Sustainable Campus Project: Potential for energy conservation and carbon reduction education in Taiwan

Shun-Mei Wang*
Graduate Institute of Environmental Education
National Taiwan Normal University, Taiwan
No. 88, Ting-Chou Rd. Sec. 4, Taipei 116, Taiwan (R.O.C.)
Phone: +886-2-77346554
Fax:+886-2-29336947
E-mail: t73004@gmail.com

Chien-Kuo Ku
Department of Applied Physics and Chemistry Department,
Taipei Municipal University of Education
No.1, Ai-kuo West Rd. Taipei, Taiwan (R.O.C.)
Phone: +886-2-23113040
E-mail: kuo@tmue.edu.tw

Chun-Yu Chu
Xi Men Elementary School, Taiwan
No. 98, Chen-Du Rd, Taipei, Republic of China (R.O.C.)
Phone: +886-2-23892182
E-mail: ynna@tp.edu.tw

*** Corresponding Author**

ACKNOWLEDGEMENTS

This research was supported by the National Science Council (NSC 99-3113-S-003).

Biographical Notes

Shun-Mei Wang is an Assistant Professor of Graduate Institute of Environmental Education, National Taiwan Normal University. She received her Ph.D. degree in the School of Natural Resources and Environment, University of Michigan, USA in 1993. Her research interests include Green School Project, energy and climate change education, animal and human interaction education and environmental literacy. She is commitment to the practice of Environmental Education Act in Taiwan.

Chien-Kuo Ku is a chairman of Applied Physics and Chemistry Department, Taipei Municipal University of Education. He received his Ph.D. in Chemistry Program, National Taiwan University in 2001. His field of study includes organic chemistry, solvent free reaction and photo chemistry. He is now a consultant in counseling Taiwan's elementary schools, focusing on environment and energy education.

Chun-Yu Chu is now a nature teacher at Xi Men Elementary School. He holds a M. Sc. in Natural Science Department, Taipei Municipal University of Education. Through the research on school facilities, he offers other alternatives in energy education.

Sustainable Campus Project: Potential for energy conservation and carbon reduction education in Taiwan

ABSTRACT

The reality of global warming, climate change and energy shortages has put all circles to the task of actively promoting education in energy conservation and carbon reduction. From 2004, the Ministry of Education has been promoting the Sustainable Campus Project, partially subsidizing hundreds of schools to implement hardware improvements and carry out related environmental education. This study explores whether the teachers and administrators of these schools are aware of Sustainable Campus Project facilities in their schools, whether they used the items, and whether they understand how these facilities work to conserve energy and reduce carbon emissions. Our study concludes with suggestions on how to use existing Sustainable Campus Project facilities to carry out energy conservation and carbon reduction education effectively.

*Keywords***:** Energy Conservation; Carbon Reduction; Sustainable Campus Project; Education; Facility

Sustainable Campus Project: Potential for energy conservation and carbon reduction education in Taiwan

Shun-Mei Wang, National Taiwan Normal University, Taiwan
Chien-Kuo Ku, Taipei Municipal University of Education, Taiwan
Jun-You Zhu, Taipei Simen Primary School, Taiwan

INTRODUCTION

The multifaceted effects global warming and climate change have caught the attention of all nations and have prompted international meetings to discuss conventions and set timelines to reduce carbon emissions. Starting as early as 1980, many countries have been establishing government departments, organizations, policies and plans on energy conservation and carbon reduction to promote energy education and build literacy in "energy conservation and carbon reduction" (Wang, & Huang, 2011). Taiwan is also actively promoting comprehensive plans for energy conservation and carbon reduction.

The Ministry of Education has been steering the Sustainable Campus Project for several years. Hardware improvements have been implemented in various themes including resource recycling and reuse, rainwater harvesting and use, natural purification and cycling of water, renewable energy (wind, solar, etc.), energy conservation measures, and water conservation technology. These themes directly or indirectly benefit energy conservation and carbon reduction goals. The purpose of this study is to explore school staff and teachers' cognition and use of these facilities to serve as a foundation for further research into how such facilities can assist education in energy conservation and carbon reduction.

LITERATURE REVIEW

Global warming and climate change have multiple impacts on the landscape, ecology, water resources, coastal areas, human health and economy. Climate change is typified by unpredictable fluctuations due to a myriad of complex factors, making it crucial for us to not only understand the causes of global warming and climate change, but even more importantly to educate people about how to adapt to climate change and take action to conserve energy and reduce carbon emissions.

What is Taiwan's role in global warming? Taiwan produces almost none of its

own energy, and over half of all energy consumption is in the form of electricity (Yeh, 2010). Taiwan's energy structure is thus responsible for relatively large amounts of greenhouse gas emissions.

Average per capita CO_2 emissions has increased from 1990 to 2007. According to IEA/OECD statistics on energy related CO_2 emissions published in September 2010, Taiwan's energy related CO_2 emissions reached 264.29 million tonnes in 2008, accounting for 0.9% of global emissions and ranking Taiwan 22nd in the world. On a per capita basis, Taiwan's CO_2 emissions are higher than Japan, Korea and the OECD average of 11.53 tonnes, just between Oman and Russia (Environmental Protection Administration Executive Yuan, R.O.C, 2011). Taiwan is a high-carbon society and is responsible for taking countermeasures.

Energy conservation and carbon reduction are new concepts in policy administration and are highlighted in the national Energy Conservation and Carbon Reduction Plan, which integrates different agencies and sets national conservation and reduction targets. Comprehensive planning is needed to promote low-carbon economic development and make the transformation to a society that conserves energy and reduces its carbon footprint (Executive Yuan, 2011). Policies have been set for each agency according to their role, function and area of specialization.

The Ministry of Education's focal goal in the Energy Conservation and Carbon Reduction Plan is to establish a network of Sustainable Campuses as well as an evaluation system for education in energy conservation and carbon reduction. Since 1999 the Ministry of Education has promoted the Green School Partnership Project (Wang, 2009) and the Sustainable Campus Project. The Sustainable Campus Project has focused on green buildings and ecological improvements using environmental technology, so as to create campus environments that are sustainable, ecological, environmental, health, energy efficient, and resource efficient (Jiang, 2009). The idea is to create examples of campus sustainability that can serve as models for promoting related policy. The Bureau of Energy and the Water Resources Agency have also developed related plans to assist with the purchase of renewable energy technology, energy-saving lamps or water-saving technology (Ministry of Education, R.O.C., 2011). As a great investment has been made toward hardware, it is hoped that these energy and resource conservation facilities serve to provide both education and practical models that help people understand and experience how important and feasible it is to conserve energy. It is worth asking by what mechanisms these plans intend to achieve energy conservation and carbon reduction.

School electricity fees are often very high and have become a heavy burden for some schools (Huang, 2009). How to reduce electricity use is a pressing issue for many schools in Taiwan. Some school teachers and staff are addressing electricity

usage on campus, which is mainly in the form of electric equipment, lighting, and air conditioning. Building design to suit the climate and environment, increased air circulation, and shading can be employed to maintain a comfortable environment without increasing energy consumption. According to the Sustainable Campus Project guidelines (Jiang, 2009), the theme of energy flow includes building design to conserve energy, air circulation to conserve energy, and new forms of cleaner energy such as photovoltaic, thermal energy and wind turbines.

Water conservation is another way to cycle resources and thus indirectly affects energy conservation. Considerable energy is saved by reducing the need to treat and transport drinking water and other water. The main uses of water on campuses are for flushing toilets, cleaning and irrigation. The main water equipment are hydrants and toilets. A considerable amount of water can be conserved if water-saving equipment is used exclusively. Rainwater is a clean source of water, and saving and using rainwater is a very effective way of conserving water on campus. Water conservation is not limited to water-saving equipment or installations, but also can be achieved through landscaping that uses plants with low water requirements and permeable pavements, both of which can benefit the ecological environment while also reducing irrigation needs.

These and many other improvement measures aim to make use of campus infrastructure and integrate school curriculum to provide students with daily opportunities for learning within their living environment. Interaction with the environment and real experiences that encourage living with a smaller ecological footprint can establish new core values and perspectives on life. This can in turn add momentum to continuing societal improvements and may provide individuals with a fundamental capacity to make changes later in life. How did school teachers and staff use the facilities and understand the facilities' functions in saving energy and reducing carbon emissions?

RESEARCH METHODS

The main method employed in this study was a written survey. Intentional sampling was conducted to fit the theme of this research, selecting two schools from each of Taiwan's northern, central, and southern regions that have been awarded for outstanding performance in the Sustainable Campus Project or in energy education, for a total of six schools. Surveys were designed to find the degree to which administrative staff and teachers are cognizant of energy conservation and carbon reduction hardware in their school. After verifying the functionality of facilities, the survey listed 14 kinds of equipment or products associated with energy and resource

conservation. Teachers and staff were asked three questions: 1) Does your school have any of these facilities or products? 2) Do you incorporate these facilities or products into your lessons? 3) Are these facilities or products functional in terms of "energy conservation" and "carbon reduction"? Multiple choice questions were further employed, mainly to check staff and teachers' cognition of Sustainable Campus Project facilities. Cronbach's alpha reliability coefficient for these four dimensions were 0.769, 0.833, 0.860 and 0.876, respectively. Out of 160 surveys, 143 completed surveys were received, for a return rate of 89.38%. Surveys were sent out and returned by mail. Eight of the surveys were invalid and not used, bringing the number of effective surveys down to 135, for a response rate of 94.41%. The interviewees' backgrounds are listed in table 1.

Table 1. Background information of interviewees

Background	character	Number	Percentage
Gender	male	39	28.89
	female	96	71.11
Role in school	Teacher and administrator	23	17.04
	Class teacher	90	66.67
	Science teacher	14	10.36
	Non-science teacher	8	5.93
Degree of education	Graduate degree	36	26.67
	Normal university or college	63	46.66
	Non-normal university	36	26.67
Teaching experience	<10 years	55	40.74
	10~20 years	59	43.70
	>20years	21	15.56
Area of expertise	Non-science	106	78.52
	Science	29	21.48

Descriptive statistics were employed to show the percentage of teachers and staff who identified their schools as having such facilities, have used these facilities before, and recognized energy saving and carbon reduction functions for each facility. The authors used independent sample t-tests to compare whether there was a difference in terms of cognition of sustainable facilities' functions between two groups of teachers and staff: those who thought they had such facilities and those who did not think they had such facilities.

RESULTS

The survey asked teachers and staff of schools that received Sustainable Campus Project grants to indicate their cognition of 14 kinds of facilities or products via check-boxes, including whether they have such facilities and whether such facilities work towards conserving energy and reducing carbon emissions. Results are as follows:

Teachers and staff aware of sustainable facilities in their school and the status of their use in teaching

Table 2 shows surveyed staff and teachers' understanding of whether their schools have received a Sustainable Campus Project grant. It was found that for each kind of facility there were different percentages of staff and teachers who checked that their school had such facilities. The highest percentage of staff and teachers (94.1%) thought that their schools had installed photovoltaic panels. The next highest percentages went to staff and teachers who thought their schools installed water-saving faucets (90.4%) and electricity-saving lamps (74.1%). These three items have all been part of subsidy programs by the Ministry of Education, the Bureau of Energy and the Water Resources Agency in the past. The lowest percentages went to staff and teachers who checked insulated windows (8.1%) and variable-frequency air conditioners (9.6%). Very few staff and teachers thought their schools had such equipment.

Teachers and staff are expected to use these facilities to fulfill the goals of government sponsored education projects. The highest percentages (of interviewee) went to environmentally friendly dining utensils (76.3%) and vegetated borders (75.6%), both of which have been promoted by many schools several years before the Sustainable Campus Project, as washable eating utensils are seen as an important part of encouraging simpler lifestyles. As for facilities more directly related to the Sustainable Campus Project, the highest percentage of teachers checked water-saving faucets (75.6%) and electricity-saving lamps (65.9%). Over 60% of teachers used photovoltaic panels in teaching about renewable energy. This study found corresponding results in terms of the ranking of people who checked each kind of facility and the ranking of people who use those facilities, excluding environmentally friendly dining utensils and photovoltaic panels. Results showed consistency between teachers' cognition and behavior. The more commonly mentioned environmentally friendly facilities were more commonly incorporated into lessons.

Table 2. Percentage of teachers and staff who checked that their school has a certain sustainable facility and percentage of teachers and staff who incorporate these facilities into lessons

Facilities	Percentage of respondents who said their school has this facility (ranking)	Percentage of respondents who incorporate this facility in lessons (ranking)
Photovoltaic panels	94.1(1)	61.9(5)
Wind turbines	29.6(11)	41.5(10)
Electricity-saving lamps	74.1 (3)	65.9(4)
Variable-frequency air conditioners	9.6(13)	19.3(13)
Shading devices	28.9(12)	29.6(11)
Insulated windows	8.1(14)	25.9(12)
Water-saving faucets	90.4 (2)	75.6(2)
Water-saving toilets or urinals	45.2(9)	44.4(8)
Rainwater catchment system	62.2(6)	55.6(6)
Environmentally friendly (washable) dining utensils	67.4(5)	76.3(1)
Permeable pavement	56.3(7)	43.7(9)
Vegetated borders	49.6(8)	75.6(2)
Books on energy conservation and carbon reduction	69.6 (4)	45.9(7)

Staff and teachers' identification of Sustainable Campus Project facilities as "conserving energy" and "reducing carbon emissions"

This research has divided 14 kinds of facilities or products into 4 categories of energy-related facilities as follows: alternative energy, energy conservation (appliances and buildings), resource conservation, and ecological processes (Table 3). We then analyzed whether teachers and staff think these facilities or products work to conserve energy or reduce carbon emissions, as this understanding may influence their lesson content when using these facilities in teaching.

A. Staff and teachers who think that Sustainable Campus Project facilities or products work to conserve energy

According to research results shown in Table 3, many respondents thought photovoltaic panels and wind turbines work to conserve energy. This was especially true with photovoltaic panels, as 94.8% of teachers and staff thought this technology works to conserve energy.

As for the next highest percentages, over 90% of respondents identified that energy-saving lamps and energy conserving installations conserve energy, but a lower percentage of respondents identified that variable-frequency air conditioners conserve energy, possibly showing a lack of understanding about how this technology works.

The third category of technologies is shading devices and insulating windows. Approximately 70% of respondents thought that these technologies conserve energy.

The fourth category concerns the conservation of resources. While water-saving faucets, water-saving toilets and urinals, and rainwater harvesting systems were seen as technologies that save water or increase usable water resources, more teachers and staff thought that water-saving faucets also work to conserve energy. Environmentally-friendly dining utensils reduce the use of disposable utensils and thus indirectly save energy, however only 70% of teachers and staff identified this, a lower percentage than those who identified that other water-saving installations save energy.

B. Staff and teachers who think that Sustainable Campus Project facilities or products work to reduce carbon emissions

Columns 3 and 4 in Table 3 show lower percentages of respondents who identify that facilities work to reduce carbon emissions compared to those who identify that facilities work to conserve energy. The difference between these two percentages ranged from 10% to 50% in all items except wind turbines, vegetated borders, and books on energy conservation and carbon reduction.

The items that most staff and teachers thought work to reduce carbon emissions were in the “alternative energy” category, which included “photovoltaic panels,” and “wind turbines.” Fewer staff and teachers thought wind turbines work to reduce carbon emissions than teachers who thought photovoltaic panels work to reduce carbon emissions. However, the percentages of those who thought wind turbines reduce carbon emissions and conserve energy were about the same.

Obviously different percentages of respondents identified three main categories of “energy-saving” electric appliances, building design, and water-saving technologies as working to reduce carbon emissions. However there was little discrepancy between specific items in each category. For example about 70% of respondents identified that some electric appliances work to reduce carbon emissions, while about 50% identified that some “energy conserving” building designs work to reduce carbon emissions, the

highest of which was insulating windows at 59.81%. Of water-saving items under the "resource conserving" category, only about 40% of respondents identified that these items work to reduce carbon emissions, fewer than those who thought electric appliances work to reduce carbon emissions.

Vegetated borders and permeable pavement in the second column of Table 2 have a greater relationship to the local ecological environment than other items on the list. About 70% thought that vegetated borders work to reduce carbon emissions, while only 35.5% thought that permeable pavement works to reduce carbon emissions.

Table 3. Percentages of respondents who identified that Sustainable Campus Project facilities conserve energy or reduce carbon emissions

Category	Facilities	A: Percentage of respondents identifying item works to conserve energy (ranking)	B: Percentage of respondents identifying item works to reduce carbon emissions (ranking)	A-B (%)
Alternative energy	Photovoltaic panels	94.81(3)	83.18(1)	11.63
	Wind turbines	76.30(9)	75.70(3)	0.60
Energy conservation (Electric appliances)	Electricity-saving lamps	97.04(1)	77.57(2)	19.47
	Electricity-saving installations	91.85(4)	72.90(4)	18.95
	Variable-frequency air con	79.26()7	69.16(6)	10.10
(Building design)	Shading devices	78.52(8)	52.34(9)	26.18
	Insulated windows	74.81(10)	59.81(8)	15.0
Resource conserving	Water-saving faucets	96.30(2)	42.99(11)	53.31
	Water-saving toilets or urinals	86.67(5)	42.99(11)	43.68
	Rainwater catchment system	81.48(6)	42.99(11)	38.49
	Environmentally friendly (washable) dining utensils	70.37(12)	64.49(7)	5.88
Ecological processes	Permeable pavement	56.30(13)	35.51(14)	20.79
CO_2 absorption	Vegetated borders	71.11(11)	71.96(5)	-0.85
Knowledge	Books on energy conservation and carbon reduction	48.15(14)	48.60(10)	-0.45

Difference between staff and teachers' cognition of whether there are sustainable facilities in their school and their identification of those facilities as conserving energy or reducing carbon emissions

This study found that staff and teachers' awareness of their school having sustainable facilities has an influence on their cognition of whether those facilities work to conserve energy or reduce carbon emissions. Columns 3 and 4 in Table 4 show that more staff and teachers identify the following items as working to conserve energy, reaching $p<0.05$ on significance tests: wind turbines, electricity-saving installations, variable-frequency air conditioners, shading devices, insulated windows, water-saving toilets, rainwater harvesting systems, washable dining utensils, and environmental books. As for staff and teacher identification of facilities that reduce carbon emissions, we looked at two groups: one group said their school had such facilities and one group said they did not. There was a more obvious difference between these two groups in terms of whether they thought such facilities work to reduce carbon emissions, reaching the significance level. The only two items in which there was no significant difference between these two groups of teachers were electricity-saving installations and water-saving toilets.

Table 4. Difference between staff and teachers cognizant of their school's having such a facility and their cognition of the facility's ability to conserve energy or reduce carbon

Facilities	Staff and teachers cognizant of facility（N）	F-value of discrepancy between cognition of facility and cognition of the facility's ability to conserve energy	F-value of discrepancy between cognition of facility and cognition of the facility's ability to reduce carbon
Photovoltaic panels	127	2.07	7.01**
Wind turbines	40	60.25***	52.33***
Electricity-saving lamps	100	.042	7.83**
Electricity-saving installations	57	4.58*	1.56
Variable-frequency air conditioners	13	8.92**	6.17*
Shading devices	39	66.31***	11.82***

Insulated windows	11	11.55***	17.70***
Water-saving faucets	122	2.87	80.16***
Water-saving toilets or urinals	61	96.95***	2.28
Rainwater catchment system	84	52.06***	5.57*
Environmentally friendly (washable) dining utensils	91	27.58***	4.35*
Permeable pavement	76	3.44	37.64***
Vegetated borders	67	4.57*	19.43***
Books on energy conservation and carbon reduction	94	9.80**	37.71***

* : <.05, ** : <.01, ** : <.001

DISCUSSION AND RECOMMENDATIONS

Favorable impressions of common facilities or products

Our survey results generally showed staff and teachers are less familiar with carbon reduction concepts and in nearly all items the percentage of teachers identifying facilities as working to conserve energy was higher than the percentage of staff and teachers identifying facilities as working to reduce carbon emissions (Table 3). This may be due to previous promotion of energy projects, for example the Sustainable Campus Project (Jiang, 2009) rarely directs attention to global warming and climate change. The author once interviewed several staff and teachers from schools that have received Sustainable Campus Project grants, and discovered that these schools' staff teachers were unable to correlate how their facilities work to reduce carbon emissions.

This research found interviewees had a favorable impression of alternative energy, with a high proportion of teachers identifying photovoltaic panels and wind turbines as contributing to energy conservation and carbon reduction. It is possible that these staff and teachers equate the use of alternative energy with energy conservation and carbon reduction behaviors, while in actuality alternative energy is not directly related to energy conservation and carbon reduction. The utilization of alternative materials and methods to generate electricity does not require conservative behavior.

It is easy for some people to confuse CO_2 with air and wind due to their physical

state as invisible gases. For example, some respondents thought that wind turbines and variable-frequency air conditioners directly reduce CO_2 from the atmosphere (Table 3). In actuality, these items are only capable of circulating indoor air and making use of air flow to generate electricity.

Results showed that the more teachers and staff are aware that their schools have sustainable facilities, the more likely they are to incorporate these facilities into their lessons (Table 2). Staff and teachers' attitudes are different toward products or facilities they are familiar with in everyday life compared to items they are less familiar with. As for the item "environmentally friendly dining utensils" (Table 3), 20% more respondents checked that this item works to reduce carbon emissions compared to those who checked that this item works to save water.

Table 4 shows that a higher proportion of those who checked that their school has a certain sustainable facility identified that facility as working to conserve energy or reduce carbon emissions.

The previous conclusions show that for items such as "environmentally friendly dining utensils," "photovoltaic panels," and "wind turbines," which have been regularly promoted and people are knowledgeable about or have operated, touched or frequently see or hear, more people think such items work to protect the environment and use these items more often than the other surveyed items. It is probable that the promotion process raises ones awareness of a facility or product and may impart a favorable impression about a certain environmental facility or product.

Comparison with other research

Climate change can have a large impact on human society and ecosystems. Many nations have set deadlines for making greenhouse gas reductions, which require appropriate response actions. Energy conservation is commonly listed as the main method of response. Yet while some citizens in the UK purchase energy-saving lamps or choose to own fewer vehicles, surveys show a continual rise in energy consumption year after year due to lack of participation by the general public at large (Whitmarsh, 2009). Other European countries may be facing the same situation in not being able to reach expected reduction targets (European Environment Agency, 2006). Whitmarsh's (2009) studies on climate change response actions found that although decision makers hope to respond to climate change through energy conservation, the general public regards recycling as the main way to care for the environment and reduce the effects of climate change. Steg, Groot, Dreijerink, Abrahamse, & Siero (2011) found in two studies several antecedents that affect intentions and policy acceptance; one antecedent that has the most evident positive effect is ecological values. Our study, however, focuses on the Ministry of Education's Sustainable Campus Project, an

education policy that provides assistance for making improvements to campus hardware. This is different than the abovementioned studies, which target the general public and simply focus on understanding behavioral changes. Taiwan's government has taken a more proactive approach in hoping to develop ecological values through installation of physical structures. The conclusions from our survey of staff and teachers' cognition and educational usage of sustainable campus facilities suggest that more effort should be placed on strengthening staff and teachers' understanding of structural improvements. Further training can be provided on how to teach energy conservation and low-carbon concepts. Training can focus on critical thinking and understanding of short and long term effects and general or specific influences of technology on the environment.

Energy conservation and carbon reduction functions of Sustainable Campus Project facilities

The 14 kinds of facilities or products examined in this research are divided into 4 categories of alternative energy, replacement of electric equipment, improvement of building design, and reduction of the use of resources. Each item uses different mechanisms to conserve energy or reduce carbon emissions. Photovoltaic panels and wind turbines are categorized as alternative energy and mainly work to reduce dependency on imported fossil fuels. Installation of these two technologies does not assist the user to conserve energy, but rather use an alternative energy source other than fossil fuels. This may indirectly reduce the use of electricity generated from the combustion of fossil fuels.

As for the other three categories, the replacement of electric equipment directly increases energy efficiency by reducing the use of electricity, thereby achieving energy conservation. This study mentions three technologies in this category: electricity-saving lamps, electricity-saving installations, and variable-frequency air conditioners. The use of these technologies entails the replacement of traditional technologies to effectively reduce the amount of electricity used. The installation of shading devices and insulated windows indirectly reduces the use of electricity by improving hardware so that summer sunlight does not directly shine indoors, possibly making the interior more comfortable, reducing the use of air conditioning, and thus indirectly reducing the use of electricity. Reduction of the use of resources includes facilities or actions related to the Sustainable Campus Project's focus on resource flow. This category does not consider energy flow, but does reduce the use of electricity as conservation of resources indirectly reduces the production of materials. There are three items in this category concerning water-saving installations: water-saving faucets, water-saving toilets or urinals, and rainwater harvesting systems, all of which

conserve water resources.

Energy conservation can effectively reduce CO_2 emissions. Each kilowatt-hour of electricity saved can reduce as much as 0.63 kilograms of CO_2 emissions. There is potential to reduce carbon emissions by using renewable energy as an alternative to burning fossil fuels. Energy-saving electric appliances reduce carbon emissions by way of saving electricity. Improving building design through shading devices or insulated windows indirectly influences the use of air conditioning and may reduce the use of electricity, thereby also reducing carbon emissions. Water-saving devices under the category of "resource-conserving" technologies work to save electricity required to produce or transport water for consumption, thereby reducing the generation of CO_2.

Compared to environmentally friendly dining utensils, vegetated borders and permeable pavement are more closely related to ecological processes of the local environment. Vegetated borders reduce CO_2 in the air and increase local O_2 amounts through photosynthesis where there is sunlight. There is a fundamental difference between this item and others on the list, which all actually increase CO_2 through manufacture of materials. Thus vegetated borders have a direct positive effect. Permeable pavement helps maintain hydrated soil conditions, which can moderate local climates and benefit plant growth. This indirectly reduces the need for air conditioning and thus reduces CO_2 emissions. Finally, environmentally friendly dining utensils not only reduce the use of disposable bowls and chopsticks, but also reduce the electricity required to produce disposable dishware and reduce the amount of CO_2 produced through garbage incineration. Thus keeping a set of environmentally friendly dining utensils on one's person at all times is a behavior that can help reduce carbon emissions.

The need for critical thinking and whole-systems thinking about energy conservation and carbon reduction strategies

The above points show that energy conservation and carbon reduction concepts are behind the scenes in each Sustainable Campus Project facility or product and we must clarify why certain behaviors or improved facilities are appropriate. It is necessary to create models for each situation and engage in comparison and discussion to encourage critical thinking and whole-systems thinking. For example what are the raw materials of each facility or product? How much energy is used in their production and transport, and can the materials be reused? Education can be designed to cultivate citizens capable of evaluating and adopting appropriate actions to mitigate and adapt to climate change.

We recommend targeting Sustainable Campus Project teachers and staff to attend

energy conservation and carbon reduction related courses in the future so they have a comprehensive understanding of how energy conservation and carbon reduction response measures relate to climate change. It is necessary to strengthen their knowledge of energy conservation and carbon reduction actions, rather than accept a shallow understanding at the slogan level as we are reminded by Jensen and Schnack (1997) and Jickling (1991). We can conduct further research by observing teachers and staff after they undergo training in energy conservation and carbon reduction to see whether they use sustainable school facilities more frequently or design more comprehensive lessons.

REFERENCES

Environmental Protection Administration Executive Yuan, R.O.C (2011). *Transnational comparison of carbon emissions*. Retrieved from http://www.epa.gov.tw/ch/aioshow.aspx?busin=12379&path=12439&guid=d0df71ac-b986-47d6-87ae-da9c6696e788&lang=zh-tw.

European Environment Agency. (2006). *Greenhouse gas emission trends and projections in Europe 2006. EEA Report No 9/2006*. Denmark, Copenhagen: EEA.

Executive Yuan (2011). *Actions toward energy conservation and carbon reduction*. Retrieved from http://www.ey.gov.tw/policy/4/index.html.

Huang, Yu Jie (2009, December 11). No discount! School electricity fees. *CTS* [Online]. Retrieved from http://news.cts.com.tw/cts/life/200912/200912110361968.html.

Jensen, B., & Schnack, K. (1997). The action competence approach in environmental education. *Environmental Education Research, 3*(2),163-178.

Jiang, Z. M. (2009). Chapter 1: Introduction. In H. Z.Su (ed.), *Taiwan sustainable campus project guidelines*. Retrieved from http://www.esdtaiwan.edu.tw/upload/%7BEE832687-2AD7-4D05-B91D-83CC2D3508F8%7D/封面.pdf

Jickling, B. (1991). Environmental education and environmental advocacy: The need for a proper distinction. *Canadian Issues*, *13*, 169-175.

Ministry of Education, R.O.C (2011). *Sustainable schools*. Retrieved from http://www.esdtaiwan.edu.tw/index_c_context.asp?Display=NEWS&Pkey={D404E946-1E1D-4AF1-8E8D-23A76FE4A8B2}

Steg, L., Groot, J. I. M., Dreijerink, L., Abrahamse, M., & Siero, F. (2011). General antecedents of personal norm, policy acceptability, and intention: The role of values, worldviews and environmental concern. *Society and Natural Resources*, *24*, 349-367.

Wang, S. M. (2009). The green school project in Taiwan. In John Chi-Kin Lee &

Michael Williams (Eds.), *Schooling for sustainable development in Chinese communities: Experience with younger children* (pp. 213-231). Dordrecht, The Netherlands: Springer.

Wang, R. Z., & Huang, Y. C. (2011). *Promoting education and building literacy in "energy conservation and carbon reduction": International perspectives and case study*. Taiwan, Taipei: High Education Press.

Whitmarsh, L. (2009). Behavioural responses to climate change: Asymmetry of intentions and impacts. *Journal of Environmental Psychology, 29*, 13-23.

Yeh, S. C. (2010). *The key report for fighting global warming*. Taiwan, Taipei: Naturalist Press.