AC 2008-1445: INTERACTIVE ENERGY COURSEWARE

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Interactive Energy Courseware

Abstract

Innovative methods for teaching engineering concepts are receiving broader attention in a variety of contexts. This is in keeping with the perception that improvements is content delivery tools and techniques would further sustain students' interests in the various topics, as well as enhance comprehension or understanding of difficult topics. This paper presents four interactive learning tools that were developed by students in the energy systems and conversion course – (1) Energy calculator, (2) Off-line energy database, (3) Energy Jeopardy quiz game and (4) Appliance energy audit system. The tools are developed primarily to enable junior-level students learn and review some concepts learned in the semester course.

I. Introduction

The use of interactive learning tools in advancing engineering education has steadily gained support and enthusiasm among faculty ranks across the disciplines and internationally. In many cases it has been argued persuasively that students' performance improved in courses that use some form of interactive courseware as an instructional adjunct. A number of case studies [6] show instructor-developed courseware facilitates the development of student-centered learning environment; provides the tool for asynchronous learning; addresses space limitation issues and significantly increase access to educational resources. Application of courseware tools in thermodynamics [3], soil mechanics [4], structural analysis [7], and industrial engineering [8] were favorably received by students enrolled in those courses. The tools offer them a self-paced learning mechanism, acts as supplement to the course textbook and made possible the formation of collaborative learning communities in the industrial engineering course [8].

For quite some time simulation packages are used extensively as the basic interactive learning tool because they are relatively affordable and easy to use, in contrast to developing custom tools for learning purposes. Simulation packages however generally make assumption about user's background, the engineering methodology they were previously exposed to and the visual metaphors used in communicating concepts [1]. These may impact the effectiveness of the tool for a category of learners who do not fit those assumptions.

As many more instructors are expected to infuse some form of technology into their instructional repertoire because of the credible benefits in student engagement, efficient courseware development strategy is becoming paramount. A sample of such visual courseware authoring tool is discussed by Lau and Mak [5], and offered as an instructor-enabling medium that would encourage instructors to devote time and effort to content and not towards becoming web application expert. Others have advocated platformindependent [2] courseware that would facilitate easy and instant accessibility. Furthermore, there have been attempts to evolve strategies for connecting learning context to presentation media by use of appropriate visual metaphors [11] in web-based learning courseware.

This paper presents four interactive learning tools that were developed by students in the energy systems and conversion course – (1) Energy Calculator, (2) Off-line Energy Database, (3) Energy Jeopardy quiz game and (4) Appliance Energy Audit system. The tools are developed primarily to enable junior-level electrical engineering students learn and review some concepts presented in the semester course, as well as to supplement materials presented in the course textbook. The energy system and conversion course, which covers renewable and non-renewable energy sources, as well as energy conversion devices, is part of the core curriculum at Penn State University – Harrisburg. The Energy Calculator program was conceived to help students compare and contrast a range of energy units introduced in the textbook. The Energy Database offers students an avenue to access new information on energy issues hosted on the Internet as the typical course textbooks are unable to keep up with the deluge of new developments. The Energy Jeopardy game creatively combines energy system concepts with a popular American pastime that many students could relate to, while the Appliance Energy Audit tool succinctly ties together costs of energy, appliance selection and energy conservation issues covered briefly in the course.

Students created the courseware as an integral part of the course requirements to reflect some of the desirable benefits highlighted above. They provide an environment for interactive self-paced learning, served as supplement to the textbook, and in some cases effectively connects learning context to media by appropriate choice of visual metaphors. By bringing the perspectives of students to bear on the design and implementation of these learning tools, it is implicit that students' learning styles are accommodated. This interactive energy courseware therefore holds the potential of enhancing their learning experience.

II. ENERGY CALCULATOR

The energy calculator program was conceived to help students compare and contrast a range of energy units introduced in the textbook selected for the energy systems and conversion course. The introductory chapters of the textbook covers topics that discuss energy levels as low as electron-volt (eV) when electrons are in motion, to Quads (quadrillion Btu) used in composite annual energy utilization or projections. The scales are so divergent and are often difficult to relate together for students who are typically familiar with the Joule or Watt-hour from previous junior level coursework in electrical circuits. Energy calculator is an interactive Excel-based program that enables users to quickly and conveniently relate a given quantity of energy to some common or familiar energy intensive appliance or system. When the user enters a numerical value for the quantity of energy and selects the preferred unit of measure, a set of consumption equivalent charts are generated (Figure 1). One of the charts compares typical home appliances (refrigerator, air conditioner, dishwasher and clothes washer); showing how long each would run on the specified energy. Other charts show the length of time an average household or the average American car would run on the same energy value. The choice of Excel as the platform for this interactive calculator ensures that the student could make use of the tool readily on any personal computer equipped with Microsoft Office. In addition students may further customize the visual feedback to reflect personal preferences, as well as expand the list of energy measures. The measures currently available include tons of coal equivalents, fuel oil equivalents, Hartree energy, and horsepower-hour, among others.

III. OFF-LINE ENERGY DATABASE

Energy-related themes have received tremendous exposure in the news media over the last half of this decade. The sources of energy, the conversion methods, utilization, conservation, environmental impacts, and many more continue to dominate news headlines worldwide. The political and economic realities continue to drive the discussions on daily basis. It is therefore impractical to expect course textbooks on energy themes to keep pace with new materials on the issues. The Internet however has distinguished itself as the avenue where new information is propagated with unprecedented quickness. It is therefore paramount to attune the student to the arena that would be helpful in connecting them to updated information on energy.

The purpose of the off-line energy database is to offer students a comprehensive and very organized web interface to several hundred Internet links on renewable as well as non-renewable energy sources. The information should be organized or sorted by source types (geothermal, natural gas, nuclear, ocean thermal, wind, etc) and information provider (US or foreign). As topics in energy development, utilization and conservation continue to emerge students are encouraged not to rely solely on the materials (especially statistical data) provided in the textbook. The material is often dated, so it becomes crucial for the student to know where and how to find reliable sources for the information. The database significantly simplifies this process for the students by making available over 500 energy-related links that covers a broad array of information. The list of references covers government historical record for energy-flow from source to end user, manufacturer equipment specification and costs, conservation as well as industry sector advocacy groups, among others. The consolidated information makes student research and investigation more efficient.

The project was initiated by the course instructor and carried over a number of semesters. Students were guided towards the goal of improving upon the work completed by other students in prior semesters. To accomplish the work involved in the development of this interactive information system the instructor had to modify the pace and the expectation as needed because the web development and programming skills required are not considered prerequisites to enroll in the energy systems course. A Microsoft Excel-based platform is used to organize and search the energy database off-line. The database interface has two tabs, a pivot table tab (Figure 2a), and a database tab (Figure 2b). Through the database tab users could include new links, delete or update dead links, as well as add new energy classifications. The Excel table lists the website title for the energy resource information, the energy classification (type – gas, biomass, general, solar, etc.), the URL, and the source of the information (international or USA). The pivot function is used for querying the database. Using pull down menus user could select categories of information to retrieve and display. The relevant URLs are listed for users to access. The ease of use, modification and portability of the energy information database encourages students to be more involved in the learning process.

IV. ENERGY JEOPARDY

The first version of "Energy Jeopardy" game [10] was developed as a quiz game patterned after the United States TV show "Jeopardy". The TV game has been very successful and draws wide viewing audience over the years. The Energy Jeopardy game attempts to ride on the popularity of the TV game show. It is used as a vehicle for guiding players through a review of concepts taught and covered in an energy systems course through a multiple choice quiz format. The first version of the game, developed in 2006 was designed primarily as a two player game with colorful background images mimicking the theme of the current question. The quiz provides helpful feedback to contestants when incorrect responses were selected. This newer version of Energy Jeopardy game (Figure 3a) has included several enhancements to the original (2006) version, to broaden its appeal to potential users. The quiz offers the options of either one or two players (Figure 3b), it provides for score tracking, penalty for wrong answers and a timer. A "question editor" is integrated into the new design that offers an instructor an avenue to add or delete questions, modify or expand quiz categories, provide up to five multiple choice options for each question, customize background picture (visual metaphor – Figure 3c) for each question and randomize questions in the database. The Energy Jeopardy game creatively combines learning with a popular American pastime that many students could relate to. The utility of the interfaces for adapting game questions and answers to different learning objectives underscore the significance of the game as a learning tool.

V. APPLIANCE ENERGY AUDIT SYSTEM

The Appliance Energy Audit system is a refrigerator comparator that was originally conceived by a group of students in the energy systems class. The Microsoft Excel based learning tool is simple and quickly engages learners to focus on the impact of appliance choices on energy use. The user is presented with an interface (Fig. 4) where the current energy rate for the location of the refrigerator may be entered manually if known. As an alternative the user may elect to go by the average energy rate for the state by selecting one state from the pull-down menu. There are two lists of refrigerator models, one for current (existing) refrigerator, and the other for a newer model under consideration for purchase. The Excel worksheet displays a variety of information for the user after the input parameters are entered. The display includes: Year of manufacture, volume (capacity), energy rate, energy cost per year, and energy cost per year per cubic feet. A summary of energy savings information is provided; these include energy savings per year, energy savings per cubic feet per year, and kilowatt-hours saved per year. In addition a graphical display relates the energy savings to the average US residential energy use equivalent.

The Appliance Energy Audit tool succinctly ties together cost of energy, appliance selection and energy conservation issues. The database for energy costs as well as list of refrigerator models could easily be updated to reflect changes in the marketplace. Moreover the tool could be adapted for other electric appliances.

VI. Student Evaluation of the Learning Tool

The four learning courseware presented in this paper were developed by students as part of the Energy systems and conversion course requirements. The learning tools were formally presented and demonstrated before the class audience of about 30 students at the conclusion of the semesters, when they were evaluated by the course instructor. The four tools presented in this paper scored high points for design creativity, implementation, features and ease of use. Student peers found the tools attractive and engaging as well. Since the perspectives of students are directly embedded in the development process the tools reflect varied learning styles that resonate well with the students. Since the tools were created by the students for their peers there should be no need for significant time investment in learning how to use the courseware, and to take advantage of the benefit they offer. Another set of quantitative assessment is planned for the next class of 30 students this spring that would have no prior exposure to the learning tools before the course.

VII. Conclusions

Four interactive learning tools presented in this paper were developed by students enrolled in an energy systems and conversion course. The tools are created primarily to enable junior-level students learn and review some concepts presented in the semester course. Students created the courseware as an integral part of the course requirements to engage them in the learning process. The courseware developed is based on tools and technology that are widely accessible to engineering students. They provide an environment for interactive self-paced learning, served as supplement to the textbook, and in some cases effectively connects learning context to media by appropriate choice of visual metaphors. By bringing the perspectives of students to bear on the design and implementation of these learning tools, it is implicit that students' learning styles are accommodated.

VIII. ACKNOWLEDGEMENT

The following students, enrolled in the Energy systems and Conversion course at Penn State Harrisburg over the last few years have contributed to the development of the learning tools featured in this paper: Brian Bell, Robert Kendrick, Marc McKinley, Jason Dorwart, Chris Kramm, William Dietz, Jatin Patel, Matthew Schmick, Alexander TsyKalyuk, Dinesh Asnani, Ryan Humberger, John Cimino, and Scott Laliberte.

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Power Symposium, 2006. NAPS 2006. 38th North American, Sept. 2006, p 371 – 374.

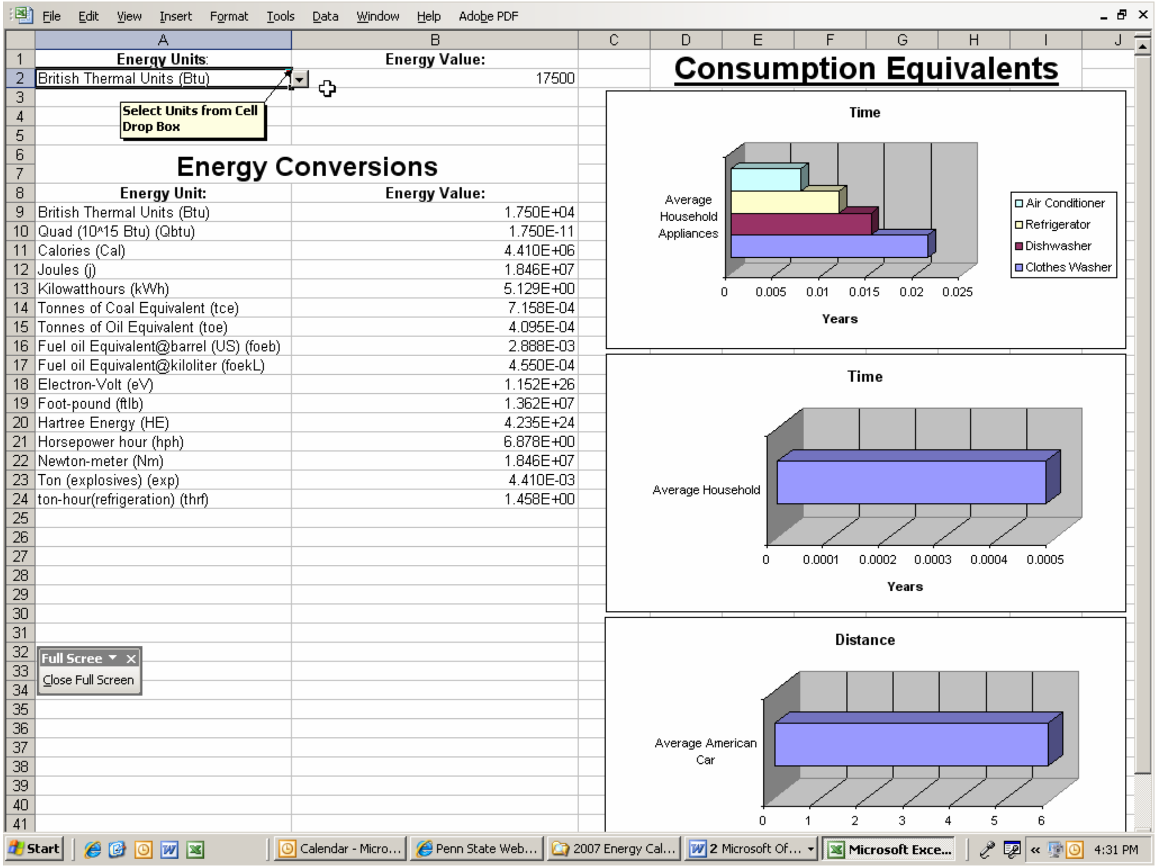


Fig. 1. Energy Calculator Interface.

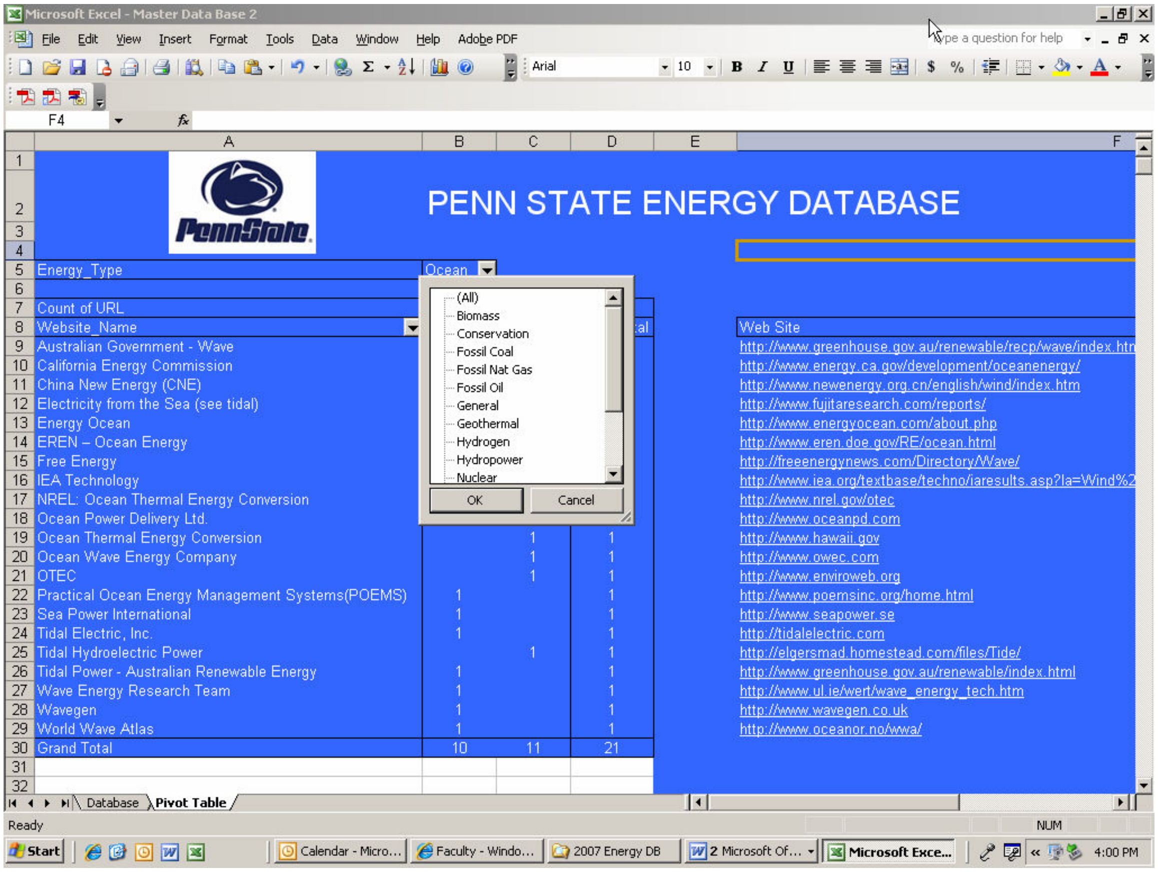
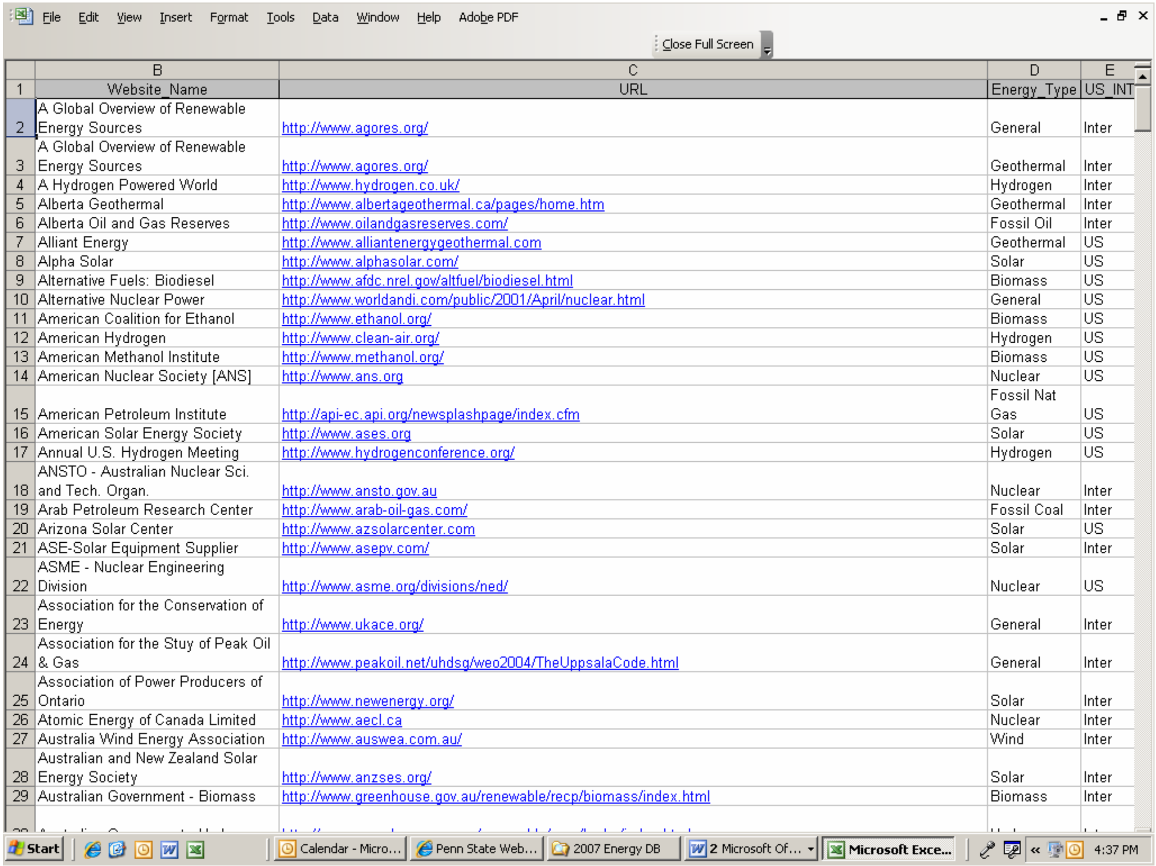


Fig. 2a. Offline Energy Database – Pivot Table Tab.



	B	C	D	E
1	Website_Name	URL	Energy_Type	US_INT
2	A Global Overview of Renewable Energy Sources	http://www.agores.org/	General	Inter
3	A Global Overview of Renewable Energy Sources	http://www.agores.org/	Geothermal	Inter
4	A Hydrogen Powered World	http://www.hydrogen.co.uk/	Hydrogen	Inter
5	Alberta Geothermal	http://www.albertageothermal.ca/pages/home.htm	Geothermal	Inter
6	Alberta Oil and Gas Reserves	http://www.oilandgasreserves.com/	Fossil Oil	Inter
7	Alliant Energy	http://www.alliantenergygeothermal.com	Geothermal	US
8	Alpha Solar	http://www.alphasolar.com/	Solar	US
9	Alternative Fuels: Biodiesel	http://www.afdc.nrel.gov/altfuel/biodiesel.html	Biomass	US
10	Alternative Nuclear Power	http://www.worldandi.com/public/2001/April/nuclear.html	General	US
11	American Coalition for Ethanol	http://www.ethanol.org/	Biomass	US
12	American Hydrogen	http://www.clean-air.org/	Hydrogen	US
13	American Methanol Institute	http://www.methanol.org/	Biomass	US
14	American Nuclear Society [ANS]	http://www.ans.org	Nuclear	US
15	American Petroleum Institute	http://api-ec.api.org/newsplashpage/index.cfm	Fossil Nat Gas	US
16	American Solar Energy Society	http://www.ases.org	Solar	US
17	Annual U.S. Hydrogen Meeting	http://www.hydrogenconference.org/	Hydrogen	US
18	ANSTO - Australian Nuclear Sci. and Tech. Organ.	http://www.ansto.gov.au	Nuclear	Inter
19	Arab Petroleum Research Center	http://www.arab-oil-gas.com/	Fossil Coal	Inter
20	Arizona Solar Center	http://www.azsolarcenter.com	Solar	US
21	ASE-Solar Equipment Supplier	http://www.asepv.com/	Solar	Inter
22	ASME - Nuclear Engineering Division	http://www.asme.org/divisions/ned/	Nuclear	US
23	Association for the Conservation of Energy	http://www.ukace.org/	General	Inter
24	Association for the Stuy of Peak Oil & Gas	http://www.peakoil.net/uhdsg/weo2004/TheUppsalaCode.html	General	Inter
25	Association of Power Producers of Ontario	http://www.newenergy.org/	Solar	Inter
26	Atomic Energy of Canada Limited	http://www.aecl.ca	Nuclear	Inter
27	Australia Wind Energy Association	http://www.auswea.com.au/	Wind	Inter
28	Australian and New Zealand Solar Energy Society	http://www.anzses.org/	Solar	Inter
29	Australian Government - Biomass	http://www.greenhouse.gov.au/renewable/recp/biomass/index.html	Biomass	Inter

Fig. 2b. Offline Energy Database – Database Tab.

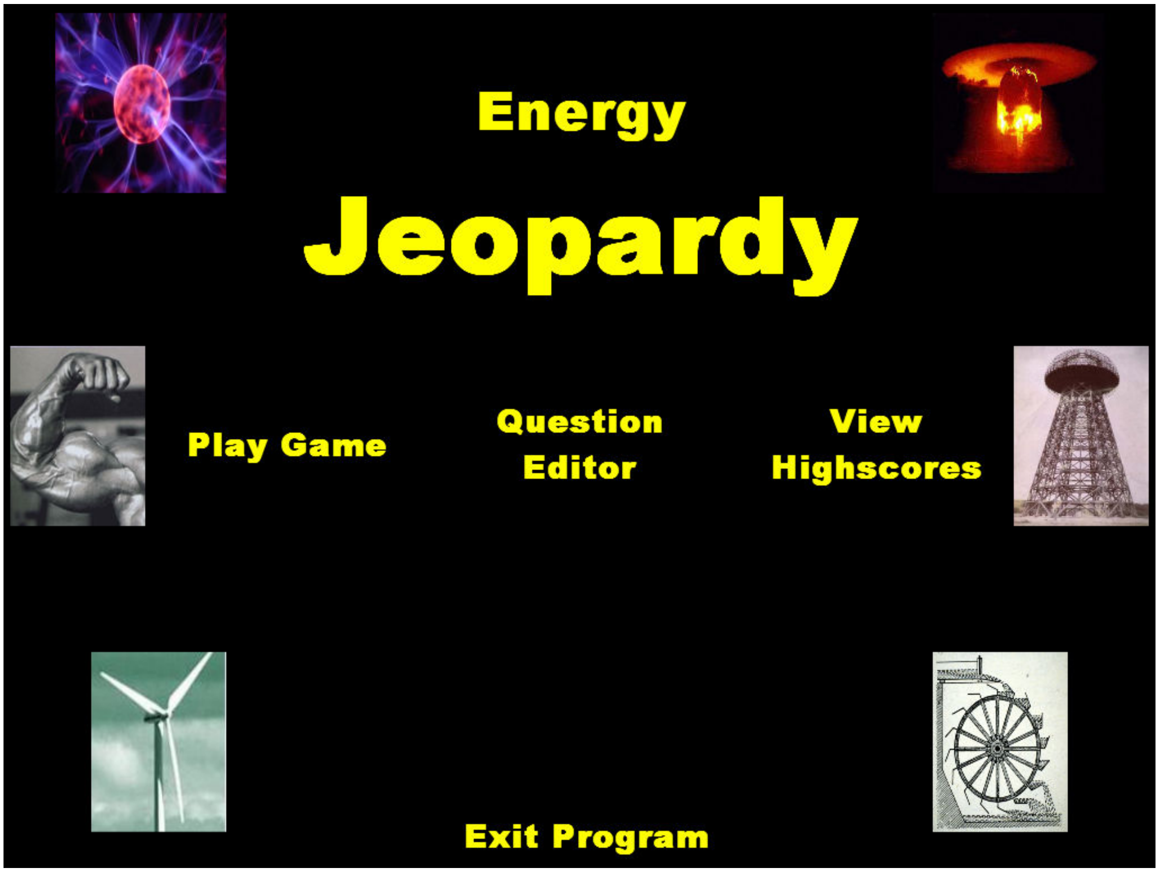


Fig. 3a. Energy Jeopardy Quiz Game Interface.

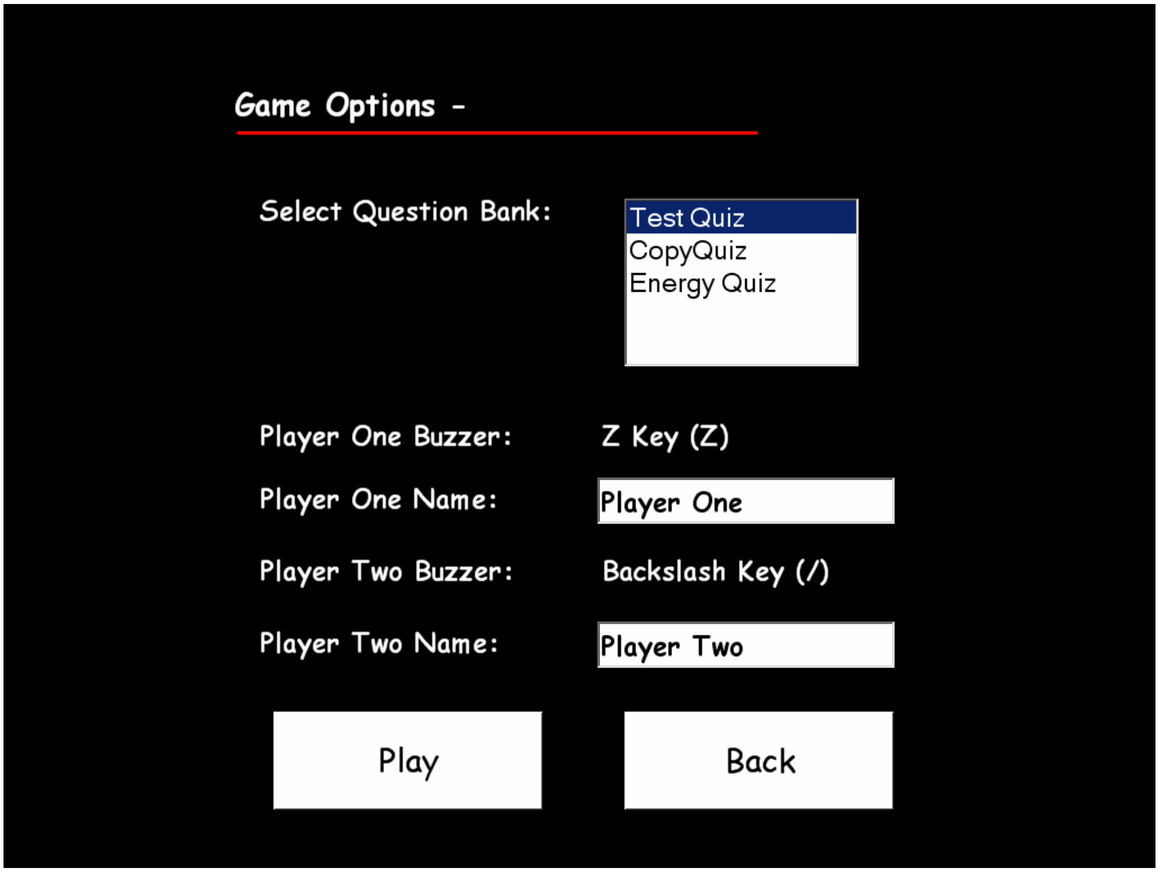


Fig. 3b. Energy Jeopardy – Game Options.

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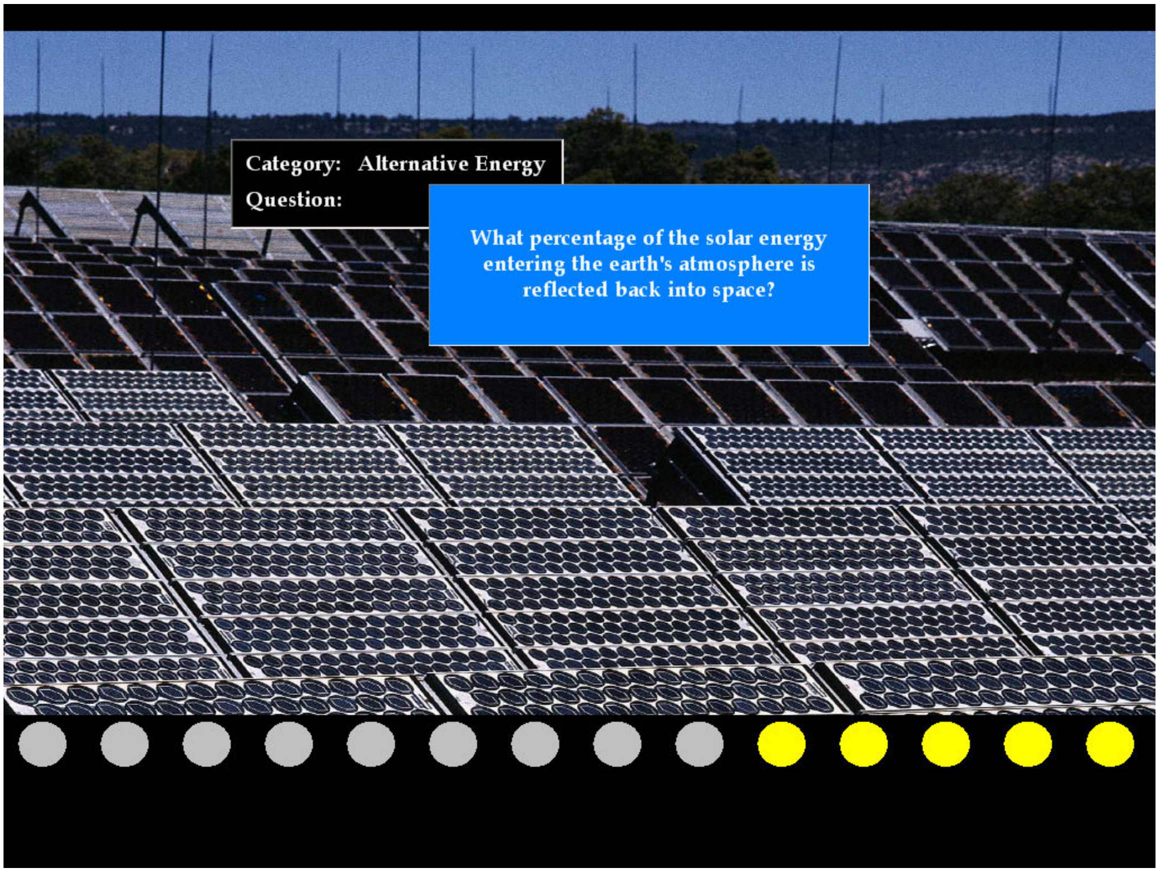

Fig. 3c. Energy Jeopardy – Visual Metaphor.

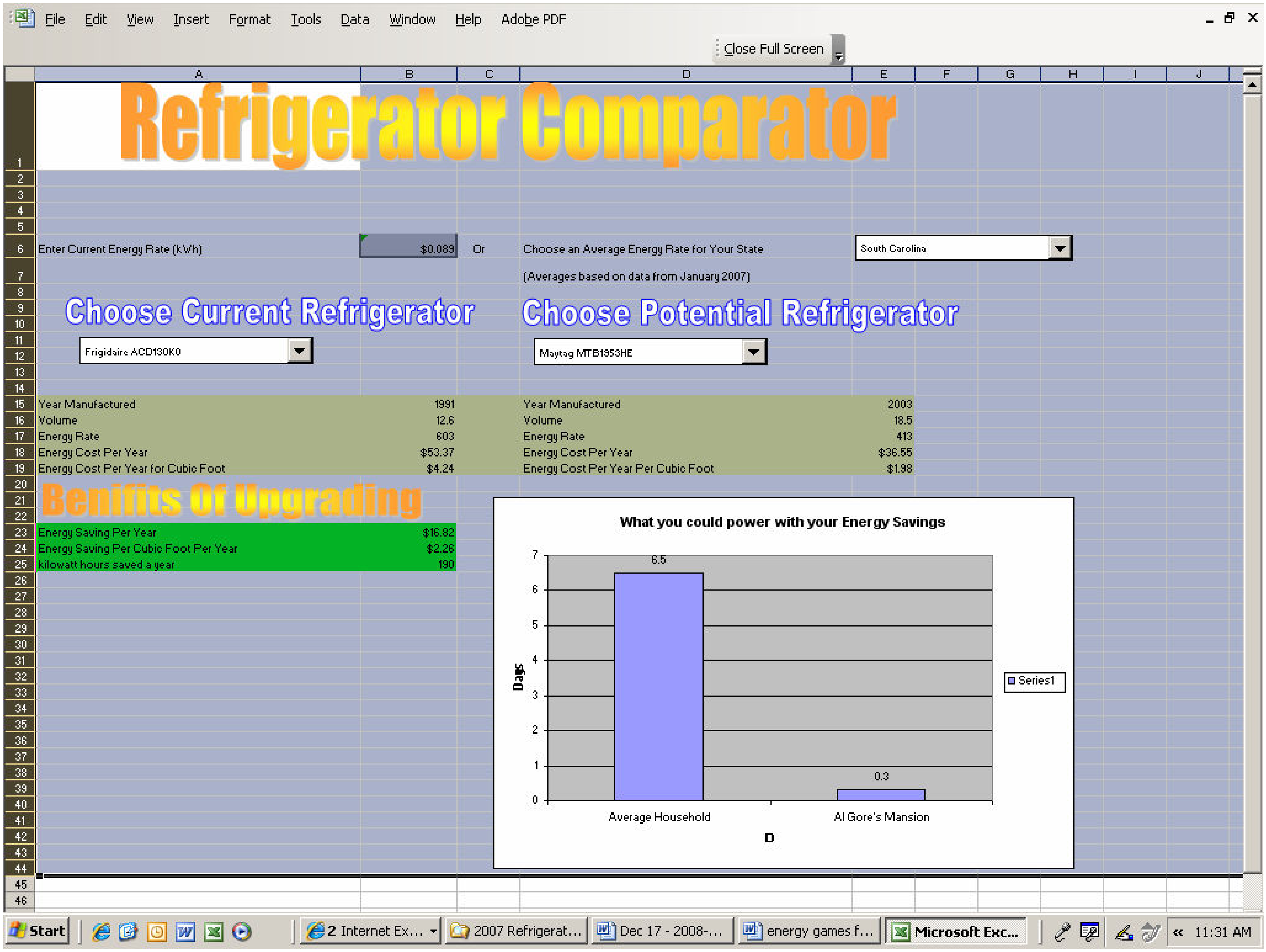

Fig. 4. Appliance Energy Audit System.