Energy_Surveys_Tips

Wednesday, April 30, 2025 3:47 PM

https://www.teachgreenpsych.com/wp-content/uploads/2018/01/Gardner-Stern-2008-The-short-list-The-most-effective-actions-U.S.-households-can-take-to-curb-climate-change.pdf?utm_source=chatgpt.com

https://www.oecd.org/en/data/datasets/pisa-2015-database.html

https://aistudio.google.com/prompts/1vroHq7TAQgqof9bZIagWzjtvjCBvGxsj

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Are there any studies that have measured the perceived, psychological difficulty of either 1) changing energy behavior generally; 2) Reducing usage of particular appliance; 3) Implementing various energy savings tips ?

Are there any studies that have collected estimates about how frequently participants use various types of appliances?

List all studies that have had participants estimate energy usage of particular appliances.

Starke Thesis Appendix has feasibility ratings for a ton of energy savings actions

- Starke, A. D. (2019). *Supporting energy-efficient choices using Rasch-based recommender interfaces* [Phd Thesis 1 (Research TU/e / Graduation TU/e), Technische Universiteit Eindhoven].
- https://pure.tue.nl/ws/portalfiles/portal/119737279/20190226_CO_Starke.pdf
- https://osf.io/iz4wt/files/osfstorage

Attari Tech Survey

https://osf.io/gt46s/
https://osf.io/gt46s/wiki/home/

DeWaters, J., & Powers, S. (2013). Establishing Measurement Criteria for an Energy Literacy Questionnaire. *The Journal of Environmental Education*, *44*(1), 38–55. https://doi.org/10.1080/00958964.2012.711378

Chiu, M.-S., & DeWaters, J. (2018). Development and Validation of the Energy-Issue Attitude Questionnaire: Relations with Energy Knowledge, Affect, and Behavior. Journal of Advances in Education Research, 3(1), 25-37.
https://doi.org/10.22606/jaer.2018.31003
https://aistudio.google.com/prompts/1x9OLfngF6avIMzfoEC_E2z7dIWWBDqbl

1. Energy-Issue Attitude Questionnaire (EIAQ)

This questionnaire was developed for the study and focuses on student attitudes toward energy issues, organized into ten constructs presented as five pairs with inherent tension.

- **Response Scale:** 5-point Likert-type scale ranging from 5 (Agree strongly) to 1 (Disagree strongly).
- **Source for Items:** Table 1 in the paper.

Constructs and Items:

a. Energy-Saving Knowledge

1. Earth's resources are limited and will be used up one day.
2. Human activities spend a lot of energy, which is the main reason why Earth's resources are running out.
3. Humans conserving energy can prevent Earth's resources from being used up so fast.
4. Using less electricity can conserve energy.

b. Carbon-Reducing Knowledge

5. Earth's temperature keeps rising, which causes climatic anomaly.
6. Greenhouse gas produced by humans (e.g., CO2) is the main reason why Earth's temperature keeps rising.
7. Reducing greenhouse gas produced by humans can slow down Earth's increase in temperature.
8. Using less electricity can reduce the release of greenhouse gas.

c. Having Lifestyle

9. Making lots of money is important.
10. If I were rich, I would choose to live in a mansion.
11. Having a car (especially expensive cars) is very important.
12. Being able to shop often is important.

d. Being Lifestyle
13. Being able to lead a simple life is bliss.
14. Living in a healthy, energy-conserving home is important.
15. Use personal cars only when it's necessary.
16. I only buy what I really need.

e. Questioning Authorities
17. Powerful countries need to use more resources. (Reversed)
18. The government needs to use more energy than the common public. (Reversed)
19. Major industries need to use more energy. (Reversed)
20. Rich and powerful people need to use more resources. (Reversed)

f. Conforming to Authorities
21. Powerful countries should lead everyone to reduce carbon emissions.
22. If the government introduces good energy-conservation/carbon-reduction policies, I'd be pleased to follow them.
23. If powerful people (e.g., the president, school principals, business owners, and major industries) take part in energy-conservation/carbon-reduction, I would follow their action.
24. Religious people will follow energy-conservation/carbon-reduction campaigns led by religious leaders.

g. Technology Approaches
25. Complete switch to renewable energy can promote energy-conservation/carbon-reduction.
26. Inventing energy-conserving electronics and vehicles can promote energy-conservation/carbon-reduction.
27. Choosing eco-friendly, energy-conserving materials to build houses can promote energy-conservation/carbon-reduction.
28. Reinforcing eco-friendly and energy-conservation-related industries can promote energy-conservation/carbon-reduction.

h. Nature Approaches
29. Planting trees and protecting forests can promote energy-conservation/carbon-reduction.
30. Back-to-nature farming can promote energy-conservation/carbon-reduction.
31. Buying natural, eco-friendly merchandises can promote energy-conservation/carbon-reduction.
32. Reinforcing local production of goods can promote energy-conservation/carbon-reduction.

i. Future Goals
33. Energy-conservation/carbon-reduction is to allow our future generations to have a better life.
34. Energy-conservation/carbon-reduction is to prevent humans' liveable environment from early obliteration.
35. Energy-conservation/carbon-reduction is to allow humans to thrive for a long time.

j. Present Goals
36. Energy-conservation/carbon-reduction has a direct relationship with my current life.
37. Energy-conservation/carbon-reduction is to prevent natural disasters.
38. Energy-conservation/carbon-reduction is to allow us to lead a better life at the present.

2. Energy Literacy Questionnaire (ELQ)

This questionnaire was adapted from the DeWaters & Powers (2011) ELQ for the Taiwanese context. The paper describes the sections and adaptations but does not list all the items used.

Sections:

- **a. Energy Knowledge:**
  - Adapted from the original high-school version (38 items).
  - 12 items were slightly changed (e.g., country names, answers based on local context like oil imports).
  - 5 items were deleted due to difficulty obtaining single correct answers in the Taiwanese context.
  - **Resulting items in this study:** 33 items.
  - **Format:** Multiple choice (one correct answer from five choices).
  - *(Note: The specific 33 items are not listed in the paper).*
- **b. Energy Affect:**
  - Adapted from the original ELQ (17 items).
  - All 17 items were kept, with only country names changed where necessary.
  - **Resulting items in this study:** 17 items.
  - **Format:** 5-point Likert-type scale (5 = strongly agree to 1 = strongly disagree).
  - **Sample Item:** 'Saving energy is important'.
  - *(Note: The specific 17 items are not listed in the paper).*
- **c. Energy Behavior:**
  - Adapted from the original ELQ (10 items).
  - 2 items (heater/air-conditioner usage) were excluded as not fitting the Taiwan context well.
  - 1 item text was adapted slightly for context ('I turn off electronics (such as televisions and computers)...' assuming not all students had computers).
  - **Resulting items in this study:** 8 items.
  - **Format:** 5-point Likert-type scale (5 = almost always or always to 1 = hardly ever or never).
  - **Sample Item:** 'I turn off electronics (such as televisions and computers) when they are not being used'.
  - *(Note: The specific 8 items are not listed in the paper).*

DeWaters, J. E., & Powers, S. E. (2011). Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. Energy Policy, 39(3), 1699–1710. https://doi.org/10.1016/j.enpol.2010.12.049

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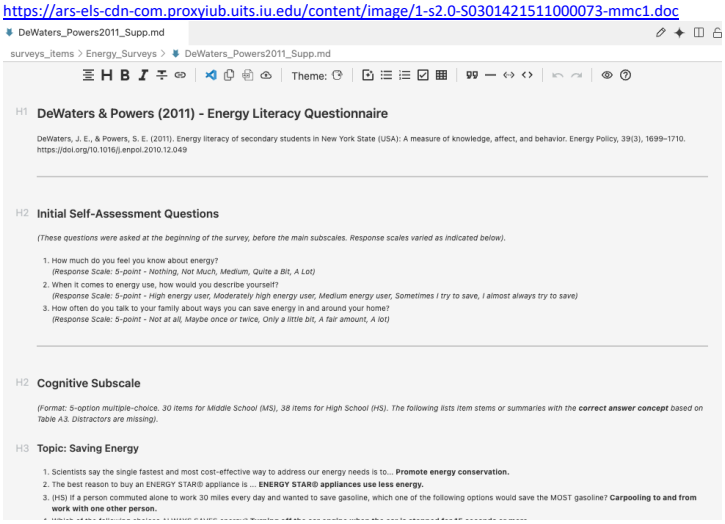

4. Which of the following choices ALWAYS SAVES energy? **Turning off the car engine when the car is stopped for 15 seconds or more.**

H3 Topic: Forms, Conversions, Units

5. The amount of ELECTRICAL ENERGY (ELECTRICITY) we use is measured in units called ... **Kilowatt-hours (kWh).**
6. The amount of ENERGY consumed by an electrical appliance is equal to ... **The power rating of the appliance (watts or kilowatts) multiplied by the time it's used.** *(Note: Wording simplified for MS version).*
7. We know that a piece of wood has stored chemical potential energy because ... **It releases heat when burned.**
8. (HS) When you turn on an incandescent light bulb, the following energy conversion takes place: **Electrical energy to radiant energy (light) and thermal energy (heat).**
9. (MS) When you turn on an incandescent light bulb, some of the energy is converted into light and the rest is converted into ... **Heat.**
10. (HS) The energy conversion for a battery powered flashlight is ... **chemical energy – electrical energy – light energy.**

H3 Topic: Home Energy Use

11. Which uses the MOST ENERGY in the average American home in one year? **Heating and cooling rooms.**
12. Which uses the LEAST ENERGY in the average American home in one year? **Lighting the home.**
13. Which of the following items uses the MOST ELECTRICITY in the average American home in one year? **Refrigerator.**

H3 Topic: Basic Energy Concepts

14. Each and every action on Earth involves... **Energy.**
15. The original source of energy for almost all living things is ... **the Sun.**
16. Energy is defined as ... **The ability to do work.**
17. All of the following are forms of energy EXCEPT... **Coal.**
18. What does it mean if an electric power plant is 35% efficient? **For every 100 units of energy that go into the plant, 35 units are converted into electrical energy.**
19. It is impossible to... **Build a machine that produces more energy than it uses.**

H3 Topic: Energy Resources

20. Most of the Renewable Energy used in the United States comes from ... **Water (hydro) power.**
21. Which is the most abundant fossil fuel found in the United States? **Coal.**
22. Over the last 10 years, petroleum imports to United States from other countries have ... **Steadily increased and Become more expensive.**
23. Which resource provides about 85% of the energy used in developed countries like the United States and Europe? **Fossil fuels.**
24. Which resource provides MOST of the ENERGY used in the United States each year? **Petroleum.**
25. Most of the ELECTRICITY produced in the United States comes from ... **Burning coal.**
26. (HS) Which country provided the single largest volume of oil imported to the United States in 2007? **Canada.**
27. (HS) Which of the following is NOT currently used to produce electricity? **Nuclear fusion.**
28. (HS) Many useful manufactured products are made out of which of the following energy resources? **Petroleum.**
29. (HS) Renewable energy resources provided approximately **[between 2% and 15%]** of the total U.S. energy consumption at the end of 2007. *(Note: Exact percentage range might have been options).*
30. The term "renewable energy resources" means ... **Resources that can be replenished by nature in a short period of time.**
31. Which of the following energy resources is NOT renewable? **Coal.**

H3 Topic: Critical Analysis about Renewable Resources

32. Some people think that if we run out of fossil fuels we can just switch over to electric cars. What is wrong with this idea? **Most electricity is currently produced from fossil fuels (coal, oil, natural gas).**
33. (HS) Select the choice that makes the following statement TRUE: Renewable energy resources like wind and solar are STILL HARMFUL to human health and the environment because ... **It takes a lot of energy and material to manufacture wind turbines and photovoltaic (solar) cells.**
34. (MS) Which of the following is NOT a biofuel? **Gasoline.**
35. (HS) Indicate which of the following statements is FALSE: Currently, there is a growing interest in biofuels like ethanol in the United States because ... **Cars that run on ethanol get better gas mileage than cars that run on gasoline.**

H3 Topic: Environmental Impacts

36. One advantage to using nuclear power instead of coal or petroleum for energy is that... **There is less air pollution.**
37. Many scientists say the Earth's average temperature is increasing. They say that one important cause of this change is... **Increasing carbon dioxide concentrations from burning fossil fuels.**
38. Which of the following energy-related activities is LEAST harmful to human health and the environment? **Generating electricity with photovoltaic (solar) cells.**
39. (HS) Which of the following correctly describes how radioactive waste from nuclear power plants is CURRENTLY managed? **It is stored on-site at the nuclear power plant.**

H3 Topic: Societal Issues related to Energy

40. (HS) Which of the following statements is FALSE? **People who live in countries that have large amounts of fossil fuel resources generally have a high standard of living.**

DeWaters, J., Qaqish, B., Graham, M., & Powers, S. (2013). Designing an Energy Literacy Questionnaire for Middle and High School Youth. *The Journal of Environmental Education*, *44*(1), 56–78.
https://doi.org/10.1080/00958964.2012.682615
https://aistudio.google.com/prompts/1vroHq7TAQggof9bZIagWzjtvjCBvGxsj

APPENDIX
Final Survey Items

Cognitive items (correct multiple choice option in bold)

1. Energy is defined as . . . **The ability to do work**.
2. The amount of ELECTRICAL ENERGY (ELECTRICITY) we use is measured in units called . . . **Kilowatt-hours (kWh).**
5. (HS) The amount of ENERGY consumed by an electrical appliance is equal to . . . **The power rating of the appliance (watts or kilowatts) multiplied by the time it's used.**
5. (MS) The two things that determine the amount of ELECTRICAL ENERGY (ELECTRICITY) an electrical appliance will consume are . . . **The power rating of the appliance (watts or kilowatts), and the length of time it is turned on.**
6. (HS) The energy conversion for a battery-powered flashlight is: **chemical energy → electrical energy → light energy.**
7. We know that a piece of wood has stored chemical potential energy because . . . **It releases heat when burned**.
8. All of the following are forms of energy **EXCEPT** . . . **Coal.**
9. (HS) When you turn on an incandescent light bulb, the following energy conversions take place: **Electrical energy to radiant energy (light) and thermal energy (heat)**.
9. (MS) When you turn on an incandescent light bulb, some of the energy is converted into light and the rest is converted into . . . **Heat**.

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APPENDIX
Final Survey Items *(Continued)*

10. What does it mean if an electric power plant is 35% efficient? **For every 100 units of energy that go into the plant, 35 units are converted into electrical energy.**
11. It is impossible to . . . **Build a machine that produces more energy than it uses**.
12. The original source of energy for almost all living things is . . . **the Sun.**
13. The term "renewable energy resources" means . . . **Resources that can be replenished by nature in a short time.**
14. Which of the following energy resources is NOT renewable? **Coal.**
17. (HS) Many useful manufactured products are made out of which one of the following energy resources? **Petroleum.**
18. Most of the RENEWABLE ENERGY used to produce electricity in the United States comes from . . . **Water (hydro) power.**
19. Which resource provides about 85% of the energy used in developed countries like the United States and Europe? **Fossil fuels.**
20. Which is the most abundant fossil fuel found in the United States? **Coal**.
22. Some people think that if we run out of fossil fuels we can just switch over to electric cars. What is wrong with this idea? **Most electricity is currently produced from fossil fuels (coal, oil, natural gas).**
24. (HS) Indicate which of the following statements is FALSE: Currently, there is a growing interest in biofuels like ethanol in the United States because . . . **Cars that run on ethanol get better gas mileage than cars that run on gasoline.**

(new) (MS) Which of the following choices is NOT a biofuel? **Gasoline**

25. Which of the following choices ALWAYS SAVES energy? **Turning off the car engine when the car is stopped for 15 seconds or more.**
27. If a person commuted alone to work 30 miles every day and wanted to save gasoline, which one of the following

options would save the MOST gasoline? **Carpooling to and from work with one other person.**
28. Scientists say the single fastest and most cost-effective way to address our energy needs is to . . . **Promote energy conservation.**
30. (HS) Which of the following is NOT currently used to produce electricity? **Nuclear fusion.**
32. Each and every action on Earth involves . . . **Energy.**
35. Which uses the MOST ENERGY in the average American home in one year? **Heating and cooling rooms.**
(new) Which uses the LEAST ENERGY in the average American home in one year? **Lighting the home.**
36. Which of the following items uses the MOST ELECTRICITY in the average American home in one year? **Refrigerator.**
37. Which resource provides MOST of the ENERGY used in the United States each year? **Petroleum.**
38. ((HS) Renewable energy sources provided approximately what percentage of total United States' energy consumption at the end of 2011? **Between 2% and 15%.**
39. Most of the ELECTRICITY produced in the United States comes from . . . **Burning coal.**
40. (HS) Which of the following statements is FALSE? **People who live in countries that have large amounts of fossil fuel resources generally have a high standard of living.**
41. Over the past 10 years, petroleum imports to United States from other countries have . . . **Steadily increased and become more expensive.**
(new) (HS) Which country provided the single largest volume of oil imported to the United States in 2007? **Canada.**
42. Many scientists say the Earth's average temperature is increasing. They say that one important cause of this change is . . . **Increasing carbon dioxide concentrations from burning fossil fuels.**
44. (HS) Which of the following correctly describes how radioactive waste from nuclear power plants is CURRENTLY managed? **It is stored on-site at the nuclear power plant.**
45. One advantage to using nuclear power instead of coal or petroleum for energy is that . . . **There is less air pollution.**
48. Which of the following energy-related activities is LEAST harmful to human health and the environment? **Generating electricity with photovoltaic (solar) cells.**
49. (HS) Select the choice that makes the following statement TRUE: Renewable energy resources like wind and solar are STILL HARMFUL to human health and the environment because: . . . **It takes a lot of energy and material to manufacture wind turbines and photovoltaic (solar) cells.**

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APPENDIX
Final Survey Items *(Continued)*

50. The best reason to buy an ENERGY STAR® appliance is . . . **ENERGY STAR appliances use less energy.**

Affective (attitude) items (5-point Likert-scale option described below)

52. Energy education should be an important part of every school's curriculum.
53. I would do more to save energy if I knew how.
55. Saving energy is important.
57. We don't have to worry about conserving energy, because new technologies will be developed to solve the energy problems for future generations.
58. All electrical appliances should have a label that shows the resources used in making them, their energy requirements, and operating costs.
59. The government should have stronger restrictions about the gas mileage of new cars.
61. We should make more of our electricity from renewable resources.
62. America should develop more ways of using renewable energy, even if it means that energy will cost more.
63. Americans should conserve more energy.
64. Efforts to develop renewable energy technologies are more important than efforts to develop new sources of fossil fuels.
65. Laws protecting the natural environment should be made less strict in order to allow more energy to be produced.
67. More wind farms should be built to generate electricity, even if the wind farms are located in scenic valleys, farmlands, and wildlife areas.
68. More oil fields should be developed as they are discovered, even if they are located in areas protected by environmental laws.
71. The way I personally use energy does not really make a difference to the energy problems that face our nation.
72. I believe that I can contribute to solving the energy problems by making appropriate energy-related choices and actions.
73. I believe that I can contribute to solving energy problems by working with others.
74. I don't need to worry about turning lights and computers off in the classroom, because the school pays for the electricity.

Behavioral Items (5-point Likert-scale option described below)

75. I try to save water.
77. I walk or bike to go short distances, instead of asking for a ride in the car.
78. When I leave a room, I turn off the lights.
79. I turn off the computer when it is not being used.
80. Many of my everyday decisions are affected by my thoughts on energy use
81. My family turns the heat down at night to save energy.
82. I am willing to encourage my family to turn the heat down at night to save energy.
83. My family buys energy efficient compact fluorescent light bulbs.
84. I am willing to encourage my family to buy energy-efficient compact fluorescent light bulbs.
85. I am willing to buy fewer things in order to save energy.

Table notes: Item numbers refer to original order in item pool, not to numbers used in survey forms. Items with no number (new) were created after second pilot.

(HS) and (MS) denote items used only in high school or middle school survey form, respectively.

Attitude and Behavior items use a 5-point Likert-type scale, with options including "strongly agree," "agree," "neither agree nor disagree," "disagree," "strongly disagree" (Attitude); and "almost always" or "always," "quite frequently," "sometimes," "not very often," "hardly ever" or "never" (Behavior).

Attari, S. Z., DeKay, M. L., Davidson, C. I., & Bruine De Bruin, W. (2010). Public perceptions of energy consumption and savings. *Proceedings of the National Academy of Sciences*, *107*(37), 16054–16059. https://doi.org/10.1073/pnas.1001509107

https://aistudio.google.com/prompts/1ZMHKdiP4vLUVlVjvIafYox-bq-0wG8Z3

https://www.pnas.org/action/downloadSupplement?doi=10.1073%2Fpnas.1001509107&file=sapp.pdf

A Survey on Energy

1. Energy-Saving Behaviors

In your opinion, what is the most effective thing that you could do to conserve energy in your life?

_____

2. Energy Consumed by the Average Household

Think about an average household in the United States.

Now think about the total amount of energy that is used directly by that household in one year.

Consider that the energy used by a household can be divided into household operations, transportation and food production.

Household operations include electricity, natural gas, and heating oil that is used for the house.

Transportation includes air travel, motor travel, and public transportation used by people in the household.

Food production includes growing and shipping food that people in the household eat.

Please enter whole numbers with no other text (not decimals, ranges, or percent signs).
What percentage of the total energy consumed per year by an average household in the United States is attributed to energy used by household operations?___

What percentage of the total energy consumed per year by an average household in the United States is attributed to energy used by transportation?___

What percentage of the total energy consumed per year by an average household in the United States is attributed to energy used by food production?___

3. Energy Used by Devices in One Hour
A 100-Watt incandescent light bulb uses 100 units of energy in one hour.

How many units of energy do you think each of the following devices typically uses in one hour?

Enter a number less than 100 if you think the device uses less energy than a 100-Watt bulb. Enter a number greater than 100 if you think the device uses more energy than a

Assume that you are driving a 20-miles-per-gallon car for 60 miles. Reducing your highway speed from 70 miles per hour to 60 miles per hour would reduce energy use by how many units for the trip? ___

6. Energy Used to Transport Goods

In your opinion, which of the following modes of transportation uses the most energy per mile to transport one ton of goods? Please check the mode that uses the most energy, the second most, the third most, and the least energy.

	Most energy	Second most energy	Third most energy	Least energy
Ship				
Train				
Airplane				
Truck				

7. Energy Used in Recycling and Manufacturing
In your opinion, which of the following uses the most energy?

Please check the activity that uses the most energy, the second most, the third most, and the least energy.

	Most energy	Second most energy	Third most energy	Least energy
Making a can out of virgin aluminum				
Making a can out of recycled aluminum				
Making a glass bottle out of virgin glass				
Making a glass bottle out of recycled glass				

8. Ease or Difficulty of Energy-Saving Behaviors
Please indicate how easy or hard it would be for you to make each of the following changes.

Please consider all aspects of the changes, including the physical or mental effort required, the time or hassle involved, and any relevant monetary costs.

Kantenbacher, J., & Attari, S. Z. (2021). Better rules for judging joules: Exploring how experts make decisions about household energy use. *Energy Research & Social Science*, *73*, 101911. https://doi.org/10.1016/j.erss.2021.101911
https://gemini.google.com/app/4adc672f39199393
https://aistudio.google.com/prompts/1pKM_I48YH4sXSGU3qqlr5W8IsYu6ZPqc

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Better rules for judging joules: Exploring how experts make decisions about household energy use

Joseph Kantenbacher [1], Shahzeen Z. Attari

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Supplemental Text for

Better rules for judging joules: Exploring how experts make decisions about household energy use

Joseph Kantenbacher and Shahzeen Z. Attari

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Theme:

Estimation task

[These appliances will all appear on one page in a table format as shown below; correct values have been added in parentheses but we presented online via Qualtrics if interview is remote]

A standard incandescent light bulb uses about **100 units of energy** in one hour. When you are asked to estimate units of energy, pleas **more energy** than this light bulb. Please use this number to help you make your estimates.

How many **units of energy** do you think each of the following devices typically consumes if used for **one hour**? Please provide you bes

Appliance	Your estimate of energy use
Compact fluorescent light (CFL) bulb	(23 Wh)
Desktop computer	(138 Wh)
Laptop computer	(32 Wh)
Window air conditioner	(1157 Wh)
Clothes dryer	(3938 Wh)
Dishwasher	(1201 Wh)
Vacuum	(809 Wh)
Charging a smartphone	(3 Wh)
Refrigerator	(280 Wh)
Electric oven	(3050 Wh)
Washing machine	(478 Wh)
DVD player	(9 Wh)
Ceiling fan	(69 Wh)
Microwave	(1101 Wh)
Electric kettle	(1390 Wh)
Toaster	(1213 Wh)
LED light bulb	(15 Wh)

Supplementary Methods 2: Survey 2

[Presented online via Qualtrics to all participants; heuristic presentation order is randomized]

Please indicate how accurate or inaccurate you think each of the following rules are for energy use by devices in the home. When evaluating these rules, please consider their general accuracy rather than application to outlier cases.

Heuristic Rule	Mostly inaccurate (1)	Somewhat inaccur
Devices that primarily heat or cool use more energy than devices with a primary function involving motion (1)	o	o
Heating or cooling something takes a lot of energy (2)	o	o
A greater temperature change requires more energy than a smaller temperature change (27)	o	o
Heating takes more energy than cooling (3)	o	o
Cooling takes more energy than heating (4)	o	o
Appliances that move or heat water use a lot of energy (5)	o	o
Electronics that produce graphics (images) use more energy than other types of electronics (6)	o	o
Devices with small or focused functions (for example, a desk lamp) need less energy than devices that are designed to perform large or broadcast functions (for example, an overhead lamp) (7)	o	o
Performing a task quickly tends to take more energy than performing that same task more slowly (8)	o	o
Boiling water and turning it into steam requires a lot of energy (9)	o	o
Producing sound (music) does not require much energy (10)	o	o
Devices with heating elements use a lot of energy (11)		

Devices with heating elements use a lot of energy (11)	o	o
It takes less energy to heat something with microwaves than with heating elements (12)	o	o
Devices that need to be cooled while they are working use a lot of energy (13)	o	o
Devices that can run on batteries are low energy consumers (14)	o	o
Insulation helps to reduce the energy use of devices that heat and cool (15)	o	o
A device that runs on its own circuit uses a lot of energy (16)	o	o
LED lights do not use a lot of energy (18)	o	o
Devices that either make lights dim/flicker or trip circuits when turned on use a lot of energy (19)	o	o
The longer the plug a device has, the more energy it will use (20)		

Supplementary Table 1: Choice task codebook

To extract the list of heuristics employed by experts during the choice task, the verbal reports made by the participants were transcribed and analyzed. The first layer of analysis entailed developing a coding scheme to categorize the content of the verbal reports. A codebook was developed to sort the information used by the experts into primary and secondary categories. Primary codes were developed for the three general content areas of the expert interviews: references to (1) observable cues about energy use, (2) device functions, and (3) device components. Each primary code was disaggregated into several secondary codes, each of which refers to a more detailed aspect of the primary code's general theme. For example, the *"Observable Cues"* primary code family contained eight secondary codes, including *"hot to touch," "dims lights/trips circuits,"* and *"thick cord."*

Primary code	Secondary code	Description
External cues		Discusses the easily observable features or effects on the environment of a device
	Color	Assesses the color or color change of a device when in use
	Dim lights/trip circuit	Assesses whether room lighting dims or a circuit is tripped when a device is turned on or used
	Hot to touch	Mentions that the appliance or the air immediately around it gets warms up/gets hot while the appliance is in operation, or that the appliance needs a period of cool down after use
	Noisy	Assesses the amount of sound associated with the appliance while in use
	Plug size	Assesses the size or type of plug that a device uses, including references to physical dimensions or voltage
	Size	Assesses the size (volume) of a device or its components ("X is small"), excluding references to the volume of space that the device affects (e.g., "Ovens heat a small space" or "Space heaters hea
	Thick cord	Assesses the size or type of the device's power cord
	Weight	Assesses the size (weight) of a device
Function		References function, activity, or purpose of the device; these could be either primary functions (e.g., space heaters heat the air) or secondary functions (e.g., dishwashers heat water to clean dishe
	Comparisons	Makes a direct comparison of the relative energy requirements of two different functions (e.g., heating versus cooling) or compares the energy use of different devices with the same function (e.g.,
	Cooling	Explicitly names "cooling" or "moving heat" or decreasing the temperature of an object as a primary function or activity of the device
	Frequency	Comments on how often a device is used in day-to-day living, excluding references to their own ownership
	Graphics	Names producing graphics on a screen as a primary function or activity of the device
	Heating	Explicitly names heating or increasing the temperature of [air, water, or objects] as a primary function or activity of the device
	Information processing	Names**computing/processing** data/information/signals as a primary function or activity of the device
	Lighting	Names generating light as a primary function or activity of the device
	Motion/compression	References moving components (e.g., a spinning washing machine drum) or compression as part of the operation of a device
	Sound	Identifies making sound as a primary function or activity of the device

Supplementary Table 2: Novice heuristics

The following set of 24 heuristics were collected by van den Broek and Walker (2019)[4]. The accuracy of the heuristics in **bold** was evaluated in Survey 2.

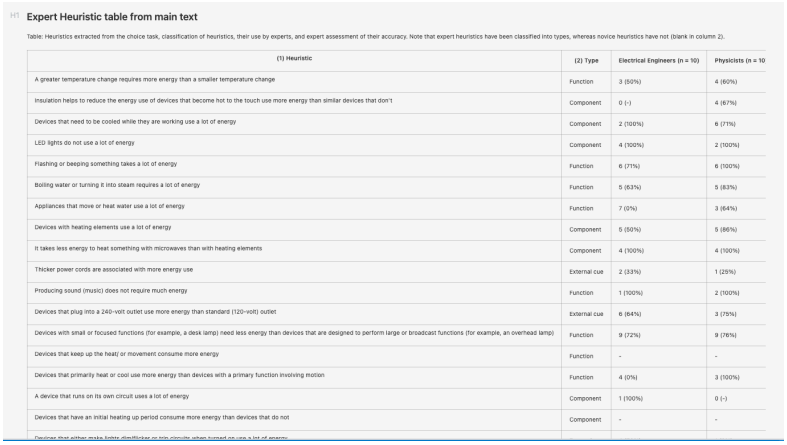
1. When the device can be set on a higher unit (e.g., higher temperature) the device uses more energy
2. The more a device produces heat to heat up air or water or itself, the more energy it consumes
3. The fast a device completes its task, the more energy the device consumes
4. More active devices use more energy
5. **Larger devices consume more energy**
6. Knowledge about the energy consumption of the device that stems from public discourse or an unspecified sources
7. Devices with similar functions consume same levels of energy while devices with different functions consume different levels of energy
8. **Devices with a lot of components use more energy**
9. **Devices use less energy in the utility phase compared to its use in a 'preparation phase'**
10. Devices that use a lot of Wattage consume more energy
11. Devices that reduce the temperature of an element such as air or water will consume high levels of energy
12. Devices that have previously cut out the fuse box consume a lot of energy
13. **Devices that have an initial heating up period consume more energy than devices that do not**
14. **Devices that have an energy label use more energy**
15. Devices that complete several tasks (either simultaneous or successive), or large tasks, consume more energy
16. **Devices that charge other devices use more energy**
17. Devices that carry out complex tasks consume more energy
18. Devices that are switched on for a longer period of time consume low levels of energy
19. Devices that are small but conduct a large task use a lot of energy
20. Devices that are more powerful use more energy
21. Devices that are less energy intense use less energy
22. **Devices that 'keep up the heat' or movement consume more energy**
23. Devices from some brands or certain type of devices are more energy consuming
24. **Appliances that are semantically related to each other consume similar levels of energy**

Correctness as a Function of Wattage Proximity

To test whether expert performance on the choice task was dependent on the magnitude of difference between devices, we examined the correlation between these two terms. Expert performance was measured in terms of the number of experts (out of 30) who correctly selected the appliance with the lowest energy use. Wattage difference was assessed by taking the logarithmic difference between the device with the second-lowest wattage and the device with the lowest wattage within each choice set (see Table S1 below). The correlation between expert performance and wattage difference ($r = 0.14$, $p = 0.72$) was small and non-significant, suggesting that expert choice performance was not dependent on the magnitude between choice wattages.

Table S1. Wattage values, wattage difference values, and count of correct experts for each choice task

Choice task	Lowest wattage (α)	Second-lowest wattage (β)	$\text{Log}_{10}(\beta/\alpha)$	Number of correct expert choices (out of 30 total)
1	1157	3050	0.421	20
2	363	809	0.348	18
3	197	967	0.691	22
4	185	358	0.287	17
5	27	33	0.087	23
6	478	1201	0.400	14
7	1101	1390	0.101	18
8	145	225	0.191	9
9	39	69	0.248	24



H1 **Expert Heuristic table from main text**

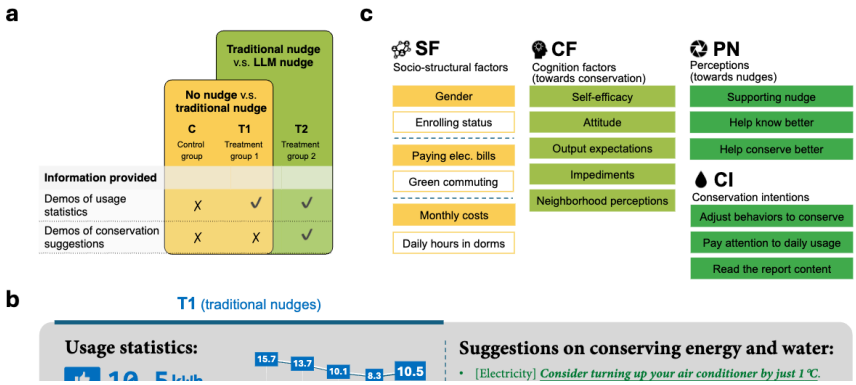
Table: Heuristics extracted from the choice task, classification of heuristics, their use by experts, and expert assessment of their accuracy. Note that expert heuristics have been classified into types, whereas novice heuristics have not (blank in column 2).

(1) Heuristic	(2) Type	Electrical Engineers (n = 10)	Physicists (n = 10
A greater temperature change requires more energy than a smaller temperature change	Function	3 (50%)	4 (60%)
Insulation helps to reduce the energy use of devices that become hot to the touch use more energy than similar devices that don't	Component	0 (-)	4 (67%)
Devices that need to be cooled while they are working use a lot of energy	Component	2 (100%)	6 (71%)
LED lights do not use a lot of energy	Component	4 (100%)	2 (100%)
Flashing or beeping something takes a lot of energy	Function	6 (71%)	6 (100%)
Boiling water or turning it into steam requires a lot of energy	Function	5 (63%)	5 (83%)
Appliances that move or heat water use a lot of energy	Function	7 (0%)	3 (64%)
Devices with heating elements use a lot of energy	Component	5 (50%)	5 (86%)
It takes less energy to heat something with microwaves than with heating elements	Component	4 (100%)	4 (100%)
Thicker power cords are associated with more energy use	External cue	2 (33%)	1 (25%)
Producing sound (music) does not require much energy	Function	1 (100%)	2 (100%)
Devices that plug into a 240-volt outlet use more energy than standard (120-volt) outlet	External cue	6 (64%)	3 (75%)
Devices with small or focused functions (for example, a desk lamp) need less energy than devices that are designed to perform large or broadcast functions (for example, an overhead lamp)	Function	9 (72%)	9 (76%)
Devices that keep up the heat/ or movement consume more energy	Function	-	-
Devices that primarily heat or cool use more energy than devices with a primary function involving motion	Function	4 (0%)	3 (100%)
A device that runs on its own circuit uses a lot of energy	Component	1 (100%)	0 (-)
Devices that have an initial heating up period consume more energy than devices that do not	Component	-	-
Devices that either make lights dim/flicker or trip circuits when turned on use a lot of energy			

Table 1. Heuristics extracted from the choice task, classification of heuristics, their use by experts, and expert assessment of their accuracy. Note that expert heuristics have been classified into types, whereas novice heuristics have not (blank in column 2).

(1) Heuristic	(2) Type	(3) Number of experts who used the heuristic at least once (conditional probability in parenthesis: when the heuristic is used, does the expert choose the correct answer)			(4) Expert assessment of heuristic accuracy (N = 16) (1 = mostly inaccurate, 4 = mostly accurate) Mean (SE)
		Electrical Engineers (n = 10)	Physicists (n = 10)	Energy Analysts (n = 10)	
A greater temperature change requires more energy than a smaller temperature change	Function	3 (50%)	4 (60%)	1 (100%)	3.9 (0.06)
Insulation helps to reduce the energy use of devices that heat and cool	Component	0 (--)	4 (67%)	3 (50%)	3.8 (0.10)
Devices that become hot to the touch use more energy than similar devices that don't	External cue	7 (91%)	6 (71%)	4 (100%)	3.8 (0.11)
Devices that need to be cooled while they are working use a lot of energy	Component	2 (100%)	0 (--)	1 (100%)	3.8 (0.11)

Li, Z., Tong, S., Liu, Y., Peng, K., & Wang, C. (2025). *Potential of large language model-powered nudges for promoting daily water and energy conservation* (No. arXiv:2503.11531). arXiv. https://doi.org/10.48550/arXiv.2503.11531



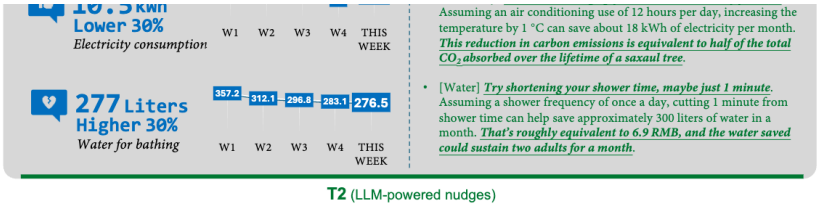


Figure 5. Measurements and experimental design. a. Groupings and included demonstrations of nudge content used to measure conservation intentions. **b.** An example of a demonstration of a nudge. **c.** Measurements used in the questionnaire survey.

Validation of the scales

(1) Confirmatory factor analysis (CFA) results.

Supplementary Table S1 CFA results

Factor		Item	Estimate	SE	95% CI		p
					Lower	Upper	
Self-efficacy	(i)	I believe I have the ability to avoid unnecessary water and energy use in the dormitory.	0.63***	0.02	0.59	0.68	<.0001
	(ii)	I give up when I feel it is difficult to implement water and energy conservation.	0.49***	0.02	0.44	0.53	<.0001
	(iii)	How much control do you feel you have over the water and energy consumption in your dormitory? (1=Very little control, ... ,5=Complete control)	0.44***	0.03	0.39	0.50	<.0001
Output expectations	(i)	I can contribute to slowing down climate change and resource depletion through saving water and energy.	0.73***	0.01	0.70	0.76	<.0001
	(ii)	My family expects me to save water and energy.	0.79***	0.01	0.77	0.81	<.0001
	(iii)	My friends believe that I should make efforts to save water and energy.	0.67***	0.02	0.64	0.70	<.0001
	(iv)	It makes me feel like a better person to save water and energy in my dormitory.	0.64***	0.02	0.61	0.67	<.0001
	(v)	I feel bad if I use more water and energy resources than necessary.	0.66***	0.02	0.63	0.69	<.0001
Perceived impediments	(i)	As the conditions are, it is difficult to avoid unnecessary water and energy consumption in my dormitory.	0.81***	0.02	0.77	0.85	<.0001
	(ii)	It takes a big extra effort from me to avoid unnecessary water and energy consumption in my dormitory.	0.82***	0.02	0.77	0.86	<.0001
	(i)	It's important to conserve water and energy.	0.66***	0.02	0.62	0.69	<.0001
	(ii)	Resource depletion is irrelevant to me.	0.53***	0.02	0.49	0.57	<.0001

He, S., Blasch, J., Robinson, P. J., & van Beukering, P. (2024). Social comparison feedback in decision-making context: Environmental externality levels and psychological traits matter. *Ecological Economics*, *216*, 108047. https://doi.org/10.1016/j.ecolecon.2023.108047

https://ars-els-cdn-com.proxyiub.uits.iu.edu/content/image/1-s2.0-S0921800923003105-mmc1.pdf

Phase 2

Instructions

In Phase 2, you will make a purchase decision for multiple rounds.

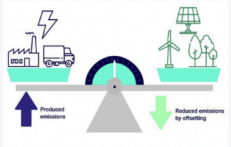
In each round, you own 100 initial points. You will decide how to allocate the points to purchasing the experimental product. Every unit of purchasing costs 1 point (unit cost = 1 point), and brings 2 points of benefit (unit benefit = 2 points). Your payoff of a round will be:

payoff = initial points - unit cost * purchase amount + unit benefit * purchase amount
= 100 points - 1 point * purchase amount + 2 points * purchase amount

Apart from the points, there will be carbon offsets for the amount of 100 kg CO_2 (= carbon dioxide, or in short: carbon) at the beginning of each round (initial carbon offsets = 100 kg). Purchasing every unit of the experimental product causes 0.5 kg carbon emissions from its production, which will reduce the initial stock of 100 kg carbon offsets by 0.5 kg (unit emissions = 0.5 kg). At the end of each round, the carbon offsets that can be contributed will be:

carbon offsets contribution = initial carbon offsets - unit emissions * purchase amount
= 100 kg - 0.5 kg * purchase amount

Carbon offsets are used to compensate the carbon emissions from human activities: carbon emissions are reduced by contributing money to environmental projects that reduce emissions, such as reforestation and solar energy generation. The picture visualises the principle of a carbon offset:



At the end of this phase, **one round will be randomly selected for payment**. Your decision in that round will determine

your payoff and the carbon offsets contribution of Phase 2. At the end of the experiment, your payoff will be exchanged into British pounds at a rate of 50 points = £1 and will be paid via *Prolific*. The carbon offsets will be donated to a real-world project via *Gold Standard*. More information about the *Gold Standard*-certified projects will be available at the end of this experiment.

If you are still unclear about the task, do not worry. The instructions are available throughout this phase. On the next page, you will see an example on how your payoff and the carbon offsets contribution are determined in a round. Then you will be asked to answer two questions to help comprehension.

Next

Figure A.7: Instructions.

Phase 1: The norm-following task

Phase 1

Instructions

Here you are in Phase 1 of the experiment. You will decide how to allocate 50 balls between two buckets.

Your task is to put each of the balls, one-by-one, into one of the two buckets: the blue bucket or the yellow bucket. You can allocate each ball by clicking either the "Blue bucket +1" button or the "Yellow bucket +1" button.

For each ball you put in the blue bucket, you will receive 2 points, and for each ball you put in the yellow bucket, you will receive 4 points. Your payoff of Phase 1 will be based on your decisions: it is the sum of points from the blue and yellow buckets.

The rule is to put the balls in the blue bucket.

At the end of the experiment, your payoff will be exchanged into British pounds at a rate of 50 points = £1 and will be paid via *Prolific*.

If you are still unclear about the task, do not worry. The instructions are available throughout this phase. On the next page, you will be asked to answer two questions to help comprehension.

Next

Figure A.3: Instructions.

Please correctly answer the following questions before starting the task.

Q1. How many points will you receive for each ball you put in the **yellow** bucket?
Please enter **a number** in the form below.

4 points

Your answer for Q1 is correct.
For each ball you put in the blue bucket, you will receive 2 points, and for each ball you put in the yellow bucket, you will receive 4 points.

Q2. The **rule** is to put the balls in the _____ bucket.
Please enter **a number (1=blue, 2=yellow)** in the form below.

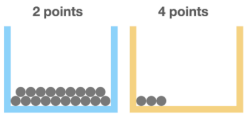
1

Your answer for Q2 is correct.

Put the balls by clicking either the "Blue bucket +1" button or the "Yellow bucket +1" button.

The rule is to put the balls in the blue bucket.

You still have **28** balls to allocate. You've put 19 balls into the blue bucket and 3 balls into the yellow bucket.



Blue bucket +1 Yellow bucket +1

Instructions

- You will decide how to allocate 50 balls between two buckets.
- Your task is to put each of the balls, one-by-one, into one of the two buckets: the blue bucket or the yellow bucket. You can allocate each ball by clicking either the "Blue bucket +1" button or the "Yellow bucket +1" button.
- For each ball you put in the blue bucket, you will receive 2 points. For each ball you put in the yellow bucket, you will receive 4 points
- The rule is to put the balls in the blue bucket.
- Your payoff of Phase 1 will be based on your decisions: it is the sum of points from the blue and yellow buckets.
- At the end of the experiment, your payoff will be exchanged into British pounds at a rate of 50 points = £1 and will be paid via *Prolific*.

Figure A.5: Decision-making page.

Result Phase 1

In total, you allocated **47** balls in the blue bucket and **3** balls in the yellow bucket.

Your payoff of Phase 1 is **106 points**.

Proceed to Phase 2

Results of the previous round

In the previous round, you purchased 50 units. In the same round, other participants from a previous session on average purchased 78 units.

Your purchase decision caused 25.0 kg carbon emissions, which on average equals to 208 km of driving a car and requires 14 months for a tree to absorb.

Your payoff is 150 points. The carbon offsets that can be contributed are 75.0 kg.

You purchased 28 units less compared to the average purchase of other participants.

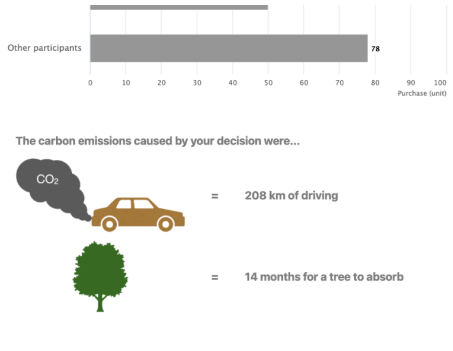


Figure A.13: Tangible emissions feedback (positive).

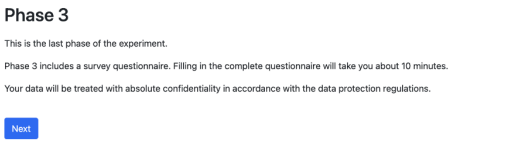


Figure A.15: Instructions.

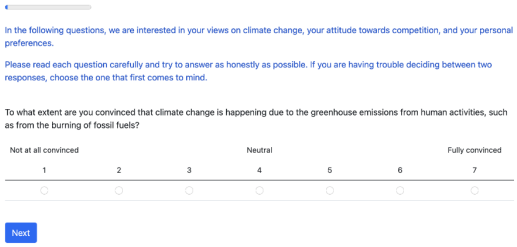


Figure A.16: Belief of climate change.

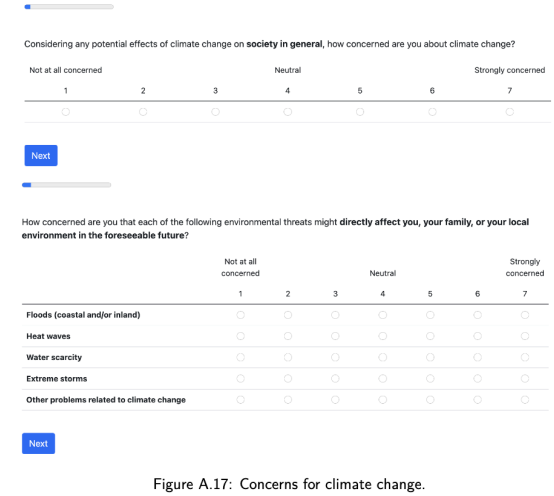


Figure A.17: Concerns for climate change.

Cotton, D. R. E., Zhai, J., Miller, W., Dalla Valle, L., & Winter, J. (2021). Reducing energy demand in China and the United Kingdom: The importance of energy literacy. *Journal of Cleaner Production*, *278*, 123876. https://doi.org/10.1016/j.jclepro.2020.123876

Table 3
Attitudes toward energy issues (mean score out of 5 on Likert scale, with higher score indicating more agreement). [1 = strongly disagree, 5 = strongly agree]. Highlight shows which group had stronger agreement.

Energy-related attitudes:	China mean (SD)	UK mean (SD)	Mann-Whitney test
I would do more to save energy if I knew how	2.69 (1.29)	4.09 (0.78)	U= 1240125, p= .000
The way I personally use energy does not make a difference to the national energy situation	2.72 (1.14)	2.25 (0.99)	U= 2287366.5, p= .000
I can influence what the government does about energy problems	3.04 (0.96)	2.65 (1.01)	U= 2323751, p= .000
I can influence what companies do about energy problems	3.13 (0.97)	2.54 (1.03)	U= 2029215, p= .000
I trust the government to do something about any energy problems	2.86 (0.97)	2.52 (1.03)	U= 2441919, p= .000
Scientists will find ways to solve energy problems	2.82 (1.08)	3.66 (0.86)	U= 1663330, p= .000
More wind farms should be developed to generate electricity, even if they are located in scenic environments	2.99 (1.01)	3.59 (1.13)	U= 2026657.5, p= .000
The government should have stronger standards on fuel efficiency of cars	2.69 (1.23)	3.99 (0.89)	U= 1267401, p= .000
Climate change has been established as a serious problem and immediate action is necessary	2.64 (1.31)	4.20 (0.93)	U= 1102534, p= .000
Climate change is caused by human activities related to using energy	2.79 (0.98)	4.03 (0.95)	U= 1102040, p= .000
There are benefits to people in our country from climate change	2.81 (1.03)	2.50 (1.02)	U= 2472825.5, p= .000
Behaving sustainably can have health benefits	2.68 (1.35)	4.05 (0.81)	U= 1309070.5, p= .000

Table 4
Self-reported behaviours (Highlighted box shows which group had higher likelihood of undertaking each behaviour where significant). [1 – never, 4 – always] [** significant at 0.001, – not significant].

Behaviour:	China %	UK %	Significance
Turn off lights when they are not in use	2.21	3.61	**
Turn down the heat	2.26	3.08	**
Try to save water	2.24	3.03	**
Walk or cycle short distances instead of going by car	2.22	3.40	**
Buy things that are likely to involve less energy or resource use	2.27	2.45	**
Pay a bit more for environmentally friendly products	2.41	2.43	--
Avoid charging mobile phones overnight	2.45	2.01	**
Turn off standby button on the TV or switch appliances off at the plug	2.36	2.95	**
Use rechargeable batteries	2.42	2.55	**
Try to learn what I can do to help solve environmental issues	2.45	2.50	--
Talk with others about environmental issues	2.47	2.47	--
Try to convince friends to act responsibly towards the	2.42	2.51	**

Try to convince friends to act responsibly towards the environment	2.42	2.51	--
Participate in environmental campaigns (including online petitions)	2.44	1.86	**

https://www.oecd.org/en/data/datasets/pisa-2015-database.html

Questionnaires

The questionnaires below are available in English and in French.

- Student questionnaire (computer-based assessment)
- Student questionnaire (paper-based assessment)
- School questionnaire (computer-based assessment)
- School questionnaire (paper-based assessment)
- Education career questionnaire for students (optional - see list of countries)
- ICT familiarity questionnaire for students (optional - see list of countries)
- Parent questionnaire (optional - see list of countries)
- Teacher questionnaire (optional - list of countries)
- National questionnaire versions are also available.

Codebook and compendia

Codebooks

- Main files
- Additional files for Albania, Argentina, Kazakhstan and Malaysia*

Compendia (compressed)

- *Questionnaire compendia* provide the distribution of student responses and performance means according to the variables collected through the questionnaires.
  Questionnaire items (33MB)
- *Cognitive compendia* provide the distribution of student responses per cognitive item.
  Cognitive items (15MB)
- *Compendia for Financial Literacy* regroups both questionnaire and cognitive items on the topic.
  Compendia for Financial Literacy (4.6Mb)
- *Compendia for Collaborative Problem Solving* regroups both questionnaire and cognitive items on the topic.
  Compendia for Collaborative Problem Solving (18 Mb)

PISA data

Public Use Files (PUFs)

Public Use Files containing individual unit record data in SAS and SPSS formats are available for downloading for all countries participating in the PISA 2015 Survey.

Download the datasets

Borzino, N., Hiepler, B., Schmitt, K., Schmitz, J., Schubert, R., & Tiefenbeck, V. (2025). Switching Off: Energy Saving Goals Outshine Incentives—Evidence from a Field Experiment. *Environmental and Resource Economics*. https://doi.org/10.1007/s10640-025-00973-3

D: Study Information, Treatment Messages and Energy Savings Tips

Dear Sir/Mdm (Serial Number: **S700**),

Dear XXX,

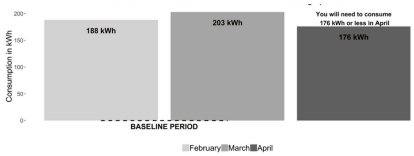
To demonstrate how easy it is to save energy, NTU-EcoCampus organises the "Energy Challenge", which starts on **25th March 2018**. The Challenge is a call to households at NTU campus to reduce their electricity consumption and contribute to a sustainable environment.

In this "Energy Challenge", we ask you to reduce your electricity consumption by **10% or more** in each of the three months of the **"Challenge Period" (i.e. April, May and June 2018).**

Your electricity consumption in each of the months of the Challenge will be compared with your average consumption in the **"Baseline Period" (i.e. February and March 2018).**

Your average electricity consumption in February and March was 195 kWh. We ask you to reduce your electricity usage by 10% or more next month. This means that you need to consume 176 kWh or less. We will inform you at the end of next month whether you achieved this electricity reduction goal.

You will need to reduce your electricity consumption by
at least 10% in each of the 3 months of the challenge period



✓ Reduce your energy consumption to 176 kWh or less in each of the three months of challenge

Sincerely,

To save energy is easier than you think by following the advices below!

If you use an air conditioner, **set the temperature at 25°C or higher**. You could **save up to $25 a year for every degree you raise.**

Air-conditioners account for the bulk of a household's electricity bill. **A fan uses less than 1/10th the electricity of an air-conditioner!** This means you **save up to $840 a year.**

Standby power can account for up to 10% of your home electricity use. **Don't leave electrical appliances on standby.** Switch them off when not in use and you can **save up to $70 a year.**

Use more efficient lighting fixtures such as LED. **By choosing energy-efficient light bulbs,** you can **save up to $30 a bulb per year.**

Choose an energy-efficient appliance (e.g. air-conditioner, refrigerator) by checking the energy labels. A 4-tick air-conditioner **saves you about $450 in electricity bills a year** compared with a 1-tick model. A 4-tick refrigerator saves you about $70 a year, when compared with a 2-tick model.

Habibi Asgarabad, M., Vesely, S., Efe Biresselioglu, M., Caffaro, F., Carrus, G., Hakan Demir, M., Kirchler, B., Kollmann, A., Massullo, C., Tiberio, L., & Klöckner, C. A. (2024). Promoting electricity conservation through behavior change: A study protocol for a web-based multiple-arm parallel randomized controlled trial. *PLOS ONE*, *19*(3), e0293683. https://doi.org/10.1371/journal.pone.0293683

S2 Table. *Items pertaining to electricity-related behaviors/values/habits with substantial potential for energy conservation.*

	Socio-demographics [1]							
1	Which year were you born?							
2	Which is your gender?	male	female	other				
3	In which County of [your country] do you live?							
4	How many people live in your house/apartment?							
5	How many of these are under 6 years old?							
6	How many of these are between 6 and 11?							
7	How many of these are between 12 and 17?							
8	What is your highest education level?	basic education	vocational training	highschool degree	university degree	still in education		
9	What describes best your job situation?	working full time	working part time	in fulltime education	without paid work / looking for work	retired	not able to work	other
10	How would you describe your social status?	1 = worst-off						10 = best off
11	Being a citizen of [your country] is an important part of who I am	1= strongly disagree	2 = moderately disagree	3= neither disagree nor agree	4 = moderately agree	5 = strongly agree		
	Risk of Energy Poverty							
11	Do you struggle to pay for your electricity bill, because it takes too much from your monthly income?	never	rarely	sometimes	often	always		
12	On average across the year, how much of your household's income did you use to pay for energy (electricity, wood, gas, oil, gasoline, diesel etc. together) during the last 12 months?	0	below 5%	5-10%	10-15%	15-20%	20-30%	more than 30%
	Environmental Concern [2]							
13	How worried are you about climate change?	very worried/concerned	somewhat worried/ concerned	not very worried/concerned	not at all worried/concerned			
14	How concerned are you generally about environmental problems?	very worried/concerned	somewhat worried/ concerned	not very worried/concerned	not at all worried/concerned			
15	How concerned are you generally about using too much electricity?	very worried/concerned	somewhat worried/ concerned	not very worried/concerned	not at all worried/concerned			
	Personal Norms [3]							
16	Because of my personal values, I feel morally obliged to save electricity	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
	Electricity Assets in the Household (EAH)							
17	Do you use electricity to warm your hot water?	no	yes	do not know				
18	Do you use electricity as a main heating source?	no	yes	do not know				
19	Do you charge an electric car at home	no	yes	do not know				
20	I have downloaded the app of my electricity net provider or have checked my consumption on their website.	no	yes	do not know				
21	I have an air condition	no	yes	do not know				
22	I have a tumble dryer	no	yes	do not know				
23	I have a heat pump	no	yes	do not know				
24	I have a dishwasher which is highly energy efficient	no	yes	do not know				
25	I have a washing machine which is highly energy efficient	no	yes	do not know				
26	I have LED lights installed everywhere I can	no	yes	do not know				
	Perceived Behavioral Control of electricity-saving tips (PBC)[3]							
27	Keeping lids on pots when cooking	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
28	Taking a shower instead of a bath	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	

29	Letting food cool down before setting it in the fridge or freezer	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
30	Putting in sealing tape in windows or doors where there is pull	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
31	Only heating the required amount of water when boiling water	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
32	Adjust the temperature of the fridge and freezer to the best efficiency	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
33	Taking short showers (about 3 minutes)	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
34	Adjusting the air condition temperature up one degree	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
35	Keeping the door of the warm oven or cold refrigerator closed as much as possible and only open it to take things in or out	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
36	Using energy saving LED lightbulbs everywhere	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
37	Remove the dust from the cooling coils of your fridge or freezer	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
38	Using lower temperatures for washing clothes	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	

39	Heating water in a kettle instead of on the stove	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
40	Deice the fridge or freezer when it is icy	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
41	Avoiding using electricity during the peak hours	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
42	Switching appliances with standby completely off	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
43	Using thicker curtains during winter	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
44	Dishwasher: Using lower temperatures or shorter programs	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
45	Avoid using the tumble dryer	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
46	Turning down the heating with one degree	very easy to do	somewhat easy to do	neither easy nor difficult	somewhat difficult to do	very difficult to do	not relevant for me / do not have that	
	Peak Hour Consumption							
47	Highest consumption during an hour last day							
48	Which hour during that day did you consume the most?							
	Intention to Save Electricity [3]							
49	I intend to save electricity during next week	very unlikely	somewhat unlikely	neither unlikely nor likely	somewhat likely	very likely		
	Attitude to Saving Electricity [3]							
50	Saving electricity next week would be	very unpleasant	somewhat unpleasant	neither unpleasant nor pleasant	somewhat pleasant	very pleasant		
	Perceived Behavioural Control to Save Electricity [3]							
51	I am confident that I am able to save electricity next week	totally false	somewhat false	neither false nor true	somewhat true	Totally true		
52	Saving electricity next week is up to me	strongly disagree	moderately disagree	neither disagree nor agree	moderately agree	strongly agree		
	Social Norms to Save Electricity [3]							
53	Most people who are important to me approve of me saving electricity next week	strongly disagree	moderately disagree	neither disagree nor agree	moderately agree	strongly agree		
54	Most people like me save electricity next week	very unlikely	somewhat unlikely	neither unlikely nor likely	somewhat likely	very likely		

	Habit Strength [4]							
55	Saving electricity is something I do without thinking	strongly disagree	moderately disagree	neither disagree nor agree	moderately agree	strongly agree		
56	Saving electricity is something I do automatically	strongly disagree	moderately disagre	neither disagree nor agree	moderately agree	strongly agree		
	Collective Efficacy [5]							
67	I think that we in [your country] are able to save electricity	strongly disagree	moderately disagree	neither disagree nor agree	moderately agree	strongly agree		
68	I do not think that we in [your country] can make a difference with respect to saving electricity in the long run	strongly disagree	moderately disagree	neither disagree nor agree	moderately agree	strongly agree		
	Emotional Reaction to Electricity Campaign							
69	How do you feel at the moment about your electricity consumption?	very negative	somewhat negative	neither positive nor negative	somewhat positive	very positive		
60	I feel happy, when I think about my electricity consumption	strongly disagree	moderately disagree	neither disagree nor agree	moderately agree	strongly agree		
61	I feel upset, when I think about my electricity consumption	strongly disagree	moderately disagree	neither disagree nor agree	moderately agree	strongly agree		
62	I feel excited, when I think about my electricity consumption	strongly disagree	moderately disagree	neither disagree nor agree	moderately agree	strongly agree		
	Reactance to Study (only last survey) [6]							
63	Did you feel participating in the project encroached on your freedom in any way?	not at all	a little bit	somewhat	quite a lot	very much so		
	Self-reported Implementation of Energy Saving Behaviors							
64	reduced heating with at least one degree	no	yes	do not know				
65	adjusted air conditioning up at least one degree	no	yes	do not know				
66	shorter showers (about 3 min)	no	yes	do not know				
67	Shower instead of bath	no	yes	do not know				
68	Substituted less energy efficient light bulbs with LEDs	no	yes	do not know				
79	I adjusted the temperature of the fridge or freezer to a more efficient level	no	yes	do not know				
70	I deiced the fridge or freezer	no	yes	do not know				
71	I removed dust from the cooling coils of the fridge or freezer	no	yes	do not know				
72	I let warm food cool down outside the fridge or freezer first	no	yes	do not know				
73	I reduced the temperature for most of the washing in my washing machine	no	yes	do not know				
74	I used lower temperatures or shorter programs in my dishwasher	no	yes	do not know				

75	I did not use my tumble dryer to dry clothes	no	yes	do not know				
76	I used a kettle to warm water	no	yes	do not know				

77	I only heated the required amount of water when cooking	no	yes	do not know				
78	I remembered to keep the lids on the pots when cooking	no	yes	do not know				
79	I did not open the door of the oven or fridge unnecessarily	no	yes	do not know				
80	I switched devices with standby completely off	no	yes	do not know				
81	I tried to reduce my electricity consumption in the peak hours	no	yes	do not know				
82	I have put up thicker curtains	no	yes	do not know				
83	I have put in sealing tape where it pulled	no	yes	do not know				

Note. The initial survey included the first 46 items, while the remaining items were measured repeatedly over the course of 6 weeks at 6 different time points.

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The materials for all four surveys are presented below. These were computer surveys, so the materials here do not look exactly like they did in the actual experiments.

STUDY 1

Welcome to the Household Energy Survey. Please answer the questions to the best of your ability, without looking up any answers online. Please press the ">>" button to begin the survey.

Please consider the total amount of energy (electricity, natural gas, propane, or heating oil) used by typical American households in a given year. Please indicate what percentage of total energy you think is used by devices or appliances in that category for typical American households. Each time you type a number into a box, the bottom box "Total" will adjust to let you know how many percentage points you have used. You can change any of your answers until you are satisfied. You are not expected to know the exact answers, but give your best estimate. After you have assigned all 100 percentage points, and you are content with your answers, please press the ">>" button.

_____ SMALL ELECTRIC APPLIANCES
_____ TELEVISIONS
_____ SPACE HEATING
_____ LIGHTING
_____ CLOTHES WASHING/DRYING
_____ DISHWASHERS
_____ COOKING
_____ WATER HEATING
_____ AIR CONDITIONING
_____ SWIMMING POOL HEATERS, GRILLS, AND OUTDOOR HEATING LAMPS
_____ REFRIGERATORS/FREEZERS
_____ COMPUTERS
_____ OTHER

For each of the following categories, please indicate how often you INTERACT WITH items in that category. By "INTERACT WITH," we mean turning the device on, turning the device off, or adjusting the device in some way.

	Never	Rarely	Occasionally	Moderately Often	Very Often
SMALL ELECTRIC APPLIANCES	❍	❍	❍	❍	❍
TELEVISIONS	❍	❍	❍	❍	❍
SPACE HEATING	❍	❍	❍	❍	❍
LIGHTING	❍	❍	❍	❍	❍
CLOTHES WASHING/DRYING	❍	❍	❍	❍	❍
DISHWASHERS	❍	❍	❍	❍	❍
COOKING	❍	❍	❍	❍	❍
WATER HEATING	❍	❍	❍	❍	❍
AIR CONDITIONING	❍	❍	❍	❍	❍
SWIMMING POOL HEATERS, GRILLS, AND					

HEATERS, GRILLS, AND OUTDOOR HEATING LAMPS	❍	❍	❍	❍	❍
REFRIGERATORS/FREEZERS	❍	❍	❍	❍	❍
COMPUTERS	❍	❍	❍	❍	❍
OTHER	❍	❍	❍	❍	❍

Starke, A. D., Willemsen, M. C., & Snijders, C. (2021). Using Explanations as Energy-Saving Frames: A User-Centric Recommender Study. *Adjunct Proceedings of the 29th ACM Conference on User Modeling, Adaptation and Personalization*, 229–237. https://doi.org/10.1145/3450614.3464477

Using Explanations as Energy-Saving Frames: A User-Centric Recommender Study

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ABSTRACT

Recommender systems usually seek to cater to the preferences of a single user. However, societal issues that involve multiple stakeholders, such as climate change, cannot be mitigated this way. We address this issue by going beyond traditional algorithms, using psychological theories to not only optimize *what* is recommended (i.e., the algorithm), but also *how* interface items are presented. We present the 'Saving Aid' recommender system for household energy conservation, encouraging users to adopt energy-saving measures with high kWh savings, such as buying environmentally-friendly electronic appliances. In an online user study (N = 258), we compare different interfaces that promote measures with high kWh savings using different framing techniques, presenting either a kWh savings score or a Smart Savings Score that combines effort and kWh savings. We show that framing positively affects the extent to which users consider kWh savings when choosing a measure, without compromising the user's system evaluation.

CCS CONCEPTS

• **Information systems** → **Decision support systems**; • **Human-centered computing** → **Human computer interaction (HCI)**.

KEYWORDS

Behavioral Change, Energy Conservation, Rasch Model, Recommender Systems, Framing

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goals a recommender's developer seeks to attain [41], which can complicate system design if specific items in an interface need to be promoted. Energy recommender systems seek to support users to adopt more energy-efficient products, habits or behaviors [24, 28, 32, 36, 38], by presenting user-tailored content. While most studies have focused on developing an appropriate user model [11], the current study investigates how psychological decision-making principles can be incorporated in a recommender interface to promote sustainable decisions. We adhere to research that seeks to optimize *how* different recommender items are presented [30, 35], rather than *what* is recommended.

We present a recommender system for household energy-saving behavior called 'Saving Aid' (cf. Figure 1). An important issue in this domain is that users hardly consider the actual energy savings (in kWh) of most measures they can take [31]. One alleged reason is that people are generally bad at estimating the magnitude of energy savings [3], while other studies point out that the main operator, kWh savings, is too hard to understand [4, 25, 36]. Energy recommender interfaces would be more effective in affecting user preferences if they highlight important attributes.

Studies in psychology have relied on framing and persuasion to influence decision-making without changing the content [39], such as by presenting information selectively [14, 18]. While most people consider many attributes of an energy-saving measure, such as its investment costs and perceived effort, only few can correctly gauge its kWh saving content [3, 31]. Although changing how kWh savings are presented (e.g., as a 0-100 score) might help [21, 22], this has yet to be examined within a list of tailored recommendations. In fact, it is an open question whether interface aspects that explain personalized content through specific information can support behavioral change among its users.

Table 2: Results of the confirmatory factory analysis on user experience aspects. All aspects meet the requirements for convergent validity ($AVE > 0.5$). Items in grey and without factor loading were omitted from the final Structural Equation Model.

Aspect	Item	Loading
Domain Knowledge	I know the energy consumption of all devices in my household.	
	I understand the difference between different types of energy-saving measures.	.709
	I know energy-saving measures that most others haven't heard of.	
AVE = .63	I know which energy-saving measures are useful to implement.	.797
α = .77	I am able to choose the right energy-saving measures.	.861
	I don't understand most energy-saving measures.	
Perceived Support	I would use the saving aid tool more often if possible.	
	The saving aid was useless.	
	Because of the system I could easily choose measures.	.788
AVE = .79	The saving aid made me more energy-conscious.	.771
α = .92	I would recommend the saving aid to others.	
	The saving aid is helpful to find appropriate measures.	.873
	Because of the saving aid I could easily choose measures.	.838
Choice satisfaction	I like the measures I've chosen.	.625
	I think I chose the best measure(s) from the list.	.526
	I would enjoy performing the measures.	
AVE = .71	The chosen measures exactly fit my preference.	.650
α = .82	I would have liked to choose different measures than the ones I have chosen.	

savings on choice was mitigated by each of our energy-saving frames.

4.3 User Evaluation of Framing Interfaces

4.3.1 Confirmatory Factor Analysis. We examined whether a user's system perception was affected by the framing interfaces and, in turn, influenced a user's behavior and evaluation. We submitted the responses of user study survey to confirmatory factor analysis (CFA) using ordinal dependent variables. Table 2 shows that we

Savings condition. First, users to which measures were explained in terms of a combined savings-effort score reported higher levels of perceived support, a relationship that was moderated by a higher number of measures hovered in that condition (β = .992, $p < 0.01$). This suggested that users explored more measures in the Smart Savings condition and, therefore, perceived the 'Saving Aid' as more supportive. In turn, perceived support positively affected choice satisfaction ($p < 0.001$), forming a pathway from 'Smart X Hover' to choice satisfaction: a test of indirect effects indicated that

https://pure.tue.nl/ws/portalfiles/portal/119737279/20190226_CO_Starke.pdf

Table 3.6. Results of the confirmatory factory analysis on user experience aspects used in study 2. All aspects meet the requirements for convergent validity (AVE > 0.5). Items in grey and without factor

loading were omitted from the final Structural Equation Model (cf. section 3.8.3).

Aspect	Item	Loading
Domain Knowledge	I know the energy consumption of all devices in my household.	
	I understand the difference between different types of energy-saving measures.	.709
	I know energy-saving measures that most others haven't heard of.	
AVE: .63	I know which energy-saving measures are useful to implement.	.796
Alpha: .77	I am able to choose the right energy-saving measures.	.862
	I don't understand most energy-saving measures.	
Perceived Support	I would use the saving aid tool more often if possible.	
	The saving aid was useless.	
	Because of the system I could easily choose measures.	.767
AVE: .79	The saving aid made me more energy-conscious.	.750
Alpha: .92	I would recommend the saving aid to others.	
	The saving aid is helpful to find appropriate measures.	.850
	Because of the saving aid I could easily choose measures.	.815
Choice satisfaction	I like the measures I've chosen.	.615
	I think I chose the best measure(s) from the list.	.514
	I would enjoy performing the measures.	
AVE: .71	The chosen measures exactly fit my preference.	.639
Alpha: .82	I would have liked to choose different measures than the ones I have chosen.	

Starke, A. D. (2019). *Supporting energy-efficient choices using Rasch-based recommender interfaces* [Phd Thesis 1 (Research TU/e / Graduation TU/e), Technische Universiteit Eindhoven].
https://pure.tue.nl/ws/portalfiles/portal/119737279/20190226_CO_Starke.pdf

Appendix A.1

Tabulated overview of fit statistics of Rasch scale measures in **Chapter 3**, for both used Rasch scales (RS-25 and RS-20). We report each measure's estimated behavioral cost level (Behav. Costs), Mean Square (MNSQ), and Standardized Mean (ZSTD), based on infit.

		RS-20 (N = 304)			RS-25 (N = 310)		
			Infit			*Infit*	
	Measure	Behav. Costs	MN SQ	ZSTD	Behav. Costs	MN SQ	ZSTD
1	Wash only full loads of laundry	**−5.97**	1.00	0.00	**−3.67**	0.95	0.09
2	Do not leave your exhaust hood on when not in use	**−3.07**	1.10	0.36	**−2.76**	1.03	0.20
3	Run a dishwasher only when full, but not overloaded	**−2.98**	0.89	−0.09	**−2.27**	0.90	−0.23
4	Cook with pots & pans the same size as the heating element	**−2.66**	0.78	−0.47	**−2.73**	0.80	−0.50
5	Hang/air dry laundry	**−2.65**	1.03	0.21	**−2.25**	1.19	0.81
6	Rake leaves with a garden rake instead of a leaf blower	**−2.51**	1.17	0.54	**−1.81**	1.12	0.62
7	Cover pots & pans when cooking	**−2.46**	1.12	0.52	**−2.26**	1.02	0.16
8	Install a laptop (instead of a desktop computer)	**−2.38**	1.03	0.21	**−2.46**	1.02	0.18
9	Refrain from installing an air conditioner unless necessary for safety	**−2.35**	0.77	−0.72	**−2.12**	0.86	−0.49
10	Refrain from using an electric blanket	**−2.32**	1.10	0.43	**−1.89**	1.08	0.42
11	Cool hot food before putting it in the refrigerator	**−2.30**	0.97	0.01	**−2.32**	1.04	0.26
12	Repair leaky faucets	**−2.26**	1.10	0.39	**−2.12**	1.07	0.34
13	Turn off or down heating/cooling system when going away for several days	**−2.22**	1.14	0.59	**−2.37**	1.25	0.91

14	Replace incandescent light bulbs with CFLs	**−2.09**	0.94	−0.21	**−2.02**	0.89	−0.51

15	Install double-pane windows	**−1.94**	0.97	−0.07	**−1.61**	0.90	−0.51
16	Use blankets (instead of a heater)	**−1.92**	1.10	0.48	**−1.76**	1.08	0.46
17	Switch off the coffee machine completely	**−1.92**	1.01	0.11	**−2.02**	0.98	−0.02
18	Decide what you want from the refrigerator before opening the door	**−1.85**	0.84	−0.75	**−1.77**	0.84	−0.87
19	Refrain from using a screensaver	**−1.82**	0.96	−0.12	**−1.76**	0.92	−0.38
20	Take a shower instead of a bath	**−1.78**	1.01	0.11	**−1.97**	1.12	0.57
21	Replace all incandescents with CFLs or LEDs	**−1.71**	0.97	−0.11	**−1.78**	0.91	−0.44
22	Use natural light in the daytime	**−1.64**	0.95	−0.20	**−1.41**	0.85	−0.94
23	Open blinds/curtains/drapes/shades at night when cooling your home	**−1.53**	1.15	0.96	**−1.34**	1.21	1.63
24	Wash laundry at a low(er) temperature	**−1.52**	1.02	0.19	**−1.40**	1.00	0.04
25	Turn off monitors when not in use	**−1.47**	0.86	−0.82	**−1.54**	0.90	−0.60
26	Switch off the dishwasher immediately after use	**−1.45**	0.81	−1.10	**−1.31**	0.86	−1.02
27	Thaw food in a refrigerator or sink	**−1.39**	1.13	0.83	**−1.15**	1.11	0.83
28	Turn off bathroom exhaust fans 20 minutes after bathing	**−1.34**	0.96	−0.23	**−1.29**	0.97	−0.24
29	Boil only as much water as you need	**−1.24**	0.93	−0.43	**−1.48**	0.97	−0.17
30	Cook with a frypan (instead of an oven)	**−1.24**	1.06	0.39	**−1.17**	0.94	−0.43
31	Install a light switch at both ends of hallways	**−1.20**	1.18	1.14	**−1.33**	1.14	0.95
32	Set refrigerators to the warmest food-save temperature (4°C)	**−1.19**	1.01	0.14	**−1.29**	1.05	0.41
33	Towel/air dry hair instead of using electric hair dryer	**−1.17**	1.12	0.83	**−1.07**	1.08	0.65
34	Use rechargeable batteries	**−1.15**	0.87	−0.93	**−0.79**	0.95	−0.41
35	Turn off air conditioners in unoccupied rooms	**−1.03**	0.93	−0.32	**−0.92**	0.97	−0.15
36	Dry only full loads of laundry	**−1.02**	1.14	0.94	**−1.24**	1.22	1.52
37	Air rooms for 20 minutes a day	**−1.00**	1.12	0.91	**−0.79**	1.01	0.09

104	Switch off the refrigerator when on holiday	**0.98**	1.18	1.01	**0.98**	1.17	1.07
105	Switch off the computer screen when downloading	**0.99**	1.17	1.00	**0.99**	1.06	0.44
106	Lower the boiler temperature	**1.00**	1.16	0.79	**0.97**	1.10	0.66
107	Vent radiators regularly	**1.00**	0.83	−1.04	**1.04**	0.84	−0.98
108	Set your TV to energy efficient settings	**1.07**	1.06	0.35	**1.10**	1.03	0.24
109	Check the pressure in your boiler	**1.11**	0.90	−0.43	**0.63**	0.91	−0.63
110	Insulate the attic, including the trap/access door	**1.16**	0.80	−1.12	**1.25**	0.79	−1.22
111	Replace your water heater if it is more than 7 years old	**1.36**	0.91	−0.37	**1.24**	1.06	0.41
112	Install door closers	**1.44**	1.20	0.89	**1.48**	1.19	0.86
113	Descale the washing machine	**1.52**	1.04	0.25	**1.53**	0.97	−0.09
114	Install solar powered garden lights	**1.54**	0.96	−0.12	**1.72**	1.01	0.12
115	Use electric blankets (instead of a heater)	**1.62**	1.10	0.44	**1.69**	1.11	0.47
116	Install an induction stove instead of a natural gas stove/range	**1.63**	1.00	0.10	**1.60**	1.01	0.11
117	Install exterior wall insulation (house wrap)	**1.70**	1.11	0.47	**1.52**	1.04	0.27
118	Clean lights & light fittings regularly	**1.76**	0.83	−0.51	**1.81**	0.87	−0.48
119	Install solar panels	**1.78**	1.13	0.53	**1.65**	1.11	0.55
120	Install a remote controlled thermostat	**1.82**	1.11	0.52	**1.77**	0.93	−0.25
121	Install heat-resistant radiator reflectors between exterior walls and radiators	**1.95**	1.09	0.39	**1.96**	1.04	0.22
122	Install a timer on your boiler	**2.07**	0.92	−0.13	**2.21**	0.95	−0.05
123	Turn off the oven 10 minutes early	**2.30**	0.78	−0.48	**2.63**	0.81	−0.34
124	Set timers on space heaters	**2.83**	1.14	0.44	**2.99**	1.09	0.34
125	Install a shower water usage feedback system	**2.85**	0.68	−0.70	**2.89**	0.72	−0.67

Appendix A.2

Tabulated overview of attribute values of energy-saving measures used in **Chapter 3**, Study 1 and Study 2. The actual values are based on range of scientific sources based on US data (Boudet et al., 2016; Wenzel et al., 1997), which were compared to a database from Dutch governmental organization Milieucentraal and publicly available information from Dutch energy supplier Eneco.

	Measure	Est. [kWh] savings	Inv. Costs	Frequency	Effort
1	Wash only full loads of laundry	30	€5<	weekly	1.73
2	Do not leave your exhaust hood on when not in use	18	€5<	daily	1.13

3	Run a dishwasher only when full, but not overloaded	40	€5<	daily	1.55
4	Cook with pots & pans the same size as the heating element	5	€5<	daily	1.33
5	Hang/air dry laundry	290	€5<	weekly	2.22
6	Rake leaves with a garden rake instead of a leaf blower	36	€5<	weekly	2.71
7	Cover pots & pans when cooking	5	€5<	daily	1.25
8	Install a laptop (instead of a desktop computer)	40	€100-€1000	once every 3 years	2.21
9	Refrain from installing an air conditioner unless necessary for safety	400	€5<	once every 3 or more years	1.56
10	Refrain from using an electric blanket	60	€5<	weekly	1.63
11	Cool hot food before putting it in the refrigerator	2	€5<	daily	1.45
12	Repair leaky faucets	70	€5<	seasonal	2.73
13	Turn off or down heating/cooling system when going away for several days	115	€5<	daily	1.36

Table 4.2. Results of the confirmatory factory analysis on user experience aspects. All aspects meet the requirements for convergent validity (AVE > 0.5). Items denoted in grey without loading were removed from the final model.

Aspect	Item	Loading
Perceived Feasibility	The recommended measures are hard to perform	–.806
	I do not have the possibility to perform the recommended measures	–.561
AVE: .54	The recommended measures are applicable in my home environment	
Alpha: .72	It takes little effort to perform the recommended measures	.738
Perceived Helpfulness	The scores/percentages next to a measure were helpful	
	I could easily select an appropriate measure because of the scores or percentages	
	The measure scores did not help me to make a choice	
Perceived Support	I would use the saving aid tool more often if possible.	
	The saving aid was useless.	
	Because of the system I could easily choose measures.	
	The saving aid made me more energy-conscious.	
	I would recommend the saving aid to others.	
	The saving aid is helpful to find appropriate measures.	
	Because of the saving aid I could easily choose measures.	
Choice satisfaction	I like the measures I've chosen.	.693
	I think I chose the best measure(s) from the list.	.656
	I would enjoy performing the measures.	.750
AVE: .67	The chosen measures exactly fit my preference.	.824
Alpha: .87	I would have liked to choose different measures than the ones I've chosen.	

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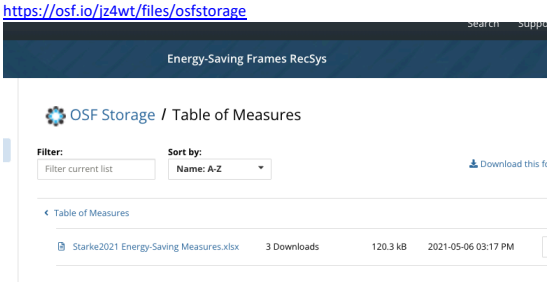
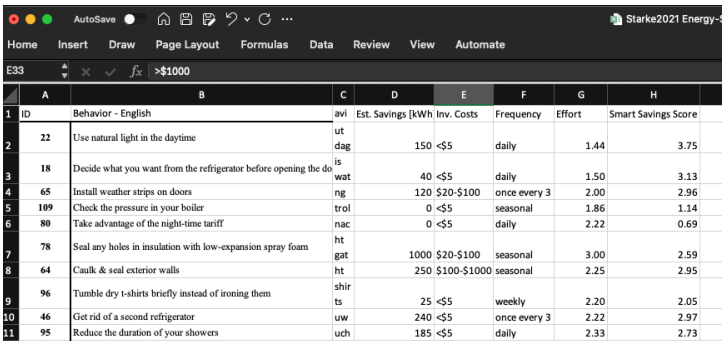
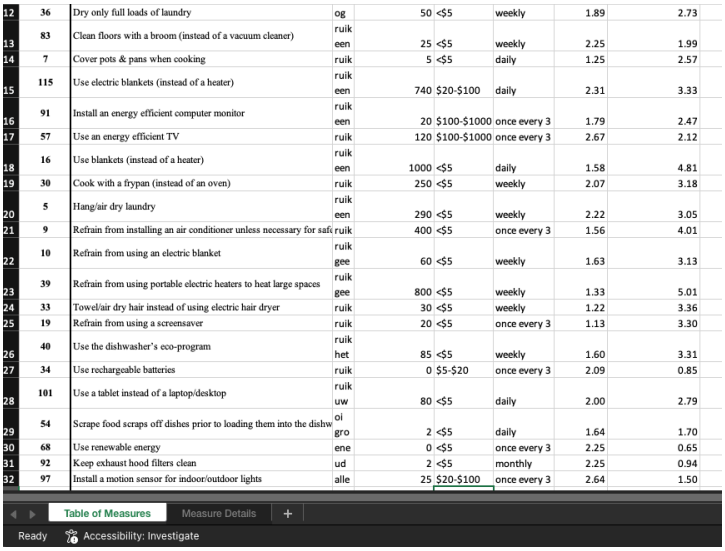




	A	B	C	D	E	F	G	H
1	ID	Behavior - English	avi	Est. Savings [kWh	Inv. Costs	Frequency	Effort	Smart Savings Score
2	22	Use natural light in the daytime	ut dag	150	<$5	daily	1.44	3.75
3	18	Decide what you want from the refrigerator before opening the do	is wat	40	<$5	daily	1.50	3.13
4	65	Install weather strips on doors	ng	120	$20-$100	once every 3	2.00	2.96
5	109	Check the pressure in your boiler	trol	0	<$5	seasonal	1.86	1.14
6	80	Take advantage of the night-time tariff	nac	0	<$5	daily	2.22	0.69
7	78	Seal any holes in insulation with low-expansion spray foam	ht gat	1000	$20-$100	seasonal	3.00	2.59
8	64	Caulk & seal exterior walls	ht	250	$100-$1000	seasonal	2.25	2.95
9	96	Tumble dry t-shirts briefly instead of ironing them	shir ts	25	<$5	weekly	2.20	2.05
10	46	Get rid of a second refrigerator	uw	240	<$5	once every 3	2.22	2.97
11	95	Reduce the duration of your showers	uch	185	<$5	daily	2.33	2.73



12	36	Dry only full loads of laundry	og	50	<$5	weekly	1.89	2.73
13	83	Clean floors with a broom (instead of a vacuum cleaner)	ruik een	25	<$5	weekly	2.25	1.99
14	7	Cover pots & pans when cooking	ruik	5	<$5	daily	1.25	2.57
15	115	Use electric blankets (instead of a heater)	ruik een	740	$20-$100	daily	2.31	3.33
16	91	Install an energy efficient computer monitor	ruik een	20	$100-$1000	once every 3	1.79	2.47
17	57	Use an energy efficient TV	ruik	120	$100-$1000	once every 3	2.67	2.12
18	16	Use blankets (instead of a heater)	ruik een	1000	<$5	daily	1.58	4.81
19	30	Cook with a frypan (instead of an oven)	ruik	250	<$5	weekly	2.07	3.18
20	5	Hang/air dry laundry	ruik een	290	<$5	weekly	2.22	3.05
21	9	Refrain from installing an air conditioner unless necessary for saf	ruik	400	<$5	once every 3	1.56	4.01
22	10	Refrain from using an electric blanket	ruik gee	60	<$5	weekly	1.63	3.13
23	39	Refrain from using portable electric heaters to heat large spaces	ruik gee	800	<$5	weekly	1.33	5.01
24	33	Towel/air dry hair instead of using electric hair dryer	ruik	30	<$5	weekly	1.22	3.36
25	19	Refrain from using a screensaver	ruik	20	<$5	once every 3	1.13	3.30
26	40	Use the dishwasher's eco-program	ruik het	85	<$5	weekly	1.60	3.31
27	34	Use rechargeable batteries	ruik	0	$5-$20	once every 3	2.09	0.85
28	101	Use a tablet instead of a laptop/desktop	ruik uw	80	<$5	daily	2.00	2.79
29	54	Scrape food scraps off dishes prior to loading them into the dishw	oi gro	2	<$5	daily	1.64	1.70
30	68	Use renewable energy	ene	0	<$5	once every 3	2.25	0.65
31	92	Keep exhaust hood filters clean	ud	2	<$5	monthly	2.25	0.94
32	97	Install a motion sensor for indoor/outdoor lights	alle	25	$20-$100	once every 3	2.64	1.50

Table of Measures | Measure Details | +

Ready | Accessibility: Investigate

Poortinga, W., Steg, L., Vlek, C., & Wiersma, G. (2003). Household preferences for energy-saving measures: A conjoint analysis. *Journal of Economic Psychology*, *24*(1), 49–64. https://doi.org/10.1016/S0167-4870(02)00154-X

Table 1
Average acceptability of 23 energy-saving measures and their characteristics

Energy-saving measure	Domain	Strategy	Amount	Mean	SD
Switching off lights in unused rooms	H	2	+	4.6	0.68
Appliances not on stand-by	H	2	+	4.4	0.87
Energy-efficient heating system	H	1	++	4.3	0.94
Walking or cycling short distances (<$2\frac{1}{2}$ km)	T	2	++	4.3	1.00
House insulation	H	1	++	4.3	0.89
Line drying of laundry	H	2	++	4.0	1.13
Compact fluorescent light bulbs (CFLs)	H	1	+	4.0	0.94
Applying radiator insulation (foil)	H	1	+	4.0	0.99
Energy-efficient refrigerator	H	1	+	3.9	1.01
Shorter showers	H	2	++	3.6	1.10
Walking or cycling short distances (<5 km)	T	2	++	3.6	1.18
Econometer in car	T	1	+	3.6	1.16
Energy-efficient car	T	1	++	3.4	1.15
Car-pooling	T	2	+	3.4	1.33
Drive at most 100 km/h on the highway	T	2	+	3.3	1.35
Using public transport	T	2	++	3.2	1.42
No greenhouse vegetables	H	3	+	3.1	1.14
Thermostat maximally 18 °C	H	2	++	3.1	1.27
Energy-extensive presents (no flowers)	H	3	+	2.9	1.19
Rinsing the dishes with cold water	H	2	+	2.9	1.31
Holiday by train	T	3	+	2.8	1.32
Altering food pattern	H	3	+	2.7	1.26
Hiring a housekeeper	H	3	++	2.7	1.31

Note: The scale ranged from 1 "unacceptable" to 5 "very acceptable".
Note: H: home measures, T: transport measures, 1: increasing energy efficiency (technical measures), 2: a different use of products (behavioral measures), 3: shifts in consumption (behavioral measures), +: small energy saving; ++: large energy saving.

(a) *Domain* (two levels): home energy-saving measures versus transport energy-saving measures.
(b) *Strategy* (three levels): increasing energy-efficiency, different use of products, and shift in consumption.
(c) *Amount* (two levels): small versus large energy saving. Respondents were informed about the amount of energy reduction per option.

3.2.2. Environmental concern

Attari, S. Z., Krantz, D. H., & Weber, E. U. (2016). Energy conservation goals: What people adopt, what they recommend, and why. *Judgment and Decision Making*, *11*(4), 342–351. https://doi.org/10.1017/S1930297500003776
https://static.cambridge.org/content/id/urn%3Acambridge.org%3Aid%3Aarticle%3AS1930297500003776/resource/name/S1930297500003776sup004.pdf

Judgment and Decision Making, Vol. 11, No. 4, July 2016, pp. 342–351

Energy conservation goals:
What people adopt, what they recommend, and why

Shahzeen Z. Attari[*] David H. Krantz[†] Elke U. Weber[‡]

Abstract

Failures to reduce greenhouse gas emissions by adopting policies, technologies, and lifestyle changes have led the world to the brink of crisis, or likely beyond. Here we use Internet surveys to attempt to understand these failures by studying factors that affect the adoption of personal energy conservation behaviors and also endorsement of energy conservation goals proposed for others. We demonstrate an asymmetry between goals for self and others ("I'll do the easy thing, you do the hard thing"), but we show that this asymmetry is partly produced by actor/observer differences: people know what they do already (and generally do not propose those actions as personal goals) and also know their own situational constraints that are barriers to action. We also show, however, that endorsement of conservation goals decreases steeply as a function of perceived difficulty; this suggests a role for motivated cognition as a barrier to conservation: difficult things are perceived as less applicable to one's situation.

Keywords: energy conservation, actor/observer bias, motivated reasoning

1 Introduction

As part of a study of perceptions of energy use and savings, Attari, DeKay, Davidson and Bruine de Bruin (2010) asked subjects to name "the most effective thing that you could do to conserve energy in your life". Many answers (about 20%) involved variations on "turning off lights", but others suggested more major changes in life style (e.g., "drive less") or increased efficiency of cars or appliances. In the present studies we explore some factors that correlate with choice of these different answers. In particular, we ask how answers for oneself differ from answers proposed for others (the most effective thing that *Americans* can do). These explorations are important in order to understand both adoption of individual change goals and endorsement of energy conservation policies that would apply to all Americans.

We expected people to favor "low hanging fruit" both for themselves and others: changes that are highly effective but not too difficult. Thus, two obvious factors that we expected to correlate with behavioral change goals (for self) and policy goals (changes that others should make) are the *perceived effectiveness* and the *perceived difficulty* of the changes. In addition, we expected people to omit goals not applicable to their lives: for example, urban dwellers who rely mostly on public transportation will not propose to conserve energy by driving less or buying energy-efficient cars (even though they may suggest these changes for others). Finally, there is a conversational rule (Grice, Cole & Morgan, 1975) that may be important: something that one does already is not usually put forward as a goal. Someone who is already assiduous about turning off lights is thus less likely to endorse that as a behavioral goal for self.

These obvious factors suggest reasons why goals for self and others might differ. Perceived effectiveness and difficulty should play a role in both; but perception of appli-

Table 1: Percentage of open-ended endorsements provided in Study 1 and Study 2 for the single most effective behavior for self and Americans.

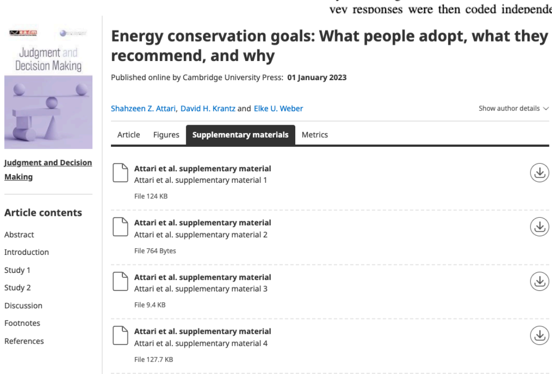
	Study 1 (N = 717)		Study 2 (N = 685)	
Categories	Self	Americans	Self	Americans
Turn off lights	19.5	13.0	13.6	10.2
Drive less	19.3	31.8	19.3	31.8
Turn off appliances	10.9	7.8	12.6	10.7
Change setting on the thermostat	9.1	4.6	10.7	5.7
Sleep/relax more	7.3	4.6	1.8	1.3
Use appliances less	5.4	4.6	8.3	4.7
Unplug appliances	5.0	2.8	7.0	4.5
Conserve water/energy	4.6	4.5	4.2	1.5
Use energy efficient bulbs	2.8	3.6	2.8	3.6
Consume less	2.7	4.0	0.9	2.2
Other (each only mentioned once)	2.4	1.8	4.5	3.2
Use efficient cars/hybrids	2.2	2.2	2.3	6.7
Use efficient appliances	1.8	2.9	3.9	3.1
Change my lifestyle	1.8	2.5	1.3	0.9
Buy green energy	1.3	3.2	1.6	3.4
Buy green products	1.1	1.0	0.3	0.0
Eat green	1.0	1.0	0.6	0.3
Recycle	0.7	1.4	0.9	1.5
Insulate my home/weatherize	0.4	0.4	1.3	1.5
There is no way/I don't know	0.4	0.4	0.1	0.0
Awareness/education; more attention	0.1	1.4	1.8	2.8
Phase out inefficient technologies	0.1	0.4	0.0	0.6

behaviors they perceive as difficult, but might do this less in recommendations for others.

In this article we present a very brief Study 1, showing an asymmetry between goals for self and for others, and a more complex Study 2, which replicates the asymmetry and explores the factors that affect adoption of conservation goals for self and conservation policies for others.

In your opinion, what is the single most effective thing that **Americans** could do to use less energy in their life?

Coding. The open-ended responses to both questions were sorted by two independent coders into 22 categories (see row labels in Table 1). These categories were devised by examining an initial subset of 40 surveys. All the survey responses were then coded independently by the two



Energy and Behavior Survey: SELF-OTHER ORDER

Dear Participant:

Your involvement in this study will help us understand behaviors related to energy consumption. Thank you for your time and help with this effort.

Please note that participation is voluntary. The survey is anonymous, and no one will know what answers you give. For this reason, please do not type your name or anyone else's name anywhere in the survey. The survey is relatively brief and should not take any more than 10 minutes to complete.

Thank you again for participating in this study. The asterisks denote questions for which you must provide answers for before going to the next screen. If you feel uncomfortable in answering any question, you can exit the survey. On completing the survey, you will be paid via $3 MTurk within 72 hours. There is a limit of one gift certificate per person.

If you have any questions, please do not hesitate to send me an email at: sattari@indiana.edu.

Sincerely,
Shahzeen Attari

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1. OPEN-ENDED SELF QUESTION

In your opinion, what is the single most effective thing that ***you*** could do to use less energy in your life?

_____

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2. OPEN-ENDED OTHER QUESTION

In your opinion, what is the most effective thing that ***Americans*** could do to use less energy in their life?

_____

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3. CLOSED-ENDED SELF QUESTION

Which of the following behaviors is the single most effective behavior that ***you*** could do to use less energy in your life? *(Please check one behavior)*

_Turn off lights and appliances when not in use
_Drive less and use other forms of transportation
_Buy green energy from my utility provider
_Use energy-efficient bulbs
_Change settings on the thermostat (turning up air-conditioner in the summer and turning down thermostat in winter)
_Consume less
_Buy a fuel-efficient car

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4. CLOSED-ENDED OTHER QUESTION

Which of the following behaviors is the single most effective behavior that ***Americans*** could do to use less energy in your life? *(Please check one behavior)*

_Turn off lights and appliances when not in use
_Drive less and use other forms of transportation
_Buy green energy from my utility provider
_Use energy-efficient bulbs
_Change settings on the thermostat (turning up air-conditioner in the summer and turning down thermostat in winter)
_Consume less
_Buy a fuel-efficient car

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5. EASE/DIFFICULTY OF ENERGY-SAVINGS BEHAVIORS

Please indicate how easy or hard it would be for you to make each of the following changes. Please consider all aspects of the changes, including the physical or mental effort required, the time or hassle involved, and any relevant monetary costs.
If you already engage in the activity please check the option on the far left.

	Do it already	Extremely easy	Very easy	Somewhat easy	Neither easy nor hard	Somewhat hard	Very hard	Extremely hard
Turning off lights and appliances	O	O	O	O	O	O	O	O
Driving less and using other forms of transportation	O	O	O	O	O	O	O	O
Buying green energy from utility provider	O	O	O	O	O	O	O	O
Using energy-efficient bulbs	O	O	O	O	O	O	O	O
Changing								

settings on the thermostat (turning up air-conditioner in the summer and turning down thermostat in winter)	O	O	O	O	O	O	O	O
Consuming less	O	O	O	O	O	O	O	O
Buying a fuel-efficient car	O	O	O	O	O	O	O	O

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6. EFFECTIVENESS OF ENERGY-SAVINGS BEHAVIORS

Please indicate how effective or ineffective each of the following behaviors is in terms of decreasing an individual's energy use.

	Extremely ineffective	Very ineffective	Somewhat ineffective	Neither ineffective nor effective	Somewhat effective	Very effective	Extremely effective
Turning off lights and appliances	O	O	O	O	O	O	O
Driving less and using other forms of transportation	O	O	O	O	O	O	O
Buying green energy from utility provider	O	O	O	O	O	O	O
Using energy-efficient bulbs	O	O	O	O	O	O	O
Changing settings on the thermostat (turning up air-conditioner in the summer and turning down thermostat in winter)	O	O	O	O	O	O	O
Consuming less	O	O	O	O	O	O	O
Buying a fuel-efficient car	O	O	O	O	O	O	O

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7. APPLICABILITY OF ENERGY-SAVINGS BEHAVIORS

Please indicate how applicable or not applicable each of the following behaviors is to your life. In considering how applicable each behavior is, consider whether the behavior is relevant to your life.

	Very applicable	Somewhat applicable	Not at all applicable
Turning off lights and appliances	O	O	O
Driving less and using other forms of transportation	O	O	O

Buying green energy from utility provider	O	O	O
Using energy-efficient bulbs	O	O	O
Changing settings on the thermostat (turning up air-conditioner in the summer and turning down thermostat in winter)	O	O	O
Consuming less	O	O	O
Buying a fuel-efficient car	O	O	O

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8. ATTITUDES (PRO-ENVIRONMENTAL VIA NEP SCALE)

Please indicate how strongly you agree or disagree with each of the following statements.

	Completely agree	*Agree*	*Somewhat agree*	*Neither agree nor disagree*	*Somewhat disagree*	*Disagree*	*Completely disagree*
We are approaching the limit of the number of people the earth can support.	O	O	O	O	O	O	O
Humans have the right to modify the natural environment to suit their needs.	O	O	O	O	O	O	O
When humans interfere with nature it often produces disastrous consequences.	O	O	O	O	O	O	O
Human ingenuity will insure that we do NOT make the earth unlivable.	O	O	O	O	O	O	O
Humans are severely abusing the environment.	O	O	O	O	O	O	O
The earth has plenty of natural resources if we can just learn how to develop them.	O	O	O	O	O	O	O
Plants and animals have as much right as humans to exist.	O	O	O	O	O	O	O

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ATTITUDES (PRO-ENVIRONMENTAL VIA NEP SCALE) CONTINUED

Please indicate how strongly you agree or disagree with each of the following statements.

	Completely agree	*Agree*	*Somewhat agree*	*Neither agree nor disagree*	*Somewhat disagree*	*Disagree*	*Completely disagree*
The balance of nature is strong enough to cope with the impacts of modern industrial nations.	O	O	O	O	O	O	O
Despite our special abilities, humans are still subject to the laws of nature.	O	O	O	O	O	O	O
The so-called "ecological crisis" facing humankind has been greatly exaggerated.	O	O	O	O	O	O	O
The earth is like a spaceship with very limited room and resources.	O	O	O	O	O	O	O
Humans were meant to rule over the rest of nature.	O	O	O	O	O	O	O

The balance of nature is very delicate and easily upset.	O	O	O	O	O	O	O
Humans will eventually learn enough about how nature works to be able to control it.	O	O	O	O	O	O	O
If things continue on their present course, we will soon experience a major ecological catastrophe.	O	O	O	O	O	O	O

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CLIMATE CHANGE ATTITUDE QUESTIONS

Please indicate how strongly you agree or disagree with each of the following statements.

	Completely agree	*Agree*	*Somewhat agree*	*Neither agree nor disagree*	*Somewhat disagree*	*Disagree*	*Completely disagree*
Humans are responsible for global warming and climate change.	O	O	O	O	O	O	O
Humans do not need to change their lifestyles to address global warming and climate change.	O	O	O	O	O	O	O
I believe that my actions contribute to global warming and climate change.	O	O	O	O	O	O	O
I believe that I need to change my lifestyle to address global warming and climate change.	O	O	O	O	O	O	O

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9. NUMERACY

To answer the following questions, please enter whole numbers or decimals with no other text (not ranges or percent signs).

Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips?

In the BIG BUCKS LOTTERY, the chance of winning a $10 prize is 1%. What is your best guess about how many people would win a $10 prize if 1000 people each buy a single ticket to BIG BUCKS?____

In ACME PUBLISHING SWEEPSAKES, the chance of winning a car is 1 in 1,000. What percent of tickets to ACME PUBLISHING SWEEPSAKES win a car?____

<*page break*>

10. DEMOGRAPHICS

Please answer the following questions about yourself and your situation. Your confidential answers will help us understand the types of people who have completed the survey.

Do you think you could use less energy in your home if you tried?
_Y _N

Would you like to consume less energy in your home if you could?
_Y _N

About how much was the last monthly electric bill for your household? Please provide a dollar amount (rounded to the nearest dollar) with no other text. Your best estimate is fine. ___

https://static1.squarespace.com/static/54e39dcfe4b033c7e0e77c20/t/5e6ff908c80356332ba7042a/1584396554209/EnergyMix_SI.pdf

Shared vision for a decarbonized future energy system in the United States

Deidra Miniard, Joseph Kantenbacher, and Shahzeen Z. Attari (2020) *Proceedings of the National Academy of Sciences*, 117 (13) 7108-7114.

- Supplemental Information
- Data
- R Code (RMD)

Solar energy can be used two ways. One method is using photovoltaic panels to convert sunlight into energy. Another method uses solar thermal energy to heat water or homes and can be used to generate electricity.

Wind is used to generate electricity using the kinetic energy collected by wind turbines. Wind turbines can be placed on land or off-shore in large bodies of water.

In the U.S., our energy comes from a mix of these sources. Some sources contribute a

lot of energy and other sources contribute only a little. The breakdown of those contributions is referred to as the **"energy mix."**
What do you think is the ***current*** energy mix of the United States? In other words, what percent of the total energy consumption in the U.S. is supplied by each source ***today***?

Please enter whole numbers (no decimals, ranges, or percentages) with no other text (no spaces, punctuation, or words). For example, if you think one out of every four people owns a dog, you would respond 25.

[Energy sources appear in randomized order]

Energy Source	Percentage (%)
Oil	
Natural Gas	
Coal	
Nuclear	
Geothermal	
Solar	
Wind	
Biomass	
Hydroelectric	

[Page Break]

2. Now we're going to ask about your ***hopes*** for the ***future*** energy mix of the United States. What do you think would be the ***absolute best possible*** energy mix for the U.S. by the year ***2050***?

In other words, what percent of the total energy consumption in the U.S. do you ***hope*** is supplied by each source in the year 2050? If there are energy sources that you hope

Access to quality health care	☐	☐	☐	☐

What do you think is the **most** important problem facing the ***world in the future***?
- ☐ Economy and jobs
- ☐ Climate change
- ☐ Immigration
- ☐ Access to quality healthcare

[Page Break]

Policy Support: all participants were asked the following questions. Shown in random order.

	Strongly Oppose	Oppose	Neutral	Support	Strongly Support
Construct new nuclear power plants to replace coal fired power plants.	☐	☐	☐	☐	☐
Lower the fuel-economy standards that automobile industries are required to meet.	☐	☐	☐	☐	☐
Tax carbon emissions using a rate that can be increased or decreased over time.	☐	☐	☐	☐	☐
Decrease federal subsides for wind, solar, and other renewable energy technologies so they can be market tested against traditional fossil fuels.	☐	☐	☐	☐	☐
Provide government funding for development of renewable energy sources.					
Construct and complete pipelines to transport oil across the United States.	☐	☐	☐	☐	☐
Subsidize the production of electric cars to replace gasoline burning vehicles.	☐	☐	☐	☐	☐
Place tariffs on imported solar panels.	☐	☐	☐	☐	☐
Halt construction of pipelines that transport oil across the United States.	☐	☐	☐	☐	☐

Lundberg, D. C., Tang, J. A., & Attari, S. Z. (2019). Easy but not effective: Why "turning off the lights" remains a salient energy conserving behaviour in the United States. *Energy Research & Social Science*, *58*, 101257.
https://doi.org/10.1016/j.erss.2019.101257
https://www.szattari.com/publications

Easy but not effective: Why "turning off the lights" remains a salient energy conserving behaviour in the United States

Daniel C. Lundberg, Janine A. Tang, and Shahzeen Z. Attari (2019) *Energy Research & Social Science*, 58.

- Survey
- Data (xlxs)

SURVEY

Dear Participant,

Please complete this survey on a relevant public policy issue. The survey is anonymous, and no one will know what answers you give. This brief survey should take no more than 10 minutes to complete Thank you for your time and help with this effort.

Sincerely,
Dr. Shahzeen Attari
Indiana University Bloomington

{Page Break}

What is the single most effective thing you **currently do** to save energy in your life? {Text Box}

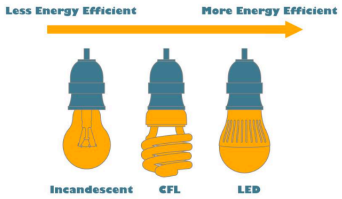
_____

What is the single most effective thing you **could be doing** to save energy in your life? {Text Box}

_____

{Page Break}

During this survey, please keep the infographic below in mind. Incandescent light bulbs are less energy efficient than CFL (compact fluorescent light) bulbs, and CFL bulbs are less energy efficient than LED (light emitting diode) bulbs.



{Page Break}

Assume a friend of yours wants to know which of the two actions below saves the most energy over the course of a month. Which one would you tell them saves the most energy?

Always turning off the lights when leaving a room	Replacing incandescent light bulbs with more efficient light bulbs, like CFL and LED bulbs

{Page Break}

How did you choose your previous answer?

As a reminder, you were telling a friend which option saves the most energy over the course of a month: turning off the lights or replacing incandescent light bulbs with more efficient light bulbs.

{randomized; efficiency attribute section and curtailment attribute section appear in different orders equally}

Now think about the action of **turning off the lights.**

Please state how strongly you agree or disagree with each statement below.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
This is easy to do					
This saves me money on my electricity bill					
I am able to do this where I live					
I was taught to do this					
This is my habit					
This helps the environment					
This will make my light bulbs last longer					
This significantly reduces my carbon footprint					
Everyone else does this, so I do it too					
I do this because of public advocacy (advertisements, media, etc.)					

{Page Break}

Continue thinking about the action of **turning off the lights.**

Please state how strongly you agree or disagree with each statement below.

Now think about the action of **replacing incandescent light bulbs with more efficient light bulbs, like CFL and LED bulbs.**

Please state how strongly you agree or disagree with each statement below.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
This is easy to do					
This saves me money on my electricity bill					
I am able to do this where I live					
I was taught to do this					

{Page Break}
{A/B randomized}

For each question below, read the two options presented and choose the option that you think **saves the most energy.**

Decreasing one incandescent light bulb's use from 4 hours to 3 hours	Using one LED light bulb for 4 hours **instead of** an incandescent light bulb
Reducing the use of a window air conditioning unit from 5 hours to 3 hours	Keeping a ceiling fan on for 5 hours **instead of** using a window air conditioning unit
Reducing the use of a dehumidifier from 10 hours to 5 hours	Purchasing a 20% more efficient dehumidifier and using it for 10 hours **instead of** using a standard

	dehumidifier
Decreasing the use of one CFL bulb from 2 hours to 1 hour	Using one LED bulb for 2 hours **instead of** a CFL bulb
Decreasing the use of one CFL bulb from 10 hours to 1 hour	Using one LED bulb for 10 hours **instead of** a CFL bulb
Reducing the use of a projector to watch movies from 10 hours to 9 hours a week	Using a smartphone for 10 hours a week to watch movies **instead of** a projector
Decreasing the use of a central air conditioning unit from 6 hours to 5 hours	Using a ceiling fan for 6 hours **instead of** a central air conditioning unit
Reducing the use of a space heater from 5 hours to 4 hours	Using an electric blanket for 5 hours **instead of** a space heater
Reducing the use of a desktop computer to play music from 10 hours to 5 hours	Using a stereo to play music for 10 hours **instead of** a desktop computer

{Page Break}

Schille-Hudson, E. B., Margehtis, T., Miniard, D., Landy, D., & Attari, S. Z. (2019). Big, hot, or bright? Integrating cues to perceive home energy use. *Proceedings of the 41st Cognitive Science Society*.

Appendix: Features

1. How **big** is each appliance?
2. How **long** is each appliance typically used?
3. How much **light** does each appliance produce?
4. How much does each appliance **heat** itself or its environment?
5. How **loud** is each appliance?
6. How much **water** does each appliance use?
7. How much does each appliance **cool** itself or its environment?
8. How big is the **motor** of each appliance?
9. How much does each appliance **heat water**?
10. How complex is the **software** each appliance runs?
11. How **electronic** is each appliance?
12. How **mechanical** is each appliance?
13. How much does each appliance **move** itself or its environment?
14. How **frequently** do you use each appliance?

Brandsma, J. S., & Blasch, J. E. (2019). One for all? – The impact of different types of energy feedback and goal setting on individuals' motivation to conserve electricity. *Energy Policy*, *135*, 110992. https://doi.org/10.1016/j.enpol.2019.110992
https://data.mendeley.com/datasets/zgy44yc22r/1

One for all? – The impact of different types of energy feedback and goal setting on individuals' motivation to conserve electricity

Jeroen S. Brandsma, Julia E. Blasch*

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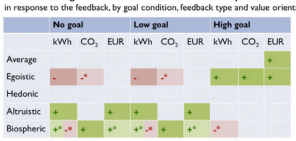
GRAPHICAL ABSTRACT

Observed change in motivation to conserve electricity in response to the feedback, by goal condition, feedback type and value orientation.



* only when accounting for goal acceptance
° only when not accounting for goal acceptance

ARTICLE INFO

Keywords:
Energy conservation behaviour
Energy feedback
Goal setting
Value orientation
Goal framing

ABSTRACT

We investigate how different types of energy feedback, combined with goal setting, impact on consumers' motivation to conserve electricity. Using an online survey, we test the influence of energy feedback in physical units (kWh), monetary values (EUR) and environmental values (avoided CO_2 emissions). We asked participants to set themselves either a high, low or no energy conservation goal. In addition, we assess the respondents' value types - hedonic, egoistic, altruistic and biospheric – to test predictions derived from goal framing theory. In general, individuals scoring high on biospheric values were more motivated to conserve electricity and their motivation did not increase in response to setting an energy conservation goal. Individuals with egoistic values seem less willing to reduce their electricity consumption, unless in the monetary feedback or high goal conditions. A high conservation goal was only found to be effective in combination with monetary feedback: it increased the motivation to save electricity by 6.7 percentage points in comparison to the low goal condition and 6.6 percentage points in comparison to the control condition.

The following questions are concerning your energy bill.
Indicate on a scale from 1 to 5 how often you perform the following activities, where a higher value indicates a higher frequency.

3. When you receive your energy bill, do you read the specifications of your energy usage?

Frequency	Never		Sometimes		Always

4. When you receive your energy bill, do you compare it to previous energy bills?

Frequency	Never		Sometimes		Always

5. How much energy do you think a computer uses daily in standby mode?

Consumption	0 kWh	0.37 kWh	20 kWh	4 kWh	0.05 kWh

6.
A. (33.33% of the participants) Imagine your energy provider invites you to set yourself an energy conservation goal of 10%. This means that in the coming month you will need to use 10% less energy than the same month in 2016. Would you be willing to set yourself that goal?

B. (33.33% of the participants) Imagine your energy provider invites you to set yourself an energy conservation goal of 2%. This means that in the coming month you will need to use 10% less energy than the same month in 2016. Would you be willing to set yourself that goal?

C. (33.33% of the participants) Do you have a smart meter? (this means that you receive an 'overview usage smart meter' from your energy provider every two months)

Yes / No

Yes -> You have agreed to set yourself an energy conservation goal. Keep this in mind while answering the next questions.

7. Would you be willing to turn your standby appliances (computer, television, coffee machine, microwave) completely off on a daily basis in order to conserve 37.5 kWh electricity per month (450 kWh per year)?

Yes / No

8. Would you be willing to turn your standby appliances (computer, television, coffee machine, microwave) completely off on a daily basis in order to reduce your monthly environmental impact by an equivalent of 123.28 kilometres driven by car (1479.38) kilometres per year)?

Yes / No

9. Would you be willing to turn your standby appliances (computer, television, coffee machine, microwave) completely off on a daily basis in order to reduce your energy bill by 8.21 euros per

10. On the next page you will find 16 values. Behind each value there is a short explanation concerning the meaning of the value. You have to rate how important each value is for you AS A GUIDING PRINCIPLE IN YOUR LIFE.
The rating scale is as follows:
-1 means the value is opposed to the principles that guide you

0 means the value is not important at all; it is not relevant as a guiding principle in your life

3 means the value is important

6 means the value is very important

7 means the value is of supreme importance as a guiding principle in your life; ordinarily there are no more than two such values

Your scores can vary of -1 up to 7. The higher the number (-1, 0, 1, 2, 3, 4, 5, 6, 7), the more important the value is as a guiding principle in YOUR life. Try to distinguish as much as possible between the values by using all the numbers.

	Opposed to my values	Not important	Important					Very important	Of supreme importance
1. EQUALITY: equal opportunity for all	-1	0	1	2	3	4	5	6	7
2. RESPECTING THE EARTH: harmony with other species	-1	0	1	2	3	4	5	6	7
3. SOCIAL POWER: control over others, dominance	-1	0	1	2	3	4	5	6	7
4. PLEASURE: joy, gratification of desires	-1	0	1	2	3	4	5	6	7
5. UNITY WITH NATURE: fitting into nature	-1	0	1	2	3	4	5	6	7
6. A WORLD AT PEACE: free of war and conflict	-1	0	1	2	3	4	5	6	7
7. WEALTH: material possessions, money	-1	0	1	2	3	4	5	6	7
8. AUTHORITY: the right to lead or command	-1	0	1	2	3	4	5	6	7
9. SOCIAL JUSTICE: correcting injustice, care for the weak	-1	0	1	2	3	4	5	6	7
10. ENJOYING LIFE: enjoying food, sex, leisure, etc.	-1	0	1	2	3	4	5	6	7
11. PROTECTING THE ENVIRONMENT: preserving nature	-1	0	1	2	3	4	5	6	7
12. INFLUENTIAL: having an impact on	-1	0	1	2	3	4	5	6	7

12. Do you consider energy conservation in everyday appliance use (e.g. computer, television or washing machine)?

Frequency	Never		Sometimes		Always

13. How often do you completely turn off standby devices (computer, television, coffee machine, microwave)?

Frequency	Never		Sometimes		Always

14. How much Euros do you think one kWh costs on average in Holland?

€….

These are different ways of displaying energy feedback.

15. Which type of energy feedback do you prefer?

a. kWh

b. Euro

c. Converted into kilometres driven by car

https://gemini.google.com/app/2c97bf3c50fa76f5
Okay, drawing directly from the comprehensive report compiled previously, here is the Resource Availability Summary Table detailing the research materials discussed:

Resource Availability Summary Table

\#	Source	Material Type	Topic / Content Description	Availability/Access Information	Open Source Status
1	National Energy Foundation (NEF) (2018/2017)	Questionnaire (33 items)	Comprehensive energy literacy (KAB), behaviors, knowledge, attitudes, trust (US High School Seniors/Grads).	Openly available online PDF.	Yes (Creative Commons)\<br\>[Link](https://nef1.org/wp-content/uploads/2018/01/NEF-Energy-Literacy-Questionnaire-FINAL.pdf)
2	DeWaters & Powers (2011/2007/2008)	Survey Instrument (Framework) / Questionnaire	Energy Literacy (Cognitive, Affective, Behavioral - Secondary Students). 38/30 knowledge MCQs, 13 attitude, 4 self-efficacy, 10 behaviors/intentions.	Framework described. Full instrument stated as available from authors upon request ([email address removed], [email address removed]). Not found publicly available.	Unclear (Requires author contact)
3	DeWaters et al. (2013)	Survey Instrument (\>60 items)	Energy Literacy (Knowledge, Attitudes, Behavior - Secondary Students). Comprehensive survey items.	Full survey in published article appendix (check for open-access status).	Openly Accessible (via article appendix)
4	Devney (2023)	Survey (19 items)	Household Energy Literacy (cognitive, affective, behavior).	Via Thesis Appendix. Open-access Thesis PDF contains survey in Appendix.	Openly Accessible
5	Canfield et al. (2017)	Questionnaire Items / Questionnaire	Energy Literacy (8 items); Understanding/Preferences/Intentions re: Bill Info (7 T/F, 10 Likert, 1 Likert).	Stated as in SI via DOI. Stated as available in Supplemental Materials via DOI. Link access failed during review. Alt Link: [DOI Link](https://www.google.com/search?q=http://dx.doi.org/10.1080/13669877.2015.1121909).	Unclear/Access Failed
6	He et al. (2022)	Measures List	Energy Literacy (Knowledge, Attitudes, Behaviors); Other survey vars.	Stated as available in Supplementary Information. Not found during review.	Unclear
7	WHO (2018)	Survey Questions / Survey	Standardized questions for household energy use assessment (fuels, cooking, heating, lighting, electricity access).	Openly Available Online. Full question sets available via WHO website links.	Yes ([Link](https://www.who.int/tools/core-questions-for-household-energy-use))
8	Attari et al. (2010)	Experimental Task / Survey Questions / Experimental Protocol / Survey	Energy Use/Savings Estimation (Appliances/Activities) vs. Reference; Most Effective Action Perception. Includes stimuli list & actual values.	Via SI/Supplement. SI Appendix & Text via PNAS: [SI Link](https://www.google.com/search?q=www.pnas.org/lookup/suppl/doi:10.1073/pnas.1001509107/-/DCSupplemental). Link access failed on author site during review.	Openly Accessible (via PNAS SI)
9	Marghetis et al. (2019)	Data / Experimental Task / Interventions / Survey Data / Survey/SI	Energy Use Estimation; Heuristic/Numerical Interventions.	Data on OSF. Survey/SI links failed on author site. Task concept described.	Data: Yes (OSF/GPL 3.0) ([Link](https://osf.io/2qbxt/)); Survey/Task Items: Unclear
10	Schille-Hudson et al. (not specified)	Survey / Task Items	Appliance Features Rating (Cues for energy judgment) on 7 features.	Items described in paper; No separate materials available. Appendix/SI mentioned.	No (Unclear)
11	Blasch et al. (2019, 2021)	Experimental Task / Intervention Descriptions / Survey Questions	Lifetime Cost Calculation (Appliance Choice); Education vs. Calculator Tool.	Task described. Interventions described. Appendix figures/tables mentioned but not found. 2019 Survey stated as online (CER-ETH Paper link).	Unclear (Task); Yes (2019 Survey - Online)
12	Li et al. (2025)	Experimental Survey / Questionnaire Items	Psychological constructs (impediments/facilitators, attitudes, conservation intentions) related to LLM nudges. Specific item wordings provided.	Specific items described in paper. No separate materials.	No
13	Brandsma & Blasch (2019)	Goal Setting Procedure; Feedback Description	Goal Setting (High/Low/None); Feedback Type (kWh/EUR/CO2).	Procedures described; Full survey/SI access unclear.	Unclear
14	Kanay, Hilton, et al. (2021)	Goal Setting Procedure; Feedback Mechanism; Survey Measures	Carbon Basket Goal Setting (Numerical/Graphical); Online Supermarket Task.	Detailed procedures, feedback, measures available in working paper PDF.	No (Working paper available)
15	Mallik et al. (2005)	Survey Instrument (ECSS); Framework	Frequency/Effectiveness of Energy Conservation Strategies (Fatigue context); "4 Ps" framework.	Instrument concept & structure described; "4 Ps" framework described; Full 14 items not found.	Unclear
16	Thanh Nguyen et al. (2021)	Questionnaire Scales (7 scales)	Household Energy Saving Behavior Predictors (TPB: ATT, SN, PBC, Intention; PB, PQ). Full item lists provided in paper.	Full item lists provided in paper.	Items Reproduced (Yes); Status Unclear
17	Habibi Asgarabad et al. (2024)	Study Protocol (includes measures) / Measures	Psychological Predictors of Energy Saving Behavior (Intentions, Attitudes, PBC, Norms, etc.).	Via OSF. Protocol described; Measures detailed in protocol/preregistration on OSF. OSF access failed during review.	Yes (OSF) ([Link](https://www.google.com/search?q=https://osf.io/9vtn4) - Verify access)
18	Rakitta & Wernery (2021)	Survey Items / Survey	Cognitive Biases (Limited direct energy knowledge/behavior). Relevant to building energy decisions.	Via Article Appendix B.	Via Article Appendix
19	Schley & DeKay (2015)	Survey Items (for multiple studies)	Perceptions of End-Use Energy Consumption (%). Cognitive Accessibility.	Via SI/Supplement. Stated as available in Supplementary Materials. Link not found during review.	Supplementary Materials (Unclear Access)
20	Borzino et al. (2025)	Intervention Content / Goal Setting Intervention / Tip Sheets	10% Reduction Goal Prompt; Monthly Tip Sheets.	Via SI/Supplement. Open-access supplementary figures (Appendix D, Figure f) contain text/images.	Openly Accessible (Supplement)
21	Ramachandran & Ellis (2023)	Scale / Goal-Setting Scale	Energy Goals & Plans Scale (5 items). Tied to 10%-reduction targets.	Via OSF.	Yes (OSF)
22	York Electric Coop. (2024)	Tip List / Energy Conservation Tips	101 Household Energy Saving Tips (Categorized).	Openly Available Online.	Yes ([Link](https://www.yorkelectric.net/energy-savings/101-energy-tips/))
23	SEAI (2022)	Recommendations / Communication Recommendations (14)	14 Evidence-Based Energy Conservation Communication Strategies.	Openly Available Online. Full PDF available online.	Yes ([Link](https://www.seai.ie/sites/default/files/blog/energy-conservation-comms/Communication-strategies-to-encourage-energy-conservation_Final-\(002\)-\(002\).pdf))
24	Student Switch Off (Laskari et al., 2017)	Tip List / Energy-Saving Tips (6 items)	Six Key Energy Saving Tips for Dorms.	Via Article. Detailed in open-access article text.	Openly Accessible (via article)
25	Ashkinaze et al. (2024)	Code, Prompt, Data / Task Code / Prompts	Alternate Uses Test (AUT) Creativity Classifier Code; ChatGPT Prompt; Fine-tuning Dataset.	Via GitHub / Correspondence. Code link provided. Prompt in source. Data via correspondence.	Yes (Code/Prompt); Data (Restricted) ([Code Link](https://www.google.com/search?q=https://github.com/massivetexts/llm_aut_study/.../Process_AUT_GT.ipynb))
26	Si et al. (2024)	Data, Code / Task Design/Methodology	LLM Research Idea Generation (NLP).	Via OSF.	Yes (OSF) ([Link](https://www.google.com/search?q=https://osf.io/z6qa4))

27	Rooij & Biskjaer (2025)	Data, Scripts / Task Design/Methodology	AI & Human Creativity Meta-Analysis.	Via OSF.	Yes (OSF/GPL 3.0) ([Link](https://www.google.com/search?q=https://osf.io/2xdba/%3Fview_only%3Dd7eef35d12d74b91a796247d19b81730))
28	Sun et al. (2024)	Data, Materials / Data and Materials	LLM Creativity Study.	Via Figshare.	Yes (Figshare) ([Link](https://www.google.com/search?q=https://doi.org/10.6084/m9.figshare.24878421))
29	Simulated Energy Planning Task (Source: AI_Energy_Study_Ideas)	Task Design/Methodology / Experimental task description/interface	Energy saving decisions (simulated planning). Allocation task with potential info search.	Described (Figures 4, 12, 14 in source). Code availability not mentioned.	Unclear
30	Radensky et al. (2025)	Prompts / Task Design/Methodology	Scientific idea generation (LLM prompts). Human-LLM tool.	Prompts in Source and Appendices (Appendix G mentioned). Data/code availability not mentioned.	Unclear
31	Gray et al. (n.d.)	Instructions / Task Design/Methodology	Thought collection ("forward flow"). Idea generation process.	Instructions provided in Source. Supplemental materials mentioned (link not in excerpt).	Unclear
32	Chen et al. (2024)	Tip List / Tip List Structure / Intervention	Energy Saving Tips Categories (5 themes).	Not Found. Themes listed; Full list requires accessing paper.	No
33	DOE / ENERGY STAR / Utility Websites (Various)	Tip Lists	Comprehensive Residential Energy Saving Tips.	Extensive lists available publicly on respective websites.	N/A (Public Info)
34	Newell & Siikamäki (2014)	Experimental Paradigm; Task Description	Choice Experiment (Appliance Purchase); Randomized Label Treatments.	Paradigm described; Some details in NBER WP appendix; Full instrument unclear.	Unclear
35	Wekhof & Houde (2023)	Review	Review of Conversational Agents for Energy (eco-feedback via chatbots).	Paper available via provided citation.	N/A (Review)
36	Kantenbacher & Attari (2021)	Heuristics List; Task/Interview Description / SI/Data	Expert Heuristics for Energy Judgment (N=24); Energy Estimation Task.	Via SI/Data. SI/Data linked on author site. Link access failed during review.	Data: Yes ([Link](https://www.google.com/search?q=https://www.szattari.com/s/Data_quantitative.xlsx)); SI/Heuristics List: Yes ([Link](https://www.google.com/search?q=https://www.szattari.com/s/Kantenbacher_Expert-SI_2021.docx)) (Verify links)
37	Brounen et al. (2013)	Energy Awareness Quiz	Knowledge (e.g. appliance comparison) and self-reported behaviors.	Published in journal (no separate supplement).	Unclear (Requires journal access)
38	Harding & Hsiaw (2014)	Interface Description / Program Interface Description; Goal Setting Prompts	Self-set electricity savings goal interface/prompts. Utility program.	Via Working Paper Appendix. Documented in appendix; Participant materials proprietary.	No (Proprietary elements)
39	Attari & Rajagopal (2015)	Description of Tip Lists / Overview of Decision Aids	Examples of Tip Content/Structure (NRDC). Information Types (calculators).	Mentioned/Described.	N/A
40	Lesic et al. (2018)	Review Table	Studies comparing consumers' perceptions of electricity use/savings with actual data.	Table within paper lists reviewed studies and key methodological features.	Unclear (Requires journal access)
41	Pereira and Chisik (2017)	Online survey description	Perceptions of appliance electricity consumption (visual icons, Likert scale).	Described in article. Not publicly posted separately.	Unclear (Requires journal access)
42	Liu, Y., et al. (2021)	Goal Setting Procedure / Field Experiment / Knowledge scale desc.	Goal Setting (Self-Set/Assigned/Assigned+Reward); Spillover. Energy knowledge scale (T/F, 11 items).	Procedures described. Full materials/data access unclear. Knowledge items not provided.	Unclear
43	Abrahamse & Steg (2009)	Household Energy Use Survey	Self-estimated energy usage and reported appliance use frequencies.	Described in article. Not publicly posted separately.	Not publicly posted
44	Navigant Energy Literacy Battery (ComEd study 2014)	Internal Quiz (19 items)	Gauging customer energy knowledge.	Internal, not formally published.	No (Internal)
45	Lin & Lu (2018)	Experimental Protocol	Measuring energy literacy improvements via project-based activities. Pre-test/post-test.	Described in paper. Full protocol not openly available.	No

This table should provide a useful starting point for identifying and accessing relevant materials for your research on LLM-assisted energy conservation planning.