Does the promotion of photovoltaics in schools influence energy behaviours: An evaluation of the Queensland solar schools initiative

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Abstract
In order to meet the requirements of Australia's Mandatory Renewable Energy Target (MRET), energy providers in the state of Queensland have agreed to purchase green energy for State Government Buildings by supporting a program to install solar photovoltaic (PV) power systems in schools. The objective of the Queensland *Solar Schools* initiative is to provide schools with an educational resource that raises awareness about green energy technologies while reducing school electricity usage costs. This initiative is based on a widespread belief that exposure to renewable energy technology will create a number of conservation spin-offs such as the uptake of energy efficiency and energy conservation measures in schools. The central purpose of this paper is to evaluate the Queensland *Solar Schools* initiative and to investigate whether schools with solar PV installations come to view and use energy differently.

Identifying whether the installation of solar PV technology is a catalyst for stimulating energy efficiency measures and energy conservation behaviours in schools is beneficial to a broad range of stakeholders involved in promoting renewable energy, energy efficiency, and sustainable energy use. Using feedback from solar schools, this paper will identify problems associated with the Queensland *Solar Schools* initiative and barriers to the uptake of energy efficiency and energy conservation measures in solar schools as well as possible solutions for the future of the program. The study is applicable to government officials, energy providers, and policy makers as well as school administrators, curriculum designers, and practitioners.

Introduction

> *Australia is one of the many global regions experiencing significant climate change as a result of global emissions of greenhouse gases (GHGs) from human activity…These seemingly small changes have already had widespread consequences for Australia.*
>
> *CSIRO, 2006*

Although Australia only contributes 1.5 % of the world's greenhouse emissions (Energy Futures Forum, 2006), we as a nation are now confronted with the challenge of how to rapidly adjust from a culture of excessive energy consumption and high per capita greenhouse gas (GHG) emissions to one of minimising our environmental footprint and achieving sustainability. As a result, the Australian Government has implemented a mitigation style approach to reducing anthropocentric GHGs through its Greenhouse Gas Abatement Program (GGAP), which aims to reduce GHG emissions by supporting activities that reduce or offset emissions (Australian Greenhouse Office, 2007).

The energy industry in Australia has also embraced a number of initiatives to help reduce GHG emissions, and one of the most popular methods is the installation of solar photovoltaic (PV) power systems in schools. The states of New South Wales, Queensland, Victoria, and Western Australia all have solar school programs. While the funding, stakeholders, educational materials, and installation process varies from state to state, program objectives are very similar:

- to educate students about renewable energy sources
- to reduce greenhouse gas emissions
- to initiate cost-saving measures in schools; and,
- to increase societal awareness and acceptance of renewable energy sources

Schools are viewed as an excellent showcase for the educational, environmental, social and financial benefits of solar PV electricity. However, the motivation to install solar panels on school buildings has more to do with society's perceptions that children are the energy consumers of the future and that the lessons children learn at school will automatically be transferred to the home and permeate throughout the community, than it does with developing effective sustainable energy programs in schools. Often, solar school programs become more about the installation of technology and the promotion of a positive image of sponsors, than about actually working with schools to decrease energy consumption through a holistic educational/technological approach that focuses on instilling life-long energy conservation behaviours.

A comprehensive review of the existing literature reveals that although there are numerous solar school programs, there are very few program evaluations. The evaluations that have been conducted tend to focus on whether the technology is actually decreasing electricity usage costs and GHG emissions (Hoffner, Pichumani & Wiese, 2002), or investigate the knowledge and attitudes that school members have about the photovoltaic system (Sustainable Consumption Roundtable, 2005). Sponsor based studies tend to report on how to successfully implement solar programs in schools (NEED Project, 2006; Utility PhotoVoltaic Group, 1999). A review of the literature also indicates that there are very few studies investigating the effects of exposure to renewable energy technology on user behaviour (Association for the Conservation of Energy, 2004). To date there is a serious gap in knowledge regarding the influence of renewable energy technology on energy efficiency and energy conservation behaviours in schools.

Therefore, this paper presents a discussion on whether the installation of solar PV power systems is an effective catalyst for stimulating energy efficiency and energy conservation behaviours in schools. This is investigated by presenting findings from a mixed methods program effects study of the Queensland *Solar Schools* initiative in Australia. The central purpose of this paper is to evaluate the Queensland *Solar Schools* initiative and to discuss whether schools with solar PV installations come to view and use energy differently. Using feedback from solar schools, this paper will identify problems associated with the Queensland *Solar Schools* initiative and barriers to the uptake of energy efficiency and energy conservation measures in solar schools as well as possible solutions for the future of the program. Identifying whether the installation of solar PV technology is a catalyst for stimulating energy efficiency measures and energy conservation behaviours in schools is beneficial to a broad range of stakeholders involved in promoting renewable energy, energy efficiency, and sustainable energy use.

This paper will begin with a discussion of current energy issues in Australia, then some background information about the Queensland *Solar Schools* initiative and the stakeholders' objectives for the program will be provided. Data collected for the study will then be discussed in order to illustrate some of the barriers to the uptake of energy efficiency and energy conservation behaviours in schools. Finally, recommendations to improve the promotion of photovoltaics, energy efficiency, and energy conservation behaviours in schools will be presented.

Energy Use in Australia

Currently, the majority of Australia's electricity comes from black and brown coal-fired power stations, which contributes significantly to making Australia one of the highest CO_2 producing countries per capita in the world (Clean Energy Future Group, 2004; Roarty, 2000; World Wildlife Fund Australia, 2003). The WWF *Living Planet Report* (2006) indicates that Australia has the fourth highest energy footprint per person at 3.41 global hectares and Australia's total ecological footprint equals 6.6 global hectares, which is three times the average global footprint.

A 2002 Australian Government report stated that 32 % of Australia's GHG emissions were produced by the electricity industry (MacGill, Outhred & Nolles, 2006). However, more current estimates put emissions produced by the stationary electricity sector at almost 50 % of Australian's total GHG emissions (Alternative Technology Association, 2003; Australian Bureau of Statistics, 2005). Coal-fired power stations account for 92 % of Australia's electricity; and, according to Government reports, coal will remain the country's main energy source (Commonwealth of Australia, 2004). Australia's heavy reliance on coal as the main source of energy has significant economic, environmental, social and political ramifications; and, is one of the reasons why the Australian Government refused to ratify the Kyoto Protocol.

GOVERNMENT SUPPORT FOR RENEWABLE ENERGY INITIATIVES

Although the Australian Government has not ratified the Kyoto Protocol, it has made a commitment to meet the Kyoto target of limiting GHG emissions by developing and investing in domestic programs to reduce Australia's GHG emissions by 30 % against the business-as-usual projections for the period from 2008 – 2012 (Kemp & Downer, 2002). In June 2004, the Australian Government reconfirmed its commitment to generate 9 500 gigawatt hours of extra renewable energy by 2010 through the Mandatory Renewable Energy Target (MRET), which stipulates that energy providers must purchase at least 2 % of their electricity from renewable sources (MacGill *et al*, 2006). In order to achieve this 2 % target, the Federal and State governments of Australia have committed to encouraging the development of renewable energy sources through a number of initiatives, projects and subsidies.

Australia has been a pioneer in solar PV technologies, and government financial support has contributed to the doubling of solar PV sales and installations in the past five years. For example, the Australian Government allocated AUD 31 million (1 EURO = 1.68 AUD) over a four year period (2000-2004) in order to promote the installation of grid connected solar PV systems on residential and community use buildings through the Photovoltaic Rebate Program (PVRP). In 2003, an additional AUD 5.8 million was provided to extend the PVRP through 2005, and another AUD 11.5 million to extend the

program through 2007. An additional AUD 264 million has been made available until 2010 under the Renewable Remote Power Generation Program (RRPGP) to increase the use of renewable energy generation in off-grid areas. The Australian Government has also announced that it will financially support the uptake of grid connected photovoltaic projects in urban centres across Australia through the Solar Cities program, which has been allocated AUD 75.3 million in funding from 2004 to 2013 (Commonwealth of Australia, 2004).

QUEENSLAND ELECTRICITY GENERATION AND THE ENERGY INDUSTRY

Queensland is the second largest state in Australia, accounting for 25 % of the continent's landmass. Over the past two decades more than 60 000 people annually have moved to Queensland (Robson, 2006), making it the fastest growing and most energy intensive states in the country; and putting increasing pressure on natural resources such as water, land, and fossil fuels (Department of Energy, 2005). The state's need for energy is fuelled primarily by black coal, which accounts for more than 90 % of the electricity generated in Queensland. However, the Queensland Government is attempting to diversify the state's energy generation by investing in renewable energy projects as well as gas-fired generation. In order to meet MRET requirements, energy providers in Queensland have agreed to purchase green energy for State Government Buildings.

In 1999, the Queensland Environmental Protection Agency (EPA) and the Australian Greenhouse Office (AGO) funded an initiative to install solar PV power systems in Queensland schools. Three state government owned energy providers – Stanwell Corporation, Ergon Energy, and ENERGEX – have partnered with the EPA in the Queensland *Solar Schools* initiative. Stanwell Corporation is a both a generator and retailer of energy, and supplies 20% of the state's electricity requirements. Ergon Energy is one of the largest electricity companies in Australia, and provides energy services to regional Queensland. ENERGEX owns and operates the electricity distribution network in south-east Queensland, providing electricity to Brisbane, the Gold Coast, and the Sunshine Coast. Government and energy industry sponsors believe that the *Solar Schools* initiative provides a valuable educational resource for students while reducing overall electricity usage costs in schools as well as providing the energy industry with a means to fulfil MRET requirements and increase community awareness of renewable energy technology, thereby increasing the uptake of green power products offered by energy retailers.

History of the Queensland Solar Schools Initiative

In 1999, the Queensland EPA used a grant of AUD 25 000 from the Queensland Energy Innovation Fund to sponsor a solar schools feasibility project in partnership with Stanwell Corporation. Two state schools received 2.5 kW grid connected solar PV power systems.

SOLAR SCHOOLS PILOT PROGRAM (2001-2003)

The Queensland EPA and Stanwell Corporation initiated the *Solar Schools Pilot Program* with the introduction of the Photovoltaic Rebate Program (PVRP) in 2000. The goal was to install 2 kW grid connected solar PV systems, at an approximate cost of AUD 25 000 (14 868 EUR) per system, at seventeen schools across Queensland. The objectives of this program were to increase the use of photovoltaics and to educate school children about the ease of use and environmental benefits of renewable energy. The Queensland Government contributed AUD 7 700 for each system, with an additional rebate of up to AUD 10 000 available from the PVRP. Stanwell Corporation provided additional funds and technical expertise as well as training and educational components. However, due to a change in Stanwell management, the energy provider pulled out of the pilot program leaving the EPA looking for other energy industry partners to sponsor the remainder of the planned solar school installations (N. Martin, email communication 10 October 2004; C. Robertson, telephone communication 1 December 2005). In 2003, the EPA found a willing partner with Ergon Energy. Under the *Solar Schools Pilot Program*, seven solar PV installations were sponsored by Stanwell Corporation, five by EPA, and five by Ergon Energy.

Feedback from some of the initial pilot solar schools indicates that there was no consistency in the technical equipment, data monitoring software, training or educational materials provided to schools; and, the success or failure of the school to embrace the solar PV technology and energy conservation behaviours varies widely. There has been no follow-up conducted by energy industry sponsors in order to determine whether the solar PV systems are working optimally, or by the EPA to see if stated program objectives have been met. Some of the pilot schools are not even included on the EPA list of solar schools and have essentially fallen off the grid.

SOLAR SCHOOLS URBAN PROGRAM (2003-2005)

In 2003, the EPA launched the *Solar Schools Urban Program* in partnership with Ergon Energy and ENERGEX. Funding for this program came as part of an agreement with both energy providers to purchase green energy for State Government buildings. Under the PVRP, schools could apply for an additional AUD 8 000 rebate to be received by the installer after installation. In addition to the educational objectives of the pilot solar schools program, this partnership brought with it the goal of increasing the uptake of green power programs offered by each energy sponsor. There is some indication that the uptake of green power products has increased in communities with solar schools but no definitive evidence that the two occurrences are linked. At the end of 2005, which marked the closure of this *Solar Schools Urban Program*, forty state schools had received grid connected solar PV installations.

Feedback from solar schools included in this phase of the initiative indicates that some schools received adequate training and educational materials as well as a stand-alone computer with data monitoring software; while other schools received no training, no educational materials and no data monitoring equipment. The only follow-up has been initiated by solar schools that are experiencing technical difficulties with the PV installation.

SOLAR SCHOOLS GOES BUSH PROGRAM (2004 – 2006)

In addition to the installation of solar PV systems on urban and regional state schools, the *Solar Schools Goes Bush Program* was launched in 2004. This program, which targets diesel based re-

mote, isolated and indigenous schools, is jointly funded by the Queensland EPA and the Australian Government. Forty-eight schools have been scheduled to receive a 5 kW system, which will produce about 8 MWh of electricity per year, reducing school power bills by approximately AUD 1 000 (EPA, 2005). Rebates are available through the Australian Greenhouse Office's Renewable Energy Diesel Replacement Scheme (REDRS). These schools were not included in the current study; therefore, there is no feedback available at this time.

Stakeholder's Program Objectives for Solar Schools

The Queensland *Solar Schools* initiative has gone through a variety of phases since its inception in 1999. The only constant stakeholder has been the EPA Sustainable Industries Division; however, the management of the initiative has gone through a number of hands. Energy industry partners have included Stanwell Corporation, Ergon Energy and ENERGEX. According to one of the *Solar Schools* EPA team leaders, although objectives for the programs were discussed, key outcomes were never identified and very little reportable data has been collected. Once the energy partners took over the technical, training and educational aspects of the program, the aim became the installation of equipment, not quantifying data such as learning outputs.

QUEENSLAND ENVIRONMENTAL PROTECTION AGENCY

An EPA *Solar Schools* fact sheet states that the educational objectives of the *Solar Schools* initiative are to "provide a community showcase and a platform for educating young people about the importance and ease-of-use of renewable energy … each school installation includes an integrated educational resource for students, teachers and the local community to learn about solar power and sustainability" (EPA, 2005). The *Solar Schools* initiative also has a number of environmental, economic, and social benefits associated with this main goal of raising awareness about renewable energy technology. A single 2 kW solar system will reduce the amount of GHGs produced by using conventional coal-powered electricity by 3.6 tonnes per year and is estimated to save the school approximately AUD 500 per year on power bills (EPA, 2005). Additionally, the initiative will provide employment and training opportunities within the community, while raising awareness about the effectiveness of renewable energy and solar power generation.

A further goal of the initiative is to increase the uptake of green power subscriptions in communities (N. Martin, email correspondence, 10 October 2004; D. Clifford, telephone conversation, 15 December 2005). Government and energy industry sponsors believe that the Queensland *Solar Schools* initiative will not only educate school children about the use and benefits of photovoltaics and increase community awareness of renewable energy technology, but will also provide the energy industry with a means to fulfil MRET requirements, and increase the uptake of green power products in communities with solar schools.

The EPA hopes that their investment in the *Solar Schools* initiative will not only reduce GHG emissions, but will serve as a hands-on educational tool and working example of how communities can embrace and use renewable energy; and, ultimately modify energy consumption behaviours in order to become more energy efficient. However, to date no follow-up has been conducted to investigate whether the program goals and objectives are actually being met.

ENERGY INDUSTRY PARTNERS

In order to support the development of renewable energy, the Australian Government introduced enforceable legislation under the *Renewable Energy* (electricity) *Act* 2000 that requires the generation of 9 500 gigawatt hours of extra renewable electricity by 2010. MRET has committed Australia to increase the amount of renewably generated electricity from 10.7 % of the total electricity supply produced in 2000 to 12.7 % by 2010, at an estimated cost of AUD 3 billion in infrastructure investment (Roarty, 2000). Currently, electricity generated from renewable sources such as hydro, wind, solar, wood, and bagasse (biomass) only accounts for about 10 % of Australia's total electricity supply, with the bulk of electricity generated from coal-burning power stations. However, in a greenhouse gas constrained future, governments, energy suppliers, and end-users are being forced to rethink traditional approaches to energy production, supply, delivery, and consumption (Wright, 2000).

Queensland's energy providers are making an effort to increase the uptake of renewable energy power generation and enhance their environmental credentials by sponsoring "clean and green" programs with large public appeal. Both ENERGEX and Ergon Energy have green power programs that rely on the voluntary subscription of residential and business customers. One of the stated objectives of sponsoring solar schools is to increase the uptake of green power subscriptions. Another objective is to raise community awareness of renewable energy technology by funding media launches at new solar schools and distributing information packages about renewable energy options. In order to raise their profile as supporters of community renewable energy projects, solar schools are also promoted through energy industry newsletters and annual reports.

Ergon Energy has thus far sponsored seventeen solar schools throughout regional Queensland, and is in negotiations to sponsor an additional seven schools. Ergon Energy contracted out the actual school installations to Choice Electric, who were responsible for the installation of the system as well as a data monitoring meter box and a software package. ENERGEX has sponsored thirty solar schools in south-east Queensland, but due to the recent sale of the retail divisions of the energy provider, ENERGEX has not committed to sponsoring any additional schools. ENERGEX contracted out the actual installation of solar PV systems to Kyocera Solar, who were responsible for installing the system as well as a new computer with data monitoring software; however, educational materials were the responsibility of the EPA. Energy providers believe that the solar PV systems will provide students with hands-on experience using solar-energy technology and will "contribute to a greater community awareness of the benefits of alternative energies" (ENERGEX, 2005).

However, feedback from solar schools reveals that there has been little follow-up conducted by the installer, energy industry sponsor or the EPA after installation. The level of training provided to schools is inconsistent, ranging from half a day to none at all; and, some schools have reported that the data monitoring software package is not user-friendly and limited

in the amount of teachable data it can produce. A number of schools have indicated that without a computer hooked-up to the system, the metering box provided is not readily useable as an effective teaching tool. Furthermore, some of the schools have reported that the solar PV system has not been used as an effective hands-on learning tool due to the positioning of solar PV panels on a rooftop which makes them invisible and inaccessible.

SOLAR SCHOOLS

The third stakeholders in the Queensland *Solar Schools* initiative are the schools themselves. Between 1999 – 2005, seventy-eight state schools (62 primary schools and 16 secondary schools) received solar PV installations. Under the pilot program, the majority of schools were contacted directly about participating in the program. With the urban program, schools had to submit an application to be considered for the installation. In this phase of the initiative, schools heard about the program through word of mouth, local city councils, and energy industry sponsors. When asked why schools applied for a solar PV system, the responses varied from educational to financial reasons.

Feedback from solar schools indicates that schools felt a solar PV installation would provide an innovative and useful teaching tool that would help support environmental education programs and further sustainability issues in the school by raising awareness about renewable energy sources, while at the same time reducing electricity bills. Although schools feel that the installation does help to reduce electricity bills, the majority of schools surveyed also indicated that their energy bills have been continually increasing, primarily due to the installation of air-conditioners as well as the addition of more computers, more buildings, and more students. While most schools have integrated the solar PV system into the curriculum, the degree and effectiveness depends largely on the motivation of the school administration and teaching staff as well as whether the solar PV installation is viewed as an effective teaching tool.

QUEENSLAND DEPARTMENT OF EDUCATION, TRAINING AND THE ARTS

The Queensland Department of Education, Training and the Arts supports 1 276 state schools, 78 of which have solar PV systems. According to the 2005 – 2006 *Annual Report*, the Education Department's energy expenditure for the 2004 – 05 school year was AUD 21 932 000, with students and staff consuming 335.6 kilowatt hours of electricity per capita and producing 176 kilotonnes of CO_2 emissions. While not actually a direct participant in the Queensland *Solar Schools* initiative, Education Queensland is a stakeholder in this program and has had two levels of involvement in the initiative: educational and financial.

In 2000, Education Queensland collaborated with the EPA on the *Power for a Sustainable Future* resource kit which was provided to every state school, and contained a 30-minute video and 100-page booklet with lessons and materials aimed at upper primary and lower secondary students. A website was also developed to supplement and reinforce the resource kit, but has not been updated since 2000. The resource kit and website are intended to be used together to support the Education Department's key learning areas of Science and Studies of Society and Environment (EPA, 2004). The Department also supports renewable energy education by funding the *Energy Efficiency in Schools* program offered to schools through Departmental Environmental Education Centres.

Since the solar PV systems are installed on government owned buildings, Education Queensland must approve the installation; however, maintenance of the system lies with the installer. A foreseeable problem will arise when the warranty expires on the equipment and the installer is no longer responsible for maintenance or repairs. Some solar schools have already run into difficulties getting equipment repaired as it can take months to get the installer out to look at the system, ship a faulty component out for servicing, and then re-boot the system. Additionally, there is the issue of who is financially responsible for repairs – the sponsor, the school, or Education Queensland. While the educational and environmental benefits of installing solar PV systems on school buildings has been applauded by the Education Department, the financial responsibility of maintaining systems still needs to be addressed.

Evaluating the Queensland Solar Schools Initiative

Although the EPA is in negotiations with Ergon Energy to continue to install solar PV systems on school buildings, the funding and structure of the initiative has changed since its inception in 1999. Neither Stanwell Corporation nor ENERGEX are involved in the initiative at this point, the EPA's involvement is unclear, and Education Queensland is moving towards a more holistic approach by integrating existing environmental education and sustainability programs under the guise of the Queensland Environmentally Sustainable Schools Initiative (QESSI). QESSI aims to help schools develop sustainability action plans in order to manage their resources more efficiently by focusing on the four key areas of energy, water, waste and biodiversity. The Education Queensland 2005 – 2006 *Annual Report* has acknowledged that energy is a key environmental area that needs to be addressed and has committed to reducing the Department's energy footprint by taking steps to make schools more energy efficient by retrofitting lighting and appliances at a number of schools as well as signing up 1 000 state schools to green power products offered by energy providers. The threat of climate change has made energy production and consumption a key issue for government, industry, and communities; therefore, now is an opportune time to evaluate the impact the Queensland *Solar Schools* initiative has had on school energy behaviours.

This mixed methods program effects study of the Queensland *Solar Schools* initiative was conducted by a Doctor of Education Candidate enrolled in the Faculty of Arts, Humanities and Education at Central Queensland University. The collection of data involved the distribution of two separate surveys, follow-up correspondence, focus group discussions, interviews, school visits and observations. This paper will discuss the results of a survey that was mailed out to schools that received a 2 kW grid connected solar PV system. A group of comparison schools without renewable energy systems were also sent the survey. The remote, isolated and indigenous schools that received 5 kW installations under the diesel replacement scheme were not included.

ENERGY EFFICIENCY AND ENERGY CONSERVATION SURVEY DATA

An eight-page survey was mailed to Queensland schools that had received solar PV systems between 2001-2005. Of the 56 surveys mailed out, 20 were returned – representing a 36 per cent response rate. The same survey, minus the questions about the solar PV installation was also mailed to a comparison group. Of the 54 surveys mailed out, 15 were returned – representing a 28 per cent response rate. A covering letter accompanying the survey requested that the school principal or person-in-charge of the solar school project answer the questions posed. The survey was divided into five sections, requesting information under the following headings: Demographic Information; Energy Costs; Energy Efficiency Measures; Energy Conservation Measures; and, Solar Photovoltaic (PV) Installation.

Part One: Demographic Information

Of the twenty solar school surveys that were returned, an equal number of schools were from metropolitan (urban) areas and regional (rural) areas. Fourteen surveys were from primary state schools, three from state high schools, and three from P-12 schools. Five surveys were received from schools that participated in the *Solar Schools Pilot Program*: two sponsored by EPA, two sponsored by Ergon, and one sponsored by Stanwell Corporation. Eight surveys were from solar schools sponsored by ENERGEX, and seven surveys were from schools sponsored by Ergon Energy under the *Solar Schools Urban* program.

Of the fifteen non-solar school surveys that were returned, ten were from urban schools and five from rural schools. Eight surveys were from primary state schools, six from secondary schools, and one from a P-12 school.

Part Two: Energy Costs

Sixty-five per cent of solar and 67 % of non-solar school respondents are provided with billing information about their electricity consumption. The majority of solar school respondents indicated that annual energy costs have been increasing due to the installation of air-conditioners and additional computers, buildings, and students; but still feel that the solar PV installation is helping to reduce electricity bills. Sixty-five per cent of solar school respondents indicated that the school practices energy shutdown procedures during non-school hours. However, only five (33 %) of the fifteen non-solar schools indicated that they practice evening shutdown procedures, while nine (60 %) practice weekend shutdown procedures, and ten (67 %) have vacation shutdown procedures. Five solar (25 %) and two non-solar (13 %) school respondents have a school wide energy policy, while only two solar (10 %) schools and one non-solar (7 %) school have performed an energy audit to assess electricity usage. Four of the solar (20 %) schools and one of the non-solar (7 %) schools have participated in *Energy Efficiency in Schools* educational programs for students. Approximately 20 % of staff at solar schools have received some training relevant to reducing school energy costs compared to only 13 % at non-solar schools.

Part Three: Energy Efficiency Measures

Respondents were asked to indicate the energy efficiency measures that have been taken in their school from the list of measures provided. Energy efficiency measures were defined as one-off actions that help reduce the amount of energy being used, and were broken down under the headings: lighting; school building and equipment; domestic hot water system; and, maintenance. A comparison of the energy efficiency measures taken in solar and non-solar schools reveals that there is very little difference in the types of measures taken. The most prevalent measures are ones that are convenient, inexpensive, or already being practiced as part of the school's environmental ethos. The number of solar and non-solar schools taking up energy efficiency measures is also similar, which suggests that the installation of a solar PV system has not had a significant influence.

Lighting

The most popular energy efficiency measures for both solar and non-solar schools consisted of replacing incandescent lighting with florescent lighting (55 % of solar schools and 67 % of non-solar schools) and installing time controls on light switches (30 % of solar schools and 33 % of non-solar schools). Three non-solar (20 %) schools and two solar (10 %) schools installed LED lights in EXIT signs. Two solar schools installed photo-sensor controls to detect the amount of natural light in rooms, and two solar schools removed unnecessary light bulbs. One solar school installed occupancy sensors, and another solar school installed dimming controls on light switches. The actual number of lighting energy efficiency measures taken by schools ranged from zero to three.

School Building and Equipment

The majority of both solar and non-solar school respondents indicated that equipment such as photocopiers, printers, and computers have energy saving features. One of the common reasons cited for increasing electricity costs was the installation of air-conditioners, yet only 40 % of both solar and non-solar schools automatically set air-conditioners at the recommended 25°C. Six solar (30 %) and six non-solar (40 %) school respondents had replaced faulty refrigerator seals, while five solar (25 %) and three non-solar (20 %) schools had replaced inefficient appliances with Energy Star Rated appliances. Additionally, three solar (15 %) school respondents indicated that doors and windows had been weather-stripped and caulked.

Domestic Hot Water System

In this category more non-solar schools had taken energy efficiency measures than solar schools. Twenty per cent of non-solar and 15 % of solar school respondents had lowered the hot water temperature to the recommended 60°C. Three non-solar (20 %) and two solar (10 %) schools have decentralized hot water heating; three non-solar and two solar schools installed flow restrictors; and, one non-solar and one solar school installed a solar hot water heater. Two non-solar schools installed auto-off facets. None of the respondents had installed hot water boosters or timers on hot water tanks.

Maintenance

This category had high response rates; and, again more non-solar schools practice energy efficiency measures than solar schools. Seventy-three per cent of non-solar and 70 % of solar school respondents regularly inspect for water leaks. Seventy-three per cent of non-solar and 60 % of solar schools regularly

clean light fixtures. Fifty-three per cent of non-solar and 50 % of solar schools regularly inspect building systems; and, 67 % of non-solar compared to 30 % of solar school respondents turn off hot water systems during school shut down periods. All of the solar schools with air-conditioning indicated that maintenance is performed regularly, while 67 % of non-solar schools maintain AC systems.

Part Four: Energy Conservation Measures

The respondent was provided with a list of ten actions and asked to indicate which energy conservation measures school staff and students are being encouraged to take within the school. Energy conservation measures were defined as conscious or habitual behaviours that reduce the amount of electricity being used. The list of energy conservation actions that were provided have been ranked in the following table:

A comparison of the energy conservation behaviours being encouraged in solar and non-solar schools reveals that the number of schools promoting curtailment behaviours is above 50 % for both sample groups; however, there are some differences regarding which actions are viewed as more important. The degree of difference between solar and non-solar school responses is quite small, with the exception of the number of solar schools (80 %) that encourage staff to *turn off computers when not in use*, compared with non-solar schools (47 %). Teachers in both solar and non-solar schools are being encouraged to take energy conservation actions that control classroom environment and ambiance, while students are being encouraged to take energy conservation actions related to the use of equipment.

A second question in this section asked the respondent to identify the ways in which students and staff are encouraged to reduce energy use at school. The list of measures that were provided can be ranked as follows:

While the number of energy conservation measures being practiced in schools appears to be quite high, the ways students and staff are being encouraged to reduce energy use does not fare as well. Behaviour-change theories suggest that modelling and prompts are two effective ways to aid in the diffusion of preferred behaviours (Aronson & O'Leary, 1982 – 83), yet less than half of the schools surveyed use visible reminders or modelling to encourage energy conservation behaviours. This would suggest that the installation of solar PV systems in schools has had a limited impact on the uptake of energy conservation behaviours being encouraged in schools.

Part Five: Solar Photovoltaic (PV) Installation

The final section of the survey required the respondent to provide information about the solar PV installation. Responses indicate that schools heard about the solar schools program from the EPA, energy industry sponsors, local government representatives, Education Queensland, or through word of mouth. School principals and teachers were involved in the decision to install a solar PV system, and received some training about how to use the solar PV installation. Seventeen solar schools indicated that there is a person-in-charge of the solar PV project at the school, and thirteen solar schools indicated that the solar PV system has been integrated into the school curriculum. However, only 35 % of respondents indicated that the sponsors provided educational tools, lesson plans or materials to help teachers use the solar PV system in class lessons.

Barriers to the Uptake of Energy Efficiency and Energy Conservation Behaviours

The survey findings indicate that the installation of renewable energy technology alone is not going to significantly increase the uptake of energy efficiency measures and energy conservation behaviours in schools. After compiling the data generated

Table 1. Energy Conservation Measures Encouraged in Queensland Schools

	SOLAR SCHOOLS (N=20)		NON-SOLAR SCHOOLS (N=15)	
Energy Conservation Measures	**Staff**	**Students**	**Staff**	**Students**
Turn off fans, air-conditioners, heaters in unused rooms	20 (100%)	13 (65%)	14 (93%)	09 (60%)
Turn off computers at the end of the school day	18 (90%)	14 (70%)	14 (93%)	13 (87%)
Close doors & windows when air conditioner or heater is on	18 (90%)	11 (55%)	09 (60%)	08 (53%)
Turn off lights in unused rooms	16 (80%)	14 (70%)	13 (87%)	12 (80%)
Turn off computers when not in use	16 (80%)	14 (70%)	10 (67%)	07 (47%)
Use natural daylight wherever possible	15 (75%)	11 (55%)	09 (60%)	08 (53%)
Use water sparingly	14 (70%)	10 (50%)	11 (73%)	09 (60%)
Turn off computer monitors when not in use	13 (65%)	10 (50%)	10 (67%)	07 (47%)
Set air-conditioners at 25°C	12 (60%)	06 (30%)	09 (60%)	06 (40%)
Close blinds or curtains to keep out heat in warm weather	10 (50%)	07 (35%)	07 (47%)	04 (27%)

Table 2. Ways Students and Staff are Encouraged to Reduce Energy Use

Methods to Reduce Energy Use	SOLAR SCHOOLS (N=20)	NON-SOLAR SCHOOLS (N=15)
Reminders above light switches	9 (45%)	5 (33%)
School patrols to check for lights left on, equipment left on, open doors etc.	8 (40%)	5 (33%)
Educational programs offered to students	8 (40%)	4 (27%)
Reminders in computer labs	7 (35%)	7 (47%)
Reminders on school equipment (i.e. photocopiers, printers, etc.)	7 (35%)	3 (20%)
Reminders in school newsletters	5 (25%)	4 (27%)
Special recognition of energy conscious classes, students, teachers etc.	4 (20%)	1 (7%)
Energy efficiency and energy conservation contests	1 (5%)	1 (7%)
Training courses offered to teachers	Nil	Nil
Training courses offered to school-based staff	Nil	Nil

from the returned surveys as well as focus group discussions, interviews, and school visits, a number of barriers to the uptake of energy efficiency and energy conservation behaviours in solar schools have been identified. These barriers can be divided into the following three categories: education and training; hardware and software; and, buildings and equipment.

EDUCATION AND TRAINING

A number of respondents reported that the provision of adequate training and educational materials is needed in order to increase both students' and staff's awareness about the need to conserve energy as well as the ways to conserve energy. Respondents suggested that teachers should receive adequate training on how to effectively use the solar PV system as a hands-on teaching tool as well as how to use the solar PV data so that students can better understand the environmental and financial savings of using solar energy technology. There was a suggestion that teaching resource units be provided to more easily integrate renewable energy technology into the curriculum as well as scaffolding lesson planning across the grades. Data from the surveys reveals that only a handful of school staff were given training when the solar PV system was installed, and only seven of the twenty solar schools that responded received educational materials. While some measures are being taken to remind students and staff to reduce energy use, less than half of the solar school respondents actively encourage the uptake of energy conservation behaviours within the school. None of the solar schools have provided training courses to school staff, and some of the staff indicated that they were not even aware that their school has a solar PV system.

HARDWARE AND SOFTWARE

While some schools are successfully using their solar PV systems, others have had little success. The most common complaint regarding the solar PV installation is that the system cannot be used as an effective teaching tool due to (1) the inaccessible location, (2) the lack of data monitoring equipment, or (3) the software that has been provided is not user friendly. Solar PV panels were typically placed on the highest North facing roof, which means they may not be easily visible and cannot act as a daily reminder to conserve energy. Additionally, if the metering box is not easily accessible or connected to a computer, it is difficult to collect usable data. It has been suggested that the system be hooked-up to a data-logger at a minimum, and that the downloaded information be made available either on a stand-alone computer or networked to all school computers so that every classroom can access the information. Furthermore, solar schools should be able to upload data onto a state-wide website with real-time access in order to compare their efforts with other solar schools and build a sense of community. Although a solar schools website was constructed in 2001, neither the EPA nor the energy industry sponsors have allocated money to maintain this website.

BUILDINGS AND EQUIPMENT

Another barrier to the uptake of energy efficiency and conservation behaviours is the architecture of Queensland schools. Many of the schools are more than thirty years old and are designed for a tropical climate. Although school buildings have some passive airflow designs, such as louvers, the buildings themselves are typically built to face the main road. This means that many buildings have an East/West aspect and catch the sun all day long. Efficiently air-conditioning school buildings is also quite difficult and, for some solar schools the installation of air-conditioners under the Education Department's Cool Schools program is at odds with the school's energy conservation efforts. Feedback from solar schools has indicated that the overall design of school buildings makes it very difficult for effective energy efficiency measures to be put into practice.

Reapproaching the Queensland Solar Schools Program

The data gathered for this program effects study of the Queensland *Solar Schools* initiative has provided insight into the influence solar PV installations have had on the uptake of energy efficiency and energy conservation measures in schools. Unfortunately, in the majority of cases studied, the solar PV system has had minimal impact on the way school members view and use energy, resulting in a limited uptake of energy efficiency and energy conservation behaviours. One of the common difficulties of maintaining long-lasting interest in the solar PV system has been a lack of knowledge and continuity, especially when the program champion and small group of students involved in the installation process, leave the school. Feedback from some schools indicates that staff and students are unaware the school even has a solar PV system. However, feedback from successful solar schools has indicated that the solar PV installation has worked as an effective educational resource for teaching students about the ease-of-use and benefits of renewable energy technology in schools that possess:

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

Due to a lack of pedagogical guidance and clear learning outcomes, however, the *Solar Schools* initiative became more about installing solar PV technology than about instilling long-term energy usage behaviours. To date there has been very little follow-up in order to assess whether program objectives are being met. On the upside, since the renewable energy technology has already been installed, there is an opportunity to re-approach the Queensland *Solar Schools* initiative and revitalise interest in energy efficiency and energy conservation behaviours at solar schools.

ESTABLISHING A SOLAR SCHOOLS WORKING GROUP

Using recommendations about best practices for establishing a successful solar school program, the first step now would be to establish a working group made up of all stakeholders involved in the *Solar Schools* initiative (EPA, Education Queensland, energy industry sponsors, and solar schools), and then nominate one champion or contact person to coordinate the entire program. This working group could come under the guise of the Queensland Environmentally Sustainable Schools Initiative (QESSI).

DETERMINING EDUCATIONAL AND TECHNOLOGICAL REQUIREMENTS

Solar schools should be systematically contacted in order to assess the educational materials and equipment required for teachers to effectively use the solar PV installation to teach students about renewable energy. Ready-to-use renewable energy teaching units that compliment existing Education Queensland sustainability learning outcomes need to be produced for all grades. Additionally, an energy audit should be conducted in each solar school in order to provide feedback on what energy efficiency measures are necessary to get the best possible results from the solar PV system. Education Queensland announced in its 2005 – 2006 *Annual Report* that a strategic plan is being developed to retrofit lights and appliances in 1 000 state schools as well as a plan to implement energy saving strategies and green power initiatives in schools. The QESSI solar schools working group can work with Education Queensland Facilities Management to establish a budget for the installation of energy efficiency measures in solar schools. Additionally, all solar PV systems should be checked to ensure optimal system performance, and a budget allocated for the maintenance of systems. Solar schools should be provided with a data logger, user friendly data monitoring software, and a means to network the data onto all school computers as well as through a state-wide website.

MAINTAINING ENERGY CONSERVATION BEHAVIOURS

Education Queensland currently funds *Energy Efficiency in Schools* education programs offered through regional Environmental Education Centres; however, only four of the twenty solar school respondents indicated that their school had participated in this program. All solar schools should be required to participate in this program. Solar schools also need to be provided with resources (prompts) to help remind students and staff to practice energy conservation behaviours, for example: stickers on light switches; signs in classrooms and computer labs; reminders to use energy saving functions on equipment. Staff training days should be provided periodically on how to use the solar PV system as an effective teaching tool and to serve as a reminder about the solar PV installation. Furthermore, teachers should actively model energy conservation behaviours in order to create a social practice of energy conservation within the school. A student-led energy club should be established at each school to further promote positive energy usage behaviours through communication campaigns and peer monitoring. An energy club would ensure that energy conservation is a key environmental issue in schools every year, not only when the solar PV system is first installed. Additionally, local, regional, and state-wide renewable energy contests and conferences should be organised every few years in order to facilitate information sharing and maintain momentum within schools, which tends to wane after the initial excitement wears off.

Conclusion

Although research suggests that exposure to renewable energy technology can act as a catalyst to stimulate changes in the way schools view and use energy (Sustainable Consumption Roundtable, 2005), survey responses collected for this study reveal that there is relatively little difference in the types of energy efficiency measures and energy conservation behaviours being practiced in both solar and non-solar schools. Additionally, the actual number of solar and non-solar schools practicing energy efficiency measures and promoting energy conservation behaviours is very similar, which would suggest that the Queensland *Solar Schools* initiative has not had a significant influence on the uptake of energy efficiency measures and energy conservation behaviours. Feedback from solar schools indicates that although some energy efficiency measures and energy conservation behaviours are being encouraged, schools lack the resources and finances to go beyond convenient, commonsense actions. In order to move beyond knowledge and awareness about renewable energy to the development of long-term energy conservation behaviours, the Queensland *Solar Schools* initiative requires a holistic approach that involves the active participation of all stakeholders in order to address barriers to the uptake of energy efficiency and energy conservation behaviours.

Installing renewable energy technology in schools without a pedagogical foundation that actively supports educational and environmental learning outcomes, will not result in the uptake of energy efficiency and energy conservation behaviours. In order to foster long-term positive energy usage behaviours, a holistic approach that combines technology, education, and behaviour modification needs to be implemented. By addressing the identified barriers and adopting the comprehensive efforts suggested above, the Queensland *Solar Schools* initiative could achieve its original educational, environmental, social and financial objectives by:

- acting as an educational resource that teaches students about renewable energy technology
- reducing school electricity costs and greenhouse gas emissions
- raising community awareness about renewable energy sources; and
- increasing green power subscriptions

Furthermore, by taking a holistic pedagogical approach rather than a purely technological approach to the initiative, the installation of solar PV systems in schools could influence the uptake of energy efficiency measures and energy conservation behaviours by making energy a priority in solar schools.

References

Alternative Technology Association. (2003). *Submission to the Mandatory Renewable Energy Target Review*, by K. Coulston, New South Wales, Australia.

Aronson, E. & O'Leary, M. (1982-83). The relative effectiveness of models and prompts on energy conservation: a field experiment in a shower room. *Journal of Environmental Systems*, 12(3), 219-224.

Association for the Conservation of Energy. (2004). *User behaviour in energy efficient homes: Phase 2 Report*, by J. Pett & P. Guertler, London, England.

Australian Bureau of Statistics. (2005). *Year Book Australia: Environment Greenhouse Gas Emissions*. Retrieved 9 December 2005 from http://www.abs.gov.au/ausstats/abs

Australian Greenhouse Office. (2007). *Greenhouse Gas Abatement Programme (GGAP)*. Australian Government, Department of the Environment and Water Resources. Retrieved 10 March 2007 from http://www.greenhouse.gov.au/ggap/index.html

Clean Energy Future Group. (2004). *A Clean Energy Future for Australia*, by H. Saddler, M. Diesendorf, & R. Denniss, New South Wales, Australia.

Commonwealth of Australia. (2004). *Securing Australia's Energy Future; Energy White Paper*. Australian Government. Retrieved from http://www.dpmc.gov.au/publications/energy_future/docs/energy.pdf

CSIRO. (2006). *Climate Change Impacts on Australia and the Benefits of Early Action to Reduce Global Greenhouse Gas Emissions*, Commonwealth Scientific and Industrial Research Organisation by B. L. Preston, & R. N. Jones, Victoria, Australia.

Department of Education, Training and the Arts. (2006). *Annual Report 2005-2006*. Queensland Government. Retrieved from http://education.qld.gov.au/publication/reporting/annual/2006/#content

Department of Energy. (2005). *Electricity in Queensland*. Queensland Government. Retrieved from http://www.energy.qld.au/electricity_in_queensland.cfm

ENERGEX. (2005). *Annual Report 2003-04*. Retrieved from http://www.energex.com.au/about_energex/annual_report_03_04.html

Energy Futures Forum. (2006). *The Heat is On: The Future of Energy in Australia*. Commonwealth Scientific and Industrial Research Organisation (CSIRO) ACT, Australia. Retrieved from http://www.csiro.au/files/files/pbew.pdf

Environmental Protection Agency. (2006). *Renewable Energy Solar Schools: fact sheet*. Queensland Government. Retrieved from http://www.epa.qld.gov.au/publications/p00792aa.pdf/Solar_schools.pdf

Environmental Protection Agency. (2005). *Renewable Energy Solar Schools for a Smart State: fact sheet*. Queensland Government. Retrieved from http://www.epa.qld.gov.au/publications?id=792

Environmental Protection Agency. (2004). School Programs. Queensland Government. Retrieved from http://eee.epa.qld.au/environmental_managment/sustianabiliy

Hoffner, J., Pichumani, J. & Wiese, S. (2002). *Solar schools: experiences with different utilities*. IEEE Online Publications, 1070-1709.

Kemp, D., & Downer, A. (2002). Global greenhouse challenge: The way ahead for Australia. Joint Media Release. Australian Government, 15 August 2002. Retrieved 21 September 2005, from http://www.deh.gov.au/minister/env/2002/mr15aug202.html

MacGill, I., Outhred, H. & Nolles, K. (2006). Some design lessens from market-based greenhouse gas regulation in the restructured Australian electricity industry. *Energy Policy*, 34, 11-25.

NEED Project. (2006). *Schools Going Solar Activities*. Manassas ,VA. Retrieved from www.NEED.org

Roarty, M. (2000). *Renewable Energy Used for Electricity Generation in Australia*. Science, Technology, Environment and Resources Group. Parliament of Australia. Retrieved 21 September 2005, from http://www.aph.gov.au/library/pubs/rp/2000-01/01RP08.htm

Robson, P. (2006). Thirsty Work: Does Queensland's urban explosion mean a water grab from farmers? ***OUT****BACK*, 49:Oct-Nov., 44-47.

Sustainable Consumption Roundtable. (2005). *Seeing the Light: the impact of micro-generation on the way we use energy*, by Hub Research Consultants, London, England.

Utility PhotoVoltaic Group. (1999). *Schools Going Solar: Volume 2. A Guide to Schools Enjoying Solar Energy*. Bob Gibson (Editor), USA.

World Wildlife Fund. (2006). *Living Planet Report.* World Wide Fund for Nature, Gland. Switzerland. Retrieved from assets.panda.org/downloads/living_planet_report.pdf

World Wildlife Fund Australia. (2003). Australia's Polluting Power: Coal-fired electricity and its impact on global warming, by M. Diesendorf, Sydney, NSW, Australia.

Wright, J. (2000). *Current Energy Technologies – Coping with Change*. Australia Academy of Science 2000 Annual General Meeting and Symposium, Canberra, May 2-5. Retrieved from http://www.science.org.au/future/wright.htm