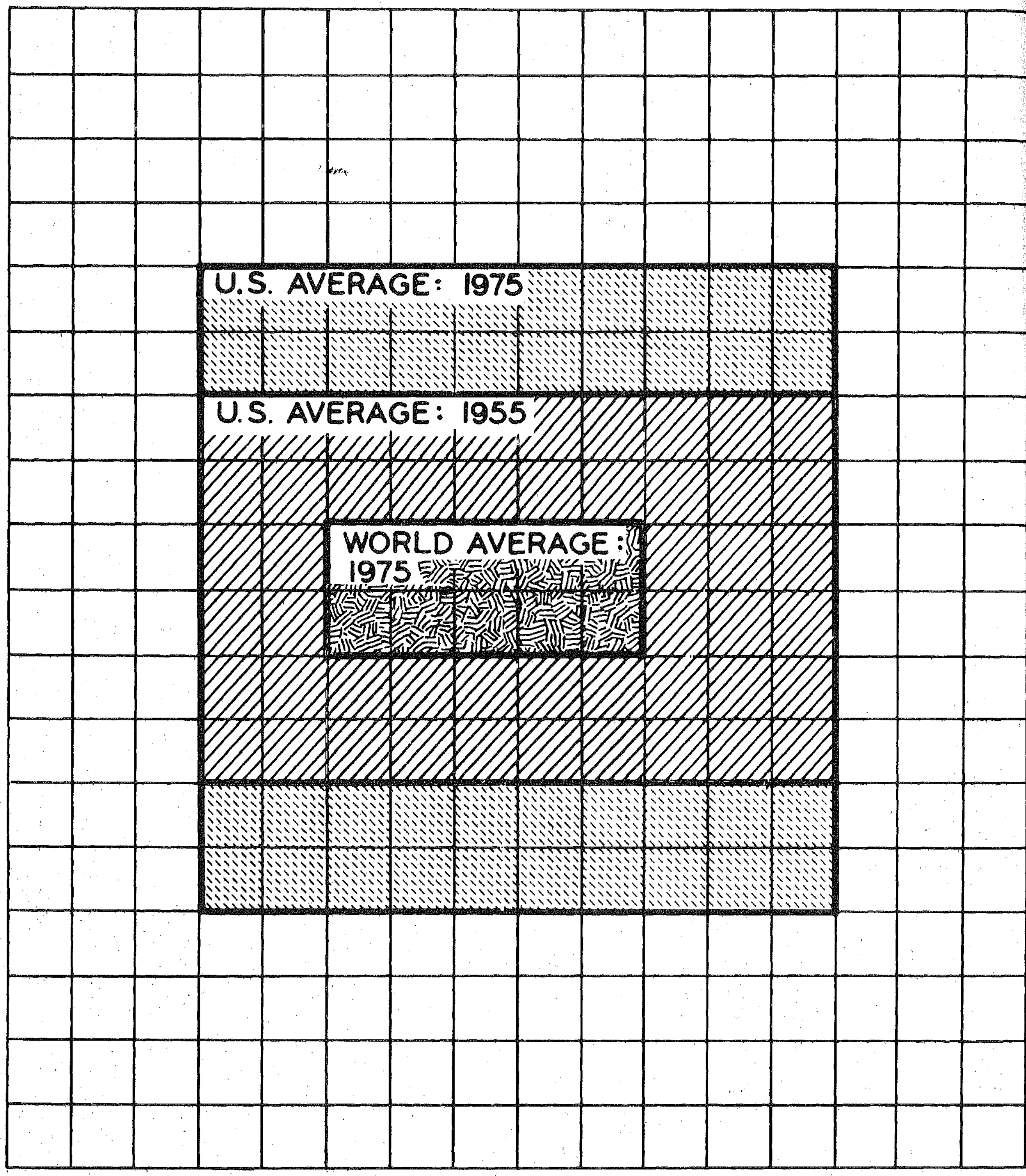
TALLY SHEET

ENERGY USE CATEGORIES											TOTAL ENERGY USE	ENERGY SAVINGS	FINAL TALLY
TRANSPORTATION	CAR #1	CAR #2	MOTOR-CYCLE	AIR TRAVEL	BUS	MASS TRANSIT	TAXI OR HITCHHIKE						
HOME HEAT	BASIC ENERGY COST	STORM WINDOWS	WEATHER STRIPPING	CORRECTION FOR OUTSIDE WISCONSIN									
HOT WATER													
AIR CONDITIONING													
MAJOR APPLIANCES	#1 REFRIGERATOR	#2 REFRIGERATOR	FREEZER	WASHER	DRYER	#1 TV	#2 TV	#3 TV					
COOKING													
LIGHTING													
MISC. APPLIANCES													
										TOTAL			

GAME GRID



HOUSEHOLD ENERGY GAME GRID



You have now finished the first part of the energy game and should have your household energy budget before you. To help you get a better overall idea of what you are spending energy on, fill in the grid below the tally sheet as indicated—one point equals one square and 100 squares represents the average household's energy consumption.

Looking over your grid might give you some ideas on where you might start saving energy.

Before starting Part Two (Saving Energy) you should pick a target for your energy use reduction campaign. Various agencies and institutions have recommended reducing consumption seven to 15 percent.[30] From an historical perspective, this appears a reasonable goal. In 1955 we used 40% less energy per household than we do now (See **Household Energy Use: 1955 vs. 1975**).

Energy use comparisons can also be made with other countries. Households elsewhere in the world get along with far less energy than we do (see **Table 3**).

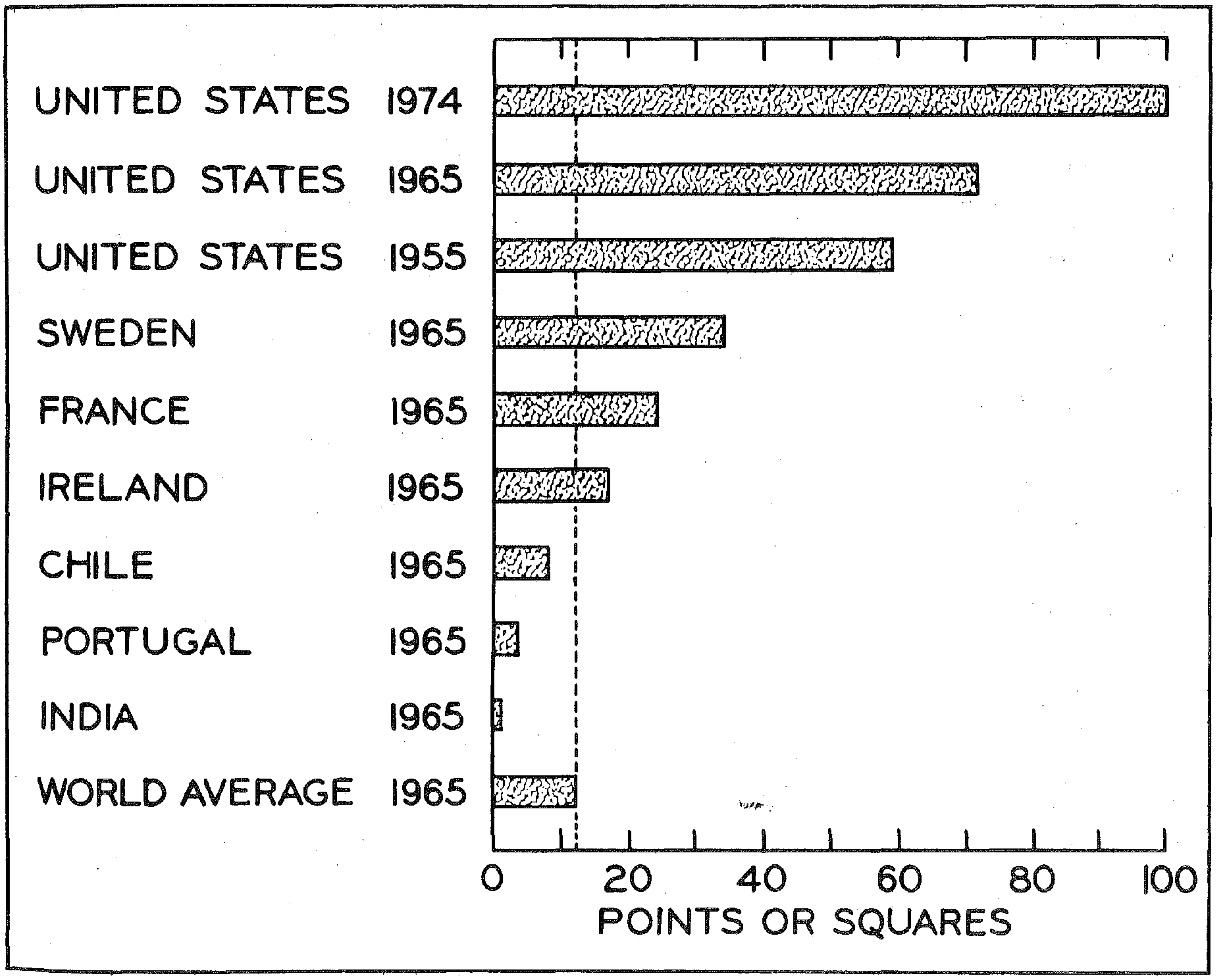
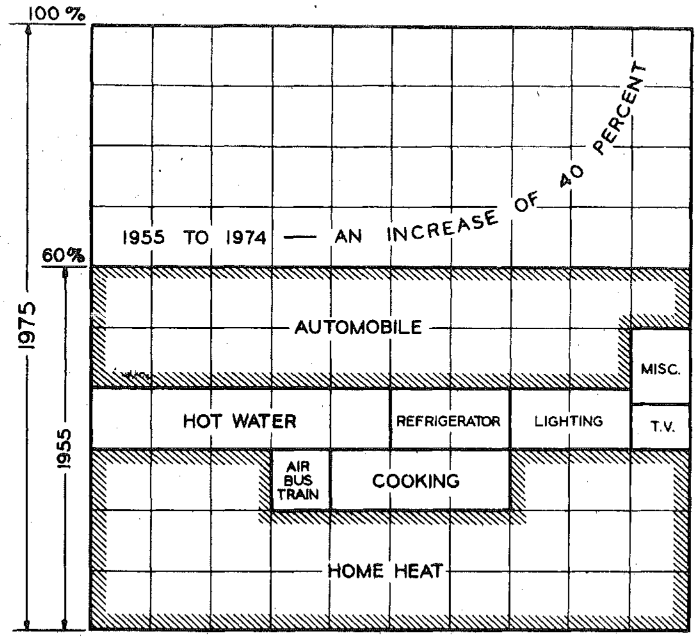


Table 3. Household Energy Use in Other Countries [31]

HOUSEHOLD ENERGY USE: 1955 vs. 1975 (32)



The average American family today consumes almost twice as much energy as it did in 1955. Where the average household now uses up 100 squares on your energy grid, it used only 60 squares 20 years ago. Where are today's extra 40 squares of energy spent? The following list will give you some idea.

---

1) **The Automobile:** 15 squares more

Today, there are more cars on the road and they are longer and heavier than they used to be. Where the 1955 car got an average of 15 miles to the gallon, the 1975 car gets 13 mpg. In 1955, each household had an average of one car; today, each has 1.5 cars.

2) **Home Heating:** 10 squares more

Although home insulation has improved, average home size has increased significantly. The single family home built today is roughly twice the size of the older family homes now being demolished.

3) **Hot Water:** 4 squares more

Dishwashers, washing machines and larger hot water heaters, which heat water almost as fast as it is drawn out, consume almost twice as much energy as they did in 1955.

4) **Air Travel:** 3 squares more

Pretty unfamiliar to the average man in 1955, air travel has since become part of almost everyone's life.

5) **Major New Appliances:** 3 squares more

Three major new appliances—the freezer, dryer and air conditioner—have been added to the home scene. Each consumes about one square's worth of energy.

6) **Television:** 2 squares more

Television sets have increased in size and number and color sets have been added to the market.

7) **Refrigerators:** 1 square more

The average size of home refrigerators has increased from less than 10 cubic feet to 12-14 cubic feet and the automatic defrosting feature has been added.

8) **Cooking:** 1 square more

Traditional family meals have been replaced by people cooking more individual meals to fit their own schedules, thus increasing the energy spent in cooking.

9) **Miscellaneous Appliances:** 1 square more

Most of today's gadgets were not around in 1955. Things like lighted clock dials, clock radios and stereo component systems have added to energy consumption.

TOTAL: 40 squares more used in 1975 as compared to 1955.

2. SAVING ENERGY

There are two ways to save energy. One is simply to eliminate certain energy uses. Getting rid of your clothes dryer, for instance, and hanging clothes on the line will save you three squares. Driving your car 500 miles less each year will save you one square.[33] This kind of energy savings can be calculated from looking at the energy budget you have already constructed. Go through your chart and use your imagination to see what could be eliminated. You might want to refer again to the 1955 chart and think about how life was different then. What do you have now that you could just as well do without?

The second way to save energy is to increase the simple efficiency of the energy you do use (See **Energy and Efficiency**). A tune-up will probably increase your automobile engine's efficiency and a good cleaning will increase the efficiency of your furnace. Both kinds of energy saving measures—reduced consumption and increased efficiency—are necessary.

Many recent newspaper and magazine articles have dealt with saving energy, and several organizations and utilities now distribute pamphlets containing handy hints for energy conservation. In preparing this game, such hints were collected from 30 different articles and booklets.[34]

These hints on saving energy are contained in the following pages. All of these measures can save quantifiable amounts of energy and all can be considered significant.

Some measures listed in the publications surveyed, such as "use the right size pan on your stove" or "dust off your light bulbs" do save electricity, but it is difficult to measure how much. Still other suggestions like "use an electric blanket to save heat at night" will work, but this suggestion is less effective than simply using more blankets.

Finally, these articles list a number of inconsequential suggestions like "get rid of your electric can opener or electric carving knife." The important thing about small electrical appliances like knives and can openers, is not how much energy they use in a year of operation, but how much energy went into producing them in the first place. Manufacturing a can opener, for example, requires about 17 times as much energy as the gadget consumes in a year. Many other small appliances and gadgets also fall into this category (See **Energy in Manufacturing**).

Rules for Part Two

The rules for this part of the "Household Energy Game" are quite simple. Your tally sheet has a second column for "Energy Savings." In this column, you are to list the points you are able to save for each category of energy use—transportation, home heating, etc.—as you go over the energy saving measures given on the following pages. Record the number of points given for any energy saving device you have adopted already or are able or willing to adopt in the future, but remember, any conservation measures you decide to take are permanent measures. A cutback in room temperature or hot water temperature must be continued indefinitely.[35]

When you have entered your points for this round, subtract them from your totals for each category in the last round and record the difference under the "Final Tally" column. This represents your final energy budget after you have taken all the steps possible to conserve on energy use.

You may want to use the grid on the back of your tally sheet to record this revised energy budget. This grid also illustrates the average American household's energy consumption for 1975 and 1955 as well as the present world average consumption to give you some idea of how your new budget compares with these figures.

ENERGY AND EFFICIENCY

The concept of efficiency is often employed in the discussion of energy use and probably requires some clarifications since it is a relative term, whose definition depends on what you're attempting to measure. For instance, if you were interested in getting from Chicago to St. Louis, a train might be the most energy efficient way to travel, a plane the most time efficient and a bus the most economically efficient.

What we are concerned with here is energy efficiency; so let us look in more detail at this concept, using another example from transportation.

An automobile engine has an energy efficiency of around 25%.[36] That is, about one-fourth of the fuel burned in the engine gets converted to useful work turning the driveshaft; and the rest is lost out the exhaust pipe or dissipated by friction within the engine.

The whole automobile has an efficiency of around 20%[37] because of friction losses in the drive-train and between the tires and the road. That is, about one-fifth of the fuel burned gets converted to useful work in moving the vehicle.

When you take into account the energy used to build and maintain the vehicles and the roads, and the energy used by police and ambulances and traffic court judges; the whole system of automobile transportation turns out to be about 10% efficient.[38] That is, about one-tenth of the fuel used to support the automobile-highway system of transportation is actually used in moving vehicles.

But ultimately we're not really interested in the simple work output of the transportation system, but in the useful work output. That is, we want to know how many passenger miles of travel are produced for each unit of energy expended—moving the vehicle, after all, is only a means of moving the passenger. In this regard, a bus is several times more energy efficient than an automobile; not because the engine is much more efficient (they're about the same) but because it uses a smaller engine in relation to its size and carries more passengers in relation to its weight. An airliner, on the other hand, is less energy efficient than an automobile, even though its engines are more efficient. This is because it moves so much faster and has so much more powerful engines in relation to the weight it carries. The chart below illustrates these comparisons in some detail.

	VEHICLE-MILES / GALLON	PASSENGERS / VEHICLE	PASSENGER-MILES / GALLON	BTU / PASSENGER-MILES
1. BICYCLES	—	—	756	180
2. WALKING	—	—	450	300
3. BUSES	5.35	20.6	110	1240
4. AUTOMOBILES	14.15	1.9	26.9	5060

from: Eric Hirst, *Energy Consumption for Transportation in the U.S.*, Oak Ridge National Laboratory Report No. ORNL-NSF-EP15.[39]

ENERGY IN MANUFACTURING 40

An electric carving knife takes 20 times as much energy to manufacture as it will use in a year. The chart shown gives this same ratio for some other common household items. It tells how much energy it takes to manufacture a product as compared to how much energy the product will use in a year.

For many power gadgets, the main energy expense is in their production, sales, service and ultimate disposal and not in their use. A good deal of the energy capital invested in our household is not used very well. People often buy expensive and complicated appliances and then only use them occasionally.

PRODUCT	ENERGY IN MANUFACTURING / ENERGY IN USE
CARVING KNIFE	20
CAN OPENER	17
GARAGE DOOR OPENER	50
GARBAGE DISPOSAL	30
POWER MOWER	3
ROTO-TILLER	25
SHREDDER	20
SNOW BLOWER	25
TRASH COMPACTOR	20

TRANSPORTATION

Automobile

The main way to cut down on the amount of energy your automobile consumes is to cut down on the number of miles you drive. Each square represents about 30 gallons of gasoline, and if you have an "average" car, which gets 13 miles to the gallon, this represents roughly 400 miles of driving. By the same token, if your car gets 7 or 26 mpg, a square would represent about 200 or 800 miles of driving respectively.

Listed below are some ways to save energy with the "average" car. If you wish, you can adjust these proportionately to reflect the mileage that your car gets. A useful target for mileage reduction might be 7,500 miles per year; this will save energy, and with many insurance companies bring a reduction in premiums.

1) If you begin car-pooling (3 per car), record 5 points 41
2) If you begin car-pooling (6 per car), record 8 points 42
3) If you cut shopping trips to once a week, record 4 43 points
4) If you start taking the bus to work, record 7 points 44
5) If you walk or ride your bicycle to work, record 11 45 points

A second way to save energy with your car is to increase your gas mileage. To achieve this, regular tune-ups and proper tire inflation are some recommended measures. Make sure you measure your gas mileage before and after these steps are taken. If you find you have increased your mileage, go back to **Table 1** and refigure your gasoline consumption according to the new mileage figure. 46

Mileage figures for new cars are a major issue - if you're thinking of a new car - you can check potential savings in Table 1. (Remember that each point saved equals $24.00 a year at 75¢ a gallon.)

Air Travel

If you take the bus or train on your next long 47 trip instead of a plane, you can record 3 points.

A Group Effort

This category includes energy spent on transportation by all members of your household. Therefore, if you have two people commuting to work or school, you can save twice as much by car-pooling or taking the bus. If you take a family of four on vacation by train instead of by plane, you can save four times as much or 12 points.

HEATING-HOT WATER AIR CONDITIONING

Home Heating

There are three ways to cut down on energy used in home heating: 1) increase the effectiveness of your insulation and weatherstripping; 2) increase the efficiency of your heating system; 3) decrease the temperature in your home or in certain rooms of your home. Referring back to Table 2 in Part I will enable you to see what difference additional insulation would make. All you have to do is compare your present energy use with your revised use, should you add insulation, to find out how many points you can subtract—hence, how much energy you can save. Increasing your insulation to R19 x R19, for instance, would save 7 to 10 points on the average home. There are a number of ways this could be done, including the new "foam-in-the-wall system." And your building supply dealer, or a local contractor can estimate R values and costs for a variety of kinds of insulation.

One very useful place to add insulation is around the foundation of your house. Concrete or block walls have a very low R value, and 2 inches of styrofoam applied outside the walls or 3½ inches of fiberglass inside can save 5 points on the average house. 48

Windows also deserve special treatment since they account for about 25% of heat loss. 49 The table below shows a number of ways to cut heat loss through windows.

Similarly, a good job of weather stripping your home will enable you to subtract the number of points given in the weather stripping row on Table 2. Infiltration losses can also be cut by adding a vestibule to your main entrance or using only entrances with "air-lock" doors, such as through a garage or porch; this will save 1 point. 50 (To get some idea on where heat goes in your home, so you can plan an energy savings program, see **The Mysteries of Heat Loss Revealed**).

Windows	Points Saved
1) Insulating shutters (2" of foam-closed at night)	4 51
2) Insulating drapes (closed at night)	2 52
3) Triple Glazing	3 53
4) Reflective Coating	2 54

The efficiency of a normal home heating system can be substantially increased. The measures listed below will save you a number of points. You should check with your local heating contractor, or gas utility, for product information. Remember, however, that some of these ideas are new, and marketing has not been very widespread as yet.

1) A "high efficiency" furnace (incorporating such features as a 2-speed blower and flue heat recovery) will save you 10% (1/10) of your heating energy points. 55

2) An automatic damper or a furnace using outside air for combustion will save you 10% (1/10) of your heating energy points. 56

3) An electronic ignition on your furnace will save 2 points. 57

To calculate your savings by reducing the temperature in your home, assume the day to be broken into three eight-hour periods: daytime, evening, and night. For each 2°F which you set your thermostat back during any one of these periods, you can record 1 point on your tally sheet. 58 For instance, a 10°F setback at night will save you 5 points; if you continue this through the daytime hours when everyone is at work or school, you can save 10 points—a very significant saving! Remember that this measure must be carried out faithfully throughout the whole year to be effective—in which case a clock thermostat might be worth considering. These point savings are based on an inside temperature of 72°, and you can take credit for any savings already achieved in this area.

The five or 10 points which you are able to cut from your energy budget in this way represent five or 10 percent of the average household's total energy use and 10 to 20 percent of your heating energy use.

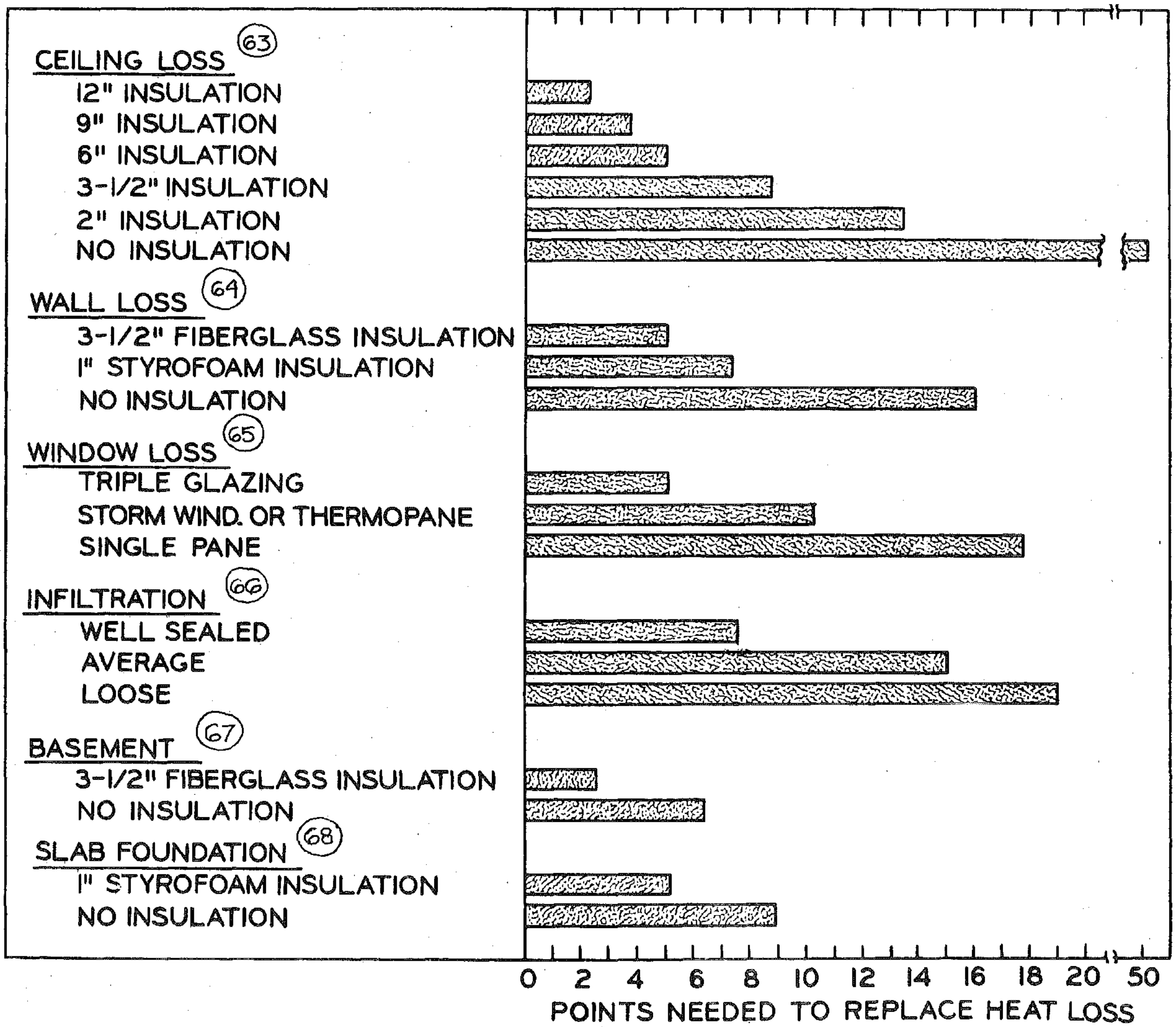
Some objections have been raised to the idea of reducing house temperatures at night, because "it takes more energy to warm the house up in the morning." This is simply not true. What it really takes is time to warn a house up in the morning—roughly two hours to warm up a house which has been kept 10° cooler at night. This means only that your toes will be cold for a little longer in the morning—it doesn't mean that you will use more energy! 59

THE MYSTERIES OF HEAT LOSS REVEALED

The standard approach to understanding home heating needs is through understanding "heat loss." Consider your house to be a large box. Once the furnace fills this box with warm air, it does not need to run again until some of the heat escapes. If your house were perfectly sealed and insulated, you could just close it up the first time the temperature went below 70° in the fall, and you wouldn't need a furnace. Of course, your house is not perfectly insulated, and some heat does escape. This escaping heat is called "heat loss." Heat loss depends on three things: the insulating value of your walls, floor, ceiling, windows and doors; the amount of cold air that seeps in through cracks in the walls and around windows and doors; and the outside temperature (or more precisely, the difference between the temperature inside the house and the outside temperature).

The total heat loss of a house is easy to grasp if we look at the house one component at a time. The five main components of heat loss are the ceiling, floor, walls, windows and doors, and the seeping in of cold air or infiltration. The chart shows how each of these components vary with the addition of insulation, storm windows or weatherstripping. 60 The scale at the bottom of the chart shows how many "squares" worth or points of energy would be needed to replace the heat lost through each component in an average size house (1200 square feet). 61 (This chart assumes a Wisconsin climate and a gas or oil furnace operating at about 60% efficiency.) 62

For example, 16 squares worth of heat energy are lost through the walls if they are uninsulated, while less than 8 squares are lost if the walls have just one inch of styrofoam insulation. Another example, adding three inches of insulation to a ceiling which already has three inches, will save you four squares or give you four points in the energy saving column.



Air Conditioning

Central Air Conditioning:

Improving your weather stripping or insulation or leaving storm windows on in summer are measures which will save energy spent on air-conditioning, just as they will save heating energy. Look again at **Table 2.** Your central air-conditioning energy expenses are equal to 10 percent (1/10) of your heating energy expenses. 69

You can figure what your air conditioning energy needs will be after improvement of insulation and weather stripping by deciding what improvements you are going to make, and then taking 10 percent of that new figure from **Table 2.** Your energy savings will be the difference between your present use and your new calculated use. Some further saving measures are shown in the chart.

Additional Savings Measures for Central A/C	Points
Install awnings or plant shade trees on the east and west sides of your house 70	1 1/2
Put a reflective coating on windows 71	1
Raise your inside temperature from 70° to 75° 72	1
Raise your inside temperature from 70° to 80° 73	2
Leave storm windows on in summer 74	1/2

Room Air-Conditioning:

The same types of measures used for central air-conditioning will save energy use in room air-conditioning. In addition, some specific measures are listed in the chart shown.

The best way to save on air-conditioning energy in Wisconsin is to get rid of the air-conditioner. Reducing the number of hours that you use it will also save some energy, but this presents other problems. Chances are that the day you decide to turn on your air-conditioner will be the same day everyone else does. And, while running an air-conditioner only a few days out of the year will not add much to your household energy consumption, it will add to the utilities' generating problems.

Electric utilities need to build facilities large enough to handle the maximum demand at any one time (the "peak demand"). This means that there is generating capacity lying idle at anything less than peak demand. This idle capacity costs money, and the fuels (oil and gas) used for generating peak electricity are also the most costly and precious fuels (See **Electricity and Peak Demand**).

Additional Savings Measures for Room Air-Conditioning	Points
Use in only one bedroom (keeping the door closed) 75	1/2
Keep temperature control set for 80° 76	1/2
Use in north facing room only (keeping the door closed) 77	3/4
Leave storm windows on in summer 78	1/4

ELECTRICITY AND PEAK DEMAND

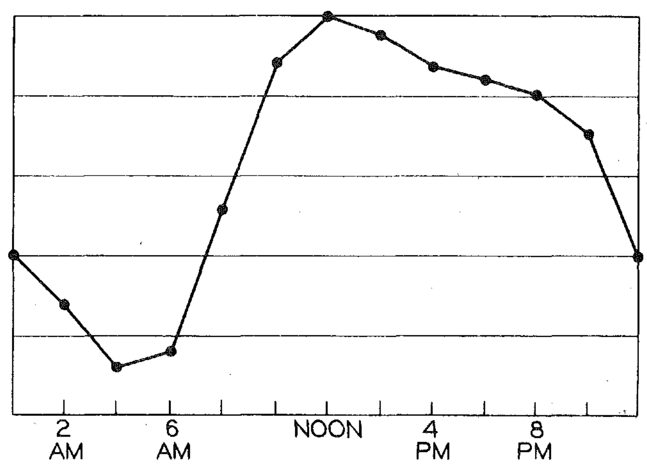
In order to compare electricity with other sources of energy in the home, we have expressed all electrical use in terms of the fuel required to produce that electricity. Virtually all of the electricity produced in this country comes from fossil fuels, with coal, oil and natural gas being converted to electricity with an efficiency of about 33% (1/3). 79

One of the compelling reasons for the use of electricity is its convenience. Electricity is almost 100% efficient in its normal home uses and therefore, there is little waste visible from its use. No excess heat, ashes or smoke is produced and so we are not very conscious of the energy that is being used. Of course, there is waste—heat, soot and ashes—being produced at the generating station miles away, out of our sight and minds.

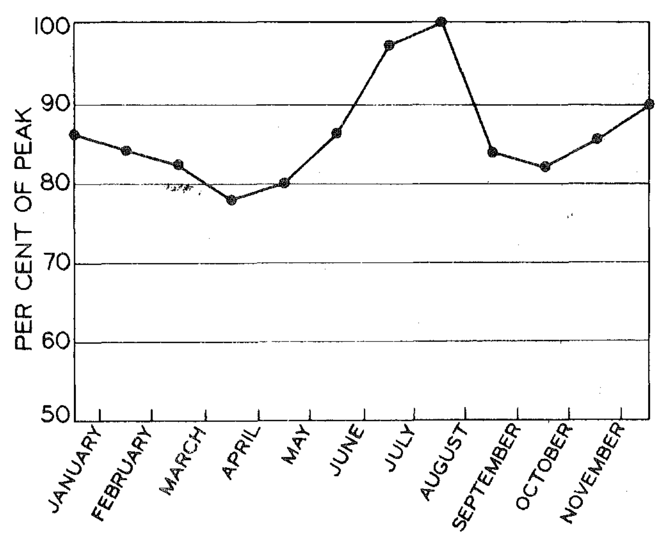
Our demand for electricity is not constant from day to day, hour to hour or month to month. This year, the peak demand for electricity will occur at about 5:00 p.m. on the hottest day of the summer, when people come home from work and turn on their air conditioners. 80 Because electricity cannot be stored readily, the utilities must build enough generating capacity to meet this peak demand. 81 And this generating equipment then sits idle or operates below capacity most of the time. This is costly in two ways: 1) the equipment used to meet peak demands burns costly fuel—gas and oil, 82 and 2) equipment which is not being used up to its capacity means that some portion of the utility's capital investment is sitting idle. Since 50 percent of the cost of generating electricity is in capital investment, this is expensive. 83

In the long run, these two factors mean that the creation of peak demands is costly to the consumer. The charts show typical daily and yearly peak demands for Wisconsin. 84 The highest peak is caused by air conditioners operating on a 100° day in the summer, but imagine what the peak would look like if we had electric heat in 50 percent of our homes! Electric heaters consume about 10 times as much electricity as air-conditioners and the temperature difference between outside and inside the home on a cold day in winter is likely to be 100° F, whereas it never gets to be more than about 30°F in the summer.

DAILY PEAK



YEARLY PEAK



Hot Water	Points	
1) Install flow-restrictors on all faucets and shower heads (cut flow by 1/2)	2	85
2) Turn off your heater when you are on vacation	1/2	86
3) Insulate all your hot water pipes	1/2	87
4) Cut temperature from 140° to 120° (may not work with a dishwasher)	1	88
5) An "energy-conserving" water heater—with extra tank insulation and more efficient heaters—could save	2	89

APPLIANCES

The following energy saving measures are grouped as in Part 1. For each measure, the amount of energy savings is listed in the column at the right. Many of these measures are not worth a whole point, but rather a half or a third of a point. Add up all the points in this category and record them on the energy saving column of your tally sheet.

Refrigerator		Points
Keep set at 38°	90	1/4
Decide what you want before opening door and open and close door quickly	91	1/2
A new "energy-conserving" refrigerator with improved motor, insulation and condenser, could save	92	2
A smaller refrigerator (reducing from 17 cu. ft. to 12 cu. ft.) will save	93	2

Freezer		
Decide what you want before opening door and open and close door quickly	94	1/2
Keep your freezer more than 1/2 full	95	1/2
A new "energy-conserving" freezer could save	96	1

Dryer		
Cut to one load per week	97	1 1/2
Hang clothes out in warm weather	98	1 1/2
Hang clothes out all year (your clothes will dry in the sun even if the temperature is below 0°)	99	3

Television			
Turn off when not watching	Black and white	100	1/2
	Color		1
Turn off the "instant-on" feature	Black and white	101	1/4
	Color		1/2
Replace with an all solid state model	Black and white	102	1/2
	Color		1

Dishwasher

Do not use the "dry cycle"[103]	1/2
Do not use at all—wash dishes by hand[104]	1

Cooking

Do not use "self-cleaning" feature on oven[105]	1/4
Do not open oven door to "check on things" while cooking[106]	1/4
An "energy-conserving" stove with electronic ignition and extra oven insulation could save[107]	1

Lighting

Clean all bulbs and fixtures regularly[108]	1/4
Replace 50% of your incandescent bulbs with flourescents[109]	1
Do not leave your yard or porch lights on all night (each 50 watt bulb left on night and day for one year equals 1 square)[110]	1
Turn off your gas post light[111]	5

Outside the House

Do lawn mowing and snow removal chores by hand[112] (this applies only if you have been using power equipment)	1/2
Put a timer on your engine block heater[113] (run for three hours only)	1/2

MISCELLANEOUS ENERGY SAVINGS

The several items listed below are miscellaneous energy saving measures whose individual effect is minimal. It will take ten of these measures to make up one point.[114]

- Locate your refrigerator away from heat sources
- Clean the coils on the back of your refrigerator
- Thaw frozen food in the refrigerator before cooking
- Replace all hall and closet lights with 40 watt bulbs
- Keep ceilings clean and painted a light color to increase reflection of light downward
- Use dimmer switches in your living room and dining room ceiling lights
- Fix all drippy hot water faucets
- Put a timer or photoelectric control on your porch light
- Clean the blades of your fans
- Clean the mineral deposits off your humidifier
- Compost your scraps—do not use the garbage disposer
- Clean the screen in your dishwasher regularly
- Use the right sized pans in cooking
- Check the seal on your refrigerator door and replace if necessary

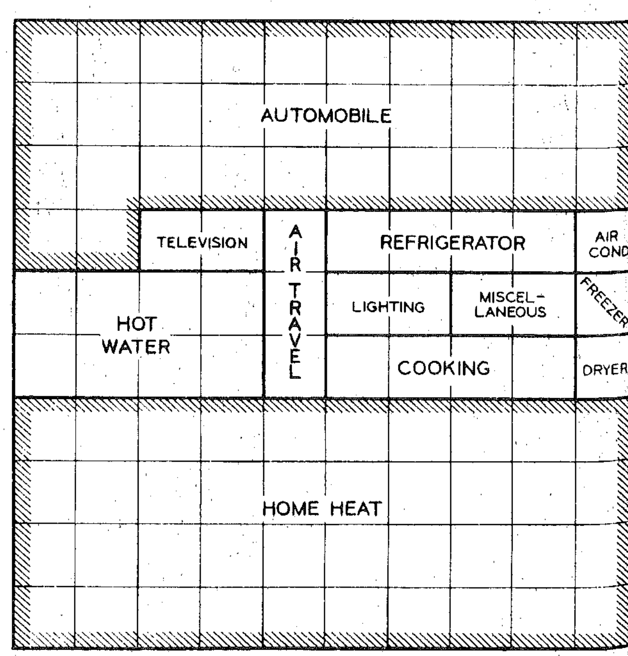
THE ENERGY OUTLOOK

You have now reached the end of the energy game. Hopefully it has given you some background for understanding energy problems and a clearer picture of how you and your family use energy and how you can conserve it. 115 Some of the principles of conservation highlighted here are also applicable to commercial and industrial operations, which together consume the other two-thirds of the nation's energy.

In the process of attaching numbers to various energy uses and comparing them, you may have learned a few new things about what energy is. You have seen what a vital role energy plays in our lives. For this reason, we will continue to hear of new plans and policies for producing more energy and using less of it. The "Household Energy Game" is designed to help you put these plans and policies in perspective and understand what they mean in terms of hard facts and concrete numbers; how much energy do they really represent and what will they cost, taking into consideration social and environmental costs as well as dollars and cents?

Certainly the future will see the development of new sources of energy and the increased exploitation of existing sources. But if the past is any guide, these are bound to be more expensive and less productive ways of getting energy. Energy conservation, on the other hand, will always be a good bet and will save you money in the process, so hang onto this booklet — after all, if worst comes to worst, you can always burn it. 116

WISCONSIN–1974, HOUSEHOLD ENERGY USE



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FOOTNOTES

1. No. 2 heating oil prices increased from 18¢/gal. in 1973 to 33¢/gal. in 1974 in Madison, Wis.

2. Petitions for electric rate increases in the U.S. rose from 25 in 1969 to 111 in 1972 (Ebasco, p. 24).

3. Berman & Hammer, p. 20 for electric use, which is about 1/4 of home use.

4. See p.26 , box titled, "What is a Square."

5. Schurr & Netschert, p. 53.

6. Stat. Abs., #523; Tyrell.

7. See p.26; many utility executives are now talking about price increases averaging 10% per year.

8. The "average household" in this case, is a composite of the mean energy consumption of each of the separate appliance and apparatuses used in the home.

9. See Table A.

10. It is assumed that households are distributed on a standard bell-shaped curve with respect to hours of use of each particular appliance.

11. Energy values of various fuels taken from U. S. Bureau of Mines publications.

12. See Table A.

13. See Table B-1.

14. Miles/year $\div$ miles/gallon x 1.25×10^4 Btu/gallon $\div$ 4×10^6 Btu/pt = pts

15. Motorcycle is assumed at 30 m.p.g. and 5,000 per year for commuting (D.O.T., p. 22) and 2,000 miles per year for sport.

16. $$\frac{780 \times 10^{12}\text{ Btu in passenger travel}}{174 \times 10^{6}\text{ passenger trips}} \quad \begin{matrix}\text{(see Table B-1)} \\ \text{(Stat. Abs., \#933)}\end{matrix} = 5.8 \times 10^{6}\ \frac{\text{Btu}}{\text{trip}}$$

17. $$\frac{128 \times 10^{12}\text{ Btu in passenger travel}}{400 \times 10^{6}\text{ passenger trips}} \quad \begin{matrix}\text{(See Table B-1)} \\ \text{(Stat.Abs.,\#933)}\end{matrix} = 0.32 \times 10^{6}\ \frac{\text{Btu}}{\text{trip}}$$

Note: The large difference between bus and air trips is accounted for by the fact that bus trips average 65 miles, while air trips average 650 miles in length.

18. Since each mass transit trip is worth 0.02 points, each 50 trips, or 10 weeks of commuting, is worth 1 point. Students are assumed to commute 9 months of the year.

19. Auto average (Stat. Abs., 898).

20. National Association of Home Builders.

21. Notes on home heat.

Home heat is calculated by adding heat loss through building components and by infiltration and multiplying this by the reciprocal of the efficiency of the heating system. In performing this calculation, the following assumptions are made.

1. Overall heating unit efficiency

a. Gas & oil = 60% (Scientific American, p. 151)

b. Electric = 32% (i.e., resistance heating assumed)

2. Building section R values taken from N.A.H.B.

3. Houses in Wisconsin assumed to have storms (R=2) and correction factor supplied for those which don't (R=1).

4. "Excellent weatherstripping" assumed to reduce air-change rate from 1 per hour to 1/2 per hour.

5. "Electric standards" taken from N.E.M.A. and all houses with electric heat are assumed to meet these standards.

6. Home dimensions are assumed to be the following:

a. 900 ft^2 = 30 x 30

b. 1200 ft^2 = 30 x 40

c. 1500 ft^2 = 30 x 50

d. 1800 ft^2 = 30 x 60

e. 2100 ft^2 = 35 x 60

f. 2400 ft^2 = 40 x 60

g. All walls 8' high

h. All homes have window area equal to 20% of the total wall area.

7. All homes are assumed to be built on a basement; therefore no heat loss is calculated for the floor.

8. One bedroom apartments are assumed to require 50% of the heat of a 1200 ft^2 home and 2 bedroom apartments, 67%. This assumption rests on some energy savings due to common walls and multi-story construction, and is taken from N.A.H.B., p. 19.

A simplified calculation of heat loss was made for each building section using the following formula, repeated for each building section (i.e., ceiling, windows, and infiltration) and totaled for building heat loss.

Annual heat loss = wall area x u x D.D. x 24 hours

Since D.D. (degree days) are based on 65°F., this means that the last 5° F. of heat needed are assumed to be provided by people and appliances and lighting within the home. This is not the most accurate way of calculating heat needs, but it is well within the range of tolerance provided by the rest of the assumptions made.

It should be clear to the reader, that space heating is not only the largest energy use represented in the game, but also the one most difficult to portray accurately in a simple manner. The result being that the inherent error of the heat loss calculation is greater than the total energy use of most of the household appliances. This cannot be helped. If one wishes to pursue greater accuracy it should be done through actual monitoring of heating fuel consumption, not assumptions about heat loss.

The reader might also note that the Federal Energy Agency is considering a computerized service to aid homeowners in calculating the optimum value of insulation which might be added to a home. This service will depend on the homeowner supplying information about home size and types of windows, doors and existing insulation. If interested, the state energy agency should be contacted.

22. The chart is made up directly from the degree day map in the ASHRAE Handbook. Each zone is 2,000 degree days wide and is centered on the even numbered iso. line, i.e., Wisconsin is in zone 4 which stretches from 7,000 D.D. to 9,000 D.D. The multiplier for this zone assumes 8,000 D.D. If one wished to be more accurate, he could take the exact degree day figure for his home and divide it by 8,000 and use that as a multiplier.

23. S.R.I., p. 44.

24. Ibid.

25. Yearly "heat gain" in Wisconsin equals approximately 10 x 10^6 Btu/year, or 10% of heat loss for the average house (N.A.H.B., p. 44). Central air

conditioning efficiency is assumed at 6.5 Btu/watt hour, which is equal in overall efficiency to a furnace operating at 62% efficiency; therefore, a direct translation from heat gain to energy needed does compare with the translation from heat loss to energy needed. It should be noted, however, that this convenient 10% figure is a rough one, and holds true only for Wisconsin climate, because cooling needs vary inversely with heating needs.

26. S.R.I., p. 59.

27. See Table B-3, which explains the derivation of all the energy values for major appliances.

28. Cooking is figured on the basis of 3.3 persons per household.

29. See Table B-4.

30. United States Federal Energy Office, 1974.

31. Darmstadter, p.67

32. See Tables C & D.

33. Assuming the car to get 13 m.p.g. - See Table 1.

34. See Appendix C.

35. For the purposes of this game, energy use is figured on an annual basis, though these calculations could easily be subdivided, if the reader wished to calculate savings for part of one year.

36. Marks.

37. Marks.

38. Hirst, p. 21.

39. Hirst, p. 13.

40. Manufacturing energy is calculated by multiplying the energy value of the materials used in each device (Makhijani & Lichtenberg, Energy and Materials) times the weight of the device (Sears Catalog). It is therefore a very conservative estimate since it does not include energy used in assembly, transport, packaging, merchandising, servicing, and ultimately disposing of the device. Addition of these factors might easily double the "manufacturing energy" input. Annual use is taken from Table E. It should be clear from the table that the ratio of manufacturing energy to energy use tells you how many years you have to keep a particular device until it has used as much energy as it cost to manufacture.

The values of this table are quite rough, due to a tolerance of ±30% built into Makhijani & Lichtenberg's work and the uncertainty of annual hours of operation built into Table E.

41. 34% of auto mileage is commuting, with an average of 1.4 persons per car (Auto. Manuf. Assoc.). This equals 11 points. Savings, then, with 3 per car = 1/2 x 11 pts. = 5 pts.

42. Savings with 6 per car = 3/4 x 11 = 8 pts.

43. 19.6% of auto mileage is shopping (Auto. Manuf. Assoc.). This equals 2-1/2 pts. Since each shopping trip averages 4.4 mi. (one-way), the average house is responsible for 130 shopping trips per year or a little more than 2 per week.

Note: Since both shopping and commuting are figured on averages, a conscientious participant should calculate his own savings according to the mileage reduction he can achieve.

44. Commuting by bus equals 4 pts. (see p.22). Therefore, the savings possible over commuting by auto is 11 pts. - 4 pts. = 7 pts.

45. Bicycling or walking are assumed to save the total of auto commuting (fn. 41). Clearly if one switches from a bus to a bicycle, the savings would be less (fn. 44).

46. Variations in the condition of individual automobiles prohibit averaging the effects of a tune-up; also it is felt that each player should measure his gas mileage for his own understanding.

47. Round trip air travel is worth 3 pts. per trip (see p.27), also table B-1. Since bus and train use is so low in comparison (see p.27), savings are put equal to the whole 3 pts. This is somewhat misleading since part of the reduced energy consumption of buses is due to reduced trip length. The counter-argument is that if people had to take the bus, they probably would not travel so far. Remember, the key word in this paragraph is <u>instead of</u>.

48. See "The Mysteries of Heat Loss Revealed" p. 41; also N.A.H.B. Assuming a 2 ft. masonry wall, a 140 ft. perimeter and a μ of .6 for a concrete wall; heat loss is 20% of total loss (40 points) or 8 points -- this can be cut to 4-6 points with 2" of styrofoam (μ=.07) depending on inside temperature.

49. See "The Mysteries of Heat Loss Revealed" p. 41; also A.I.A. <u>Energy Conservation in Building Design</u> and N.A.H.B.

50. Infiltration is estimated to be 30-40% of heat loss (fn. 61 and Hittman, <u>Phase I</u>). Hittman (Phase I) estimates that door infiltration is 19% of total infiltration or about 8% of overall heat loss. This equals about 3 points -- and if it could be cut in half by adding an air-lock door, savings would be a little more than 1 point. This is a conservative estimate.

51. In our model house (fn. 61) window area equals 224 $ft.^2$ and window heat loss=24 x 10^6 BTU/yr if storms are used. Use of R-11 shutters will reduce the μ value of windows from .56 to .07. This would imply a 21 x 10^6 BTU savings if left on 24 hrs./day or a 7 x 10^6 BTU savings over 8 hrs./day. Reducing heat loss by 7 x 10^6 BTU would cut fuel consumption by 12 x 10^6 BTU if a furnace efficiency of 60% is assumed.

52. The calculation involved is the same as fn. 51, except insulating value of drapes is assumed to be μ=0.15.

53. The calculation employed is similar to fn. 51, except that triple glazing is assumed at μ=0.37 (A.I.A., p. 45) and is obviously effective 24 hrs/day.

54. A reflective coating will reduce heat loss through windows by 20% according to information supplied by Minnesota Mining and Manufacturing for their "Scotchtint" reflective coating. Since heat loss through windows is about 10 points (p. 41; fn. 61 and fn. 51), the savings are about 2 points.

55. Hittman, Final Report, p. 54-55 and 67.

56. Hittman, Final Report, p. 67; and N.Y. Public Service Commission, p. 174.

57. See Hittman, Phase I, p. 44; and National Bureau of Standards, p. 48 and p. 69; and NY Public Service Commission, p. 167. The reader should note that there is some disagreement over how much of the heat from a furnace pilot is actually utilized in the building; we have used the N.B.S. estimate of 25%, with the remaining 75% being lost. This makes sense, because with just the pilot on, no blower is operating to transfer heat out of the plenum and into the building. Since a furnace pilot consumes from 3.5 to 8.0 x 10^6 BTUs/yr or about 1-2 points; savings vary from 3/4 to 1 1/2 points.

58. Nelson, p. 48, is one source of the "rule-of-thumb" which says that heat energy savings equals 3% per degree setback per day.

59. Nelson, p. 42.

60. Average figures for weatherstripping and storm windows from N.A.H.B.

61. The "model house" used for these caluclations is 30' x 40' x 9' with 1' of masonry wall above grade and 20% of the wall area taken up by windows and doors. Annual heat loss is calculated using the following formula; heat loss=$ft.^2$ x μ x D.D. x 24 hrs. Energy input is calculated assuming a furnace efficiency of 60% for gas or oil. Thus, annual building loss for a home of this size employing typical construction, would be:

Building Section	Area, Volume Length	Insulation "R"	"μ"	Heat Loss BTU x 10^6	Points	%
Opaque Wall	896 $ft.^2$	11	.07	12	5	11
Windows & doors	224 $ft.^2$	storms	.56	24	10	23
Volume	9600 $ft.^3$	1 air change/hr.	.02	37	15	36
Ceiling	1200 $ft.^2$	11	.08	18	7	17
Masonry	140 $ft.^2$	none	.60	16	6	15
Totals				107	43	101

62. This means energy used for heating equals "heat loss" x 1.64.

63. μ values from ASHRAE Tables.

64. Ibid.

65. Ibid. Triple glazing taken at μ=0.37 from A.I.A.

66. Well sealed = 1/2 airchange/hour, average = 1 airchange/hour, loose = 1-1/2 airchange/hour.

67. Assuming 1 ft. of masonry wall above grade as part of the "basement".

68. Insulation is placed around perimeter of slab.

69. See fn. 25.

70. Heat gain through windows equals approximately 25% of total heat gain for a reasonably insulated house in the Wisconsin climate (N.A.H.B., p. 43). Shading can cut this by 70% for a total savings of nearly 1 pt. for the average house.

71. A reflective coating can cut down heat gain through windows by 85%. Since 25-50% of heat gain is through windows (Hittman, Final Report, p. 32; and N.A.H.B. p. 43), and 3 points are charged for central air conditioning, the savings are between .6 and 1.3 points.

72. Assuming an ambient temperature of 90^{o}; when the air conditioner is running, increasing the inside temperature from 70^{o}F. to 75^{o}F. will decrease the Δt by 25% and therefore save 1 pt. out of the four alloted for cooling in the average home. Similarly, an increase from 70^{o}F. to 80^{o}F. will save 2 pts. This is certainly a conservative estimate, because the outside temperature does not average 90^{o}F. during days when air conditioners are running in Wisconsin.

73. See fn. 67.

74. See fn. 66. Storm windows will reduce heat gain by about 25%, thus giving a total reduction of 25% x 25% or 6%; which is 1/4 pt.

75. This is assumed to cut down the area cooled by 50%.

76. See fn. 72.

77. See fn. 72 & 75. A north facing room will gain approximately half the heat of a south facing room.

78. See fn. 74.

79. <u>National Power Survey</u>,

80. <u>National Power Survey</u>,

81. Pumped storage is not in widespread use as of yet, and new technologies, such as superconductive storage are still in the development stage (National Power Survey).

82. National Power Survey,

83. The proportion of capital cost to total cost varies between approximately 30% for gas turbine installations and approximately 75% for nuclear installations. (Petruschell and Salter, p. 5)

84. W.U.M.S., pp. 35-36.

85. About 55% of the energy for water heating goes to water used in the sink and shower (Hittman, phase I, p.50). Flow restrictors-along with aerators-could cut flow from 4 g.p.m. to 2 g.p.m. in the sink and from 6-8 g.p.m. to 3 g.p.m. in the shower; without reducing washing effectiveness. This is a savings of 25% or about 2 points out of the 8 points allotted for average use (table B-3, p. 67).

86. Vacation days plus long weekend holidays equal 14 to 20 days per year (Perkins, p. 7) or about 5% of the year. 5% x 8 points (table B-3) = 1/2 pt.

87. Approximately 25% of the energy used in water heating is lost through the heater hacket and piping (Hittman, phase I, p. 50; and N.Y.P.S.C., p. 119). This amounts to about 2 points (table B-3). If we assume that the loss is equally divided between heater jacket and piping and that insulation of pipes will cut heat loss by 50%, the savings equal 1/2 point.

88. Assume $\Delta t = 90°F$; i.e., inlet water temperature = 50°F, and factory setting = 140°F; then reducing the Δt by 25% (22-1/2°F) will reduce energy consumption for water heating by 25%. This equals 2 points (table B-3).

89. A number of companies offer water heaters which are claimed to save 25 to 30% (2 points). These savings are easy enough to visualize. Tank losses account for about 15% and could be cut in half with better insulation (fn. 87). Pilot lights account for about 1-2 points worth of energy use, at least 25% of which goes up the vent stack(N.Y.P.S.C., p. 167, table II-B-5). And improvements in heat transfer using larger electric coils with lower power densities (A/O Smith Corporation), or improved flue systems or gas heaters, could be expected to make up the rest (Hittman, Final Report, p. 54).

90. Temperature settings of 36°F to 38°F are recommended for refrigerators. This represents a Δt of 32° (from 70°F). If we assume a linear relationship between Δt and energy consumption, each 2°F change in temperature will equal 1/4 point. A present setting of 36°F is assumed.

91. This is assumed to cut heat gain by 15% - a very subjective assumption.

92. M.I.T., p. 196. The M.I.T. report provides an excellent treatment of the factors involved in refrigeration and television energy consumption. According to this report, the following improvements would result in an energy savings of 50% (2 points) in a 15 cu. ft., frost free, refrigerator: Replace resistance heaters for anti-sweat purposes with condenser tubing; increase condenser tubing and lower the surface temperature of the condenser; increase evaporator surface; increase motor efficiency; modify compressor.

93. See p. 6. Subtract 12 cu. ft. figure from 17 cu. ft. figure.

94. See fn. 91.

95. The more frozen food you have in your freezer, the less air there is to transfer heat from the walls of the freezer by convection and also to exchange with room air when the door is open. The savings figure is a subjective one.

96. Line of reasoning is same as employed in fn. 92. Though the M.I.T. report does not treat freezers specifically, it seems reasonable to assume that the same sort of savings are possible, since construction and features are quite similar.

97. The average dryer runs 4 hrs. per week or about 4 loads (N.Y.-P.S.C., p. 115). Cutting this to two loads will cut consumption in half.

98. Warm weather is assumed to be 6 mos. of the year, which would cut dryer consumption in half.

99. Hanging clothes out all year will eliminate the need for a dryer.

100. The average home TV is turned on 6 hrs. per day (S.R.I., p. 56), and there are 1-1/2 TV's per household, giving an average of 9 TV hrs. per day. It is assumed that the TV is being "watched" only half the time. This is a conservative assumption based on the information that the average person only admits to "watching" TV 1-1/2 hrs. per day (Perkins, p. 5). Since there are a little over 3 persons per household (Stat. Abs., #50), total "watching" time would be 4-1/2 hours per day with no overlap.

101. The "instant on" feature adds between 12% and 100% to TV consumption (N.Y.-P.S.C., p. 127). It is assumed that the average addition is 25%.

102. Solid state models consume approximately one-half the energy of tube type TVs (Sierra Club, M.I.T.).

103. The heating element which powers the "dry cycle" consumes at least one-half of the energy used by a dishwasher (N.Y.-P.S.C., p. 117).

104. This measure would eliminate the dishwasher entirely. Note: Extra hot water used by dishwashers is not considered here.

105. Self cleaning accounts for about 5% of the energy consumed by an average electric range (N.Y.-P.S.C., p. 122).

106. This is assumed to cut energy by 5%.

107. Hittman (phase I, p. 48), estimates that these improvements would save 20% of range energy use or 1 point. Hittman also estimates that only 10% of the energy input to an oven is actually useful in cooking the food. Losses occur because of poor insulation, short conduction paths around doors and direct radiation paths through glass doors. A commercial type oven could provide even greater savings as could a microwave oven.

108. Dirty bulbs reduce light transmittance by approximately 20%.

109. Fluorescent bulbs are approximately 3 times as efficient as incandescent bulbs (Marks, p. 1704). 33% of lighting energy could therefore be saved by replacing 50% of incandescent bulbs with fluorescents.

110. 50 watt x 8750 hrs. = 440 Kwh (1 pt. = 380 Kwh).

111. See p.31 or Table B-3.

112. See Table B-4.

113. Heaters are normally left on overnight or 8 hrs. Since they consume about 1 pt. worth of energy in this mode of operation, cutting the operating time in half would save 1/2 pt.

114. These measures were felt to be significant, but very difficult to evaluate. Actual savings due to these measures may well vary between 1/100 pt. and 1/2 pt.

115. In a speech to the Solar Heating and Cooling and Energy Conservation Conference (Denver, 1974), architect Richard Crowther, (A.I.A.) estimated a possible 60-80% savings in heating and cooling with a 7-10% capital cost increase and an 80-95% savings with a 20% increase in capital cost. The A.I.A. publication, Energy Conservation in Building Design, estimates 40% total energy savings possible with no cost increase (p.IV). While Owens Corning Fiberglass estimates a 65% savings in heating and cooling with capital costs the same or less (Report No. 1). Hittman Associates estimate a 40% savings with 3% capital cost increase (Final Report, p.4). In looking through the H.h.E.G., it is not difficult to add up 40 points worth of energy savings which could be achieved with an investment of $1500 (3% of the average new house). This 40 point savings is 70% of the average household use minus transportation [0.7 x (100-35) = 44], and can be achieved with only moderate lifestyle changes.

116. Each copy of the HhEG weighs about 1/4 lb. (3.8 oz.). Since the high heat value for paper or wood is around 4-6,000 BTU/lb., we will estimate one copy of the game to give up 1,200 BTU when burned. Each point in the HhEG is worth 4×10^6 BTU (4 million BTUs); therefore it takes 3,200 copies of the game to equal 1 game point (4×10^6 BTU/point $\div$ 1.2×10^3 BTU/copy = 3.2×10^3 copies/point). Thus, if we distribute 10,000 copies of the game and only 3 people actually read it thoroughly and each of them saves 1 point, the game will break even in energy terms.

Another way to look at this is from an energy input standpoint. It takes 5.5×10^6 kcal. to produce 1 ton of paper (Makhijani and Lichtenberg, 1971, p. 35); this translates to 2,728 BTU input per copy of the HhEG; so that if the same 3 points are saved as above, the game will be a success in net energy terms.

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TABLE A - UNITED STATES RESIDENTIAL FUEL USE - 1974

	Btu x 10^{12}	%	Notes
Gasoline	8,915	35	'73 total pass. car[1] minus 8% business trips[2]
Jet fuel	780	03	'73 total airline gal.[3] x 70% pass. tons[4] x 73% personal trips[5]
Diesel	128	00.5	'73 total bus gal.[6] - assume 100% diesel
Heating oil	2,804	11	'73 total #2 htg[7] + 70 #1 htg[8]
Electricity	5,574	23	'73 total residential sales[9] + elec. transport[10]
Natural gas	5,338	21	'73 total residential sales [11]
L. P. gas	968	04	'73 total residentual sales[12]
Kerosene	300	01	assume constant decline since '68[13]
Coal	317	01	for heating only[14]
Wood	18	--	for heating and cooking[15]
	25,322	99.5	

References:

1. Stat. Abs., #898, assume 6% annual growth from 1970, i.e., avg. growth '67 to '70 = 06%.

2. Nationwide Trans. Survey, '69-'70, D.O.T., Fed. Hwy. Adm., Office of Planning.

3. Air Transportation Facts & Figures, 1972, Air Transport Assoc., Wash., D.C.,; '73 = '72 + 10%.

4. Stat. Abs., #931, gives net ton mi. pass. as 70% of total net ton mi. for 1971.

5. Incidence of Air Travel in the United States, Table 8, A.T.A., gives 73% of trips as personal.

6. Stat. Abs., #898; assume 100% credited to personal travel.

7. Petroleum Facts, Am. Pet. Institute, p. 19; assume 1.0% annual growth in #2 heating since 1968.

8. Petroleum Facts, Am. Pet. Institute, p. 19; assume constant use of #1 since 1968.

9. Stat. Abs., #831; assume 7.08% growth rate from '71. (F.P.C., Power Survey, I-3-18.)
   Conversion at 10.5×10^3 BTU/Kwh. (Bur. of Mines).

10. Elec. Transport = 6×10^{12} Btu/yr (F.P.C., Power Survey, I-3-18).

11. Gas Facts, 1971, American Gas Association, Arlington, Va.; assume 5% annual growth from -'71 ('68-'71 rate).

12. Patterns of Energy Consumption, S.R.I., 1968 data x 9% annual growth (given by S.R.I.).

13. Patterns of Energy Consumption, S.R.I., 1968 data x slight decrease.

14. General Housing Characteristics, 1970, Bureau of Census, vol. I, p. 254; 1.8×10^6 homes with coal heat x 150×10^6 Btu (same as oil input).

15. General Housing Characteristics; 0.5×10^6 homes cook with wood x 12×10^6 Btu (cooking avg.) plus 0.8×10^6 homes heat with wood x 150×10^6 Btu (same as oil heat input).

Notes on Household Energy vs. National Energy Use and the Calculation of the Value of a Point

To calculate the percentage of energy used in the household the total of Table A or $25{,}322 \times 10^{12}$ Btu was divided by $75,409 \times 10^{12}$ Btu which was the total U.S. energy use in 1974 (Statistical Abstracts #82 & extrapolation). This gives household use, as defined in the game, as 34% of total energy use.

To calculate the value of a point or square, in the game, the total household use of $25{,}322 \times 10^{12}$ is divided by the total number of households - 69×10^6 (N.A.H.B), and a figure of 367×10^6 Btu/Hh./yr. is arrived at. This is a national average and must be increased to reflect the additional heating needs in Wisconsin. This is done by subtracting the national average for heating of about 125×10^6 Btu/Hh./yr. from the Wisconsin average of about 160×10^6 Btu/Hh./yr. -- and adding the difference to 367×10^6 Btu/Hh./yr. This total - 402×10^6 Btu/Hh./yr - is then used as the average for a Wisconsin household, and 1% of it is equal to 1 point in the game. A similar correction could be made for air conditioning, but was not deemed necessary since air conditioning is a relatively minor use. The derivation of home heating figures for Wisconsin is shown in Table B-2, a similar approach was used to calculate national average consumption.

TABLE B-1 - U.S. TRANSPORTATION ENERGY USE - 1974

	Satu- ration	10^6 Units	Per Unit Annual Consump- tion 10^6 Btu	Total U.S. Household Consump- tion 10^{12} Btu	Per Household Annual Average Consumption 10^6 Btu	Game Points Each Trip	Game Points Each Use
Automobiles	142	98	91	8,915	129		32.1
Airplane trips	195	134	5.8	780	11.3	1.4	2.8
Intercity bus trips	570	398	0.07	28	0.4	0.07	0.10
Intracity transit trips	1,000	7,000	0.02	135	0.2	0.02	0.05

Notes:

1) Automobile consumption figures come from Statistical Abstracts, #898.

2) Automobile saturation figures come from Statistical Abstracts, #891.

3) Airplane trip figures come from Stat. Abs., #932, corrected for percent personal trips using Air Transport Association figures. (Air trips are approximately 70% personal business.)

4) Airplane fuel use comes from Air Transport Association annual report.

5) Intercity bus trips come from Stat. Abs., #908.

6) Intercity fuel consumption comes from Stat. Abs., #908 and 898.

7) Intracity transit trips come from Stat. Abs., #910, wherein bus trips make up about two-thirds of intracity transit, the rest being subway, trolley, and commuter train.

8) Intracity transit fuel consumption comes from Stat. Abs., #910, assuming all intracity transit to have the same energy efficiency as buses.

9) All figures corrected for 1974 by extrapolation.

10) For an explanation of column headings, see Table B-3

TABLE B-2 - RESIDENTIAL HEATING IN WISCONSIN - 1970

Fuel	Saturation	10^3 Units	Total Wisconsin Consumption (10^{12} Btu)	Per Household Annual Average Consumption (10^6 Btu)	Game Points
Utility gas	49.3	654	114.5	175	43
L.P. gas	6.4	85	14.8	175	43
All distillate oil	39.4	521	74.3	143	36
Electricity	1.9	25	4.15	166	41
Coal	2.2	30	6.0	200	50
TOTAL	100 %	1,335	213.8	avg = 160	avg = 40

Notes:

1) Utility gas consumption comes from Foell, p. 10.

2) L.P. gas consumption comes from Wisconsin Energy Office.

3) Distillate oil consumption from Wisconsin Energy Office.

4) Electricity consumption comes from multiplying installed units from Census of Housing and per unit consumption from Wis. Power & Light Co. data. The per household figure is lower than might be expected, because a large fraction of the installed electric heat is in apartment units.

5) Coal consumption comes from multiplying installed units from Census of Housing and assuming per unit consumption to be slightly higher than gas or oil.

6) "Saturation" is a percentage of all Wis. households.

7) "Game points" are explained in Table A .

8) Average per household consumption obtained by dividing total consumption, by total heating units. $213.8 \times 10^{12} \div 1,335 \times 10^3 = 160$.

TABLE B-3 - MAJOR APPLIANCES - 1974

Appliance or Use	Saturation	Units Installed x 10^6	Per unit Annual Consumption KWHe	Per unit Annual Consumption BTU x 10^6	Total Consumption In U.S. Hh. BTU x 10^{12}	Average Consumption per Hh BTU x 10^6	% of an Average Wisconsin Household (Game Points) Ea Use	Ea Appl
Refrigerator								
elec. avg.	99	68.7	1,525	16.0	1,098	15.8	3.92	4.3
gas avg.		0.4		14.0	5			3.4
12 ft^3			728	7.6				1.8
14 ft^3			1,137	12.0				3.0
12 ft^3, f.f.			1,217	12.8				3.2
14 ft^3, f.f.			1,829	19.2				4.8
14 ft^3, tot. f.f.			2,004	21.0				5.2
side by side			2,796	29.6				7.4
Freezer	34	23.5	1,195	12.6	296.1	4.3	1.06	
15 ft^3			1,195	12.6				3.1
15 ft^3, f.f.			1,761	18.5				4.6
Range	100	69			803	11.7	2.9	
elec. avg.	61	42.1	1,175	12.3	517.8			3.1
gas (incl. LP)	39	26.9		10.6	285.1			2.6
self-clean			1,205	12.7				3.2
Other cooking	50		80	0.84	255	3.7	0.9	
broiler			100	1.0				0.25
deep fryer			83	.8				0.20
egg cooker			14	.1				0.03
fry pan	60	41.4	86	.9	37.3	0.5		0.24
hot plate	32	22.1	90	1.0	22.1	0.3		0.30
roaster			205	2.2				0.60
sandwich grill			33	.4				0.10
waffle iron			30	.3				0.10
Dishwasher	32	22.0	363	3.81	83.6	1.2	0.33	0.94

Appliance or Use	Saturation	Units Installed x 10^6	Per unit Annual Consumption KWHe
Washing Machine	96	66.2	100
Wringer			76
Automatic			103
Dryer	51	35.3	
Elec	34	23.4	993
Gas	17	11.9	
Iron	99	68.3	144
Lighting	100	69	825
5 rm house			800
6 rm house			950
8 rm house			1,275
post light			420
gas light			
TV			425
B&W-ordinary	150	103.5	350
B&W-instant on			525
Color	60	41.4	660
Color-instant on			835
Water Heat	95	65.7	
elec avg	35	24.2	4,500
gas	60	41.4	
elec normal			4,219
quick recovery			4,811
Air Conditioning		43.7	
central elec		8.9	2,000
central gas		0.3	
window (10^4 BTU)	50	34.5	860

Per unit Annual Consumption BTU x 10^6	Total Consumption In U.S. Hh. BTU x 10^{12}	Average Consumption per Hh. BTU x 10^6	% of an Average Wis. Household (Game Points)	
			Ea. Use	Ea. Appl.
1.05	69.5	1.0	0.3	
.8				0.20
1.1				0.30
9.93	350.6	5.1	1.25	
10.4	243.5			2.6
9.0	107.1			2.2
1.5	102.5	1.5	0.4	0.4
8.7	600	8.7	2.2	
8.4				2.1
10.0				2.5
13.4				3.3
4.4				1.1
18.6				4.6
4.5	668.6	9.7	2.4	
3.7	383.0	5.6		0.9
6.9	285.6	4.1		1.7
	2329	33.8	8.4	
47.3	1145			11.7
28.6	1184			7.1
44.3				11.0
50.5				12.6
11.2	488	7.1	1.75	
21.0	186			5.2
20.0	6			5.0
8.6	296.7			2.3

Explanation of Column Headings and Sources of Data:

Col. 1 - "Saturation" - is percent of households which have this appliance or device. Data is taken from Edison Electric Institute, p. 20, Stanford Research Institute, p. 33, Statistical Abstracts, tables 821 and 1162, and A.H.A.M.; and corrected for 1973 by extrapolation of past trends. Saturation for electric appliances is normally given as a percent of "wired households," which is close enough to the total number of households to present no problems.

Col. 2 - "Units installed" - represents the total number of units of any particular appliance or device installed in a home. In the case of electrical devices, this is derived from saturation figures; in the case of gas appliances, this comes from American Gas Association data.

Col. 3 - "Per unit annual consumption Kwh" is taken from S.R.I. and E.E.I. data and refers to individual appliance types.

Col. 4 - "Per unit annual consumption, Btu x 10^6" - represents a conversion to Btu's from other fuels at the following rates (Bureau of Mines)

natural gas --	1.035×10^3 Btu/c.f.
gasoline ------	12.7×10^3 Btu/gal.
diesel --------	13.6×10^3 Btu/gal.
jet fuel ------	13.4×10^3 Btu/gal.
electricity ---	10.5×10^3 Btu/Kwh

Col. 5 - "Total consumption in households, Btu x 10^{12}" - represents the total amount of energy used in all U.S. households by a particular appliance or device. It is obtained by multiplying col. 2, "units installed," and col. 4, "per unit annual consumption". In most cases, numbers are checked against end use figures from S.R.I., E.E.I., and Steinhart & Steinhart, and a reasonable match is assured. Totals for various fuels were also matched against Table A.

Col. 6 - "Average consumption per household, U.S., Btu x 10^6"- is obtained by dividing col. 5, "total consumption households, Btu x 10^{12}, by 69 x 10^6 households (National Mineral Wool Association). This column clearly differs from col. 4, "per unit annual consumption" because households have many types of units, and because the saturations are an even 100% in only a few cases. This column is necessary to provide data for the composite chart on the inside cover of the game.

Col. 7 - "End use as a % of the average Wisconsin household use" - represents the energy used by each appliance or device category as a % of Wisconsin average use per household (402 x 10^6 Btu/yr, obtained from Table A). These figures are used to prepare the composite chart on the inside cover of the game.

Col. 8 - "Individual appliance use as a % of average Wisconsin household use" represents the energy used by each specific appliance or device as a % of Wisconsin average use per household. These figures are equivalent to the "points" or "squares" which are used in the game.

Note:

The top row of each category of use, e.g., refrigerator, presents the average statistics for that use, while the rows underneath, e.g., 12 ft^3, present statistics for that particular type of refrigerator.

TABLE B-4 - MISCELLANEOUS APPLIANCES - 1974

Misc. Electric Appliances

	Kwh/ Yr	Game Points
Kitchen		
Blender	15	0.04
Carv.knife	8	0.02
Cof. Maker	106	0.30
Gar. dispos.	30	0.08
Mixer	13	0.04
Toaster	39	0.11
Trash comp.	50	0.14
Air cleaner	216	0.63
Clock	17	0.05
De-humidifier	377	1.09
Elec. blanket	147	0.44
Fan		
Attic	291	0.82
Table	43	0.10
Window	170	0.50
Floor polish.	15	0.04
Gar.door open.	10	0.03
Hair dryer	14	0.04
Heating pad	10	0.03
Humidifier	163	0.46
Port. heater	176	0.5
Sauna	200	0.6
Sewing mach.	11	0.04
Shaver	2	0.01
Sun lamp	13	0.04
Sump pump	231	0.7
Toothbrush	0.5	0.001
Vacuum cleaner	50	0.14
Vibrator	2	0.01

Yard and Shop Tools

	Gal/ Yr	10^6 Btu/ Yr	Game Points
Gasoline pow. yd. tools			
Chain-saw	1	0.12	.03
Mower	5	0.75	.2
Roto-tiller	1	0.12	.03
Shredder	1	0.12	.03
Sno-blower	2	0.24	.06
Tractor, lawn & garden	25	3.10	.8

	Kw	Hrs/ Yr	Kwh/ Yr	Game Points
Shop tools				
Arc-welder (110)	2.0	1-5	6	.02
Drill	0.5	5-10	4	.01
Drill press	1.0	5-10	8	.02
Grinder	1.0	1-5	3	.01
Jointer	1.0	10-20	15	.05
Lathe	1.0	20	25	.07
Saw, hand	1.0	5-10	8	.02
Saw, table	1.0	10-20	15	.04
Elec. yard tools				
Engine block heater	1.0	500	500	1.42
Roof & gutter heater	2.0	200	400	1.14
Mower	2.0	20-30	50	.14

Recreational Equipment

	Gal/ Yr	10^6 Btu/yr	Game Points
Mini-bike	25	3.2	0.8
Motor boat	50	7.5	1.6
Snow mobile	25	3.2	0.8
Trail bike	3.2	3.2	0.8

Notes:

1) Miscellaneous electrical appliances, consumption figures given in Kwh only come from Edison Electric data and Stanford Research Institute. Where power rating is given followed by hours of annual use, the power rating comes from the Sears Catalog or general observation and the annual use is an estimate.

2) Yard and garden tools are all estimated consumptions.

3) Recreational vehicle consumption figures are estimates.

4) To review how "game points" are calculated, see Table A.

TABLE C - UNITED STATES RESIDENTIAL FUEL USE - 1955

Fuel	10^{12} Btu	%
Coal	938	8.6
Gasoline	3,826	34.8
Oil	2,316	21.0
Nat. Gas	2,238	20.3
L. P. Gas	252	2.3
Electricity	1,350	12.3
	10,920	99.3

Notes:

1) Gasoline consumption corrected for 92% personal use (see Table B-1).

2) Heat rate for electric production = 10.8×10^3 Btu/Kwh. (*Stat. Abs.*)

3) All consumption figures from Schurr & Netschert, Table C-6, p. 602.

FUEL USE 1955 VS. FUEL USE 1975

Per Household

$10{,}920 \times 10^{12}$ Btu $\div$ 48.0×10^6 households = 229.2×10^6 Btu/household in 1955

229.2×10^6 Btu/H.h. $\div$ 367 / 10^6 Btu/H.h. = 62% ('55 as a % of '75)

Total Residential

$10{,}920 \times 10^{12}$ Btu $\div$ $25{,}300 \times 10^{12}$ Btu = 43% ('55 as a % of '75)

Notes:

1) No. of households in 1955 is taken from *Statistical Abstracts* # 50.

2) 1975 consumption, both per household and total, comes from Table A.

TABLE D-1 - UNITED STATES TRANSPORTATION ENERGY USE - 1955

Mode	10^{12} Btu	% 1955 Total Energy Use	Relative Game Points 1975	Change in Game Points 1955 to 1975
Automobile	3,826	34.8	21.6	+14.5
Diesel train	145	1.4	0.9	--
Electric train	6	--	--	--
Bus	85	0.8	0.5	--
Airplane	145	1.3	0.8	+ 2.3

Notes:

1) Consumption data from Statistical Abstracts, #820, 821, 898, 910, 920, 932.

2) Percent growth for each transportation category is data for "Box" on "1955 vs. 1975", p. 33
This figure is obtained by comparing "% 1955" with table B-1.

3) Electric train and bus are combination of both intercity and intracity use.

TABLE D-2 - HEATING - HOT WATER & AIR CONDITIONING 1955

	10^{12}BTU	% 1955 Total Energy Use	Relative Game Points 1975	Change in Game Points 1955 to 1975
Heating	4,315	39.2	24.3	+15.7
Hot Water	854	7.8	4.8	+ 5.4
Air Conditioning	17	0.2	0.1	+ 1.0

Notes:

1) Consumption data from Schurr & Netschert.

2) Growth figure is obtained by comparing the 1955 Btu consumption with the 1975 Btu consumption, table

TABLE D-3 - APPLIANCE USE - 1955

Appliance	10^{12} Btu	% 1955 Total Energy Use	Relative Game Points 1975	Change in Game Points 1955 to 1975
Refrigerator	204.1	1.8	1.1	+3.2
Freezer	90.7	0.8	0.5	+0.7
Cooking	490.0	4.5	2.8	+1.8
Dishwasher	--	--	--	+0.3
Dryer	44.2	0.4	0.2	+1.2
Lighting	412.0	3.7	2.3	+0.1
TV	128.0	1.2	0.7	+1.9
Misc.	380.0	3.0	2.0	+1.0

Notes:

1) Data from Schurr & Netschert for 1955.

2) 1975 comparison see table B-3.

APPENDIX A

SUGGESTED DISCUSSION QUESTIONS FOR TEACHERS

Questions of Fact

Look through the game and make up your own set of factual questions. Chances are that those things which were new to you would be worth noting. Comparison questions are a good way to challenge pre-conceptions.

Examples:

1) A refrigerator uses more energy than a washing machine? T __ F __ ?

2) Household energy use, as defined in the game, accounts for ____ % of national energy use?

Awareness Questions

Home affairs:

1) How much of your family's budget goes for energy? What will your family do if energy prices do double in the next ten years?

2) Are your parents/neighbors/friends concerned about energy conservation? Why? Why Not?

National implications:

1) Discuss the other uses of energy in the U.S.

2) How will limited energy be apportioned among various end uses?

Relationship to other subjects in school:

1) Why will clothes dry on the line at 0^{o}F.?
2) What kinds of opti s exist for changing clothing materials or styles?
3) Where does one go to learn about building construction - materials and technology?

Projects

1) Interview people of different generations and encourage them to compare past uses of energy to present uses of energy.

2) Assess energy use in your school building. Look at heating and cooling, lighting and power. How does the breakdown of various uses in the school compare with the home? Why is it different? What will the impact of increased energy costs be on the school budget? Make suggestions for energy conservation and quantify their probable effect.

3) Investigate passive (non-mechanical) solutions to heating, cooling and ventilating problems. Look at historic methods of design and construction of dwellings and see if you can apply any of these ideas to your present situation. The references below might be helpful.

Williams, Christopher, Craftsmen of Necessity (New York, New York: Random House, 1974).

Olgay, Victor, Design with Climate: bioclimatic approach to architectural regionalism (Princeton, New Jersey: Princeton University Press, 1963).

The Shelter Book

The Architectural Forum - July/August, 1973. Whole issue devoted to architecture and energy.

APPENDIX B

EVALUATION QUESTIONNAIRE

The answers given to this questionnaire are percentages of the sample, which was about 100. The intent of the questionnaire was to aid the authors in modifying the game to increase its clarity and simplicity. For instance, the answers to questions 4 and 7 indicate problems with the home heat section, and this was extensively changed as a result. Also, questions 11 and 12 aided in eliminating some material from the draft version. A number of the other questions showed a substantially clear perception of the purposes of the game and thus encouraged us to continue.

Questions About the Household Energy Game

Please check one answer to each of the following questions.

1). What do you feel was the main purpose of the game?
- (01) to make you feel bad about how much energy you use
- (07) to enable you to compare your energy use to the average
- (17) to tell you how to conserve energy
- (74) to help you understand how much energy you use and how you use it
- (01) none of the above

2). How much trouble did you have following the rules?
(09) a lot (24) some (51) a little (19) none

3). The size of your refrigerator is:
(06) less than 10 cubic feet (64) more than 10 cubic feet (30) don't know

4). The insulation in the outer walls of your house is:
(49) 3-4 inches thick (10) 2 inches thick (06) 1 inch or less (36) don't know

5). If you had an extra copy of the game would you send it to a friend or relative?
(59) yes (36) no

6). How much time did you spend playing the game?
(29) less than 1/2 hour (59) 1/2 - 1 hour (17) more than 1 hour

7). If your house had no insulation at all, you would save the most energy by insulating the:
(01) floor first (56) ceiling first (41) walls first

8). In 1955, the average household used about how much energy?
(89) 1/2 as much as today (01) same as today (02) more than today

9). A washing machine normally uses more energy than a refrigerator.
(11) true (60) false (30) don't know

10). Turning your thermostat down 10° at night will save you heating energy.
(91) true (06) false (06) don't know

The questions below refer to the informational "boxes" at the end of the game. Don't bother to answer them if you didn't read these "boxes."

11). If you had to reduce the number of "boxes", which two would you eliminate?
Write the numbers here: ________ ________

12). Which informational "boxes" did you find most interesting?
Write the numbers here: ________ ________

APPENDIX C

SOURCES OF "ENERGY SAVINGS HINTS"

A Consumer's Guide to Efficient Energy Use in the Home.
-- Gas Appliance Manufacturers Association, Arlington, Virginia

Be Watt Wise - Choosing a Room Air Conditioner.
-- Association of Home Appliance Manufacturers, Chicago, Illinois

Check Yourself: Are You an Average User of Electricity?
-- Northern States Power Company, Minneapolis, Minnesota

Citizen Action Guide to Energy Conservation.
-- Citizen's Advisory Committee on Environmental Quality, Washington, D.C.

Energy: Use It Wisely and Prudently.
-- Northern States Power Company, Minneapolis, Minnesota

Energy: Conservation - Earth Week 1973.
-- Environmental Action, Inc., Washington, D.C.

Energy Conservation - Eco Tips #5, February, 1973.
-- Concern, Inc., Washington, D.C.

Energy Conservation Checklist.
-- U.S. Department of Agriculture, Washington, D.C.

Energy Conservation Through Heat Recovery.
-- Northern National Gas Company

Gas: The Energy Saver.
-- Gasco, Honolulu, Hawaii

Guide to the Efficient Use of Energy on the Farm.
-- Wisconsin Power and Light Company, Madison, Wisconsin

How to Conserve Electricity and Gas for Increased Economy and Efficiency. -- Wisconsin Power and Light Company, Madison, Wisconsin.

How to Cut the Cost of Cooling Your Home.
-- Wisconsin Power and Light Company, Madison, Wisconsin

Key to Energy Crisis is a Change in Habits.
-- University of Wisconsin-Extension, Madison, Wisconsin

Making the Most of Energy.
-- Wisconsin Power and Light Company, Madison, Wisconsin

NSP Energy Savers.
-- Northern States Power Company, Minneapolis, Minnesota

101 Ways to Conserve Electricity at Home.
-- Commonwealth Edison, Chicago, Illinois

60 Energy Savers that Make Cents.
-- Northern States Power Company, Minneapolis, Minnesota

Wise Energy Management: It's Up to You.
-- Wisconsin Power and Light Company, Madison, Wisconsin

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APPENDIX D

ENERGY BUDGET COMPARISON - 10^6 Btu/Yr/HL.

Wisconsin Climate | U. S. Average

	Northern States Power	Mpls. Tribune	Wisconsin Power & Light	Household Energy Game	Citizen's Advisory Committee on E.Q.	John Tansil, Oak Ridge N.L.	Makhijani & Lichtenberg
Automobile				130	137		
Air travel				11	8		
Home heat	152	160		160	112	152*	106*
Hot water	30	23	45	34	25	45	47
Refrigerator	9-30	10-20	15	16		13	10
Freezer		12		13		13	10
Stove	13	13	12	12		12	13
Total cooking	15	26	15	15.5	18		
TV - Color		7	7	7		5	6
- B & W	4	5		3			3
Lighting	6	7	8.5	9		8	10
Room air conditioning		10	7.5	7	7	20	14
Central air conditioning				16			21
Gas yard light	18			19			

Notes: 1) All figures are on a per household basis, obtained by multiplying per unit figures times saturation figures. Saturation figures were corrected for 1974 by extrapolating past trends. (Stat. Abs. #1162; S.R.1; Tyrell)

2) Kwh converted to Btu using heat rate of 10.5×10^3 Btu/Kwh. (Stat. Abs. - #820)

3) Citations:

- .Northern States Power figures from a company booklet.
- .Mpls. Tribune article based on information from Mpls. Gas Co.
- .Wisconsin Power and Light figures from a company summary sheet.
- .Household Energy Game figures explained in tableB.
- .Citizen's Advisory Committee figures based on staff research and are national average data; which explains low home heat figures.
- .Oak Ridge National Laboratory, "Residential Consumption of Electricity" by John Tansil, compiled mainly from Edison Electric Institute data.

Note: All budgets except the Wisconsin Power and Light survey rely on electricity consumption data from the Edison Electric Institute. WPL is somewhat higher, because of the greater average income of its customers.