Energy Conservation and Renewable Energy Generation (EnviroPower) Pilot

Completion Report

Inglewood High School

1 July 2007 – 30 June 2008

Funded by:

Energy Conservation and Renewable Energy Generation (EnviroPower) Pilot Completion Report

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Executive Summary

The energy conservation and renewable energy generation pilot project at Inglewood High School was initiated by Venture Taranaki Trust and supported through shared funding by The Ministry for the Environment.

The key objectives of the pilot were:

1. To determine if one Taranaki secondary school could reduce its electricity demand drawn from the national grid by 15% from a prior year base, through a combination of conservation initiatives and renewable energy generation technologies.
2. To determine if it was possible to integrate conservation and demonstrated renewable energy technologies into classroom curriculum.
3. To determine what multiplier effect there might be by engaging with the parent body to encourage energy conservation and renewable energy generation in the home.

Electricity usage savings of 17% over the prior year base were achieved through a combination of conservation initiatives undertaken at the school and the introduction of renewable energy generation technologies. Many variables can come into play in making these measurements such as climatic conditions year on year and extraordinary events such as the need to employ industrial fans to dry out a classroom flooded by a burst hot water radiator. Nevertheless the school achieved, by independent assessment, a 17% year on year savings, far exceeding the first of the three objectives.

Benefits in curriculum delivery were noted by many of the school's teaching staff with an obvious bias towards those subjects where "energy" could be explored for greater learning and understanding, such as the sciences and social sciences. However, most curriculum areas contributed in some way to the successful outcome of the pilot. Students valued in particular the practical, tangible, relevant and hands on opportunities the pilot presented. As was to be expected the project was not embraced by all, although the overwhelming majority of teachers and students alike were touched by the pilot to some extent.

There is no quantitative data on home conservation at this time. It is proposed that a detailed survey will be conducted following the project to try and gauge the effectiveness of the conservation measures. Anecdotally, there have been many families who have made changes to reduce energy consumption.

Inglewood High School was selected, amongst other reasons, for its enthusiasm to be the guinea pig for this pilot. There is no doubt the success of interventions like this is closely and directly linked to the enthusiasm with which they are communicated to students by teaching staff. So it proved on this occasion. Teachers are under competing pressures and those prepared to go beyond the core curriculum delivery are ultimately the ones who make 'just another programme' a flagship programme for the school today and in the future. The school and funding partners owe a debt of gratitude to these teachers, especially the two who took active leadership roles in EnviroPower.

The school received much support from the business community who generously gave their time and resources to maximise the positive outcomes from the pilot. The benefit of

having a technical specialist seconded to the pilot is also seen as critical to the success of this and any future pilots.

This pilot was implemented under the governance of a Pilot Monitoring Committee chaired by the school principal. The complimentary skill sets on that monitoring committee proved to be a good model for keeping the pilot on track, on budget and well publicised.

As a pilot it was always anticipated that there would be learned outcomes; things that could be done better the next time. Expectations of teacher and student involvement were probably over-estimated. In particular the gestation time required for new ideas or opportunities to be fully explored and developed was longer than anticipated. What made the difference at the end of the day was giving the pilot a physical context in the form of a wind turbine, solar panels and a visible display of the electricity generated.

While many would argue that conservation comes before generation, in the school context there was a detectable increase in interest once the generation technologies had been installed. There is also the belief that the pilot merely provided the spring board for further beneficial outcomes in future years ahead and so it was unrealistic to expect all the beneficial outcomes to be captured in the first 12 months.

The final question that needs answering is did the pilot return outcomes of enough significance to justify investment in other secondary schools. The answer to this question is closely linked to the critical success factors for the pilot. The answer would be yes if there was another secondary school with the enthusiasm and dedication to drive a future implementation to success.

Concept Development

In early 2007 Venture Taranaki was looking for investment opportunities in the energy sector to achieve the vision of Taranaki as New Zealand's 'energy powerhouse' by leading the uptake of distributed renewable energy generation and energy conservation. The investment was to meet the following criteria:

1. Build on Taranaki's competitive advantages in renewable energy sources:
   - Wind. Being in the roaring 40's, New Zealand has approximately twice the annual wind generation hours of Germany (a global leader in wind energy generation) and one of the best wind generation resources in the world (EECA)
   - Sunshine hours. Taranaki has the second highest in the North Island (NIWA)
   - Rainfall. The mountain river system is very well suited to micro generation

Taranaki Weather Norms (source: NIWA mean values 1971 - 2000)			
North Island Comparisons	**Wind (km/hr)**	**Sunshine (hrs p.a.)**	**Rainfall (mm p.a.)**
New Plymouth	**20 (2nd)** 5.5m/s Tararuas 10m/s	**2182 (2nd =)**	**1432 (1st)**
Tauranga	16	2260 (1st)	1198
Napier	14	2188 (2nd =)	803
Auckland	17	2060	1240
Wellington	22 (1st)	2065	1249

2. Facilitate transformational intergenerational change by:
   - Providing leadership in the uptake of distributed renewable energy technologies and energy conservation.
   - Leveraging educational curriculum in secondary schools

3. Fit with the Government's long term energy efficiency and conservation strategies (EECA):
   - Continuing improvement in energy efficiency (20% from 2002 base by 2012)
   - Progressive transition to renewable energy (29% or 132PJ in 2002 to 30-35% or 157-187PJ by 2012)

Having made the decision to invest through High Schools the choice of Inglewood High School was based on the following attributes:

- Mid sized Taranaki high school
- Within the New Plymouth District
- Has a river border
- Has close residential neighbours on eastern boundary only
- Enthusiastic staff

Pilot Description

- Pilot at one Taranaki secondary school interventions aimed at reducing electricity demand drawn from the national grid by 15% from a 2007 base through a combination of conservation initiatives and installation of renewable energy generation technologies.
- Integrate conservation and demonstrated renewable energy technologies into the classroom curriculum.
- Facilitate a multiplier effect by engaging with the parent body to encourage energy conservation and renewable energy generation in the home.

Pilot Monitoring Committee

The EnviroPower Monitoring Committee was formed at the commencement of the pilot and proved to be a well balance and committed team. The Monitoring Committee met 9 times over the twelve month period.

Committee Members	Prime role on Committee
Angela Gattung	Chairman, School Principal and School Project Champion
Warwick Foy	Teaching staff Project Champion
Michael Fenton	Teaching staff – Technology Advisor
Abbie Fowler	Student Project Champion
Michael Lawley	Project Technology partner
Kama Burwell	Enviroschools Coordinator
Maakere Edwards	Enviroschools Facilitator
Kathryn Calvert	Media promotion – Venture Taranaki
Antony Rhodes	Media Promotion – Venture Taranaki
Lucy Green	Ministry for the Environment - Liaison
Rob Trusler	Monitoring Committee Secretary – Project Manager - Venture Taranaki

Funding Partners

The $100,000 pilot was funded 50/50 by Venture Taranaki Trust and the Ministry for the Environment - Sustainable Management Fund.

Venture Taranaki Trust: Stuart Trundle, Chief Executive

New Zealand lags behind the developed world in energy conservation and the uptake of renewable energy generation technologies. This project sought to begin turning that around, by helping Inglewood High School and its 392 student families to become national champions of a modern and achievable response to the energy challenges facing New Zealand. The pilot also supports the Government's draft New Zealand Energy Strategy to 2050.

The main advantage of targeting secondary school students is the potential multiplier effect it could have on each individual student's home energy usage behaviour. While that might be difficult to measure, it is accepted that parents often learn through - and change their behaviour as a result of - knowledge taken by students from the classroom into their home environment. In addition, positive intergenerational impacts will arise as today's students move into the workforce and take on positions of leadership and responsibility, armed with the knowledge that they can make a difference.

Other Partnerships

Inglewood High School

Inglewood High School was eager to embark on this project, which it saw as very relevant to the lives of the young people in its care. These days the availability and price of electricity and environmental concerns dominate the media, people's pockets and questions about the health of the planet. We saw this project as a way of educating and encouraging our students to encourage them to think about and take practical steps to manage their power consumption. The project was created from a vision and a belief that we can all make a difference – individually and collectively. The success of EnviroPower is directly attributable to the co-ordination of organisations and individuals who share this common goal. We acknowledge that the strength of our project was in the strong relationships fostered through our shared vision. We thank Venture Taranaki Trust and the Ministry for the Environment for inviting our involvement and all the organisations and individuals who have assisted us. With this project, we have started a journey investigating issues of sustainability. We hope the messages of education, conservation and generation will continue to be developed and promoted in our school community and beyond into the foreseeable future.

EcoInnovation Limited

Greater uptake of energy conservation and generation technologies will occur as the world awakens to an energy squeeze. This will lead to business opportunities for the mass production and installation of renewable generation equipment.

An ideal picture of the future will include small scale generation at a domestic level that can compete with generation at larger remote power stations. We all have a roof on our house and this can generate all of the power that we need if are not wasteful. The current barrier to achieving this is the cost of the equipment, though it is anticipated that this will fall to a level where it is economic in the next 10-20 years.

It has been an honour to be involved with pupils and staff at Inglewood High School, assisting them to value energy and work with them through this important pilot project.

The efficient use of our energy resources cannot be overstated.

Enviroschools

This is a project that demonstrates great vision, a great willingness, and a sense of adventure from Venture Taranaki, the Ministry for the Environment and Inglewood High School. The outcomes and learning from the EnviroPower project will inspire and inform schools all around New Zealand and quite possibly the world.

PowerCo Limited

Powerco is committed to playing its part to achieve the New Zealand Energy Strategy and projects like this are an important early step in educating young people about prudent use of energy and the benefits of investment in energy efficient technologies.

Mark Harris

Having the wind turbine, solar panels and their associated measurements in front of the students will give many their first and hopefully formative opportunities to reflect on energy production and how renewable energy can contribute. Similarly the energy efficiency and conservation measures undertaken at the school have assisted with forming life long habits.

I enjoyed being involved with this project and look forward to being involved with EcoInnovation in the future - such a great resource for Taranaki and New Zealand.

Rimu Electrical: Bruce Verry

Rimu Electrical has been happy to have been able to play a part in this project with the electrical inspection. You guys are doing a good job out there.

Sunworks NZ Ltd: Dave Johnson

Of all of the active technologies out there - actively producing energy as opposed to conserving - solar water heating is the one form of energy capture that is viable and cost effective right now and in fact has been for a few decades. It is the only appliance that has a decent tax free return on investment from day one.

I am proud to have been associated with this project as it will hopefully implant in the minds of young people the fact that producing energy where it is consumed should be the norm rather than the exception. You should have heard the positive comments from those students during the installation! The school staff and especially the school maintenance crew went out of their way to help. It was a super effort from everyone involved.

Smithies Technology Ltd: Andrew Smithies

Working with EcoInnovation at Inglewood school was an excellent project to contribute to. This project provided learning opportunities about power generation and energy conservation that are difficult to gain anywhere else. These learning opportunities have not been kept to any one party.

Energy conservation is a hot topic, and to see a project of this type deliver measured energy savings while maintaining full school functionality has been a huge achievement.

Ian Sumner - Energy Conscious Design Limited

Thank you for this opportunity. We are always pleased to be involved in projects of this nature. Educating current and future generations to respect and effectively manage our natural resources is key to the future sustainability of mankind.

This demonstration project has great potential to effectively promote energy efficiency and renewable energy technologies into the wider community, and hopefully the project can be replicated in other schools and communities around the country.

Project Milestones & Budget

Milestone	Tasks	Due date	Estimated Cost (ex GST)
1	**Energy Conservation – Preparation** Identify local school to be involved in pilot project. Meet with Boards of Trustees to brief them on what the schools involvement would need to be and the benefits of being involved. Meet with the local Environment Centre Enviroschools coordinators to brief them on the project and ask for their involvement. Enviroschools coordinators will work with the school to provide environmental educational support. Establish Pilot Monitoring Committee. Committee to comprise of two representatives from the School (one to be the Energy Conservation Champion appointed by the school), Eco Innovation, the Enviroschools coordinator and Venture Taranaki. Hold inaugural Monitoring Committee meeting and elect a Chairperson. Promote and hold a project launch the week of June 7-12 to raise public awareness of the project. Local media and other key stakeholders and interested groups will be invited to attend. Television New Zealand to film feature for their national prime time television “Close Up” programme. Feature articles in Daily News and others selected media. Install check metering in classrooms to capture baseline electricity usage in the School. Develop and set up energy conservation program in the School. Introduce EcoInnovation Limited’s interactive renewable energy demonstration trailer to school staff, students and parent body. Get students to investigate their own power usage at home and report on this.	31/09/07	$15,800.00
2	**Energy Conservation – Rollout** Commence energy conservation programme and measures in the School. Create a change in student’s behaviour e.g. by turning off lights and electrical equipment after use.	31/12/07	$22,000.00

	Students to embark on energy conservation program at home. Undertake installation of water heater timers on all school hot water cylinders Undertake Installation of water heater insulation in all school electrical hot water cylinders Undertake Installation of up to 8 energy efficient laptop computers in school and measure savings compared with standard desktop PC's with CRT screens. Compare electricity usage data with base line data. Communicate project progress/results of savings against the project KPI's with staff, students and parent body via a variety of media. Teaching staff to integrate learning's from energy conservation programme into classroom curriculum.		
3	**Renewable Energy Generation** Negotiate national electricity grid interconnect agreement with Powerco and Genesis Energy that will allow electricity generated at the school to flow back into the national grid. Install demonstration grid tied photovoltaic array in one section of the school. Install demonstration grid tied wind turbine. Install demonstration solar hot water unit in one high hot water use area of the school Install micro hydro generation unit (non grid tied) in Technology block of the school. Teaching staff integrate learnings into classroom curriculum Provide installed technologies operational training and ongoing maintenance programmes to ensure installed electricity generation equipment is safety operated and appropriately maintained. Provide interpretation of the technologies and their place in New Zealand's energy future. For example, what is the potential for solar electricity generation in New Zealand, what are the advantages and disadvantages (e.g. cost, reliability, distributed vs. non distributed generation and environmental impact), of this generation technology vs. alternate generation technologies.	31/03/08	$50,100.00

4	**Pilot conclusion** Hold Conservation awards for students within the school Analyse and extrapolate savings in school. Analyse and extrapolate home savings. Determine benefits derived in curriculum delivery. Determine value in rolling pilot out to all Taranaki secondary schools.	30/06/08	$12,100.00
	Total Pilot Costs		**$100,000.00**

Project Outcomes

Conservation in the school

Summary of Electricity Savings – analysis by Smithies Technology Ltd

Smithies Technology Limited were engaged to provide a qualified and independent measurement of Inglewood High School's energy usage. The full report is attached as an appendix.

Inputs used for this report are:

- Log data of electricity consumed by the school at the power board meter for the whole school. Recording of log data was made by PowerCo and supplied in electronic format:
    - A set of reference log data from before any changes were made.
      The reference log data is from 14/05/2007 11:16:01 to 7/06/2007 11:45:01
    - A new set of log data after changes were made.
      The comparison log data is from 19/05/2008 11:41:00 to 23/06/2008 12:01:00
- Comments regarding what happened during the logging:
    - A heating system failure on 25/5/08 which lasted for 2 weeks resulting in many small electric heaters
    - A water pipe break on 28/5/08 resulting in the use of industrial carpet drying equipment.
    - School staff and students were not aware of logging until it was completed in 2007.
    - The school staff and students were not aware of logging until after the 1st week of logging in 2008.
- Knowledge of some of the changes made:
    - Installation of a grid tied Skystream wind generation
    - Installation of grid tied photovoltaic generation
    - New strategies for water heating run time with time switches and added insulation to cylinders

Comparing the 1st week of log data in 2008 with all of the log data recorded in 2007 shows a 17% efficiency gain overall. This represents a saving of 807kWhr per month which at 22c/kWhr is $178 per month.

The biggest gains have been made during the daytime, especially in the weekends. School daytime consumption is down by 22% and weekend daytime is down by 57%

Hot water

Hot water heating was audited in the school and a large amount of wastage was found. Some cylinders were used infrequently and several were never used. One cylinder was found concealed behind a gib board panel – it was still switched on. All cylinders were hard-wired *on* and none were wrapped, timed or lagged. Staff and two students worked though the school timing, wrapping and lagging the used cylinders. Disused cylinders were disconnected. The audit results are shown in the following table.

Room	No.	Location	Action
Room 2	3	Under benches	Timed: weekdays 8.30 - 15.00 Wrapped
Senior Art	1	Under Bench	Disconnected
Woodwork	1	Under bench	Timed: weekdays 7.30 - 14.45 Wrapped
Metalwork	2	1 * under bench, 1 * cleaning cupboard	Both usually off Cupboard wrapped
Science office	1	Under bench	Disconnected
Room 12	1	Under bench	Timed: Mon 6.00 – Fri 14.00 Wrapped
Room 12 office	1	1 * back of office	Disconnected
Science office	1	1 under bench (not used)	Disconnected
Prep room	1	Under bench	Timed: weekdays 8.00 - 15.00 Wrapped
Room 16	1	Under bench	Timed: weekdays 8.15 - 15.00 Wrapped
Room 17	1	Under bench on window side	Timed: weekdays 8.00 - 15.00 Wrapped
Hort room	1	Under bench by far exit	Disconnected
Library	1	Cleaners cupboard up top	Timed: weekdays 14.30 - 16.00 Wrapped
Library office	1	Under bench	Timed: weekdays 10.00 - 12.00 Wrapped
C Block Cleaner	1	In cupboard	Disconnected
Music room	1	Under bench (not used often)	Timed: weekdays 8.00 - 15.00 Wrapped
Wharenui	1	Under bench	Disconnected
Wharenui	1 'zip'	Mostly left off	
Admin	1	Back of hall	Timed: Mon 3.00 – Fri 15.00 Wrapped
Admin	1	Ladies toilet	Timed: Mon 4.00 - Fri 15.00 Insulated
Canteen	1	At left of entrance	Wrapped

A timer being installed to a hot water cylinder.

Computers

There are over 100 computers in use at the school. Several approaches to reducing computer electricity demand were discussed. Initially it was thought that the school would purchase a number of laptops to substitute desktop computers in several locations around the school. This was decided against when the shortcomings of laptops were pointed out. Screens are particularly vulnerable to damage and the physical structure of a laptop is not as robust. Depreciation is much higher and laptops do not offer the flexibility of a desktop system in terms of repair, upgrading and mixing and matching.

Eventually, the school decided to purchase Extenda kits and LCD screens. Extenda kits enable one PC CPU to power another six terminals. Therefore, electricity consumption is 1/7 of the previous installation plus the electricity consumed by the monitors. Extenda kits were trialed in several locations around the school. LCD screens were purchased because their consumption is about half that of a conventional monitor. The Extenda kits and LCD screens were split geographically in order to minimize the risks of a technical fault or difficulty taking out a whole lab.

The LCD screens have been a great success. They complimented a general overhaul of the senior computer lab and have saved electricity as shown in the data table.

Unfortunately, the Extenda kits were not successful and have now been removed and relocated around the school, resulting in a net gain of electricity consumption, but also of computing power. The kits caused a number of problems. Despite, RAM and power supply upgrades, the computers were very slow to login and would occasionally blackout. Any fault in one machine resulted in 7 having to be taken out all at once. Despite repeated service attempts from the installers few improvements occurred. It seems that the reliability of the Extenda kits was truly tested when a class load of 30 students logged in simultaneously.

An Extenda kit

Despite the failings of the kits in a lab setup, they did have a positive impact on energy savings, as shown in the following table:

Room	Before energy saving changes				After energy saving changes			
	Meter No.	Hours	KWh	Cost	Meter No.	Hours	KWh	Cost
23 (Extenda)	4	192	4.8		21	192	3.6	
23	6	191	4.9		9	192	3.6	
23	7	191	5.1		11	192	3.6	
23	8	191	5.6		10	192	3.6	
23	9	191	4.2		18	192	3.6	
Average		191	4.9	**$0.98**		192	3.6	**$0.72**
9 (LCD)	1	192	4.0		12	192	3.5	
9	2	192	3.4		17	192	2.5	
9	3*	192	4.3		13	192	3.6	
9	5	192	3.2		2	192	3.6	
Average		192	3.7	**$0.74**		192	3.3	**$0.66**

In summary, computers in the 2 main labs were using an average 4.3 kWh of electricity per week prior to intervention. After the changes were made the average consumption fell to an average 3.45 kWh per week. This represents an energy saving of 19.8%.

Other in–school savings

The main draw of electricity in a school is different to that in a home. In a home there are generally only single or double examples of many different types of appliances, such as one lamp, one toaster and so on. In a school there are only a few different types of appliance but their number is many, for example 30 classrooms of fluorescent lighting, 100 computers and so on.

It was established that our greatest energy saving potential would be reached by targeting hot water heating, computers and lighting. There are examples of some other appliances in the school but their draw is minimal in terms of the overall demand of the school.

Water heating and computers have been discussed elsewhere. Lighting was targeted by simply reminding staff to turn lights off. The student council was drafted in to assist with this. These 'Energy Champions' were trained to identify and eliminate lighting wastage around the school.

Light Emitting Diode (LED) lights have been substituted into some of the key security spot lighting positions around the school and all new lighting installations will use compact fluorescent bulbs. Coincidentally, Administration and C blocks have both been recently refurbished, with compact fluorescent lighting installed. Some lit areas frequently have lights left on. This occurs when people don't take 'ownership' of a space and simply pass through it. Examples of this are the staff room, teacher work rooms and computer rooms. The switches in these rooms have been replaced with timed/motion sensor switches. The staffroom alone contains 26 bulbs and 4 florescent tubes. This room is frequently empty during class periods and outside school hours but before the changes were made the lights frequently got left on.

Conservation in the home

There is no quantitative data on home conservation as a result of this pilot at this time. It is proposed that a detailed survey will be conducted at the end of the project to try and gauge the effectiveness of the conservation measures.

Anecdotally however, there have been many families who have made changes to reduce energy consumption. The student curriculum survey listed a number of changes that families have made. It should be noted that, during the course of the project there have been significant rises in fuel, food, and mortgage interest rates as well as a national campaign to save electricity usage. It is hard to know how much impact EnviroPower has had over and above these pressing financial power saving incentives. Hopefully, the project has helped to enlighten people as to why they face these issues, and reinforce some painless steps to conserving energy in the home.

Power Generation in the School

Solar power generation

A 1.2kW photovoltaic (PV) array was installed facing midday sun. This PV array is grid tied through a SunnyBoy inverter and the information displayed on a SunnyBeam display.

Left: Installation of the PV array

Right: The SunnyBeam display

Left: The SunnyBoy inverter

Right: the installed PV array

An array this size will generate an average of approximately 4 kWhrs/day and has a life expectancy of 25-30 years. PV is generally regarded as the most likely future energy solution for domestic homes wanting to generate some or all of their electrical power needs. PV is easily mounted on the roof, has no moving parts and no maintenance requirements.

The installation went ahead without any major issues and has been working as expected.

Wind power generation

A Skystream 3.7m diameter wind turbine was erected. This is a relatively new USA made product that is designed to be easily grid connected for the domestic market. The inverter is mounted in the head of the turbine and during strong wind events can generate over 2.5kW. Inglewood is not regarded as a particularly good wind site but the turbine is visually attractive and makes a bold statement at the school. It is likely to produce a similar amount of energy as the PV array for a similar cost. It has a 5 year warranty and is made and supplied by a reputable company. Hopefully ongoing maintenance costs will be low. It has performed as expected with only a minor ongoing issue with the remote display, yet to be resolved.

Top left: The turbine head

Top right: Tower winch

Centre left: Hauling up

Centre right: Securing in place

Left: Installation complete

Solar hot water

Three EcoSolar high efficiency copper panels were connected to the two largest electric water tanks in the school. It is a drain back system so that once the tank water reaches temperature the heat transfer fluid drains back to prevent boiling. During freezing temperatures, no fluid is in the panels and this prevents frost damage. It is a fail safe system, and is performing very well.

EcoSolar panels

Micro hydro power generation - demonstration unit

Although Inglewood school has a significant river on the property boundary, it was decided that generating power form this high flow, low head stream was a difficult project, mainly due to high flooding risks.

To complete the renewable energy theme it was decided that a small demonstration hydro turbine powered from the school water supply was the best educational solution.

This turbine runs on a very small amount of water producing 20-30 Watts. It is intended to demonstrate the principle of power generation from water. EcoInnovation now manufactures this product for sale into the global market for the same educational application.

Demonstration scale hydroelectric generator

Public Awareness

A critical part of the pilot was raising public awareness of energy conservation and generation within the school community, the local community, and on the wider Taranaki and New Zealand levels. This was successfully achieved through a number of initiatives.

An Inglewood High School staff member designed and produced a set of EnviroPower posters on the following themes:

- Energy Conservation in the home
- Solar Energy generation: advantages/disadvantages
- Wind energy generation: advantages/disadvantages

The development and display of these resources fits with the Education component of the *Education Conservation Generation* priorities of the EnviroPower project, and the posters offered a vibrant visual reminder to reinforce behavioural change messages on issues of energy conservation and generation. Further, they do not require ongoing energy expenditure to get these messages out there.

A series of electronic visual displays are being also designed and produced for ongoing display in the school's office and at the front gate of the school. A student has designed a circuit for a radio based sensor system connected to the 3 renewable energy sources in the school. The displays show in real time:

- Solar energy generated in the last hour.
- Wind energy generated in the last hour.
- Solar hot water generated in the last hour.

This fits with the Education component of the *Education Conservation Generation* priorities of the EnviroPower project.

The front gate display is solar powered and this colourful moving visual display will raise interest and awareness of different renewable energy options. It will also contribute to the aim of changing behaviours, by providing a very public display of energy generation to accompany the wind and solar generation devices also visible from the school gate, on State Highway 3.

Other opportunities for engaging the public have occurred throughout the project such as:

- The Sustainability Fair at school.
- Media coverage.
- School website (home energy audits, primary and secondary school teaching resources).
- Special school assemblies.
- Public presentations.
- Official opening ceremony for the wind turbine.
- School newsletter articles.
- School competitions.

Government Spokesperson for Energy Efficiency Jeanette Fitzsimons officially opens the wind turbine, with (l-r) Venture Taranaki CEO Stuart Trundle, student project champion Abbie Fowler, Ministry for the Environment's Lucy Green, and New Plymouth Mayor Peter Tennent.

Articles, stories or features on the EnviroPower project have featured in the media channels:

- TV1 *Close Up*: Feature (with Michael Lawley), July 2007.
- PPTA News: Short write up of project – school not consulted for story, May 2008.
- Taranaki Daily News: Sustainability Feature, May 2008.
- Opunake and Coastal News, Feature, April 2008
- Education Today: Feature and contributions from Abbie Fowler (student) from April 2008.
- Interface Magazine: Feature, November 2007.
- Taranaki Daily News: Wind Turbine story, January 2008.
- Taranaki Daily News: Turbine launch story, March 2007.
- Taranaki Daily News: EnviroPower story, July 2007.
- Sustainability.govt website: Turbine story, February 2007.
- School newsletters and magazine.
- Beyond the Chalkface Magazine: EnviroPower story, June 2008.
- Sciencelearn.org.nz: article, June 2008
- Portal magazine: article, EnviroPower story, July 2008
- Central Today magazine: EnviroPower story, July 2008

A competition was held where staff, students and families were invited to submit their energy saving strategies. The entry form was delivered twice to every school household, and featured a simple entry procedure and good prize range, though the competition did not receive a high uptake. It was, however, evident that a lot of time and effort had gone into the entries. It was thought that the many smaller changes that homes had made were considered insignificant compared to what others may have done, resulting in the lower than expected level of entries.

The winning entry involved the construction of a backyard hydro generator, utilizing simple materials found around the farm, and contributing to a wider range of energy savings on the student's family farm. It was great to see the whole family clearly taking on board the conservation and generation messages.

Conservation Awards

The EnviroPower project was entered into the Ministry for the Environment Green Ribbon competition. The project was not selected as a winner.

The EnviroPower project was entered into the Taranaki Regional Council Environmental awards. The project was a winning entry. The school received a plaque, $200 and a presentation from the TRC.

The EnviroPower project was also entered into the Taranaki Chamber of Commerce environmental awards in July 2008.

Curriculum implementation and evaluation – Teachers perspective

Pedagogy and student involvement

Michael Fenton, M.Sc., Dip.Tchg.
Ministry of Education E-Fellow (2008)
EnviroPower Technical Advisor

Preamble:
Teaching and learning have been described as a means to create a "knowledge economy" (Bolstad and Gilbert, 2006) yet from my experience in industry and outside the classroom "understanding" is much more important. Understanding is the pre-cursor to solving authentic problems and innovation later in life or in the work place.
Piaget and other psychologists believe that the learner must be active to be engaged in real learning (Piaget, 1954, 1974).

Strategies:
The EnviroPower project used three main strategies to actively engage students and raise their awareness of the EnviroPower priorities (Education, Conservation, Generation).

1) The first strategy involved a **teacher directed** focus on the EnviroPower project whenever a unit or achievement standard had elements that could be taught using the EnviroPower project as a context for teaching, learning and/or assessment. Examples of curriculum subjects that took this approach are mentioned in the following section. Students also managed to gain NZQA credits from activities based around the EnviroPower project.

   Informal surveys of staff and students indicated that the students could engage with the class topic better if linked to EnviroPower as it had some relevance to something real (eg, Level 1 Maths students discussing budgeting power costs and calculating % increases). It was also noticed that many senior students will become bill payers in the very near future so a recent exposure to conservation concepts should translate into changed attitudes and behaviours.

   Teachers that valued the EnviroPower project appeared to use it as a context for multiple learning opportunities over extended periods of time. Again, this multiple exposure to conservation concepts should increase the likelihood of attitudinal and behavioural changes.

2) The second strategy was involved a **student centered** approach based on authentic learning. Authentic learning is a pedagogical approach that allows students to explore, discuss, and meaningfully construct concepts and relationships in contexts that involve real-world problems and projects that are relevant to the learner (Donovan, Bransford, & Pellegrino, 1999). The term authentic is defined as genuine, true, and real (*Webster's Revised Unabridged Dictionary*, 1998). If learning is authentic, then students should be engaged in genuine learning problems that foster the opportunity for them to make direct connections between the new material that is being learned and their prior knowledge. This kind of experience will increase student motivation. In fact, an "absence of meaning breeds low engagement in schoolwork and inhibits [learning] transfer" (Newmann, Secada, & Wehlage, 1995).

Fenton (2007) reported that authentic learning is important and occurs when students develop meaningful understanding from activities they initiate and have control over. Ideas for learning activities may come from other students OR the teacher but each student should take "ownership" and the activity becomes student centered. Some authors make the mistake of dismissing ideas from the teacher yet authentic learning still takes place if the student owns the idea and runs with it.

Evidence from students working together using authentic learning principles indicates students gained more than empirical knowledge and in fact authentic learning is what the new curriculum encourages.
Examples of authentic learning from students includes

a) student EnviroPower committee members presenting to Venture Taranaki and talking of how the project has impacted on their beliefs and attitudes.
b) Art work being created for the front gate sign
c) EnviroPower name and logo created by various students
d) ICT and technology problem solving to build an interactive real time display of energy generation at the school (involving electronics engineering and computer programming)
e) School competitions encourage creativity and authentic activities

3) The third strategy involved ICT and e-learning to communicate EnviroPower ideas to the local, national and international community via dedicated pages on the Inglewood High School website. Opportunities to carry out home, school or workplace energy audits, as well as debate different energy generation options were available. Material for both Primary and Secondary age students is available.

Conclusion:
Overall, many students and staff are only just getting to see how they could get more involved with the EnviroPower issues. Due to the innovative and experimental nature of the project, there has been a significant time lag of about 6 months before technology such as the solar panels and wind turbine were installed, and 12 months lag before data logging of the school energy use is available for analysis. The data and technology now available would lead to more authentic and relevant learning activities if the EnviroPower project could be extended. Legitimate data encourages students to engage in their own investigations and in particular the new RIGEL pocket data loggers are ideal for use in homes (Fenton, 2008).

I believe from a literature review of over 100 papers that a blended approach of both a teacher directed and student centered learning was appropriate. High school age students are more likely to remember and implement the EnviroPower messages since they are likely to be living on their own the near future as opposed to primary age students.

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Social studies

All Year 10 students completed a four week EnviroPower topic. This was the main subject area for project specific content. The lesson plan included:

1. Introduction: the issues.
2. What is electricity?
3. The history of electricity.
4. What is it used for?
5. How is electricity generated?
6. Renewable/non renewable resources and sustainability.
7. Conservation
8. How to conserve electricity.
9. Future demand and supply.
10. Case studies – Auckland power crisis 2006.
11. EnviroSchools.
12. EnviroSchools.
13. EnviroPower at Inglewood High School.
14. Home energy monitoring using watt-hour meters
15. Data processing.

Many students became personally engaged with this topic as it corresponded with media coverage of energy issues such as record oil prices, low hydro lake storage levels etc. Students learned about these issues in detail and discovered what they could do to try and mitigate them. They learned about an energy future which will be characterized by fossil fuel decline and carbon emission issues. The installed renewable technology in the school was used in the teaching of this topic. The wind turbine in particular captured the imagination of many of the students.

General science

Year 9 and 10 Science: Types of energy, energy transformations, insulators and conductors. These topics will become expanded and more relevant as the new national curriculum places more emphasis on sustainability.

Physics

The EnviroPower pilot was used in Level 2 physics, with the investigation of how a turbine generates electricity. This also linked in to different means of driving a turbine, such as wind, nuclear, hydro, etc.

Geography

A Year 12 NCEA internal assessment was developed around the project. The students chose relevant environmental issues like global warming and peak oil and then explained how EnviroPower renewable energy and conservation methods could mitigate these. This assessment was very successful in that it ignited a real environmental passion in some students. Those same students have gone on to explore similar themes in Year 13 assessments. One student has decided to pursue a career in environmental planning partially

as a result of studying this topic. As the new national school curriculum is introduced, sustainability issues will gain in emphasis particularly in science, geography and social studies. The EnviroPower project will mean that Inglewood High School is at the forefront of sustainability education.

Technology

The school recently appointed an experienced electronics tutor, who is utilizing the wind turbine as a basis for a unit on turbines and generation. Students will ultimately design and build a bicycle-based generator.

Mathematics

Aspects of the EnviroPower project were used in a range of NCEA level one unit standards and level three calculus. Junior maths incorporated the project in looking at power generation, home power costs, percentage calculations, simple statistics (mean, range, quartiles).

Art and Photography

Imagery and dynamic concepts surrounding renewables technology, such as solar panels and, in particular, the wind turbine, were used as subjects in student portfolios for both painting and photography.

English

Year 10 students were asked to complete a research report on chosen environmental issues. Many students selected issues that they had learnt about in the social studies EnviroPower topic and explored them further. In some cases students showed significant personal engagement with the topics. This produced writing of a very high standard. Through this research, students became aware of the issues of renewable energy and conservation.

Enviroschools Programme perspective

This project has been very well-run and has produced some very good outcomes. It has been a 'top-down' expert-led approach to transforming electricity use and generation in the school.

The school's staff members did an extremely good job in using the EnviroPower project as a context for learning across many curriculum areas. In most cases, the learning was 'tagged on' to the project as students had little input into the project itself. However, there were some examples of genuine student participation, such as the students creating logos and displays, installing hot water cylinder wraps, helping to erect the wind turbine, and having a student representative on the EnviroPower Monitoring Committee.

We suggest that a student-led approach facilitated and assisted by teachers and experts would deliver greater educational outcomes, due to genuine student participation. International and local experience demonstrates that where projects are student-led, students are much more engaged in learning, essential skills are developed further, students are empowered, gain confidence, and express greater pride in their work and their school.

In this project, a student-led approach might involve the following process:

- Students explore the issues around energy, electricity use and generation prior to any audit or action.
- Assisted by experts, students undertake an audit of energy use within the school.
- Students evaluate the results, propose possible solutions, and seek advice and proposals from experts.
- Students develop action plans including expert proposals and present them to the Board of Trustees and other agencies.
- Students assist experts to implement the plans where practical.
- Students monitor progress, documenting results, and reporting on the success of the project.

At all stages of the process, experts can be involved in facilitating, teaching, advising, designing, and implementing.

Integrating such a student-led project into the curriculum has its challenges, but simply requires some creative thinking and a look at what other secondary schools have done in this area. For example, a school could offer a year-long, cross-curricula course in which senior students drive the project, using the new NCEA 'Education for Sustainability' achievement standards. Students in other subject areas and levels could be involved in various parts of the project process.

A student-led process is more difficult to control, and may take much longer. But the students' learning will be richer and more relevant.

We recommend that Venture Taranaki and Eco-Innovation work collaboratively with future schools, and an Enviroschools Facilitator or an "Education for Sustainability Advisor", to design how the project will be implemented in that school. This will allow a student-led approach to be developed.

Curriculum evaluation - Students perspective

A student who is interested in EnviroPower surveyed a sample of other students, asking the following questions and eliciting the responses summarized below:

1. List any of your subjects that have included EnviroPower content.

    - Social studies, geography, English, computing, science, art, photography, physics.

2. What have you learnt from the EnviroPower project?

    - How to conserve energy.
    - Learning about renewable energy.
    - Various ways to save power.
    - Alternative energy and fossil fuels.
    - Resource depletion and energy conservation.
    - How important fossil fuels are and how they affect us.
    - Hair straighteners and driers use a lot of electricity.
    - Peak oil.
    - How much power things use.
    - What might happen in the future in terms of power.

3. Have you changed your habits with regard to energy usage at home? At school? How?

   - We use energy efficient light bulbs.
   - I no longer use my electric blanket. We have stocked up on woollen blankets.
   - Eliminate standby on TV.
   - Turn off lights.
   - I am more aware of energy use at home.
   - Shutting down unused appliances.
   - At home I use more power. Because I save power at school I can use as much as I like at home.

4. Do you think that energy issues will be more important in the future? Why?

   - Yes because many finite fuels are still being used.
   - Yes. We cannot continue the way we are.
   - Global warming is a big issue for me.
   - Prices of oil and gas are rising. Sustainable energy is more necessary.
   - Some of our resources are running out.
   - We need to conserve what we have.
   - Yes. Demand is rising and can't be met. I witnessed this in Sim City 4 where I couldn't afford a new power plant.

5. Do you have any other comments about EnviroPower?

   - EnviroPower has raised awareness. Without it we would know nothing.
   - It's a good project. It has made us aware.
   - It's great!
   - It's fantastic!
   - A fantastic project that will prepare us for the future.
   - It's a step into the future of power saving and generation.
   - It's a good project.

Critical Success Factors for future implementations

School Perspective

- Adequate financial resources, particularly financial support for capital and specialist assistance.

- School human resources in the form of:
  - Supportive school leadership.
  - Very active teacher champion.
  - More than one teacher directly involved in the project.
  - Technical support from a teacher.
  - Interested staff willing to incorporate ideas into teaching programmes and to change their own habits.
  - Ongoing professional support from the teacher champion and technical adviser.
  - A professional learning culture amongst the staff.

- Other support from:
  - School Board of Trustees.
  - Regional economic development agency.
  - Professional support and professional development from external specialists.
  - Voluntary assistance from other members of the community.
  - Stakeholder committee which meets regularly.
  - Active student involvement, promotion and presentations.

Technical Advisor Perspective: EcoInnovation

This job was very different from the typical client that we deal with on a daily basis. Normally we are at the coal face specifying and installing renewable energy generation for people that live off the grid and have a strong economic/environmental driver for their electrical power needs.

At Inglewood High School the criteria was education, conservation and grid tied generation - the future rather than the present.

Inglewood being close to our base meant travel distances and times were low, assisting in economic delivery of the project.

EcoInnovation looks forward to the day when Solar PV is economic and more people start installing this technology. We are installing 3 large PV arrays in Taranaki on new build houses at the moment, so change is starting to happen.

It is very refreshing that Venture Taranaki and the Ministry for the Environment have supported such an initiative. We all need to change and embrace the smarter use of energy and different ways of meeting the energy challenges that face us all, and having such organisations support this message is a good start.

Learned Outcomes

Things we can do better:

- Keep it simple, particularly in the area of data display where the use of off-the-shelf products, like the logging Centameter to display generation data, will streamline processes.
- Give the project time as people need time to change. A project like this needs a 12 month timeline.
- Achieving buy-in from the pupils, teachers and wider community is critical. To do this needs a solid push at the start, ongoing review, and strong maintenance along the way.
- Wider funding sources could be considered, such as funding from EECA to help with installating the solar hot water system.
- Allow more time for resource consent and building permits, as these issues can often take time and do not always happen as you might plan.
- Allow for delays in the delivery of equipment. Much of the equipment used in the pilot is still relatively rare and takes time to arrive, as stock is not always carried locally.
- Incentivize student involvement in the competition, and provide more information as to what would constitute a competitive entry.
- The launch. Getting some technology in place before officially launching would encourage early uptake. We launched and then had to wait for 6 months before the turbine went up.

Glossary of Terms

- Grid tied — Term used to indicate a connection to the national electricity network.
- kWh — Kilo watt hour. The standard unit of measure for electricity generation/ consumption. Equal to a 1000 watt appliance turned on for one hour.
- PV — Photovoltaic solar panels
- RAM — Random access memory. Computers store short term data in RAM.
- PC — Personal Computer.
- CPU — Central processing unit.
- LCD — Liquid crystal display (flat screen).
- LED — Light emitting diodes (lamp).

Appendix

Inglewood High School Energy Savings

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29 June 2008

Contents

Executive summary

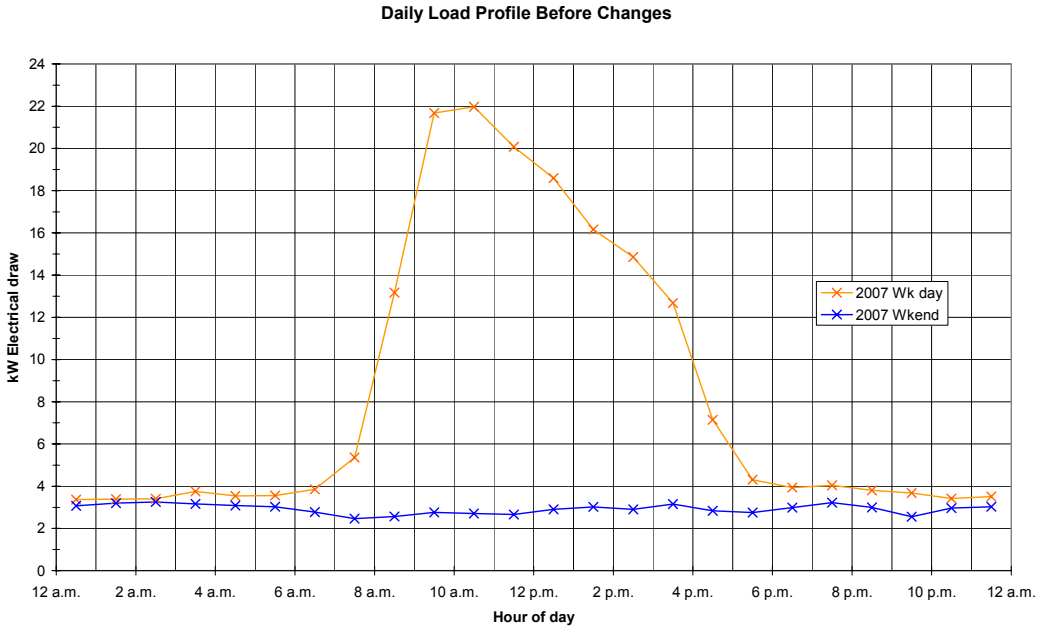
This report considers the energy savings achieved as a result of initiatives led by EcoInnovation at Inglewood High School.

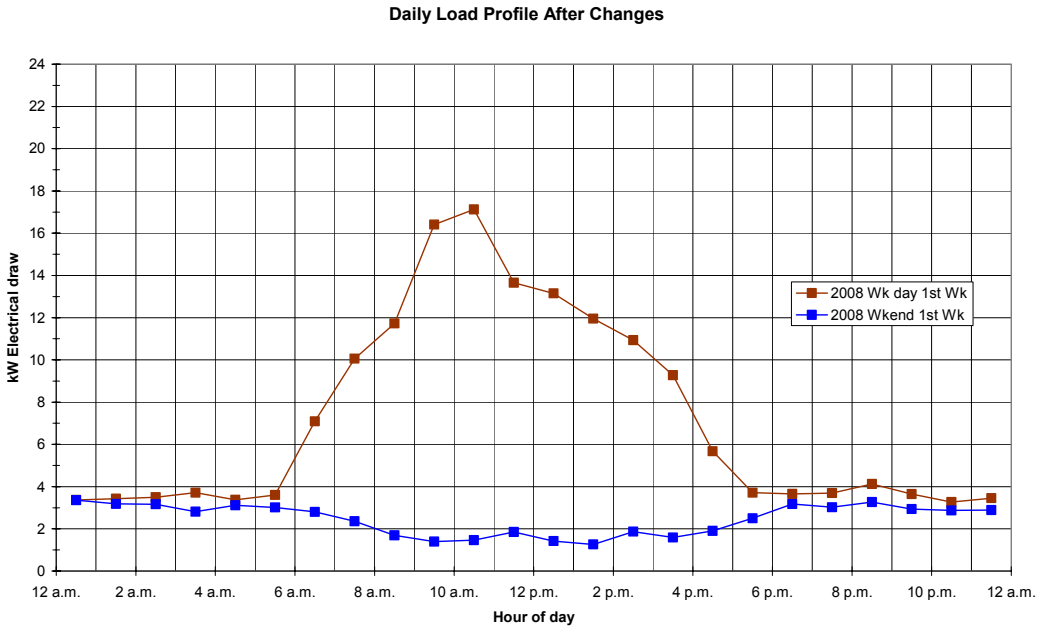
Inputs used for this report are:

- Log data of electricity consumed by the school at the power board meter for the whole school. Recording of log data was made by PowerCo and supplied in electronic format.
    - A set of reference log data is from before any changes were made.
      The reference log data is from 14/05/2007 11:16:01 to 7/06/2007 11:45:01
    - A new set of log data after changes were made.
      The comparison log data is from 19/05/2008 11:41:00 to 23/06/2008 12:01:00
- Comments regarding what happened during the logging:
    - A heating system failure on 25/5/08 which lasted for 2 weeks resulting in many small electric heaters
    - A water pipe break on 28/5/08 resulting in the use of industrial carpet drying equipment.
    - The school staff and students were not aware of logging until it was completed in 2007.
    - The school staff and students were not aware of logging until after the 1st week of logging in 2008.
- Knowledge of some of the changes made:
    - Grid tied Skystream wind generation
    - Grid tied photovoltaic generation
    - New strategies for water heating run time with time switches and added insulation to cylinders

Comparing the 1st week of log data in 2008 with all of the log data recorded in 2007 shows a 17% efficiency gain overall. This is a saving of 807kWhr per month which at 22c/kWhr is $178 per month.

The biggest gains have been made during the daytime, especially in the weekends. School daytime consumption is down by 22% and weekend daytime is down by 57%.





Power use

The provided power use data used for all calculations is a list of figures detailing electricity flow every minute for the logging period. This data in its raw form is very difficult to understand.

Actual energy flow in kW is used exclusively in this report. Other parameters such as kVA, power factor and harmonic distortion represent the quality of the load and are not part of this analysis.

The data has been processed into graphs and tables of various forms to provide an insight to the achievement in electricity conservation.

Daily power use profile

The log data is shown below for 2007 and 2008 respectively as a kW consumption rate line for each day.

1. In both 2007 and 2008 there are quite different daily load profiles between week days and weekend days
2. Peak power drawn by the school has reduced from 75kW down to 62kW.
3. The 2008 chart shows a small peak around 7am each school day when water heaters and other loads are turned on by time switch.
4. Weekend daytime power draw is now very low. There are a few minutes logged where the school was a net contributor of electricity to the national grid.

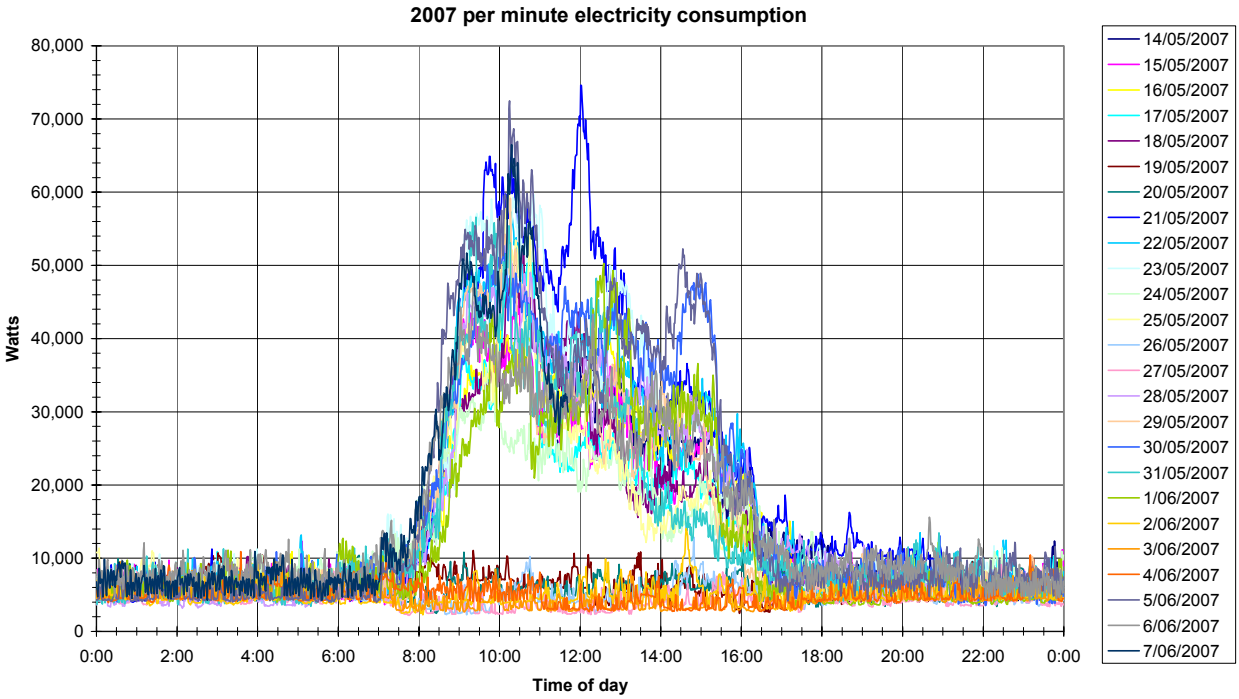


Figure 1: 2007 per minute consumption

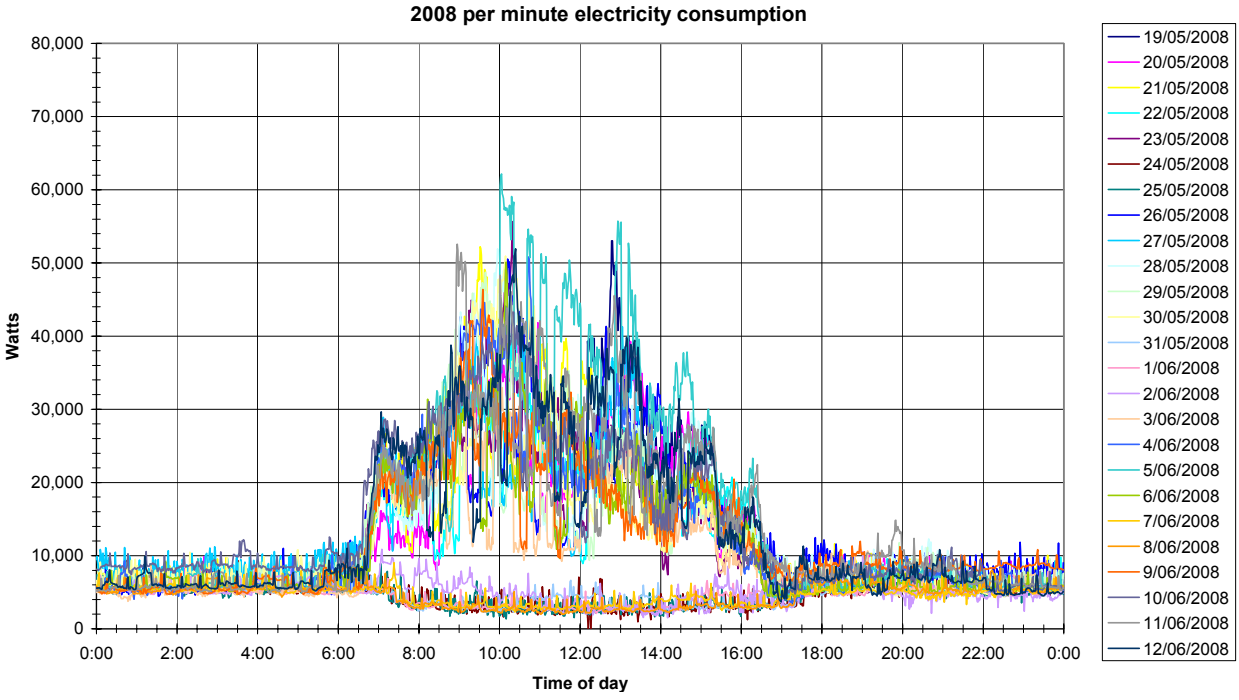


Figure 2: 2008 per minute consumption

Average daily power use

The log data was divided into hour blocks and totaled to determine;

- an average week day and
- an average weekend day.

There are three measurement assessment periods.

- 2007 reference data
- 2008 comparison data
- 2008 comparison data for just the 1st week before heating system and water leak problems occurred.

Data relating to Queens Birthday on 2/6/2008 and 4/6/2007 has been excluded as is not representative of a typical day.

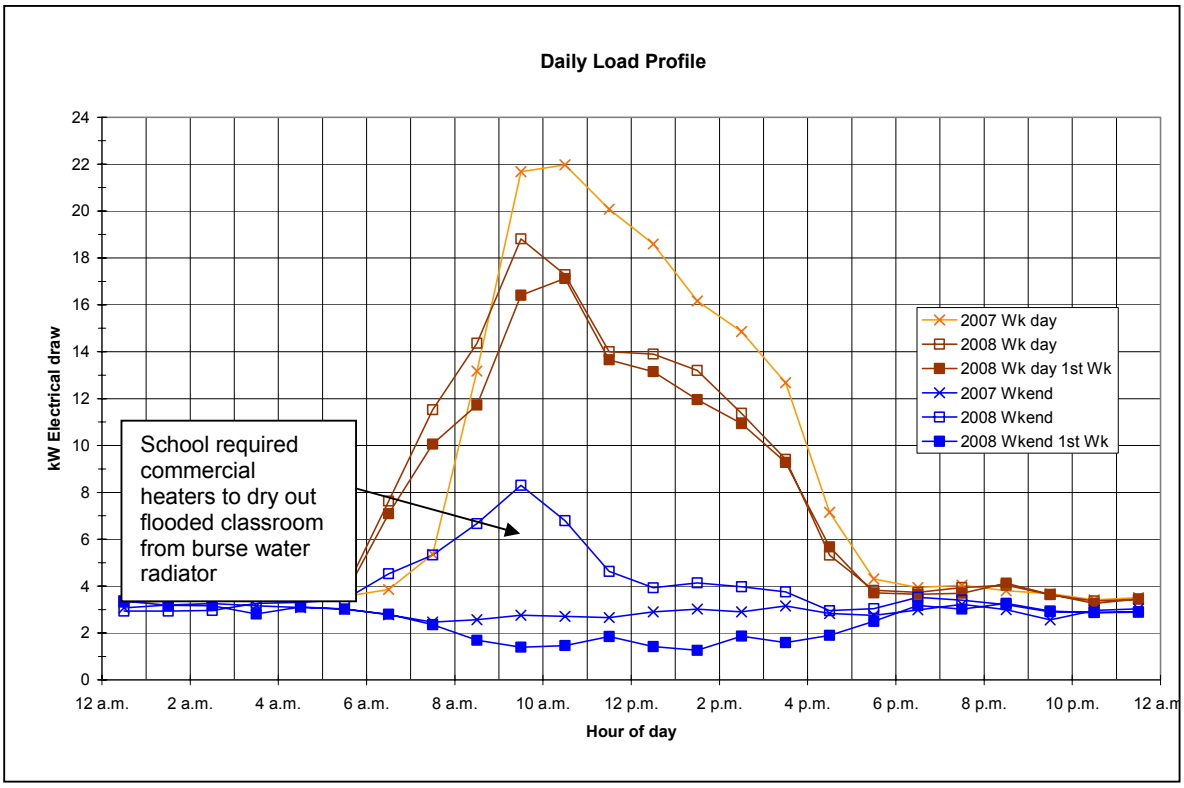


Figure 3: Per hour comparison

Figure 3 shows day time power usage as occurring from 6am to 5pm, 11hrs. This 'daytime' definition is used to distinguish between day and night time electricity use.

Below the tables gives the average kW electricity demand to run the school. This is from the same data set as in the chart above. The table is repeated considering just the first week of the 2008 log data.

Real power savings have been achieved since 2007. Energy savings are greatest during the day, particularly weekend daytime.

	2007	2008	Savings	Energy saved per month	
Weektime day	14.14 kW	12.44 kW	14%	367.95	kW hr
Weektime night	3.67 kW	3.62 kW	2%	17.01	kW hr
Weekend day	2.80 kW	1.95 kW	43%	182.94	kW hr
Weekend night	3.03 kW	2.96 kW	2%	19.64	kW hr
Totals	5,686 kW	5,098 kW	12%	587.53	kW hr

	2007	2008 1st wk	Savings	Energy saved per month	
Weektime day	14.14 kW	11.55 kW	22%	560.04	kW hr
Weektime night	3.67 kW	3.58 kW	3%	27.87	kW hr
Weekend day	2.80 kW	1.78 kW	57%	219.09	kW hr
Weekend night	3.03 kW	3.02 kW	0%	0.52	kW hr
Totals	5,686 kW	4,878 kW	17%	807.53	kW hr

The 1st week of the 2008 log data shows an energy conservation of 17% overall without a concerted effort by staff and students.

Considering the water leak and heating issues it is still impressive to see an overall energy savings.

A concerted effort without heating or other operational issues is likely to yield interesting, and better, results.

Electricity demand visualisation

Figure 4 Figure 5 below represent the power use graphically through each day and per day at the same time. Height represents electricity draw and the x and y axis the date and time of day respectively. This type of chart shows the changes in power use from week to week and between the two sets of log data.

Note that Figure 5 for the 2008 data has less height during the day and both charts show significant increases in electricity drawn after the 1st week in both cases.

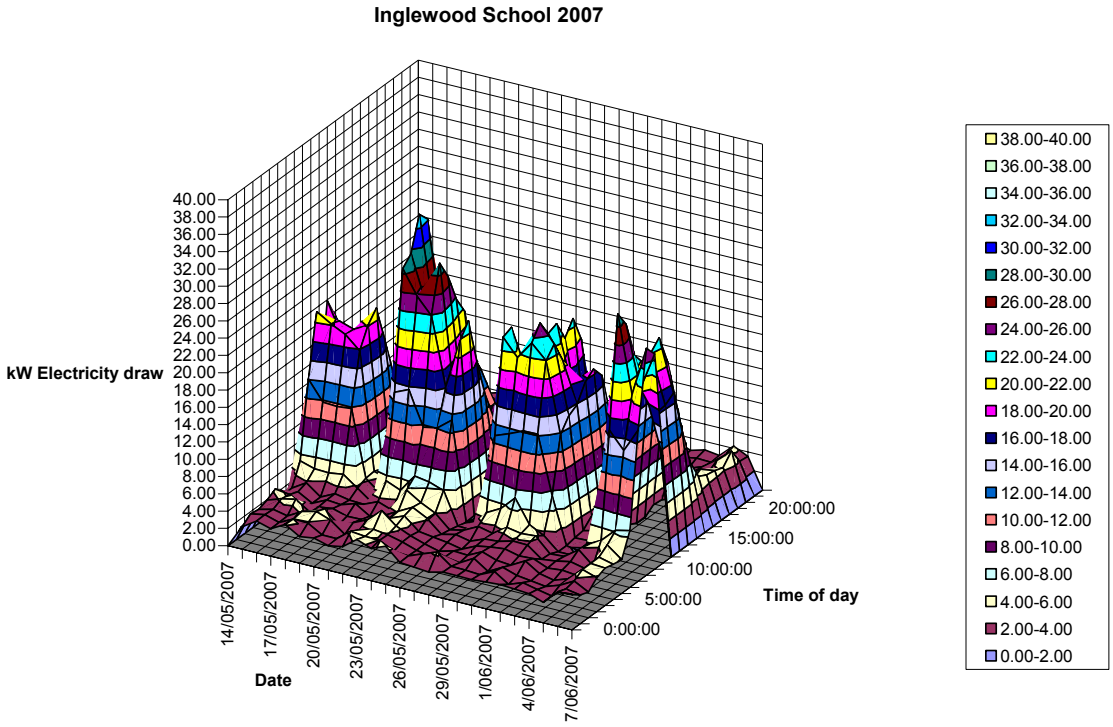


Figure 4: 2007 electricity use map

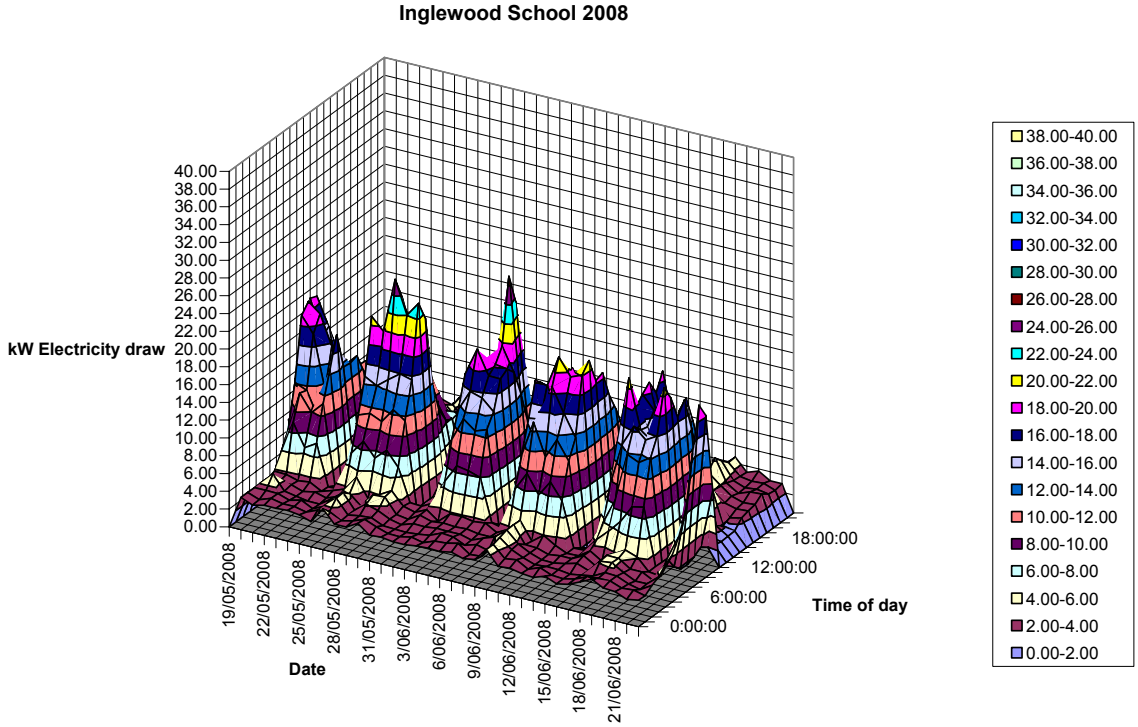


Figure 5: 2008 electricity use map