

AN EMPIRICAL STRATEGY FOR IDENTIFYING RESIDENTIAL ENERGY CONSERVATION TECHNIQUES*

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ABSTRACT

This study reports the results of a survey designed to identify potentially important energy conservation behaviors. Forty-four experts in the area of energy conservation were surveyed. These experts rated the importance and use of 201 energy conservation techniques. The survey results found a total of seventy-four specific conservation activities that were considered by the experts to be very important. In addition, the perceived frequency with which these techniques are used by residential energy consumers was also assessed. This empirical strategy for identifying important conservation techniques should be of interest to researchers attempting to select important behaviors for energy-related research and to consumers attempting to make critical changes in their residential use of energy.

Energy conservation has been identified as a method of saving money for consumers [1], reducing detrimental impacts of energy use and production [2, 3], and reducing both the national rate of inflation and U.S. reliance on foreign oil [4]. Further, conservation has been viewed as an important "source"

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of additional energy that will provide the time needed to develop alternative energy sources [5].

Accordingly, research on methods of reducing energy consumption has been extended to a variety of target behaviors and procedures. For example, prompts, such as signs [6–8] and mechanical signals of improper equipment use [9] have been used to reduce electricity consumption. Feedback on consumption has been used frequently to reduce residential electricity use [1, 10–16], home heating oil use [17], and automobile use [18]. Finally, incentives such as monetary rebates have been used to promote electricity conservation [11, 19–22], reduce miles driven in private cars [23], and increase bus ridership [24–27]. These behavioral research studies have examined the effects of experimenter-developed procedures on experimenter-selected conservation target behaviors. In most cases, the rationales for selecting one conservation technique for examination rather than another, were unclear.

The contributions of behavioral research to energy conservation might be enhanced by an empirical strategy for identifying important energy conservation techniques. Energy researchers are faced with a wide variety of choices for conservation target behaviors. For example, should techniques for promoting car pooling or nighttime temperature setback be examined? An empirical approach to identifying important research goals might lead to more efficient developments in the application of behavioral research methods to energy conservation.

One empirical approach to selecting potentially important target behaviors is through the process of social validation. Wolf suggests that the social significance of research goals might be clarified by identifying and polling individuals with special expertise in an area [28]. Thus, a social validation of energy conservation techniques might involve the identification of energy experts who could evaluate the importance of conservation techniques identified in the literature. An additional assessment of how frequently important techniques are used by energy consumers would be helpful in identifying critical behaviors for future research efforts. The purpose of the present study was to conduct such a social validation of residential energy conservation techniques.

METHODS

Participants

Ninety-eight individuals, identified as having expertise in the area of energy conservation, were asked to participate in this study. These individuals included the authors of recent energy-related publications, employees of government organizations concerned with energy management (e.g., Federal Energy Administration, State Energy Offices, County Extension Services), and employees of private sector organizations involved in the production, delivery,

Table 1. Categories of Energy Conservation Techniques

<i>Category</i>	<i>Sample Item</i>	<i>Number of Items in Category</i>
Lighting	Use natural illumination.	11
Yard and Workshop	Plant deciduous trees on south and west sides of house.	8
Electrical Appliances	Dry clothes on clothes line instead of in dryer.	33
Solid Waste Management	Buy returnable containers.	9
Food Preparation and Storage	Turn off all appliances when you're finished with them.	34
Cooling and Heating	Insulate all surfaces exposed to outside temperatures.	18
Cooling	Open windows to cool the house when possible.	14
Heating	Keep thermostat set at 65° or less.	15
Transportation	Join a car pool for commuting to and from work.	29
Water Heating	Turn water heater off if it will not be used for an extended period of time.	30

or management of energy resources (e.g., Edison Electric Institute; American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.). Of the ninety-eight individuals or organizations to which energy conservation questionnaires were mailed, forty-four completed and returned the questionnaire. These experts resided in twenty-seven different states and the District of Columbia, representing each of the geographic regions of the United States.

The Energy Conservation Questionnaire

A literature review was conducted in order to identify potentially effective energy conservation techniques. The review included pamphlets (e.g., [29, 30]), books (e.g., [31, 32]), research articles (e.g., [1]), and review articles (e.g., [33, 34]). This review yielded 201 different energy conservation techniques that were classified into ten major categories. Table 1 identifies each category and provides one example of a technique included in each category.

This information was used to develop a questionnaire that listed the 201 specific energy conservation techniques. Each participant was asked to rate the importance of each technique as a method for conserving energy and to rate how commonly each technique was used by consumers. These evaluations were provided in the form of ratings on a five-point scale, where 0 corresponded to not important/common and 4 corresponded to very important/common. Below is an example of the questionnaire format:

	<i>How important is this technique in conserving energy?</i>					<i>How commonly is this technique used by consumers?</i>				
	<i>Very</i>		<i>Not</i>			<i>Very</i>		<i>Not</i>		
<i>Cooling and Heating</i>										
Keep filters on heating and cooling equipment clean.	4	3	2	1	0	4	3	2	1	0
Keep radiators, wall units, and baseboard units free of dust.	4	3	2	1	0	4	3	2	1	0

The final section of the questionnaire asked participants to rate the comprehensiveness of each section of the questionnaire (e.g., Lighting) and the overall comprehensiveness of the instrument using a similar five-point scale.

Procedures

The questionnaire was mailed to the ninety-eight energy experts, who were asked to rate each item and return the questionnaire to the investigators. An accompanying cover letter described the purpose of the study and provided instructions for completing the questionnaire. A stamped, self-addressed envelope was also provided.

To determine the judges' overall evaluation of the importance and use of the techniques, the rating data for each technique were converted into a percentage¹ using the following equation:

$$\frac{n4 + n3 + n2 + n1 + n0}{N4} \times 100 = \text{per cent importance/use}$$

RESULTS

The energy conservation questionnaire contained a total of 201 different energy conservation techniques. The median ratings of importance for individual items ranged from 30 to 96 per cent. The median ratings of how commonly these techniques are used by consumers ranged from 8 to 65 per cent. A total

¹ This formula was developed by Don Bushell, Jr. in his work with S.C.A.L.E. (The School Client's Annual Local Evaluation).

of 74 of the 201 items received a median importance rating of 75 per cent or greater. Table 2 lists these seventy-four items and displays their median ratings of importance and use.²

Each of the ten general categories of energy conservation techniques included in the questionnaire contained some items that were identified by the experts as 75 per cent or more important. Table 3 lists each of these categories, the number of techniques included in each category, the number of items rated as greater than or equal to 75 per cent important, and the median importance rating for the category.

The experts rated the overall comprehensiveness of the energy conservation questionnaire at 91 per cent. The comprehensiveness ratings for individual categories ranged from 85 per cent for the category of Lighting to 95 per cent for the category of Electrical Appliances.

DISCUSSION

Of the 201 techniques identified in the energy conservation literature, seventy-four received high importance ratings (i.e., 75% or higher) by this group of energy experts. Further, of the seventy-four techniques rated as important by the experts, none were rated by these experts as being very commonly used by consumers ($\bar{x} = 43\%$). While the majority of these techniques were included in categories related to space heating and cooling, water heating, and transportation, all categories of energy conservation behaviors contained at least two important techniques.

Although some general areas of conservation, such as heating and cooling, may be particularly important, specific behaviors (e.g., joining a car pool) in other categories may also be very important. Concentration on only space heating and cooling, transportation, and water heating would neglect important endeavors in the areas of solid waste management, selection and use of electrical appliances, food preparation and storage, lighting, and yard and workshop. Thus, *promotion* of specific behaviors of apparent importance in a *variety* of areas of conservation may be a more appropriate strategy for researchers and consumers.

The rating data on importance and use might be helpful in the development of educational programs or information systems designed to aid consumers in making decisions regarding which energy conservation techniques to adopt or which behaviors to modify. It may also aid researchers in the selection of target behaviors, allowing researchers to focus their efforts on those behaviors that experts consider to be most important, but least commonly used. Regional information on specific energy conservation behaviors of importance and infrequent use could be generated by surveying experts from the local geographic

² A list of the median ratings of importance and use for all 201 energy conservation techniques is available upon request from the authors.

Table 2. Median Ratings of Importance and Use for Techniques Receiving a Median Importance Rating $\geq 75\%$

<i>Energy Conservation Technique</i>	<i>Median Importance Rating (%)</i>	<i>Median Use Rating (%)</i>
1. Join a car pool for commuting to and from work.	96	28
2. Insulate all surfaces exposed to outside temperatures.	96	52
3. Keep windows and doors tightly closed when heating or cooling equipment is on.	96	59
4. Close damper when fireplace is not in use.	96	58
5. Walk or bicycle whenever possible.	96	29
6. Weatherstrip and caulk around windows, doors, and chimneys.	95	53
7. During warm weather, open windows to cool the house when possible.	94	54
8. Use public transportation whenever possible.	94	33
9. During cold weather, keep thermostat set at 65° or less.	94	39
10. Dress for cooler temperatures.	93	52
11. During warm weather, keep thermostat set at 78° or higher.	93	45
12. During cold weather, use night time thermostat set backs.	93	46
13. Install storm doors and windows.	92	63
14. Dry clothes on clothes line instead of dryer.	92	29
15. Plan short trips carefully and consolidate driving by combining short trips.	91	39
16. Adequately insulate ducts.	91	46
17. Keep your car's engine properly maintained.	91	47
18. Use awnings, shades or shrubs to keep heat out.	90	46
19. Turn the heat down when you leave.	90	47
20. Use natural illumination.	89	46

Table 2. (Cont'd.)

<i>Energy Conservation Technique</i>	<i>Median Importance Rating (%)</i>	<i>Median Use Rating (%)</i>
21. Turn water heater off if it will not be used for an extended time period.	88	23
22. Dress for warmer temperatures.	88	55
23. Ventilate attics and crawl spaces.	88	53
24. Lower water heater thermostat setting to 120° (140° if you have a dishwasher).	87	42
25. Drive at moderate speeds.	87	48
26. Turn off window air conditioner units when you leave for several hours.	87	43
27. Drive at steady speeds.	87	46
28. Only heat the rooms in use by shutting off unused rooms.	87	41
29. Buy returnable containers.	86	32
30. Turn off the gas pilot light on the furnace during the summer.	85	46
31. Recycle materials.	85	30
32. During cold weather, use quilts, comforters, or several light blankets on beds.	85	60
33. Place thermostats on an interior wall away from drafts, appliances, sunlight, and fireplaces.	84	56
34. Buy products that will last.	84	48
35. Have heating, cooling, and ventilation systems checked annually; repair if necessary.	84	39
36. Turn all appliances off when you're finished.	83	65
37. Patronize stores in your immediate area.	83	43
38. Keep filters on heating and cooling equipment clean.	83	46
39. Select the most efficient appliances (in terms of hot water and electricity required).	83	47
40. Install a whole house ventilating fan in attic or upstairs window.	83	31

Table 2. (Cont'd.)

<i>Energy Conservation Technique</i>	<i>Median Importance Rating (%)</i>	<i>Median Use Rating (%)</i>
41. Use drapes and shades to allow sun in and prevent heat loss in cold weather.	82	49
42. Insulate water heater tank.	81	35
43. Turn off lights that are not in use.	81	62
44. Buy products made of recycled material or material that can be recycled.	81	34
45. When shopping for an unusual item, telephone ahead to see who has it.	80	35
46. Avoid excessive engine idling in automobile.	80	35
47. Locate window air conditioning units on north and/or shady side of the house.	80	35
48. Close windows and doors during the hottest part of the day.	80	50
49. Avoid unnecessary use of air conditioning.	79	32
50. Keep wheels properly aligned and tires filled with air.	79	45
51. Don't run dishwasher until there is a full load.	79	50
52. Reduce duration of showers.	79	38
53. Use appropriate water temperature, water level and washing time for the type and size of laundry load.	79	52
54. Select washing machine with controls that permit rinsing with cold water regardless of wash cycle temperature.	78	47
55. Plant deciduous trees on the south and west sides of the house.	78	38
56. Take short showers instead of baths.	78	44
57. Bake several things at once rather than heating the oven several times.	78	45
58. Take a train or bus instead of the family car on vacation.	78	22

Table 2. (Cont'd.)

<i>Energy Conservation Technique</i>	<i>Median Importance Rating (%)</i>	<i>Median Use Rating (%)</i>
59. Install flow restricter in the shower.	78	26
60. Avoid driving during peak traffic times.	77	31
61. Don't pump the accelerator or race the engine when your car isn't moving.	77	48
62. Don't set thermostat lower than normal when you first turn on the air conditioner.	77	37
63. Vacation at or close to home.	77	40
64. Make sure refrigerator door seals well.	77	42
65. With a manual transmission, run through the lower gears gently and quickly and build speed in high gear.	76	46
66. Always rinse clothes with cold water.	76	46
67. Open and close refrigerator doors as little as possible.	76	40
68. Turn off dishwasher during drying cycle and allow dishes to air dry.	76	31
69. Drive your car slowly the first few blocks instead of idling it to warm it up.	76	37
70. Make sure oven door seals well.	75	33
71. Recirculate materials (e.g., to secondhand stores, service centers, etc.).	75	40
72. Don't leave equipment on unnecessarily.	75	43
73. Don't set thermostat higher than normal when you first turn it on.	75	43
74. Turn off all lights and equipment after use.	75	60

region. Such data might permit greater flexibility in program development for local areas, allowing adaptation to a variety of individual lifestyles in a variety of climatic situations.

It should be emphasized that these social validation data provide information on the importance of *goals* for energy conservation. The data do not provide

Table 3. Median Importance Ratings of Categories and Number of Items Within Categories Receiving Median Importance Ratings $\geq 75\%$

<i>Category</i>	<i>Number of Items In Category</i>	<i>Category's Median Importance Rating (%)</i>	<i>Number of Items Rated $\geq 75\%$</i>
Cooling and Heating	18	79.2	10 (56%)
Transportation	29	76.5	18 (62%)
Cooling	14	74.1	10 (71%)
Solid Waste Management	9	71.5	5 (56%)
Heating	15	70.0	8 (53%)
Water Heating	30	67.1	10 (33%)
Electrical Appliances	33	64.4	4 (12%)
Food Preparation and Storage	34	58.8	5 (15%)
Lighting	11	58.7	2 (18%)
Yard and Workshop	8	58.3	2 (25%)
TOTAL	201	64.1	74 (37%)

information on the effectiveness of practicality of specific techniques with specific individuals in specific situations. It is hoped that these findings stimulate more research into the effectiveness of practical methods for promoting adoption of important energy conservation techniques or the modification of important conservation behaviors.

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