# THE ENERGY RESOURCES CONTENT ASSESSMENT

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Energy holds a central role in topical socioscientific issues, such as energy supply, distribution and utilization, consumption, and transport economics (Hinrichs & Kleinbach, 2002; Papadouris, Constantinou, & Kyratsi, 2008). The need to conserve finite energy resources is the subject of increasing public awareness, and the debate concerning the possible contributions to the energy economy of sustainable resources has high public profile (Boyes & Stanisstreet, 1990). As fossil fuel reserves are being depleted worldwide and energy costs are increasing, the use of sustainable energy resources is being more widely considered as a solution to our current energy crisis. With environmental issues related to energy use playing a more prominent role in the lives of citizens, it is important that young adults be equipped with fundamental knowledge and understandings about energy resources so as future citizens they will be able to make informed decisions to effectively confront the energy issues that face the environment (Gambro & Switzky, 1999).

Science education programs in schools should have an ultimate goal of providing students with a conceptual knowledge of energy and the issues related to energy use in order for them to be able to critically analyze and decipher information to effectively make informed decisions as future citizens (Barrow & Morrisey, 1989; Farhar, 1996; Hofman, 1980; Solomon, 1992; Van Koevering & Sell, 1983). Environmental science topics related to energy resources are quite established in U.S. science education frameworks and environmental science curriculum (AAAS, 1993; Barrow & Morrisey, 1987; Blum, 1981; NRC, 1996). Concepts pertaining to the acquisition of renewable and nonrenewable resources, energy generation, storage, and transport, and energy consumption and conservation are included in the conceptual strand maps of the AAAS *Atlas of Science Literacy* (2007) as important learning goals that should be achieved by the completion of 8th grade.

A review of the research literature that investigated the conceptual knowledge relating to energy resources and related socioscientific issues for middle school age learners was conducted. Since only a limited number of studies specifically addressed middle school age students' understandings of environmental science issues of energy acquisition, energy generation, storage and transport, and energy consumption and conservation, the literature review was expanded to include all age levels. The majority of published data indicate a lack of general energy-related knowledge in our society. Studies showed that students had knowledge deficiencies about the availability and use of fossil fuel resources (Lawrenz, 1983); about the availability and use of renewable resources (Holmes & States, 1978; Liarakou, Gavrilakis, & Flouri, 2009); about the viability of nuclear power (Arcury & Johnson, 1987; Blum, 1984; Lawrenz, 1983); about the nature of energy use (Richmond & Morgan, 1977); about practical considerations involved in power generation (Lawrenz, 1983), and about energy consumption and conservation (DeWaters & Powers, 2008; Holden & Barrow, 1984; Holmes, 1978; Valhov & Treagust, 1988). Many of these studies based their findings by using a small sample of energy-related items as part of a larger environmental knowledge assessment measure. In some studies, subscale reliabilities pertaining to a cluster of energy items were not reported. Researchers have noted the importance of developing a variety of environmental knowledge scales (Arcury & Johnson, 1987; Gambro & Switzky, 1999).

The development of energy knowledge scale measures is quite timely as the science education community is now working to assess and promote energy learning progressions (Lee & Liu, 2010).

We developed a list of explicit learning goals using the AAAS Atlas of Scientific Literacy (2007) as a starting point to establish important ideas about energy resources and associated issues. Potential assessment items were identified that aligned to the learning goals by reviewing existing knowledge assessment items published in the research literature that related to energy and the environment (Arcury & Johnson, 1987; Barrow & Morrisey, 1989; Blum, 1987; DeWaters & Powers, 2008; Farhar, 1996; Gambro & Switzky, 1996, 1999; Holden and Barrow, 1984; NEEFT and Roper 2002; Richmond & Morgan, 1977; Stubbs, 1985) and released items from the TIMSS studies in 1995, 1999, 2003, and 2007 (International Association for the Evaluation of Educational Achievement 1995, 1999, 2003, 2007). Twelve items were identified and each was modified to enhance the item's readability for use with English language learners. In addition, alternative selection items were included to reflect more recent advances in renewable energy. Additional assessment items were developed to align to the learning goals. The resulting instrument consisted of forty 5-option multiple-choice items with one correct answer. Misunderstandings about energy and the environment found in the literature were included as distractors in the assessment items. Item construct validity was established by having the items reviewed by a panel of 5 earth and environmental scientists and science educators to ensure content accuracy, alignment with the targeted content understandings, and construct validity. The items were grouped into three subscales corresponding to three main energy content areas:

(1) Energy Acquisition - Renewable and Nonrenewable Energy Resources (EA) [13 items].

Questions #1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 14, 25

(2) Energy Generation, Storage and Transport (EGST) [13 items]

Questions #10, 12, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26

(3) Energy Consumption and Conservation (ECC) [14 items]

Questions # 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

To pilot the instrument, we employed a purposeful sampling strategy using intact classrooms of 2 teachers in one urban school and 2 teachers in one suburban school in Spring 2009, close to the timing of the administration of the 8$^{th}$ grade state science assessment. Distinguishing among forms and sources of energy (renewable and nonrenewable) are included in the science standards for 8$^{th}$ grade. These schools were selected because of their close proximity to our institution to enable us to interview the teachers to find out which items students had difficulty understanding. Two hundred fifty-nine eighth grade students completed the pilot instrument.

Total score reliability (Cronbach's alpha) for the pilot assessment was .681. Subscale reliabilities were EA: .520, EGST: .435, and ECC: .243. Item analysis was conducted for each item that included item difficulty, frequency for each response selection, and item discrimination. Each individual item was removed one at a time to determine if its removal improved the reliability of each subscale and the entire assessment. After considering the results from the statistical item analysis, individual questions were also evaluated based on the teacher feedback for items that students had difficulty understanding. One ECC item was removed, minor editing was made to seven question stems to enhance the readability, and 6 selection choices were modified.

The final instrument consisting of 39 items was administered in Spring 2010 to 1,043 students taught by 13 teachers in 5 middle schools located in two northeast cities in the USA. These middle schools represented public school districts with students of varying degrees of language ability, socioeconomic status, and academic ability levels in science as measured by the state test. Sampling was purposeful to include both urban and suburban schools. Total score reliability (Cronbach alpha) for the assessment was .776. Subscale reliabilities were EA: .603, EGST: .565, and ECC: .477. The lower subscale reliabilities were deemed acceptable given the high construct validity of each subscale item.

The final instrument was administered again in May 2010 to 418 students taught by 5 teachers in 2 middle schools, one urban and one suburban, located in two northeast cities in the USA who completed the ELI Energy unit. Total score reliability (Cronbach alpha) for the assessment with this population was .887. Subscale reliabilities were EA: .760, EGST: .726, and ECC: .703.

A copy of the energy resources content assessment is available online at: **http://ei.lehigh.edu/eli/research/erca.pdf**.

The three subscales corresponding to three main energy content areas are:

(1) Energy Acquisition - Renewable and Nonrenewable Energy Resources (EA) [13 items].

Questions #1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 14, 25

(2) Energy Generation, Storage and Transport (EGST) [13 items]

Questions #10, 12, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26

(3) Energy Consumption and Conservation (ECC) [14 items]

Questions # 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39

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