Summary
The ARC Photovoltaics Centre of Excellence incorporates the activities of the former Key Centre for Photovoltaic Engineering. The former Key Centre started in 1999, after the award of special funding from the Australian Government to promote teaching and research in the area of photovoltaics. A major initiative of this Key Centre was the establishment of the world's first undergraduate degree in Photovoltaics and Solar Energy. The Centre was one of only eight such Key Centres awarded Australia-wide across all disciplines, demonstrating the Government's understanding of the importance of the field of renewable energy. In 2003 the Key Centre and its activities were incorporated into this Centre of Excellence, awarded to the same team at the University of New South Wales. On 1 January 2006 UNSW officially formed a new School within the Faculty of Engineering, the School of Photovoltaic and Renewable Energy Engineering, which includes the ARC Photovoltaics Centre of Excellence.

The School offers undergraduate, postgraduate and research programs encompassing a range of aspects relating to the photovoltaic and other renewable energy industries. These programs have been developed in consultation with representatives from industry to ensure graduates are appropriately qualified to enter the field upon completion of their studies. The undergraduate programs have experienced continuing strong demand growth since 2007. Since 2003, the School has seen a total of 160 students graduate from its undergraduate programs, and 126 students from its postgraduate degrees. These graduates are now taking advantage of a range of opportunities being created in the booming photovoltaics and renewable energy industries.

The higher media profile of global warming, greenhouse and energy issues in the general Australian community is helping to raise the School's profile locally and the industry growth in Asia raised the School's profile internationally.

The granting of a large number of sponsorships was finalised in August 2007 for up to $5.2m support from the Australian Government for study at the School, as part on the Asia-Pacific Partnership on Clean Development and Climate. In 2010, these scholarships attracted 21 new undergraduate and 48 (29 in Semester 1 and 19 in Semester 2) new postgraduate coursework students to the School. The number of formal agreements with Chinese universities established as a result of the Partnership grew to seven during 2010.

At the end of 2010, there were 437 undergraduate students, 88 postgraduate coursework students and 63 research students (11 Masters by research and 52 PhD) enrolled in the School’s programs.

5. EDUCATION
5.1 UNDERGRADUATE EDUCATIONAL PROGRAMS

The School offers two undergraduate coursework engineering programs, each of which can be taken in combination with a Bachelor of Arts (5 years), Bachelor of Science (5 years), Bachelor of Commerce (5.5 years) or a Bachelor of Laws (6 years). These degrees aim to develop well-educated graduates with the basic skills, attributes and knowledge required to practise as professional engineers in the booming renewable energy industries.

The Photovoltaics and Solar Energy Engineering program draws on the long history of expertise of Centre staff in this field and was the first of its kind internationally. Two new programs were established in 2009 in China, at Nanchang University in Jianxi Province and at North China Electric Power University in Beijing. The UNSW program includes education in technology development, manufacturing, quality control, reliability, life cycle assessment, system design, maintenance and fault diagnosis, marketing, policy development, energy efficiency and other renewable energy technologies. It has two unique features: a group project in the second year of the program, and a ‘strand’, which is a minor area of specialisation. Since 2003, a total of 128 students have graduated from the program, 24 graduated in 2010 and another 34 are expected to graduate in March 2011 after completing their studies in 2010. At the end of 2010, a total of 310 students were enrolled.

The second, broader degree program, in Renewable Energy Engineering, was introduced in 2003. In addition to photovoltaic devices, students in this program study solar architectural technologies, wind energy, biomass, solar thermal and renewable energy policy as part of their core curriculum. At the end of 2009, a total of 127 students were enrolled. 2010 saw 15 new graduates of this program, bringing the total to 32, and 5 more are expected to graduate in March 2011. At the end of 2010, 24% of enrolled undergraduate students were women.

Graduates of these programs are gaining employment within a variety of organisations, including in the areas of energy efficiency and sustainable design. Each year a number of graduates start on a research program at the Centre, elsewhere at UNSW or at other institutions while others are employed in industry by solar cell and equipment manufacturers, system design and integration companies, electricity utilities, energy efficiency and environmental design companies and major end users of products.
5.1.1 The Strand
The strand is unique within UNSW to the Photovoltaics and Solar Energy Engineering program, and is essentially a minor area of specialisation which complements a student’s study of photovoltaics. Students can take strands covering a wide variety of areas including computing, electronics, mathematics, physics, mechanical engineering, civil engineering, and architecture. The aim of the strand is to provide students with broader engineering backgrounds important for the cross-disciplinary nature of photovoltaic applications.

In 2011 strands will be offered to Renewable Energy Engineering students as well. These will be less formally structured than in the Photovoltaic Engineering program and take the form of sets of electives associated with various renewable energy technologies.

5.1.2 Undergraduate Second-Year Student Group Projects
In the second year of the Photovoltaics and Solar Energy program, students undertake a year-long group project. The main emphasis of the second year group project course is hands-on project engineering. The course has a lecture component covering project engineering, report writing and presentation skills and each project has a research component, a planning and design component, a hands-on component and a presentation/reporting component. This course helps to prepare students for their fourth year thesis, which is undertaken by all students enrolled in both the Photovoltaics and Solar Energy and Renewable Energy Engineering undergraduate programs.

In 2010, second-year project groups worked on the following projects: silicon and cuprous oxide thin film solar cells, photoluminescence analysis of solar cells, solar thermal water heating, Sunswift solar race car, solar water pumping, solar lanterns, cookers and a “solar suitcase” for developing countries and ice air conditioning.

5.1.2.1 Developing Countries
The School has been involved with projects in the developing countries for the last eight years. The application of photovoltaics and other renewable energy technologies can make a great difference to people’s lives and living standards in these places. Students involved with this project in the past have installed and maintained photovoltaic lighting systems in rural locations in Nicaragua, Vanuatu and Nepal and photovoltaics powered water purification in Sri Lanka. Skills that the students had developed throughout the year were put to good use in the field as invaluable lessons were gained regarding project management of activities in developing countries. Students faced and overcame many technical and non-technical issues in project implementation. With the rapidly growing student population the School is no longer involved in directly supervising international journeys for groups of second year students but, instead, suggests interested students involve themselves in the UNSW Chapter of Engineers Without Borders.

Solar Lanterns Project
Energy is fundamental to alleviate poverty in health, education, communication, economic development and social equity. Electricity impacts the lifestyles and living conditions, primarily through electric lighting. However, approximately 1.5 billion people in developing countries have no access to electricity. The majority of these people use kerosene lamps for lighting. Kerosene lamps are expensive to run, have health impacts, are potentially dangerous and are a source of greenhouse gases.

Solar lanterns have potential to improve the living conditions of people in developing countries. It can provide much needed study hours for school children as well as support after-hour income generating activities. One study has found that solar lanterns have significantly benefited school-aged children in India. The extended study hours made possible with solar lanterns shown to have a very positive impact on their performance.
There are many solar lanterns available in the market. The performance of these lanterns varies widely making it difficult for consumers to select a product. In this project students have studies a range of solar lanterns commonly available in developing countries. Using a set of tools they compared performance of solar panel, ballast electronics, charging-discharging circuits, light output and efficiency.

**Solar Cookers Project**

Stand alone PV systems (PV/diesel/battery) supply power to many households in remote parts of the world. Remote households in Australia and in particular Aboriginal communities utilise such PV systems. Cooking is an energy load that needs a substantial amount of energy. In many instances designers for stand-alone PV systems advocate use of gas or microwave cookers for cooking. However, often gas bottles are a very expensive way to get energy for cooking.

Is it possible that as the price of PV falls that some form of electric cooking could be the best option? Is microwave cooking the most efficient technology?

To answer this question we asked students: What is the most efficient way to cook? This project explored low energy approaches to cooking and PV system design to supply the energy to power such systems. One approach investigated ‘slow cookers’. Typically they are cooking systems that utilise low energy but for long periods of time. Typically they are uninsulated, so at present not very efficient!

Students investigated various approaches to insulate their cooking devices and used PV panels to charge a battery and then use the energy to heat a pot of food. Energy flows (current and voltage) were monitored, as well as the temperature of the food. Students investigated, designed, built and monitored whether small PV systems are capable of supplying such cooking systems.

**5.1.2.2 Silicon Thin-Film Solar Processing Equipment Project**

This project aims to give students a broad experience in enhancing and maintaining a world-class thin-film solar cell research laboratory. This is achieved through a two-stage process. Firstly, students develop a fundamental understanding of equipment and systems within the Centre’s thin-film laboratory, including vacuum systems, gas delivery systems, leak testing equipment, and plasma processing machines. The second stage involves the students integrating what they have learnt, by applying it to a specific project in the thin-film laboratory.

In 2010, six second-year students undertook this project. A group of three students worked on upgrading a vacuum test chamber to redesign the vacuum control interface and build it. A second group of three students worked on halogen lamp vacuum annealing stage, with the aim of being able to anneal samples at up to 1000°C. This group successfully designed and built a halogen lamp assembly that was both functional and easy to maintain.

Both groups benefited greatly from the course as they learnt to integrate project management and engineering problem solving to successfully complete their projects.

**5.1.2.3 Cuprous Oxide Thin-Film Solar Cells Project**

Students this year revived a decades-old photovoltaics technology that was once the globally leading technology, before silicon came to the fore in the 1950s. The manufacturing process for cuprous oxide cells is relatively simple and students made and tested their own cells from scratch.

**5.1.2.4 Water Pumping Project**

A group of students was charged with the task of demonstrating the pumping of water with photovoltaic power from ground level to the
roof of the UNSW Electrical Engineering building. The students worked on realistic conceptual applications such as toilet flushing in the building with excess stormwater, water supply for a rural village or stock watering on a cattle station. For their demonstration project, they were required to provide nominal flow rate and storage to demonstrate the concept. The skills learnt are directly applicable to solar water pumping for a wide range of applications, including in rural villages around the world.

5.1.2.5 Solar Thermal Water Heating Project
In our daily life, we are using lots of hot water for different purposes, needing a considerable amount of electrical or other energy sources. In this project the students learned how to use solar thermal energy to heat cold water. In this project student studied the basic principle of solar heating system and designed a new water heating system. They have also learned what materials should be used in the systems and investigated the possibilities to improve the design for better conversion efficiency. They built their designed systems using their selected materials, as shown in the following figures. They tested their systems and collected and analysed data to find conversion efficiency, cost evaluation, etc.

5.1.2.6 UNSW Sunswift Project
Over the past year, second year SPREE students have helped to design and build several major components of the UNSW solar car, which placed first in the silicon class in the 2009 Global Green Challenge (GGC), the premier international solar car race. The result was the best result achieved by the team in its 14 year history.

Students were involved in two solar car related projects – design and construction of the photovoltaic array that powers the car, and construction of the lightweight composite components that reduce the weight, and hence the energy usage of the car.

Array
The solar array is essentially an off-grid solar system, with the added complications of very fragile modules, and the requirement that it must withstand the conditions of driving 3000km of dusty, bumpy road.

The students designed the module and array sizing to conform to the race regulations, and selected the appropriate cabling and bypass diodes. They also performed array calculations and simulations in order to calculate the optimum wiring scheme that allowed for maximum output power, the most efficient battery charging, and maximum robustness against shading.

Two types of cells were used for maximum efficiency, standard industrial cells, and UNSW-produced Topcell cells. The team characterised the Topcells, initially by open-circuit voltage measurements, and later by full IV sweeps. The cells were then encapsulated, with assistance from CSG Solar, and assembled into modules.

Finally, the array team and other Sunswift members assembled the array, mounting and soldering the fragile modules onto the solar car.

Composites
Carbon fibre composites are extremely strong, lightweight materials, which are currently used, e.g. in aeroplanes and wind farms, to increase the energy conversion efficiency of the systems.

The composites team had the substantial job of building the carbon fibre composite components for a car which was almost entirely carbon fibre. These included the top shell, which housed the solar array, the bottom shell, which formed the structural chassis to safely house the driver, and the structural components which held the braking, steering and suspension systems. The team also successfully constructed the first new carbon fibre wheels for the car in 8 years. The wheels are the most complicated composite part to construct, require a great deal more care and attention, and must be thoroughly tested. The new wheels were
manufactured extremely well, and performed beautifully over the 3000km of rough terrain.

The construction of all of the components took over six months, and was done at the Boeing Aerospace facilities in Bankstown. Boeing sponsored the team the carbon fibre and other materials, and the students learned how to work with composite materials from the experts.

The carbon work on the car by these students was easily some of the highest quality work in a field of 40 international solar cars, including semi professional teams, and also suffered no issues during the race.

5.1.3 Fourth Year Thesis

The thesis project is usually completed in the last two sessions of an engineering undergraduate student’s studies. Students may start their project in either semester. They undertake directed laboratory and/or other research work on an approved subject under guidance of the School’s academic staff, sometimes with industry participation or co-supervision. Typically, the thesis involves the design and construction of experimental apparatus together with practical tests. Each student is required to present a seminar in their first semester and submit a written report and present an Open Day poster in their second semester.

Some students finished and presented their projects at the end of Semester 1, 2010. The Photovoltaic and Solar Energy Thesis Poster Prize was won by Lei Zhang (Laser Doping Technique Investigation and Optimisation for High Efficiency Laser Doped Solar Cells Fabrication). The Renewable Energy Engineering Thesis Poster Prize was won by Nicholas Boerema (Renewable Energy Integration into the National Electricity Market). Other projects coming to completion at that time were concerned with wind energy and its grid integration, annealing effects on silicon thin film solar cells, determination of carrier diffusion length and saturation current density in silicon solar cells, laser doped emitters and back surface fields, metalization effects on the optical properties of nanostructure silicon, high efficiency dye sensitised solar cells, optimization of high temperature ITO, time of flight measurement setup, sustainable transport, building integrated PV system design and testing, evaluation of pv/diesel mini grid applications in the NT, solar power for a weeding robot, silicon quantum dots, design of a domestic solar water heating system, performance assessment and evaluation of the UNSW Quad building’s rooftop PV System, feasibility of electric cars in Sydney, management strategies for building sustainability, and deploying energy efficiency policy to offset cost of meeting MRET in the residential sector, energy efficiency in buildings & Greenstar.

The Poster Prize selection in November 2010, for students completing at end of Semester 2, resulted in a wins for Hua Fan for his poster about “Solar Electrolysis System for Remote Production of Disinfectant Solutions” (Photovoltaic and Solar Energy) and Kah Howe Chan for his poster on “Wind and other renewable energies at the UNSW Wellington property” (Renewable Energy Engineering). The other topics on which theses were completed included: study of carrier transport mechanism in organic semiconductor for different electrode metals for organic solar cells, laser doping of thin film silicon solar cells, wind energy forecasting, impact of electric vehicles on LV electrical network, optical fibre/nanowire hybrid structures for dye-sensitized solar cells, design of metamorphic tandem solar cells, the 46% efficient cell project: cell modelling & testing, comparison of properties of Si QD film treated by rapid thermal annealing and conventional furnace annealing, feasibility study of biogas/electric hybrid cars, benefits of NSW wind power for the NEM, electrical characterisation of Ge nanocrystals embedded in amorphous silica matrix, 46% efficient split spectrum cells, biogas production on a Wisconsin farm, Investigation of n/p-type doping of Ge Ncs in SiO2 towards tandem photovoltaic cells, optimisation of thermal annealing parameters on planarisation and electrical properties of thin-film poly-crystalline silicon solar cells on glass, home charging for electric vehicles, reduction in office
tenant energy, doping concentration effects on metal ohmic contact formation to silicon wafer, energy efficiency on UNSW campus, optical characterisation of silicon quantum dots in SiOx/ SiN4 for optical detection of defects, design and construction of PV solar electrolysis system for medical aid kit, zero energy buildings, fabrication and characterisation of Si QD nanostructures grown by PECVD, adapting direct etching method for texturing of silicon, design of light trapping structure for organic solar cells, low energy water pump systems, PV, pumping, micro-hydro or wind at UNSW’s Wellington property, passive PV cooling using stack effect, investigation of phosphorous doping of Si-QD materials by furnace diffusion, sustainable energy in Willoughby city council buildings, design of light trapping structure for organic solar cell, boron and phosphorus doping of silicon rich oxide layers by diffusion of dopants, solar water pump testing, design of high efficiency organic solar cells, investigation of emitter sheet resistance using photoluminescence imaging, aerosol jet etching for silicon solar cells, zero energy buildings, study of temperature and doping effects on silicon wet-etching, low contact area laser doping, inverters on unstable grids, on-demand street light, electric motorcycle, investigations into over-floating of laser-doped cells, energy selective contact formed by thermal oxidation, growth of Si QD at low temperature, determination of carrier diffusion length and saturation current density in silicon solar cells (I and II generation solar cells), zero energy building for China, optics of the heliostat field and how this impacts uniformity at the receiver, novel approach to plating for low cost solar cells, size controlled growth of Ge QD in SiOx, solar access shading survey of UNSW Kensington campus, optimisation of rear localised surface plasmon enhanced light trapping in polycrystalline silicon thin-film solar cells, hybrid bulk heterojunction solar cells, carrier transport mechanism in organic semiconductor for different electrode metals for organic solar cells, aerosol jet etching for silicon solar cells, PV partial shading and minimisation of its impact, novel techniques for low cost high efficiency solar cells, temperature and doping effects on silicon wet etching, innovative rear point contact scheme for silicon solar cells, PV and RE at Wellington campus, efficiency prediction on advanced photovoltaic converter concepts, modelling of recombination activities in polycrystalline silicon thin film solar cells, properties of Sb-doped polycrystalline germanium thin film by a magnetron sputtering method, and boron doping of Si-QD materials by diffusion.

The $500 Photovoltaics Thesis Prize for 2010 was won by Xiang Zhao and Eleanor Wood was awarded the Renewable Energy Thesis Prize. These prizes are awarded for the highest marks in the final year thesis subjects.

5.1.4 Dean’s Awards
Each year the Dean of Engineering presents awards for outstanding students in each non-final year of study for each Engineering School. Prizes awarded during 2010 for academic performance in the previous year went to Dongchen Lan (stage 1), Benjamin Hughes (stage 1), John Durrant (stage 2), Vincent Allen (stage 2), Xue Bai (stage 3), Dong Lin (stage 3), Yu Feng (stage 3) and Shen-Long Ooi (stage 4).

5.1.5 N&M Radiant Design Prize
The N&M prize is awarded to one student group undertaking the School’s project in the first-year Faculty of Engineering course, ENGG1000, Engineering Design. The project is to design, build and demonstrate a solar powered “space elevator” to climb a suspended tether in the final weeks of the semester. The Prize is awarded to the fastest team. The winners in 2010 were “Captain Planet”, team members being Mingyang Jiang, Daniel Moctezuma-Baker, Syed Syed Ihsan, Edric Verbeek-Martin, Jack Wong and Heng Wu.

N&M Suntastic Project Prize
This prize, donated by the same sponsors as the N&M Prize, was offered again in 2010. It recognises best performance in SOLA2052 second year project course. It was won by Jarred Rudman.

Photovoltaics Prize
This prize honours best performance in SOLA3540, Applied Photovoltaics, and was awarded in 2010 to Yan, Xia and Yang, Chuaxni.

Steve Robinson Memorial Prize
This prize is in memory of a former PhD student, Steve Robinson, and recognises the best postgraduate performance in SOLA9002, Solar Cells and Systems. It was awarded in 2010 to Pei-Chieh Hsiao.

5.1.6 Engineers Australia Student of the Year (Sydney Division)
SPREE student Chris McGrath, won the Student Engineer of the Year Award at the Sydney Division’s Engineering Excellence Awards in September 2010. Chris finished his studies in 2009 with First Class Honours with a thesis on designing and installing a nano- hydro electric power system for the regional primary school in a remote village in Vanuatu. He continues to support this work with a 2010 UNSW final year undergraduate student and to promote further sustainable energy development projects in Vanuatu.

5.1.7 University Medals
Three students from the School are to be awarded the University Medal when they graduate in early 2011 following completion of their studies in the School’s programs in 2010. The students are Xue Bai and Yu Feng (Photovoltaics and Solar Energy) and Eleanor Wood (Renewable Energy).
5.2 POSTGRADUATE PROGRAMS

The School offers three postgraduate coursework programs, a Graduate Certificate of Engineering Science, a Graduate Diploma of Engineering Science and a Master of Engineering Science, and two research programs, Masters by Research and a Doctor of Philosophy. These degrees are intended to provide students with an exceptional education in advanced concepts and research in the photovoltaics or other renewable energy areas.

The 1.5-year Master of Engineering Science coursework program was developed to build on the prior education of engineers from other engineering disciplines who are attracted to the photovoltaics and renewable energy industries. Students study courses chosen from the areas of photovoltaic devices, photovoltaic systems and applications, energy efficiency and renewable energy technologies. Enrolments in the program have grown significantly from the previous small numbers, with total enrolments of 89 at the end of 2010. There were 37 graduates in 2010 and 21 more are expected in early 2011.

At the end of 2010, the School had 63 students enrolled in postgraduate research degrees, 52 in a Doctor of Philosophy and 11 in Masters by Research. Research topics available to these students cover the entire photovoltaic sector and building energy efficiency, but with greatest emphasis on device theory, design and production, module design, balance of system components, and photovoltaic systems and applications. Research students play a pivotal role throughout all the Centre’s activities. In 2010 the Centre produced six PhDs, and two new PhD and one Masters by research are expected to graduate in early 2011.

All the Faculty’s postgraduate coursework programs include an emphasis on engineering management and all students will be required to take some faculty-based “Engineering and Technical Management” courses of general importance. The School introduced its Managing Energy Efficiency (GSOE9017) course into this set of generally available courses in 2010 and it proved to be very popular.

5.3 SCHOLARSHIPS

The undergraduate programs at the Centre attract very bright students from across the world. The UAI cut off for local students for these programs was lifted to 91.7 for the 2010 intake. The Co-Op Scholarship Program and the Faculty of Engineering’s Rural Scholarship Program have helped to attract these high-achieving students, while the Taste of Research Summer Scholarship Program and occasional casual employment opportunities provide experience in the School’s laboratories with research leaders and encourage them to pursue research careers. The Centre’s very high international profile also allows it to attract high quality research students, evidenced by the number doctoral students undertaking research programs at the Centre who have been awarded either of an APA (local students) or IPRS (international students) scholarships.

5.3.1 Asia-Pacific Partnership on Clean Development and Climate

The School applied during 2006 for sponsorship funding from the Australian Government under the Asia-Pacific Partnership on Clean Development and Climate (APP) programme to bring students from the Asia-Pacific region, specifically China, India and South Korea, to study photovoltaics engineering at UNSW. In January 2007, APP Programme investment of $5.2m was approved by the APP Ministers and the first students were able to come in 2008. This significant grant supports study at UNSW by international PhD students (full fees), MEngSc coursework students (50% fees), and third and fourth year undergraduate students (100% fees). The undergraduate arrangement of shared education requires detailed agreements between UNSW and the selected source universities, which are restricted to China. These scholarships will address a key need for additional expertise and knowledge in the rapid expansion of the photovoltaics industry in the region and their award acknowledges UNSW’s importance in the field.

In Semester 1 of 2008, these scholarships attracted five undergraduate, one postgraduate coursework and three PhD research students to the School. In Semester 2 of 2008, these scholarships brought in a further eight undergraduate, eleven postgraduate coursework and two PhD research students. Enrolments for 2009 were much stronger and the APP students comprised a significant proportion of the year’s intake. Twenty-one undergraduate and forty-eight MEngSc APP students commenced their study in 2010.

Agreements, known as “2+2” agreements, have been signed with seven leading Chinese universities: Sun-Yat-Sen University and South China University of Science and Technology in Guangzhou; Nankai University and Tianjin Universities in Tianjin; Zhejiang University in Hangzhou; Nanchang University in Nanchang, Beijing Jiaotong University in Beijingu.
Six MEngSc students completed the APP program at end of Semester 1 2009 and a further ten MEngSc and five undergraduate completed the APP program at end of Semester 2 2009. In 2010, 10 MEngSc students completed the APP program at end of Semester 1 and 12 at the end of Semester 2 and 8 and 26 BEng students finished their studies in Semesters 1 and 2, respectively. Several of the graduating students have intended to enter the School’s PhD program but the numbers able to do so has been restricted by the availability of scholarships.

5.3.2 Co-Op Scholarship Program

The Co-Op Program is an industry-linked scholarship program where students obtain extended work experience with industry sponsors as part of their undergraduate studies, through two summer placements, and two six month placements (prior to final year of coursework), with sponsor companies. In addition to their outstanding academic achievements, students are selected based on their involvement in school and community activities, their demonstrated leadership and teamwork skills and their ability to communicate. Participation in this program enables students to apply the knowledge they have gained during their studies in real industry projects, as well as opportunities for networking, recruitment and professional development through leadership camps. This program is also highly beneficial to industry sponsors, who have access to excellent students, can observe these students in their workplace, and have the first opportunity of recruiting the best new graduates.

Co-Op sponsors currently include, BP Solar, a global company that has been supplying PV systems to Australian markets for 30 years, CSG Solar, a new technology startup with an innovative crystalline silicon on glass PV product, Suntech Power Co. Ltd., the leading Chinese photovoltaic manufacturer and Renewable Energy Corp. (REC), a Norwegian based silicon and photovoltaics company that is establishing photovoltaics manufacturing in Singapore.


5.3.3 Rural Scholarship Program

The Faculty of Engineering established the Rural Scholarship Program in 2001 to encourage high-achieving students living in rural and isolated areas to study engineering. The scholarships are valued at approximately $9,500 per annum for four years of full-time study which eases the financial hardship of relocating to and living in Sydney. Two new rural scholars began their studies in the School in 2010.

5.3.4 Thyne Reid Foundation Scholarships

During 2008 two new undergraduate four-year scholarships were awarded to the School by The Thyne Reid Foundation, one for Photovoltaics and Solar Energy Engineering and one for Renewable Energy Engineering. The two students began studies in Semester 1 of 2009 and will proceed into their third year in 2011.

5.3.5 Taste of Research Summer Scholarship Program

The Taste of Research Summer Scholarship Program is primarily for high achieving 3rd year students and, in exceptional cases, 2nd year students may be considered. As part of the program, engineering schools offer 10 week projects for students to complete during their summer break. These projects provide students with scholarship support to gain experience working as part of a research team, for example in the laboratories of the Centre. In addition to providing an opportunity for checking whether research is their ideal career path, participation in these projects helps students further develop their technical skills and their written and oral communication through written reports and poster presentation.

From December 2009 to February 2010, the Centre hosted 12 students, taking advantage of the growing interest in the it’s research programs among outstanding undergraduates, particularly from those in this School. Again, in the 2010/2011 summer the Centre was keen to retain for research training as many as possible of the outstanding senior undergraduate students and took on 10 students through the Taste of Research program.

5.3.6 Research Scholarships

Sowbaranigha Chinnusamy Jayanthi, a student from India, was awarded an e8 Sustainable Energy Development Masters Scholarships for one academic year so that she may study for a Master of Engineering Scienceon in Photovoltaics and Solar Energy, at the School. The e8 is an organization of leading electricity companies from the global electricity sector that wish to help in protecting the global environment, and to promote the efficient generation and use of electricity. The e8 has established a scholarship program to support outstanding students from developing countries who plan to study at the Masters level.
in areas directly related to sustainable energy development.

Through thesis projects and scholarships, including the Taste of Research Scholarship program, the Centre encourages some of the best undergraduate students, particularly those from the School, into research. Being an internationally recognised research organisation, the Centre attracts very high quality students to its research programs where students have the opportunity to work with leaders in this field. The fact that 21 of our doctoral students are currently in receipt of the very competitive Australian Postgraduate Award (APA) for local students or the Australian Government’s International Postgraduate Research Scholarship (IPRS) for international students is testament to the quality of these students. To be awarded an APA, the student must be a local student with first class honours graduate at Bachelor degree level, while the IPRS is available to international students and are much more competitive. Suntech Power also sponsors a PhD scholarship in the Centre. Interest in and applications for postgraduate research in the School boomed during 2009 and the School expects to have four new IPRS recipients begin their research programs in 2011. The Centre also has five PhD scholars sponsored by the Australian Government through the Asia-Pacific Partnership on Clean Development and Climate scheme.

5.3.7 Rhodes Scholarships

The Rhodes Scholarship, arguably the most prestigious scholarship in the world, is for postgraduate study at Oxford University. Late in 2010 Alice Lang, a combined undergraduate Photovoltaic Engineering/Arts degrees student of SPREE with significant research experience in the Centre’s laboratories, learned that she would become a Rhodes Scholar. Alice will complete her Arts courses in Semester 1 of 2011 and start her studies at Oxford in Semester 2.

5.4 EDUCATIONAL RESOURCES

5.4.1 New Book Translation

A new book in Japanese language, “Fundamentals and Applications of Solar Cells”, was published in 2010, including five chapters authored by the Centre’s Prof. Martin Green. A simplified Chinese translation of Silicon Solar Cells: Advanced Principles and Practice will be published by Shanghai Jiao Tong University Press in early 2011, bringing to three the number of the Centre’s books available in that language.

5.5 PVSOC

One characteristic of the Centre which has led to the success of the educational programs is the friendly atmosphere that is engendered by being a small (but strongly growing!) school with highly motivated students and academic and general staff. Students appreciate being able to form friendships and support networks with fellows, as well as feeling comfortable and familiar with academic, technical and administrative staff. PVSOC (Photovoltaics Society) is a social committee established by the students which fosters this atmosphere with organised social events and activities to encourage student interaction. In 2010, the committee organised several events, including barbeques, student participation in Sustainable House Day (organised by ANZSES and held in September) and the PVSOC Annual Dinner. Students and staff enjoyed this party at Coogee in September 2010 (held earlier in the year than previously to avoid distraction from final week assignments and exam preparations) where final year students were farewellled, staff thanked, and the 2011 PVSOC committee was elected.

A new aspect of PVSOC’s activities began in 2010 with the advent of regular consultations by the PVSOC President, as a representative of the student body, with the Head of School and the Undergraduate Coordinator to work with the staff to further improve the delivery of education to the students.
5.6 PROMOTIONAL ACTIVITIES

The Centre regularly participates in promotional activities organised by the Faculty of Engineering and UNSW Student Recruitment. These events are important for increasing awareness and interest in the Centre's educational and research programs.

5.6.1 The Shi’s Family Charitable Foundation and The Sydney Theatre Company

The School has been a major participant in the Sydney Theatre Company’s high-profile “Greening the Wharf” project that is improving the water efficiency and greenhouse gas impact of the Wharf Theatre, at Walsh Bay. UNSW, in consultation with the Shi’s Family Charitable Foundation has agreed that the STC’s “Greening the Wharf” project is a project suitable to showcase the Pluto technology as an example of UNSW and Suntech’s research excellence. The School contributed $2m, donated by the Shi’s Family Charitable Foundation, towards the establishment of a 380kW, grid-connected photovoltaic array on the Wharf’s roof, completed and opened in December 2010. The balance of funding for the $4 million project was raised by Sydney Theatre Company from The Commonwealth Government’s Green Precincts Fund, NSW Government’s Public Facilities Program, corporate sponsor Energy Australia and philanthropists.

The project grew from two sources. Firstly, Dr Shi Zhengrong, CEO of Suntech Power, expressed a wish to make a gift to UNSW and to Sydney for helping him start his successful career in photovoltaics and to use it as a promotional tool. This led to a study of several prominent sites in Sydney and a pre-feasibility study, carried out as a final year thesis project by Samantha Wong. In parallel, Cate Blanchett and Andrew Upton, the Artistic Directors of the Sydney Theatre Company, were seeking opportunities to generate a significant part of the Company’s energy from renewable sources. Bringing the two ideas together led to the official launch in July 2009 of the project at a ceremony with Federal Minister for Climate Change and Water Penny Wong and Federal Environment Minister Peter Garrett, Mrs Vivienne Shi, UNSW Chancellor David Gonski, Scientia Professor Martin Green and Dr Richard Corkish.

5.6.2 Print and Broadcast Media

Student recruitment advertisements were also placed in the HSC Survival Magazine, the HSC Change of Preference Guide, and the HSC Universities Advisory and Information Day Guide. Media mentions of the School and the Centre became more frequent in 2010 as community interest in climate change and renewable energy issues grew.

5.6.3 UNSW Information Day

Local undergraduate students must apply for admission to UNSW programs through the Universities Admissions Centre (UAC), and the first week of January is the final opportunity for students to change their preferences for entry to university programs. Therefore, the university hosted an information day in January 2010 to assist students obtain information to finalise their preferences. School administrative and academic staff attended this event and talked to many prospective students who were unsure of their career direction. Students received information on our programs and had the opportunity to ask questions of staff. A final round of interviews for the Faculty of Engineering Admissions Scheme (FEAS) was carried out on the same day.

5.6.4 UNSW Courses and Careers Day

UNSW Courses and Careers Day is the annual information day, held in the first week of September, for prospective students to obtain information about programs and student life at the university. As part of this day students and academic and administrative staff from the School provided advice and information to prospective students from information desks in the Roundhouse and in a marquee in the UNSW Quad, nearby the Sunprint model solar car race finals. This year, the weather was, unfortunately, far from ideal for the 2010 event. During the day Dr Alistair Sproul presented two public lectures about the School’s and Centre’s programs as part of the lecture series organised centrally by the university.

5.6.5 Faculty of Engineering Information Day for High School Students

Each year the Faculty of Engineering organises an information day to give high school students and their teachers an opportunity to learn about engineering and the programs offered at UNSW. As part of the day students visit three engineering schools of their choice and engage in interactive activities aimed at demonstrating the relevant engineering area. Once again in 2010 the demand to attend this event was so great that two High Schools Days were required, with the School running several tours.
5.6.6 Honeywell Engineering Summer School

The Honeywell Engineering Summer School is an event held in December and is conducted by Engineers Australia. As part of the summer school high school students from across NSW and the ACT about to enter their final year take part in a week of activities which involves industry visits and lectures and demonstrations at a number of universities. In 2010 approximately 30 students visited the Centre to participate in hands-on activities and information provision.

5.6.7 Model Solar Vehicle Challenges

SunSprint Model Solar Car Challenge

The SunSprint Model Solar Car Challenge is a photovoltaics project-based learning event designed for high school students. In the event, solar cars are designed and built according to specifications provided by the Australian-International Model Solar Challenge (AIMSC), a national organization overseeing and linking all of the state events. These specifications provide design criteria that, when followed, allow students all over Australia to build model solar cars that are uniformly competitive with respect to cost and use of materials. The students contribute ideas, inspiration, time and money. The average vehicle costs over $600 and takes the team over four months to design and build. Many schools throughout NSW have allowed final year design and technology students to adopt SunSprint as their year-long major project. High school physics and science teachers have also used SunSprint as a class-based teaching project as SunSprint addresses several aspects of the curriculum.

The UNSW Faculty of Engineering initiated the project in 1996 with the Photovoltaics Centre of Excellence taking over its operation in 1999. In 2005 the UNSW Faculty of Science joined the Faculty of Engineering and the Centre in jointly sponsoring the event.

The 2010 SunSprint Model Solar Car Challenge was run on September 3rd and 4th, 2010 under truly horrible conditions with extraordinary amounts of rain and virtually no sunlight. The winning cars were able to actively compete using only 10% of the normal amount of sunshine.
The MiniSprint and Model Solar Boats
The MiniSprint Model Solar Car Challenge and the Model Solar Boat Challenge are offshoot events allowing primary school students to design and build solar vehicles and then experience the thrill of competition. The MiniSprint competitors start with a kit containing all of the important parts of the solar car and can be built in an evening. The kit requires soldering, gluing and taping.

The Model Solar Boat Competition requires much more student design than in the MiniSprint. The boats can be made of any material and can use almost any size or shape of solar cells and motors. Getting the boat to float right side up and to competitively move through the water is quite a feat.

5.7 EDUCATIONAL COLLABORATIONS
A range of educational collaborations have been established between the Centre and other educational institutions and organisations. These collaborations involve the development and implementation of educational programs and courses, the provision of support for student projects and theses, and the exchange of students.

5.7.1 “2+2” Agreements
In 2010 the School continued collaborations with four Chinese Universities for third and fourth year students from those universities to study Photovoltaics and Solar Energy Engineering at UNSW and for Masters by coursework study with Asia Pacific Partnership sponsorship. “2+2” agreements were signed in 2007 with two prestigious Chinese universities, Nankai University in Tianjin and Sun Yat-Sen (Zhongshan) University in Guangzhou. The first students under this scheme started at UNSW in Semester 1 of 2008. During 2008 similar agreements were signed with additional two Chinese universities. The two new partner universities are Tianjin University (two agreements, each with a different school) and Zhejiang University, Hangzhou.

A new agreement has now been made in 2009 with Nanchang University, in Nanchang, which has formed a new School of Photovoltaic Engineering and an additional “2+2” agreement was signed in early 2010 with South China University of Science and Technology, in Guangzhou.

5.7.2 Thyne Reid Foundation
The Thyne Reid Foundation concluded in 2008 an agreement to sponsor the studies of two undergraduate students for four years of their studies, one in Photovoltaics and Solar Energy Engineering and one in Renewable Energy Engineering. The students began their studies in the first semester of 2009 and finished their second year in 2010.
The project team and Imaki village volunteers preparing the long trench for the power cables from the turbine to the village. (Image produced by and used with permission of E. Tehan).

5.7.3 Cundall, Infigen, Norcoast Refrigeration and Others
Cundall, a sustainable design consulting company, and the Darcy and Patricia Wentworth Fund joined forces to financially support a final year thesis project to bring hydro power to a remote village school in Vanuatu, mentioned in Sec. 5.1. The student undertaking this project, Eden Tehan, was strongly supported by an alumnus, Chris McGrath, who started the project in 2009. In 2010 the project was extended to include the secondary (boarding) school, medical clinic and church in an integrated power system supplied by two hydro turbines and including a new low-power electric vaccine refrigerator. Donors for the project extension in 2010 included Cundall, Infigen, Norcoast Refrigeration, and several private donors: John Tehan, Susan McParland, Sean Tehan, Don and Marg McGrath, Tyler Troy, Helena Colnaric, Leah Greengarten, Athron McCann, Peter Baker, Noam Field and David Gazal. Eden and Chris also raised $4,500 for the project at a Vanuatu Shakedown concert, thanks to donated performances by “The Bakery”, “The Liberators” and Emma Davis. David Thompson of Gwynneville Electrical Services was the team’s electrician during the first trip, paying his own way and donating a week of work as well as many electrical components. Dave Selke of All-round Supplies, Sydney, was a very helpful tradesman who also donated some vital electrical components. Samantha Paver, Sasha Siljanovic and Sean Tehan all contributed their time to the project.

5.7.4 Suntech Power Corporation
Suntech, a partly Australian-owned company operating in China, has been actively involved in assisting UNSW with the development, testing and evaluation of educational material in the PV area such as in the development, testing and evaluation of a teaching software package called the Virtual Production Line. Significant numbers of UNSW undergraduate students participate in industrial training or in “Taste of Research” projects at Suntech and postgraduate students often travel there to use vital research equipment. Additionally, Suntech sponsored an undergraduate Cooperative Scholarship and two PhD scholarships and has made significant financial and in-kind contributions to UNSW to support photovoltaics research.

5.7.5 Singapore Polytechnic, Ngee Ann Polytechnic and Temasek Polytechnic
The Polytechnics in Singapore offer three-year diploma programs, including in engineering. During 2007 the School arranged for future articulation of graduates from the new clean energy diploma of Clean Energy program at Singapore Polytechnic into either of the School’s Bachelor of Engineering programs. In 2008 the School set up a similar articulation arrangement with Ngee Ann Polytechnic and Temasek Polytechnic was included in 2009. Significant numbers of students may flow in future years from these institutions, once the first groups of students make their way through the new programs, fuelling Singapore’s drive to become a major photovoltaics manufacturer. Richard Corkish has accepted in 2010 the role of External Examiner for the Diploma in Clean Energy program Singapore Polytechnic.

5.7.6 Darcy Wenworth
Darcy Wentworth donated his services through 2010 as a visiting academic, supervising undergraduate student projects and coordinating two subjects.

5.7.7 Kema Consulting
Dr Hanzheng Duo, a practicing Engineer at Kema Consulting, in his role as visiting academic, donated his time and industrial project experience to supervise and assess an undergraduate thesis project through 2010.