論文（*Article*）

Encouraging Energy Saving Strategies in Schools through Solar School Programs

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As the world faces the effects of climate change, OECD countries are confronted with the challenge of how to adjust from a culture of excessive energy consumption and high greenhouse gas emissions to one of minimising their environmental footprint and achieving sustainability. Large-scale renewable energy infrastructure initiatives, such as solar school programs, are being promoted as a way to reduce national greenhouse gas emissions and increase awareness of the need for energy conservation. Unfortunately, little is known about the relationship between installing renewable energy technology on school buildings and the practice of energy saving strategies in schools.

This paper examines whether installing solar power systems is an effective catalyst for stimulating energy saving strategies in schools by investigating the findings from a mixed-methods study of an Australian Solar Schools Initiative (2001-2008). The question of whether schools with solar power installations come to view (attitudes) and use (behaviours) energy differently from schools without renewable energy technology is examined. A number of barriers to the implementation of successful solar school programs are also identified. In conclusion, recommendations for improving the efficacy of solar school programs are suggested.

Key Words : Energy Efficiency; Energy Saving Strategies; Photovoltaic; Renewable Energy; Solar Schools

Introduction

In 2009, the Japanese government announced plans to install 20 kW solar power systems on all 32,000 public schools by 2020 in an effort to reduce Japan's greenhouse gas emissions, increase society's acceptance of renewable energy technologies, and stimulate Japan's solar photovoltaic industry (Chan, 2009). Currently, 1,200 schools in Japan have solar power systems making this announcement a monumental endeavour.

Promoters of solar school initiatives claim that installing renewable energy technology on school buildings has educational, environmental, financial and social benefits for schools as well as the wider community. Stakeholders' objectives for solar school programs generally include:

- educating students about renewable energy sources (educational),
- reducing school greenhouse gas emissions (environmental),
- initiating cost-saving measures in schools (financial), and
- increasing societal awareness and acceptance of renewable energy technology (social).

Understanding the relationship between installing renewable energy technology on school buildings and the uptake of energy saving strategies in schools is crucial to achieving stakeholders' objectives.

This report describes the results of a study of energy saving strategies practiced in Australian schools. The study was designed for a Doctor of

Education Degree. The purpose of this research was to determine whether participating in the Queensland Solar Schools Initiative (2001-2008) influenced the adoption of energy saving strategies practiced in schools. The aim of the study was to address the following two research questions.

1. Have schools that participated in the Queensland Solar Schools Initiative adopted more energy saving strategies than schools that did not participate in the program?

2. What are the barriers to adopting energy saving strategies in schools?

This evaluation is both timely and significant given that the Commonwealth Government of Australia recently launched the National Solar Schools Program (2008-2015). Every school in Australia is eligible for AUD$20,000 to install a 2kW solar PV system and up to AUD$30,000 to undertake energy efficiency improvements. This means that over 9,000 schools have the opportunity to become solar schools. In light of this national sustainable energy policy, it is important to understand not only the relationship between installing renewable energy technology and the adoption of energy saving strategies in schools, but also the barriers to the uptake of sustainable energy-related behaviours.

Implementing Solar School Programs

The American Interstate Renewable Energy Council (IREC) provides government departments establishing solar school initiatives with a number of suggestions based on the Council's experience setting up solar school programs. IREC's 'Tips for Success' are divided into program hints, hardware hints, and educational hints, as depicted in Table 1.

Table 1 : IREC's Hints for Schools Going Solar (Colello, 2004)

Best Practices for Successful Solar School Programs	Component of Queensland Solar Schools Initiative (2001-2008)
Program Hints:	
• Make sure that a single office or individual has project responsibility.	☑
• Establish partnerships with business / industry.	☑
• Find an enthusiastic school champion.	☑☒
• Be sure maintenance staff are engaged and trained.	☒
• Create a sense of community ownership.	☒
Hardware Hints:	
• Choose an established, reliable solar contractor.	☒
• Make sure the roof is not due to be replaced in the next few years.	☒
• Be sure the school is using electricity as efficiently as possible (energy audit).	☒
Educational Hints:	
• Provide teachers with a curriculum, lesson plans, and/or experiments.	☑☒
• Make it easy for teachers to use the system to teach about solar energy.	☑☒
• Be sure materials meet quality assurance standards.	☒
• Provide computer hook-ups and real-time data options.	☑☒
• Make the community aware of the project through educational displays.	☑☒

IREC emphasizes that all of these aspects should be considered and in place before solar PV systems have been installed in schools. Study findings revealed that although some of these conditions were met, many 'best practices' were not considered or were inconsistently applied when rolling out this State-wide Solar Schools program.

Evaluating the Queensland Solar Schools Initiative (2001-2008)

The Queensland Solar Schools Initiative (2001-2008) was a government and energy industry sponsored program. The Queensland Environmental Protection Agency (EPA) partnered with Stanwell-Corporation, Ergon Energy and Energex to install solar PV systems on 100 schools across Queensland. The EPA Sustainable Industries Division took on project responsibility, however, the person-in-charge of the project changed at least 4 times in eight years. School installations were sponsored by one of the 3 energy providers. However, the installation of the solar PV systems was outsourced and several schools reported that it was difficult to contact the energy industry sponsor in case of technical difficulties with the system. The provision of training, educational materials, computer hook-ups with data-monitoring software, and educational displays were inconsistent. No schools were required to conduct an energy audit or develop an energy reduction action plan prior to the installation of the solar PV system, and school facilities managers were not generally involved in the process. The evidence suggests that the success of the Queensland Solar Schools Initiative (2001-2008) was hampered from the outset by not adhering to best practices.

Additionally, program sponsors did not follow-up with schools after the systems were installed or conduct an evaluation to determine whether program objectives were being met. Findings from this study revealed that schools reportedly participated in the program for the following reasons:

- to use renewable energy technology as a teaching tool (educational),
- to save money on electricity bills (financial),
- to raise awareness of renewable energy (social), and
- to reduce school energy consumption (environmental).

Although these reasons are similar to the stated objectives for the Queensland Solar Schools Initiative (2001-2008), a number of barriers were identified that hindered schools from achieving the goals intended for the solar PV system. These barriers can be divided into three categories: (1) education and training; (2) hardware and software; and, (3) locus of control.

1. Education and Training Barriers

Participants suggested that teachers receive adequate training on how to effectively use the solar PV system as a hands-on teaching tool. This would include being able to use the solar generation data in such a way that students could learn about the environmental benefits and financial savings of using solar energy technology. Data collected for this study revealed that only a handful of school staff received training when the solar PV system was installed. Professional development and training for teachers as well as facilities managers is clearly an aspect that needs more attention for future school-based renewable energy education programs.

A number of participants requested that sponsors provide quality educational materials in order to increase students' and staff's awareness about the need to conserve energy as well as practical tips on how to conserve energy within the school. Less than half of the solar schools surveyed received educational materials from sponsors, and some schools opted not to use the materials provided. Even though schools were required to produce a minimum of 10 lessons plans in order to receive the government rebate, participants still suggested that sponsors should provide teaching resource units so that the solar PV installation could be easily integrated into the curriculum.

2. Hardware and Software Barriers

While some schools were effectively using their solar PV systems as a hands-on educational tool, other schools experienced little success. The most common complaints about the solar PV installation were due to hardware and software problems. For example, in some schools the system could not be used as an effective teaching tool because the panels and/or meter were in an inaccessible location. Solar PV panels were typically placed on the highest North-facing roof, which meant that in some cases the panels were not visible. Therefore, the potential of the PV panels to raise awareness of renewable energy technology and generate interest in reducing energy consumption was decreased. Similarly, an inaccessible meter or inoperable data monitoring software limited the amount of data that could

be used in classroom lessons. Some schools did not receive any computer-based data monitoring equipment, and other schools reported that the software provided was too difficult to use.

Participants suggested that, at a minimum, the solar PV system should be hooked-up to a data-logger and that the solar generation information be made available either on a stand-alone computer or networked to all school computers, so that all classrooms could access the information. To build a sense of community and friendly competition, solar schools should also be able to upload data onto a centralised website with real-time access in order to compare their solar power generation and energy reduction efforts with other solar schools. The implications arising from this research are that school building users need to be trained on how to use the various hardware and software packages provided, and solar generation data should be automatically uploaded onto a central website that is properly maintained and regularly updated.

3. Locus of Control Barriers

While the previous identified barriers are primarily contextual in nature, locus of control is an internal barrier. Participants reported that although they knew ways to reduce school energy consumption and had taken steps to conserve energy use within the school, they felt they had very little control over reducing the school's overall energy consumption. In a school environment, where there are numerous building users with varying degrees of authority and knowledge, locus of control (agency) acts as an internal barrier to the uptake of energy saving strategies. Agency has two components: (1) a person's belief that they can successfully perform a specific behaviour; and, (2) their sense that performing that behaviour will actually make a difference. Administrators, teachers and support staff all exhibited low agency toward their ability to reduce energy consumption within the school.

Even though the majority of respondents exhibited pro-environmental beliefs, perceived responsibility, knowledge, positive social norms as well as positive attitudes and the intention to reduce energy consumption in their school, they also felt that they had no control over their ability to reduce their school's energy consumption. Respondents from schools that participated in the Queensland Solar Schools Initiative (2001-2008) expressed a higher degree of perceived lack of control. Making energy conservation a priority of school routines by creating a comprehensive energy policy that includes the participation of all school building users has the potential to remove the barrier caused by low agency. Piecemeal approaches have limited opportunity for becoming widespread practices in schools as evidenced by the findings of this research. The practical implications of this information are that adopting a whole school approach to energy is a critical key to developing a culture of using energy more sustainably.

Assessing Energy Saving Strategies in Schools

According to the data, the energy efficiency measures adopted by the majority of surveyed schools, regardless of participation in the Queensland Solar Schools Initiative (2001-2008), tended to be convenient, inexpensive, and part of routine maintenance procedures. With regards to energy conservation behaviours, although most schools were encouraging a variety of practical behaviours to help reduce energy consumption in schools, solar schools did not have a stronger energy policy than non-solar schools. Very few schools had adopted behaviour change strategies such as the use of modelling, prompts, or rewards to encourage and remind school building users to be more energy conscious. The findings suggest that the installation of solar PV systems did not directly increase the uptake of energy efficiency measures or energy conservation behaviours in schools.

However, analyses of data from schools that were reportedly using the solar PV installation as an effective educational resource, indicated that successful solar schools possessed:

- an environmental ethos,
- a proactive school administration,
- a curriculum that focused on renewable energy,
- a hands-on approach to using the installation, and
- well informed and engaged school staff and students.

Although sponsors' objectives for funding this initiative coincided with schools' reasons for participating in the program, the findings revealed that the efficacy of the Queensland Solar Schools Initiative (2001-2008) to meet stated outcomes was hampered by a number of missing components integral to implementing successful solar school programs. The installation of technology without a sound pedagogical foundation will not catalyse lasting behaviour change.

Conclusion

Both the Australian and Japanese Governments have committed a substantial amount of money and resources to energy-related programs in schools in the belief that these initiatives will result in the adoption of sustainable energy behaviours. However, this study of the Queensland Solar Schools Initiative (2001-2008) was unable to demonstrate that the installation of solar PV systems on school buildings was a catalyst for stimulating energy saving strategies in schools. Importantly this study has confirmed the negative effects of a lack of integration of technology, curriculum and social involvement of the whole community on changing behaviours and attitudes.

Schools are viewed by government and industry as an excellent showcase for promoting the educational, environmental, financial and social benefits of using solar PV technology because there is widespread belief that, "changes in schools inevitably catalyse broader changes in the surrounding community" (MACER, 2006, p. 6). Although solar school program objectives are based upon current educational theories related to education for sustainable development, sometimes solar school programs become more about installing technology and promoting a positive image of government and industry than about developing effective and sustainable energy programs in schools.

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