Technology assignment 2008

Portable Wind Turbine

Project done by:

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Age: 17
Year level: year 13
School: Otumoetai Collage
For: Transpower neighbourhood Engineers Award

(Technological Report included)

Possible problems that I could consider for my tech project

Problem 1 ~ my client is the orchard division manager for Seeka, the kiwifruit company which is responsible for two thirds of new Zealand's kiwifruit plus a lot more exported kiwifruit. He likes going camping out in the bush with his family. They usually drive in a ute out into the bush into a camping spot and camp within a 2-minute walk to the place where they set up their tent. The problem that they have is that in the holidays, they like to go for as long a camping trip out alone in the bush for as long as they can as this is what they enjoy to do. But they need lights, kettle, mini fridge, cell phones, GPS, radios and other small electronic devices whose battery life only lasts a maximum of 2-3 days. My client wants some way that he can charge the some batteries, which can run these devices so that his trip can be turned into a maximum of two and a half weeks.
Solution ~ a portable device, which harnesses the winds/suns energy that you can then use to charge electronic equipment like laptops, torches, GPS's and run mini fridges/kettles.
Advantages ~ this project is practical, affordable, challenging and achievable.
Disadvantages ~ because this device is not going to have a set location where it will be permanently set up, it would have to be designed for a wide range of locations and terrains.

Problem2 ~ my client does not want to have to turn on the watering system in the garden when ever there has not been rain for a couple of days.
Solution ~ a device, which automatically turns the sprinkling system on when the soil gets below a curtain moisture level.
Advantages ~ this device would be very practical and reduce a lot of
Disadvantages ~ this device would be extremely difficult to make and would require a lot of discipline in the research area.

Problem3 ~ my client would like a system that automatically cleans the leaves of the surface of the pull
Solution ~ Automatic system that self propels around collecting any leaves on the surface of the swimming pool.

Advantages ~ this device would mean the boring job of collecting the leaves in the pool would be cut down to practically never. The swimming pool would stay clean without the owner even having to think about it.
Disadvantages ~ this device would again be extremely difficult and would require a lot of first time designing without any direct research, as you cannot by these in the shops. My client also currently has a device that cleans the bottom of the pool automatically and it is attached to the pool pump via a pipe and this pipe would greatly interfere with the automatic leaf-collecting machine that I am considering.

Problem4 ~ my client has a BBQ on his deck and there is about two meters of overhang roof above the BBQ. The smoke comes out the back of the BBQ, up the wall, along the overhanging roof and then up into the sky. After a matter of weeks, the smoke starts to stain the white wall behind the BBQ.
Solution ~ system or unit, which extracts the smoke, as it comes out of the BBQ, up and out away from the wall
Advantages ~ this device is practical, as the wall will effectively and constantly be kept clean.
Disadvantages ~ an extracting fan system can be noisy and it will be within meters of the main entertaining area, which is a major draw back as it may be annoying due to the constant humming of the machine.

Problem5 ~ my client has two dogs and their food is kept in buckets. Every day the dogs get feed the buckets have to be opened, the right amount of food dished into each of the two dog bowls and then the buckets have to be closed again.
Solution ~ Dog food dispenser. A system, which holds all the food from the packet and when needed, releases the right amount into each bowl.
Advantages ~ decreases the hassle of feeding dogs, as it is quick and very easy. The whole system will look a lot tidier than two buckets siting on the floor with bricks holding the tops on.
Disadvantages ~ the system will have to some how close completely water tight because if even one drop of water gets in amongst the dog food, a large amount of it will puff up and go all soggy

Problem6 ~ during winter my client would like to use his pool but does not as it is too cold. And he wants a very very cheap solution
Solution ~ A pool heating system that is cheap to run. Possibly solar heated which will keep running cost down to almost zero.
Advantages ~ able to use the pool all year round which he might as well be since he is paying for the chemicals to keep it clean all year round any way.
Disadvantages ~ during winter it is cold which may affect possible solar heating system. On overcast days the possible solar heating system will be no good. A solar heating system will need space to be set up permanently and my client has limited room at his property.

Planning for research and writing a brief

	What I need to do	How will I do this	What resources will I need	How long will it take
Planning	-Plan my project.	- Identify any issues involved.	- Pen, paper - Computer	2.5 weeks
Stakeholders	- Identify stakeholders for project.	- Email - Management tools	- Pen, paper - Computer	0.5 weeks
Research	- Research materials, joining methods, finishing methods.	- Internet - Email	- Pen, paper	0.5 weeks
Key factors	- Identify key factors.	- Analyse any factors related to project and decide the importance of each.	- Pen, paper	0.5 weeks
Specifications	- Generated by key factors. - Always changing	- Consult with stakeholders.	- Pen, paper	Unknown
1st brief	- Constantly updating due to change in specifications.	- Design a brief to suit all specifications and key factors	- Pen, paper	Unknown

General workshop limitations

Casting box ~ 240 by 240 wide and 150 deep

Lathe ~ Can swing a maximum radius of 190
~ Can swing a maximum length of 9800
~ Spindle diameter is 33

Milling machine ~ Drop is 550
~ Sideways travel is 450
~ Forward/back travel is 150

Drilling machine ~ Drop is 100
~ Largest possible drill bit is 25.4

Vice ~ max open is 114

Storage space ~ Door is 2350 high and 700 wide
~ Room is 2650 high, 2700 long and 2000 wide

Sheet metal bender ~ max is 1500

Drop saw ~ can cut a piece of metal 170 wide maximum

Metal saw ~ can cut a piece of metal 200 diameter maximum

Angle grinder ~ maximum diameter griding blade is 9 inches

Stakeholder influences

Client ~ My client will be hugely affecting my project, as it will be constantly changed to suit his needs most affectively. He will also affect my project as he will decide the budget and be paying it, which means I will have to design my project to get maximum usage out of the money he gives me for the project.

Peers ~ peers also directly influence my project because they will constantly be around me whilst I am designing and building my project. They will be continuously commenting and suggesting better ways to do things. They will also give me fresh ideas and different points of views so that problems that I face are seen from all possible angles allowing for more effective solutions.

Mr Watson ~ Mr Watson affects my project, as he is my mentor. He will be affecting my project because he will be teaching me how to do things like weld, cut, bend and varies other things, affecting my project as I will be doing things the most efficient way which I would not be able to do on my own.

Scholl workshop ~ the workshop in which I build my project will greatly affect my project as its size, and available tools will limit my design to something that can fit in it and that can also be made by the tools that are there.

Me ~ I will affect my project probably the most as I will be thinking of the design and making it. I will affect my project because I will tend to do things or solve problems the way that I think will be best.

Osh ~ Osh will affect my project, as it will force me to design my project to be safe. A lot of the designing process for my project will be around trying to make a devise that is as safe as possible.

Council ~ the council may have an effect on my project for eco-friendly reasons.

Stakeholder ranking of most influence

Number 1 ~ client

I rank my client as most important as he will have the most influence on my project. All of the key factors will come from what he wants and the hole project will be suited for his needs i.e. what he likes and dislikes, its capabilities, how safe it is, how light it is, how he wants to transport it when he goes camping and how much it, when set up, fits into the environment.

Number 2 ~ me

I am ranking myself second because I think I will have the second largest influence on my project due to my limited skills in tech practise and limited prior knowledge of anything to do with the device I am going to make and so research will be critical in achieving my goals. I also think that I am going to have the second largest influence on my project because I will design most of what my client wants the way I think it will work and the whole project will come out the way I have visualised it to come out in the best possible way that it can to cater for my clients needs and specifications.

Number 3 ~ Mr Watson

Mr Watson is ranked third because he will show me how to build my project as skilfully as possible i.e. he will teach me the best way to accomplish what ever I want to do in the workshop.

Number 4 ~ school workshop

The school workshop is quiet an important influence because it has a whole set of boundaries and limitations that my project has to be between and they all have to be taken into consideration when designing my project.

Number 5 ~ Osh

Osh is ranked number four because no matter what I do or how effective the device is, it is going to have to be safe. Every single specification will be incorporated into the design of this device and they will all be accompanied by a safety factor.

Number 6 ~ peers
I have ranked my peers as five as they will not have a huge influence on the design but they will defiantly have a something to do with making the device just that much better by the comments and suggestions that they constantly throughout the year throw at me.

Number 7 ~ the council
The council is ranked number seven because although it has the least influence, it is still important because the device I am going to design will have to be eco friendly which has a definite affect on my design because it means there is a whole new criteria that it has to fit into.

Key Decision

Today I am going to make a key decision about my technological practise for the year

Issue ~ My client, his wife and three children do a lot of camping out in the bush. They drive out to one of their several nearby camping spots, set up a campsite and enjoy the environment, far from busy city life and troubles. They like going camping for at least a three days and so they take with them in their Ute all the food necessary for that amount of time as well as torches, essential electronic devices and lighting systems etc. they are unable to go camping for any longer than this time as their mini battery powered fridge, lighting systems and other small electronic devices will start to run out of battery life after this time period. My client wanted to be able to go camping with out the time restriction of the battery life of essential devices. Some way of charging a small battery bank that he could then in turn charge and run the electronic devices that are necessary when he goes camping is what he wants so that he could have more time to enjoy his camping trips and allowing for more time to relax and go on day tramps, exploring the surrounding area of the base camp.

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Key decision ~ I am going to make a portable system to charge a battery bank which my client can then run his small appliances off, run low watt lights off and charge small electronic devices from whilst camping

20/10/09 4:2

Option

The student has clearly identified the issues in a comprehensive and enterprising manner. He has investigated options and then clearly summarised and identified the problems he will be undertaking.

First consultation with Client

1) What is the maximum weight limit for the whole system, when packed into the container?

10kg

2) What is the maximum size that the transporting container can be for the battery charging system?

max space limit available for entire device is 40cm x 60cm x 1m long

4) What type of finish is required?

One which blends in with the enviroment without disregarding safety.

5) Where will the system be situated?

It will be situated behind the tent which the Laptop is in.

6) Is there any material you would prefer the device to be made out of?

The materials which are going to make it most suitable for its purpose.

7) Any other general specifications?

Quick and easy to set up.

Client signature

Roy Anderson Anderson

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Options
A description of the considerations to be addressed.

Key factors

Safety ~ safety is a key factor and is important because there will be a large amount of human interaction involved when this device is in full operation. Safety is also important because this device will most likely be used far away from any hospital so it must be designed so it cannot cause any unnecessary injury. The devices purpose is to extend the amount of time that my client can go camping and if it is unsafe, it will only end up decreasing the time he goes camping for, as he will have to come back for injures from it, which is not what is wanted so it has to be safe.

Durability ~ durability is a key factor and is important because this device will be used in the bush so it has to be rugged. The worst possible weather conditions that it has to be able to withstand will have to be seriously considered because if it just blows over when the wind speed is greater than 10 ms, there is not much point in have it. Durability is also a key factor because it must last a long time without it having to be repaired of fixed so it should be simple. This is a camping device and when you go camping, slipping, falling and tripping over is a huge factor to consider and so the device has to be able to withstand a few drops and bumps.

Budget ~ budget is a key factor and is important because it is a huge project restriction and so every single decision made to do with this project has to have some sort of budget consideration aspect to it. One of the most important things to do is to design the project to get maximum usage out of the budget without pushing safety to the side.

Materials ~ materials is a key factor and is important because the right materials have to be chosen to make the device light weight and operate with little maintenance. The materials also have to be right in order for the device to function efficiently and not break.

Efficient ~ efficiency is a key factor because in order for this device to be worth carrying the extra weight around it has to 100% succeed in accomplishing what it is wanted for or it must be able to charge a laptop every two days at least and it would make carrying it around even more worth while if it could charge a couple more extra small things like torches, cell phones ect.

Weight ~ weight is a key factor and is important because when camping without the wind turbine, you are already carrying a lot of weight i.e. food, clothes, water, tent ect. In order for this not to be a pain to carry, it has to be as light as possible. The aim is to make so you hardly know that you have it when walking but gain a lot when it is set up and operating normally.

Compactable ~ compactable is a key factor because it means the device (without getting much heavier) can be quite tall and wide, so long as it can fold down into a smallish container. The device also has to pack into a small container because a person will carry it and if it is too big it will be awkward and uncomfortable to carry. The aim is to make the person carrying it, notice it as little as possible and compact ability and weight is the key to achieving this.

Maintenance ~ maintenance is a key factor because you do not want to have to spend many hours of repairing and cleaning this device because this would make it impractical and annoying to use. As this device will only be used during holidays or long weekends when my client is most likely to be going camping, due to the time between usage of the device, there is lee way for a small amount of maintenance needed like maybe a quick clean with a cloth or a small part or two changed but nothing dramatic.

Weather proof ~ weatherproofing is definitely a key factor because this device will be operating out in the bush with no shelter covering it. So it will be getting directly hit with the sun and rain. This means the device will have to have and exterior material/paint that can stand up to long hours of direct sun shine and be water tight enough so that when it is in normal operation, the electronics inside it do not get wet.

Noise level ~ this device will be operated probably quit close to where the tents will be set up because the laptop (or other small device) will want to be kept in the tent whilst being charged for protection from weather and accidental nocking or bumping. Due to the device having to be operated so close to where people will be sleeping, it has to be able to operate reasonably quietly.

Personal limitations ~ my limitations are quite an influencing key factor as I will only be able to what I am capable of doing, but Mr Watson is my mentor and he will be able to guide me through whatever I am finding hard to do so most tasks in the workshop I should be able to do with guidance where necessary.

Workshop limitations ~ du to the size restriction of the workshop, my project will have to be designed so it can be stored in the store room and fit through the door ways ect. As my project will be designed to fold down into a small container, I do not feel storeroom space is going to be an issue. The device that I design, will have to be designed with respect to the limitations of the machinery in the workshop i.e. the maximum size piece of metal each tool can cut and what the tools can and can not do.

Research limitations ~ research is a key factor because there are not many small, portable, natural resource powered, laptop charging devices on the market today. Research will be on small residential power producing systems and some industrial power producing systems and I will have to adjust aspects of these to suit and improve my project.

Quick set up and pack away ~ this I think is one of the more important key factors for pure convenience sake. Because if the device is hard to put up it will be annoying to do and it will become a chore. It must not become a chore, you must be able to set it up in under five minutes and it must be just so easy that know one minds setting it up. It also has to be quick and easy to set up and put away because if the user is moving around the bush every couple of days, they do not want to spend two hours setting this device up every time they move camp spots. If it was ideal, it would be as easy putting this device up as it is putting a basic two man tent up if not, this device should be even easier than putting a basic two man tent up.

Other minor key factors

Cultural diversity ~ considered but nothing done as it does not affect my project.

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Optio
The student explains how the complexities of the situation have been identified and are to be explored.

Community participation ~ this is a key factor because I have to design this project so that it suits every one who has something to do with it when it is finished. This can easily be achieved by involving my stakeholders as much as I possibly can to produce a project, which everyone is happy with.

Equity and integrity ~ acting responsibly being accountable and acting ethically by not wasting and having copyright consideration with my research.

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Options
The student has identified initially many considerations and key factors reliant on his technological outcome. He has explained in detail how they relate to the problem and within his description given possible scenarios to explore.

Influences of key factors on each other

Safety/budget ~ safety and budget influence each other because no matter what budget you have for anything, safety should not be pushed aside because you do not have enough money to add something else to whatever you are making. It is far better to design your project and make a bit more basic so to keep the cost down but still making it safe than to exceed you budget on other things and not take safety into account.

Safety/weight ~ safety and weight influence each other because if my device is way to heavy, it could injure the carrier of the device by straining there back. It has to be light in order for it to be safe to carry.

Durability/materials ~ durability and materials influence each other because if the device is not made out of the right materials for the intended conditions of use, it will not last and it may break easily which makes it not durable at all.

Durability/budget ~ durability and budget influence each other because in order for the device to be durable it has to be made out of the right materials and the right materials may cost allot so the cost of the materials to make the device durable have to be taken into consideration.

Durability/compact ability ~ durability and compact ability influence each other because if the device is super compactable, it is going to have a lot of joins and folding pieces so it can compact. This is all well and good for the compactable side of things but when it is set up, there are so many joins and hinges that the whole device is rickety and unstable. This shows that a fine balance between the two has to be established.

Budget/weight ~ budget and weight influence each other because in order to keep the weight of the device down as low as possible well still keeping it durable and tough I am going to need to buy light weight and strong materials which will affect the budget as you pay a lot more for light strong metal than you do for heavy strong metal.

Compact ability/research ~ compact ability and research influence each other because I will have to be disciplined in the research area to find out how to further improve the compact ability of the device from what I come up with myself.

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Compact ability/weatherproofing ~ compact ability and weatherproofing influence each other because if it is going to be able to fold down into a small container, it may have quite a few joins which will all have to be some how sealed from the rain. So ideally I have to make it fold down to as small as possible using the least amount of joins as possible to cut down on the amount of sealing that I have to do.

Compact ability/noise level ~ compact ability and noise level influence each other because probably the easiest way to make it compactable is to have it break up into heaps of pieces but the more pieces it breaks up into means more pieces that have to be assembled. The more pieces that you assemble via nuts, bolts and screws, the more rickety the whole structure is going to be and if it is say a wind turbine sort of set up, it will rattle a lot when operating. So the aim is to make it fold down as small as possible but also assemble into as solid a structure as possible.

Compact ability/easy to assemble and disassemble ~ compact ability and assembly or disassembly influence each other because you want the device to fold into a small container but you don't want to have to sit there with a screw driver, pliers and a hammer for an hour putting all the pieces together. So I am going to make it as easy as possible to assemble with as little as possible parts to put together as possible and if there are any nuts and bolts needed you will be able to do them up with your hands or else a handy little screw driver which attaches to the device ect.

Budget/efficiency ~ budget and efficiency influence each other because if I want to the device efficient any parts that I have to buy will have to be high quality and any parts that I make will have to be made extremely precisely. Buy high quality parts that I am unable to make for what ever reason affects make the budget as they will cost a bit more than just standard budget or mass produced parts.

Materials/weight ~ material and weight influence each other because whatever material is used, the weight will get directly affected. This device has to be very light and very strong so the materials that will have to be used will be light and strong.

Materials/maintenance ~ materials and maintenance influence each other because if the device is not made out of the right materials it will often break or ware out and then it will constantly have to be maintained and repaired. I want to make it out of materials that will only ware out after many hours of use and I want to make it so that the pieces that are most likely to ware out can very easily be replaced so it can be back up and running in no time at all.

Materials/weather proofing ~ materials and weatherproofing influence each other because exterior materials need to be able to stand up to constant exposure to the sun and rain. This means the paint on the outside of the device must be good quality and not peel from constantly being in direct sunlight (it may not always be in direct sunlight but if I paint it with paint that can withstand constant sunlight then it wont matter if the device is the sun constantly as it will be able to handle it). And if the device is not painted it must be made out of a material that does not rust.

Compact ability/my limits ~ compact ability and my limits influence each other because making the device compact or able to be folded down into a very small container is going to be challenging and time consuming. If I plane everything that I aim going to build and have good time management skills with guidance from Mr Watson I should be able to accomplish what I set out to do.

Noise level/research ~ noise level and research influence each other because blade designs will have to be researched so I can find one with a high power out put for a low noise level.

Order of importance of key factors

1) **Safety** ~ safety is number one because it is the single most important key factor. It is the most important key factor because if the device is not safe, it cannot be used. Safety is also the most important key factor because the device will be used far from any hospital so in actual fact, it has to be extra safe as if it hurts some one, it may be hours before they can get to a doctor which could result in long term affects.

2) **Budget** ~ budget is placed at number two because it is also very important. It is important because it always has to be taken into account and it will affect every decision I make about my project. Budget is also very important because I will have to design my whole project around the budget to get as much as I possibly can out of the money that I am given.

3) **Durability**
Noise level
Easy to set up and pack away
Weather proof
Maintenance
Weight
Efficiency ~ these seven key factors are placed at number three because they are all as important as each other or they are equally important. As well as considering safety and budget, making my design fit the above seven key factors will be the most challenging part of the design and build of this device. These seven key factors will be the hardest to overcome as well as the most influencing on the project as far as trying to achieve them goes.

4) **Personal limits** ~ personal limits is placed at number four because although they are important, they can be easily overcome buy means of research or asking for guidance from my tech mentor.

5) **Workshop limits** ~ workshop limits is ranked as least important (still quite important) because it can be almost completely over come by designing around the limits. It is important if parts have to be made bigger than the workshop can handle because then they have to be sent somewhere else to be made.

1^{st} design brief

Brief ~ design and make a portable power generation system to charge a battery bank.

Specifications

~ The device must be **lightweight**. My client wants the device to be 10 kg or less in total.

~ The device must be **easy to set up and pack away**. My client wants the device to be as easy to set up as possible i.e. take no longer than a tent takes to set up. So I will set a goal of: any person must be able to set the device up into full operating mode in eight minutes or less.

~ The device must be designed and made for **under $120**

~ The device must be **safe**. My client wants the device to be as safe as possible to minimise unnecessary accidental injury. The device must be safe enough for anyone to use and be around with out getting harmed by it in any way.

~ The device must be **compactable**. My client wants the device to fold down into a container with measurements of one metre long. 30 cm high and 30 wide and the whole thing being a rectangular shape. This way, the whole thing can fit in his ute

~ The device must use power-generating systems that can charge up the battery bank as quickly as possible. It is understood by me and my client that you will not be able to charge everything all at once and expect the generating source to keep up but the size of battery bank and average amount of energy going into the battery bank and amount of usage will have to be looked into so that I can find a good balance between cost, efficiency and practicality.

~ The device must be **weather proof**. Which means that it must be able to permanently stay outdoors and not get damaged from rain and sun.

~ The device must be **durable,** i.e. it must be made strong so it is not all fragile and cant take a bit of bumping around. This I because were my client drives his car to go camping, they may not always be roads so it will not be a nice smooth drive to the set up destination and the way that the generator and container are designed and built must account for this possibility.

~ The device must be **easily maintained**. This means that the moving parts must not ware down over a short period of time and if the parts waring down can't be helped, they must be buyable, cheap and very easy to replace.

~ The device must be designed to produce the smallest amount of **noise** possible, it is likely that it will be used close to ware the user will be sleeping and because the device will most likely be operating throughout the night, it must be quiet enough so the user can get to sleep.

~ The **materials** used must be the most suitable materials to make it **light weight, durable and weather proof**.

Specification list

1) Safety

2) Built/designed for under $120

3) a) Durability

b) Noise level

c) Easy to set up and pack away

d) Weather proof

e) Maintenance

f) Lightweight

g) Efficiency

h) Charge the laptop as quickly as possible i.e. use the most efficient and reliable type of generating means as the budget will allow

General research planning

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Options
Initial planning outline.

What I hope to achieve

~ First I will try to find out what methods are in use today for producing electricity from natural resources.
~ Then I hope to find out the best and most efficient method of producing electricity using the resources that one would have access to when out in the bush.

How this will be done

~ I am going to start by looking at the bigger picture. I will first investigate into industrial methods of producing electricity from the resources that you would have if you were out in the bush i.e. wind, water, solar and fire (combustion of wood).

~ I will then narrow my research down to residential sized methods (residential sized methods of producing electricity using natural resources will probably be as close as I am going to get to "portable").

~ I will then do some more in depth research on my client approved method of producing electricity.

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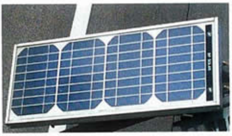
Options
There was opportunity here to better describe the safety factors regarding the use of electrical tools.

Solar panel



A photovoltaic (PV) module that is composed of multiple PV cells. Two or more interconnected PV modules create an array.

A **solar panel** is a device that collects and converts solar energy into electricity or heat which can be used by (for example) nearby buildings. Solar photovoltaic panels can be made so that the sun's energy excites the atoms in a silicon layer between two protector panels. Electrons from these excited atoms form an electric current, which can be used by external devices. Solar panels were in use over one hundred years ago for hot water heating in homes. Solar panels can also be made with a specially shaped mirror that concentrates light onto a tube of oil. The oil then heats up, and travels through a vat of water, instantly boiling it. The steam created turns a turbine for power.

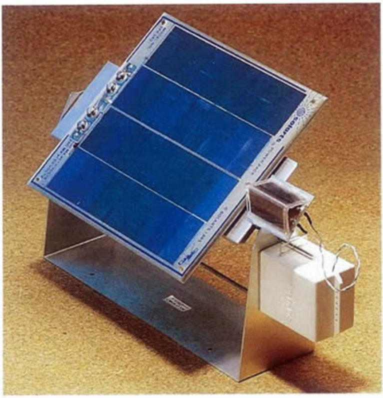
How Solar Panels Work

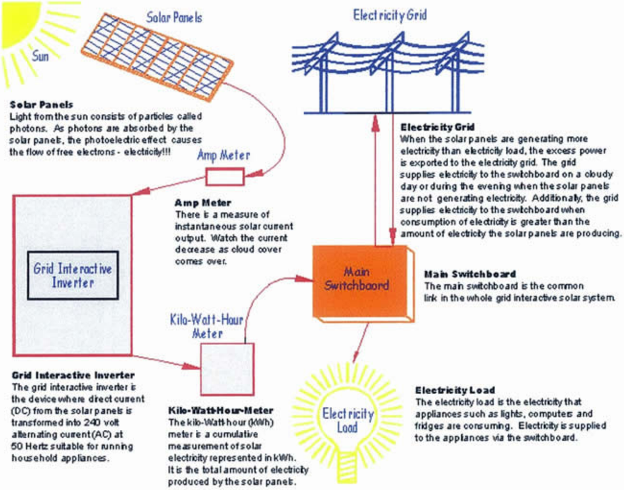
The basic element of solar panels is pure silicon. When stripped of impurities, silicon makes an ideal neutral platform for transmission of electrons. In silicon's natural state, it carries four electrons, but has room for eight. Therefore silicon has room for four more electrons. If a silicon atom comes in contact with another silicon atom, each receives the other atom's four electrons. Eight electrons satisfy the atoms' needs, this creates a strong bond, but there is no positive or negative charge. Silicon atoms combine for years to produce a large piece of pure silicon. This material is used on the plates of solar panels. Combining silicon with other elements that have a positive or negative charge can also create solar panels.[5]

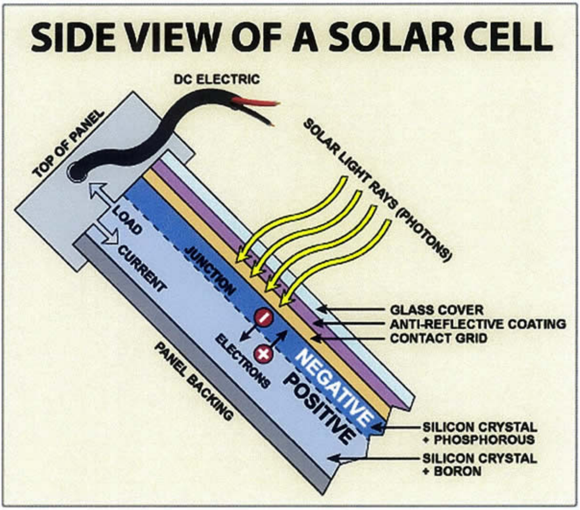
For example, phosphorus has five electrons to offer to other atoms. If silicon and phosphorus are combined chemically, the results are a stable eight electrons with an additional free electron. The silicon does not need the free electron, but it can not leave because it is bonded to the other phosphorous atom. Therefore, this silicon and phosphorus plate is considered to be negatively charged.[5]

A positive charge must also be created in order for electricity to flow. Combining silicon with an element such as boron, which only has three electrons to offer, creates a positive charge. A silicon and boron plate still has one spot available for another electron. Therefore, the plate has a positive charge. The two plates are sandwiched together to make solar panels, with conductive wires running between them.[5]

Photons bombard the silicon/phosphorus atoms when the negative plates of solar cells are pointed at the sun. Eventually, the 9th electron is knocked off the outer ring. Since the positive silicon/boron plate draws it into the open spot on its own outer band, this electron doesn't remain free for long. As the sun's photons break off more electrons, electricity is then generated. When all of the conductive wires draw the free electrons away from the plates, there is enough electricity to power low amperage motors or other electronics, although the electricity generated by one solar cell is not very impressive by itself. When electrons are not used or lost to the air they are returned to the negative plate and the entire process begins again.[




Sun
Solar Panels
Electricity Grid
Solar Panels
Light from the sun consists of particles called photons. As photons are absorbed by the solar panels, the photoelectric effect causes the flow of free electrons - electricity!!!
Amp Meter
Electricity Grid
When the solar panels are generating more electricity than electricity load, the excess power is exported to the electricity grid. The grid supplies electricity to the switchboard on a cloudy day or during the evening when the solar panels are not generating electricity. Additionally, the grid supplies electricity to the switchboard when consumption of electricity is greater than the amount of electricity the solar panels are producing.
Amp Meter
There is a measure of instantaneous solar current output. Watch the current decrease as cloud cover comes over.
Grid Interactive Inverter
Main Switchboard
Main Switchboard
The main switchboard is the common link in the whole grid interactive solar system.
Kilo-Watt-Hour Meter
Grid Interactive Inverter
The grid interactive inverter is the device where direct current (DC) from the solar panels is transformed into 240 volt alternating current (AC) at 50 Hertz suitable for running household appliances.
Kilo-Watt-Hour-Meter
The kilo-Watt-hour (kWh) meter is a cumulative measurement of solar electricity represented in kWh. It is the total amount of electricity produced by the solar panels.
Electricity Load
Electricity Load
The electricity load is the electricity that appliances such as lights, computers and fridges are consuming. Electricity is supplied to the appliances via the switchboard.


SIDE VIEW OF A SOLAR CELL
DC ELECTRIC
TOP OF PANEL
SOLAR LIGHT RAYS (PHOTONS)
LOAD
CURRENT
JUNCTION
GLASS COVER
ANTI-REFLECTIVE COATING
CONTACT GRID
ELECTRONS
NEGATIVE
POSITIVE
PANEL BACKING
SILICON CRYSTAL + PHOSPHOROUS
SILICON CRYSTAL + BORON

Steam engine

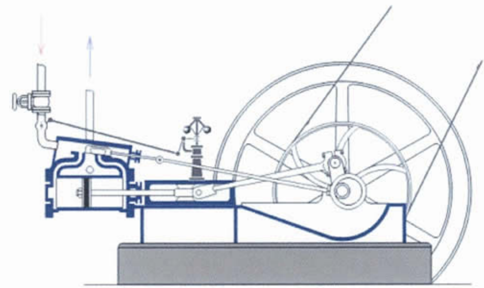
The term steam engine *may also refer to an entire railroad steam locomotive.*
The engineering definition of a steam engine is an external-combustion[*citation needed*] heat engine that converts heat energy in steam to mechanical work. There are two fundamental forms of steam engine: reciprocating (piston engine) and rotary (the steam turbine). In normal usage, 'steam engine' refers specifically to the reciprocating type; technically, however, both are heat-engines that use the Rankine cycle common to all engines that use steam as their working fluid.

Steam engines were the power source that made the Industrial Revolution possible. From 1712, when the Newcomen steam engine was first introduced to pump water from mines, continued development allowed the use of more advanced engines in a wider variety of applications. Steam engines saw widespread commercial use powering machinery in factories and mills and powering industrial utilities such as water and sewage pumping stations. In the 19th century, following Richard Trevithick's successful use of high-pressure steam, steam engines were developed as the prime mover for transportation in railway locomotives, steam ships, traction engines, and road vehicles such as the steam car and steam waggon.

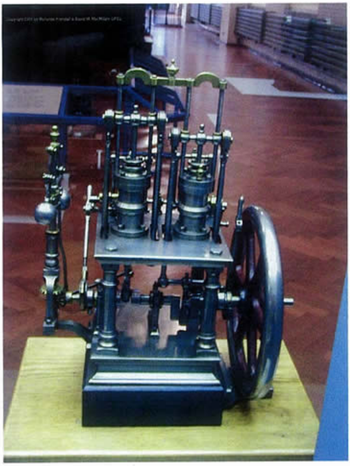
Steam engines remained the primary source of mechanical power well into the 20th century, until technological improvements in the design of internal combustion engines and electric motors rendered them 'uneconomical'. Nevertheless, steam engines (in the form of turbines) are still vitally important to the world economy, generating about 86% of all electric power used throughout the world.

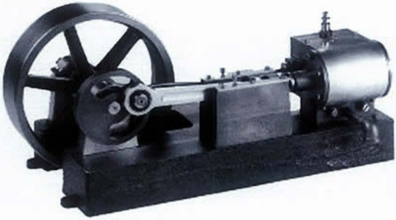
Functional overview

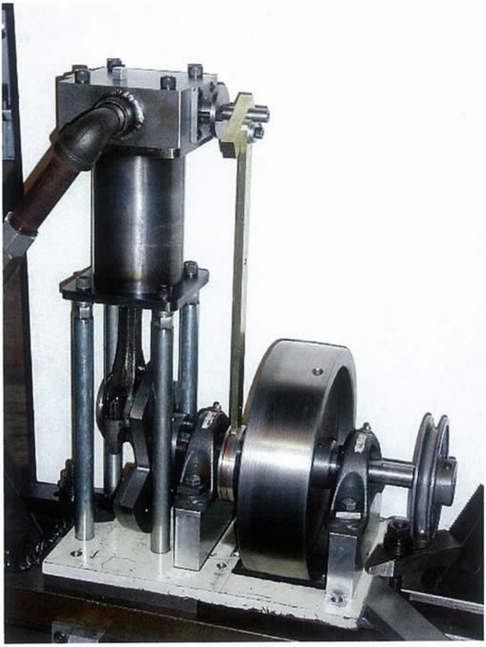
A steam engine requires a boiler to heat water into steam. The expansion of steam exerts force upon a piston or turbine blade, whose motion can be harnessed for the work of turning wheels or driving other machinery. The expanded steam must be condensed and reused, or replaced by a source of cold water. This 'feedwater' is typically pumped up to a high boiler pressure. As in a pressure cooker, pressure raises the boiling point, and this is essential to run the turbine efficiently and effectively. One of the advantages of the steam engine is that any heat source can be used to raise steam in the boiler, the most common being the combustion of wood (biomass), coal or oil. In general, these fuels are more economical to use than the fuels that can be used in internal combustion engines. More than 50% of all electric power production is by use of coal-fired Rankine steam cycles.



A steam engine in action.







Pressure cooker

~ After doing this research into steam engines, I realised that my mum had a pressure cooker used to cook and tenderise meat.

~ I wanted to see if I filled the pot up with water and then put it on the stove and let the water boil, could I funnel the steam so it is coming out of a small hole and then use it to turn a propeller. If this worked, it could be quite good for my client when he is camping as he could use some wood to make a fire, full the pot up with water, with a small turbine attached to the top of the pot which charged a battery.

Experiment planning

What I hope to achieve ~ I hope to semi pressurise the steam in a pot full of boiling water by funnelling it out of the pot through a small hole.

How this will be done ~ I will full a pressure cooker/pot up with water and then put the sealed top on (with hole in top). Then I will try varies size outlet holes and see if the steam coming out of the cooker is forceful enough to turn a small propeller. The propeller will be held so it is free to spin horizontally and I will see how that compares to it being free to spin vertically.

Pressure cooker test

~ First I used the pressure of the steam coming out of the 1 cm hole in the top of the pressure cooker and that could not turn the small plastic propeller no matter how I held the propeller.

~ Then I securely fastened a narrower metal tube to the top of the pressure cooker, this made quite a difference to the force of the steam coming out but it was still not a lot. It could barely keep the propeller spinning horizontally and couldn't start the propeller from rest but when I turned the propeller so it was spinning vertically, it spun a lot faster and the steam could easily start the propeller spinning from rest. Even though the propeller went quite fast, maybe 50 rpm, the amount of toque that needed to be applied to the propeller axle was so small, meaning if there was any opposing toque (at all) on the axle, there is no ways it would turn

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Options
The student demonstrates synthesis and integration of technological experiences in bringing together knowledge skills, ideas and methods to allow their technological outcome is to be realised.

Test conclusion

~ From my pressure cooker test, this idea has got potential but if it is going to work, it would definitely need some sort of real pressurise system so less energy is lost into the surrounding area like it was in my experiment. The whole propeller will need to also be enclosed to try get as much energy as possible out of the exiting steam.

Further research into the pressure cooker concept

~ I have conducted some research into this concept and found some one whom has actually designed a turbine that mounts on top of a pot and uses steam to turn it. The turbine mounted on top of the pressure cooker is a tesla turbine, which I also looked into to see how they worked.

Hydro

Hydro Power is one way we continue to help provide electricity to New Zealand.

Our Hydro Power Stations

Hydro power means electricity generated from water and it is the most common way of producing electricity in New Zealand. Hydro-power generation is a renewable form of generation and is a very efficient method of converting available energy into electricity. We own and operate three hydro power schemes in New Zealand.

What is a hydro power scheme?

A hydro power scheme generally has four main components:

1. Dam/intake

A dam is used to impound water for storage in a reservoir for use at a later date. The higher the water level (or head) in a reservoir, the more potential energy there is available for generation.


Moawhanga Dam

Intake structures divert water flow from a river, stream or lake to a power station.

2. Penstock

A pipe or series of adjacent pipes that carry water from a reservoir to the power station is known as a penstock.

3. Power Station

Contains the turbine and generator that converts water energy into electricity. The water is fed into the turbine blades and the force of the water turns the turbine, which turns the generator.

Tokaanu Powerstation

4. Tailrace

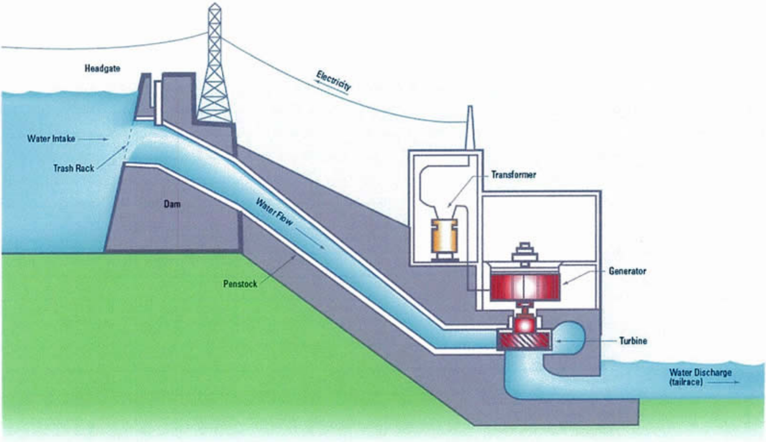
Water is released from the power station back to a river, stream or lake. Often via a man-made channel called a tailrace.

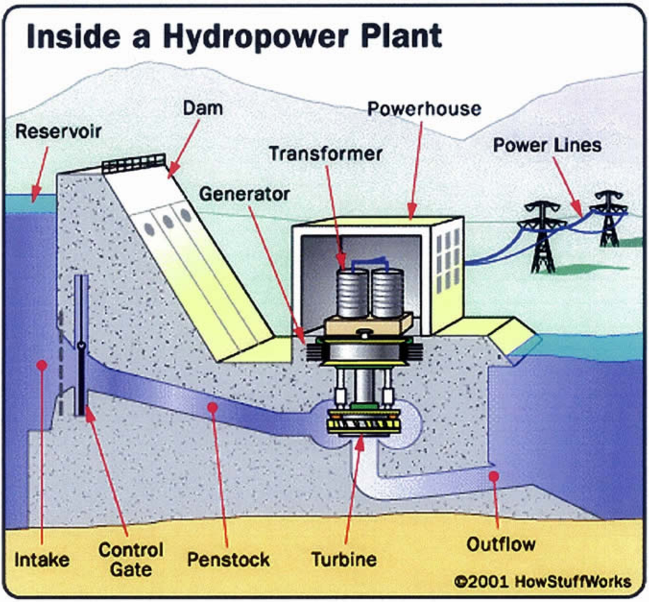
The picture below shows how water moves through a power station to produce electricity. The numbers below apply to the numbers on the picture:

1. Water is required to turn the turbine runner
2. Which turns the generator
3. The generator produces electrical power
4. A transformer boosts the voltage to supply the national electricity grid

Tokaanu Tailrace

The amount of electricity produced by a hydro power station depends on the rate at which the water flows and the difference in height between water at the reservoir and the water at the turbine.


Headgate
Electricity
Water Intake
Trash Rack
Dam
Water Flow
Transformer
Generator
Penstock
Turbine
Water Discharge
(tailrace)


Inside a Hydropower Plant
Dam
Powerhouse
Reservoir
Transformer
Power Lines
Generator
Intake
Control
Gate
Penstock
Turbine
Outflow
©2001 HowStuffWorks

Wind turbine

Wind turbines near Aalborg, Denmark. For scale, a standard doorway can be seen at the base of the pylon.

A wind turbine is a rotating machine that converts the kinetic energy in wind into mechanical energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill. If the mechanical energy is then converted to electricity, the machine is called a wind generator, wind turbine, wind power unit (WPU) or wind energy converter (WEC) .

Using the wind to create electricity has been around for a long time - you've probably seen windmills on farms. When the wind turns the blades of a windmill, it spins a turbine inside a small generator to produce electricity, just like a big coal power plant.

A windmill on a farm can make only a small amount of electricity - enough to power a few farm machines. To make enough electricity to serve lots of people, power companies build "wind farms" with dozens of huge wind turbines.

Wind farms are built in flat, open areas where the wind blows at least 14 miles per hour. Iowa currently has more than 600 wind turbines, producing enough electricity to power 140,000 homes. Minnesota and Wisconsin are also home to wind farms – and the number is growing every day.

Some schools in the Midwest have their own wind farms! In Spirit Lake, Iowa, the school playground is right underneath two wind turbines.

View a photo of the Spirit Lake school wind turbines

They sure are big!

When it comes to size, bigger is better – the bigger the wind turbine, the more wind it reaches and the more electricity it produces.

The turbines at Flying Cloud Wind Plant in northwest Iowa are about 240 feet tall. The largest wind turbine in the world, located in Hawaii, stands 20 stories tall and has blades the length of a football field!

The tower is usually hollow and made of steel. The blades, called rotors, are made of fiberglass and polyester.

View photos of the Spirit Lake wind turbines being built

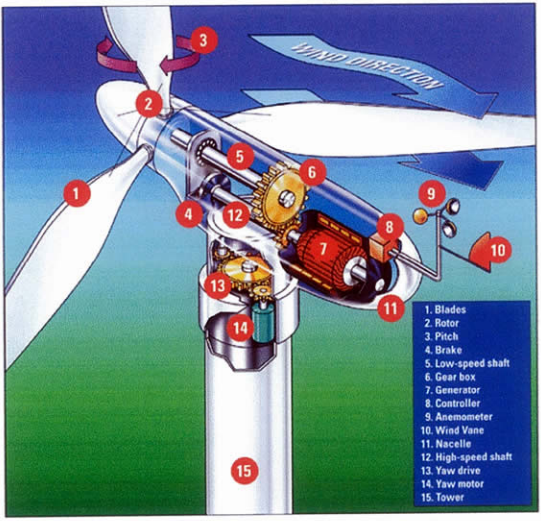
A wind farm might have only two or three turbines, or it could have as many as 150 spread across a big field. One of the largest wind farms in the U.S. is in Altamont Pass, California. It has more than 900 wind turbines.

View photos of the Altamont Pass wind turbines

How a wind turbine works

A wind turbine works the opposite of a fan. Instead of using electricity to make wind, a turbine uses wind to make electricity.

The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity. The electricity is sent through transmission and distribution lines to a substation, then on to homes, business and schools. The diagram below shows some of the pieces and parts inside a wind turbine:



First stage of General Research complete

~ I have completed the first stage of my general research, which was to find out what methods there are available today to produce electricity from resources that you would have if you were out in the bush.

~ From my research, I have realised that the system I am going to design and make, will have to use renewable resources to produce electricity, this is because renewable resources are the things abundantly available out in the bush that can efficiently be turned into electricity and I have to find the most suitable resource out of wood, water, sun and wind to suit the purpose and user of the device most practically.

From the first stage of my general research, I found that the methods, described below, are used industrially to turn renewable resources into electricity.

~ Hydro turbines, which use falling water to turn the turbines and produce electricity.

~ Wind turbines, which use wind to turn the turbines and produce electricity.

~ Steam engines, water is boiled using wood as the fuel and the steam is used to run a steam engine which turns a generator and produces electricity.

~ Solar panels, the suns energy is used to induce a current and therefore electricity.

From this stage of the initial general research I am going to rule out steam engines for a few reasons. They are very large (steam engine and boiler) and contain a lot of steel parts so they are also probably very heavy which does not meet specification number 3f. Due to the large amount of moving parts, there will need to be a fair amount of maintenance, which does not meet specification number 3e. From the first stage of the general research (pg 26 design research and planning folder) I found out that steam engines require high-pressure boilers to be efficient (design specification number 3g), which could be a very serious health risk if the boiler was not built correctly and exploded which does not meet design specification number 1. As it is an engine and it has many moving parts, it will be very noisy, which does not meet specification number 3b. As the whole thing will some how need to be packed up to meet specification number 3c, to set a steam engine up, when the user gets to there travel destination, they will have to unpack the engine, set it up, find water to put in it and make a fire to turn the water to steam. This would take a fair amount of time but the worst part is that the user would have to continuously full the engine up with water and keep the fire going nicely. I feel very strongly that due to the amount of specifications that a steam-powered generator does not meet, it would be very impractical to design one to try and solve my issue. (The pressure cooker experiment was showing another way to use steam to produce electricity, a lot smaller than what a steam turbine would be, but as I also looked into that and it is not suitable overall steam is going to be ruled out of a possible use for my clients issue as it, in the form of a generator meets little to none of my clients specifications)

~ Although hydro, wind and solar at the moment with what I have found out also may not meet dome design specifications, I would like to find out some fore about them before I rule any of them out. The reason steam was ruled out now is because from what I have found out and what I already know about it, it has little practicality until you get into the large electricity producing (kilowatts), and as my client only wants a smallish portable system, it is just not fit for purpose. The pressure cooker experiment was a good indicator of how inefficient steam is on small-scale units. I will now complete the second stage of general research, which will be to find out more about wind, water and hydro electricity producing methods.

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Options

The student critically reflects on the information, understandings and the practices of others, across a range of contexts, that were used to inform the development of their technological outcome.

How Do Solar Panels Work?

Silicon is the raw material used to make solar cells. It's the second most abundant element on Earth.

There are three main types:

1. Monocrystalline or single crystal cells
   - The first generation of solar cells
   - excellent conversion rate (12 - 16%) (23% under laboratory conditions)
     BUT,
   - making them is a painstaking, therefore expensive process
   - another drawback - it takes a lot of energy to obtain pure crystal
2. Polycrystalline cells
   - lower production costs, requiring less energy to make
   - 11 - 13% conversion efficiency (18% in the lab)
3. Amorphous
   - a more recent technology (mid-70's)
   - lower production costs, but unfortunately also
   - lower efficiency (8 - 10%) (13% in the lab)

This process can use very thin layers of amorphous silicon (0.3 - 1.0 microns compared to 500 microns for the other types). Using a vacuum spraying process, very thin layers can be applied on glass, metal or even flexible plastic surfaces. Amorphous silicon is usually the kind used in consumer goods such as calculators and watches.
-Amorphous panels need about twice the surface area to produce the same amount of electricity, and their output deteriorates more quickly over time, but they react better to diffuse and fluorescent light and work better at higher temperatures.

- A single solar cell always produces a VOLTAGE of approximately 0.5 volts, regardless of its size.
- For higher voltages, you have to connect individual cells in SERIES to add their voltages.
- The larger the solar cell, the greater the CURRENT will be. Current is measured in AMPERES.
- You can also connect cells in PARALLEL to increase current.

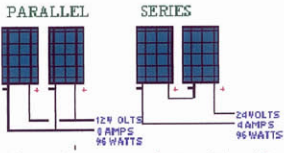
The most common solar panels are for 12 V applications. To reach that voltage, 24 cells would be sufficient, but for charging batteries and in order to compensate for voltage drops due to various factors, a PV panel normally contains between 28 and 40 cells for a higher voltage. You don't really need to think about the individual cells. All you need to know is that they are protected from humidity and the elements inside the panel, which works as a whole.
The panel has to deliver more than 12 volts to charge a 12-volt battery. Voltage can be compared with water pressure in a hose. If the "pressure" of the electrons isn't high enough, the electricity can't "penetrate" the battery.
Voltage can drop for several reasons:

- At high temperatures. (Unlike thermal solar energy, PV works less well when it's very hot! In tropical climates, choose higher voltage panels.)

- As a result of long wires. It's important to keep your wiring between your panels and other parts of your installation as short as possible.
- Diodes can also cause small voltage losses, as we'll see later.

Just as voltage can be likened to water pressure in a hose, current can be likened to the flow, or the amount of water (or electrons) passing through. A thin hose will take longer to fill a swimming pool than a thicker hose with the same pressure.
A panel that produces 2 amperes sends twice as many electrons as a one-ampere panel. When talking of PV panels, you usually refer to their POWER (measured in WATTS).
VOLTAGE (electrical "pressure") is measured in VOLTS
CURRENT is measured in AMPERES.
POWER (WATTS) is calculated by multiplying these two.

VOLTS x AMPERES = WATTS



A 12-volt PV panel producing 4 amperes of current has 48 watts of power. Panels can be connected in series or in parallel. If you take two of these 48-watt panels, you can connect them in SERIES, adding their VOLTAGE, with no change in CURRENT (amps), the result is 24 volts at 4 amps (96 watts). You can also connect them in PARALLEL, the VOLTAGE stays the same, but you add the CURRENT (amps), which gives you 12 volts at 8 amps, but still96 watts as in the case above.

How Much Will My Panels Produce?

One square meter of solar panels can produce up to 150 watts of maintenance-free power for up to thirty years. They even work on diffuse light on overcast days, albeit with less output. The voltage produced by PV panels remains roughly the same regardless of the weather, but the current (amps) and the power (watts) will vary.
The most important variable to bear in mind when planning a photovoltaic installation is the power output, which will basically depend on four factors:

- the peak power of your panels (measured in peak-watts or Wp)
- light intensity
- the number of hours of exposure to the sun and
- the angle of exposure to the sun

The Intensity of Sunlight

A panel's power is expressed in peak watts, the number of watts it will produce in optimal conditions, i.e. at noon in direct sunlight in cold weather. Maximum sun intensity is 1.000 W/m^2.
The following factors will influence the amount of sunlight reaching the PV panels:
1.Weather conditions (cloud cover, fog etc.)
2. How high the sun is in the sky
3. The number of daylight hours

4. The sun is 70° above the horizon on June 21st in Belgium, but 20° in the dead of winter. (10° in Stockholm)

5. It is advisable to have at least a 15° tilt to avoid rain accumulating on your panels. A greater angle will help keep them free of snow.

6. Snow on the ground is a welcome sight in winter -it increases diffuse light considerably!

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Options

The student explains how the complexities of the situation have been identified and explored.

1) As to the first factor, oversimplifying somewhat, a 50 watt panel should produce 50 watts for each hour of sunshine at 1.000 W/m². It will produce about half that amount (25 watts each hour) when exposed to 1/2 the light (500 W/m²). Diffuse light passing through thin clouds might mean 300 W/m². In very bad weather conditions with thick, dark clouds, light intensity could fall to 100 W/m² with only 5 Watts produced per hour.

2) The second factor, the height of the sun over the horizon varies with the seasons. When the sun is very high in the sky (summer), its rays travel through the atmosphere more quickly over a shorter distance than when it's low in the sky (winter). Light is scattered more and becomes more diffuse when passing through fog or pollution. A spot that gets plenty of sun 9 months of the year might be shadowed from November to January due to obstacles (trees, chimneys, rooftops etc.).

3) The third factor creates the greatest problems for those who don't happen to live close to the Equator, i.e. the difference in the number of hours of sunlight between the seasons. This is a huge subject that we'll have to take a closer look at later.

Looking for the Sun

It's always best to best to have your panels facing south at the ideal tilt angle depending on your latitude and the time of year. (Magnetic south as indicated by a compass is actually 16² west of true south.)

THE SUN'S RAYS SHOULD BE PERPENDICULAR TO THE PANELS. SUNLIGHT SHOULD HIT THEM AT A 90° ANGLE.

The ideal situation in Europe is to have a south-facing roof at an angle between 40 and 60 degrees, or, even better, a flat roof (or surface) on which your panels can be adjusted at will. You may decide to deviate from these values for convenience or for esthetic reasons, in order to fit them into the existing architectural structure. The future of PV will depend to a large extent on the harmonious integration of panels in buildings.-One example of this: In an apartment building in Denmark, where they wanted to install glass sides in the balconies (to limit heat loss), they realized that they could just as easily install frameless PV panels at a minimal additional cost. The loss in output due to the vertical position and the less-than-ideal location (facing south-west) was estimated at 30%.

Some people use sophisticated panel mounts called "trackers" that follow the path of the sun during the day. These automatic systems can increase output 50% in the summer and 20% in the winter, but this only increases the difference in output between the seasons. They are also expensive. The main reason against using them in Europe is the tremendous amount of diffuse light.

1. You can adjust your panels' position manually to get the best tilt angle for each season. Take your latitude and add 15° for the winter, and subtract 15° for the summer. At the spring and autumn equinoxes, the best angle is equal to your latitude.

2. If you leave your panel in a fixed position, you can decide to leave it at the best angle for the winter to help even out seasonal performance.

3. At the Equator, a panel can be placed horizontally for the most intense rays at noon. In Central Europe, when the sun is 30° above the horizon, however, this same position would mean a loss of about half of the sun's intensity (equivalent to 500 W/m²) compared to a tilt angle of 60°.

www.windenergy.org.nz
New Zealand wind energy association

1. The Power and Potential of the **Wind**

- **A very old power source is one of the power resources of the future**
- **How much energy is in the wind and how to get it out**

Wind is a very complex process which can be described very simply.

The sun heats the earth at different rates depending on whether an area is below clouds, in direct sunlight, or covered with water. The air above the warmer areas heats up, becomes less dense, and rises. The rising air creates a low pressure area. Cooler air from adjacent higher pressure areas moves to the low pressure areas. This air movement is wind.

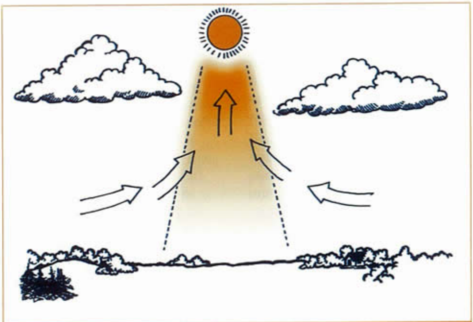


Figure 1. Wind is caused by movement of air.

People have been capturing the energy contained in the wind's movement for hundreds of years. Dutch-style windmills were first used in the 12th Century, and by the 1700s, had become a major source of power in Europe. In North America, farmers adopted windmill technology to pump water about a hundred years ago.

Today, the turning rotors of a wind energy system can still be used to run pumps, and to run a generator to generate electricity.

The wind is a renewable energy source, continuously generated or replenished by the forces of nature. Renewable energy technologies, such as wind energy systems and solar photovoltaic (PV) systems, which use sunlight, convert renewable resources into usable forms of energy that can complement or replace conventional energy sources.

Canada is a large country with a huge wind energy potential. Tapping into this potential will help decrease the amount of greenhouse gases emitted by conventional sources of energy.

Modern large wind energy installations are popping up across the Canadian landscape. These "wind farms" use an array of wind turbines, each generating around 600 kilowatts, and are hooked to the main electrical grid. While this is a promising technology, it would still take 1,500 of these large turbines to match the output of one CANDU reactor. On the other hand, if replacing an oil or coal generator, just one of these turbines could eliminate over 1,000 tonnes of carbon emissions per year.

This guide is aimed at those who are considering a wind energy system to supply energy to their homes, farms, cottages or businesses. In most cases, such small systems have capacities in the 100 watt to 25 kilowatt range.

At the low end of this scale, enough electricity is generated to run a few lights, a communications radio or entertainment equipment. At the higher end, many of the electrical needs of farm operations or institutional buildings could be met. Somewhat larger systems could also supplement municipal needs and supply power to remote communities.

While the tested technology of direct mechanical work, such as pumping water, will be touched upon in this guide, we will focus on electrical generation.

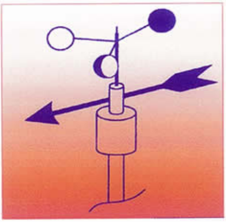


Figure 2. An anemometer.

Measuring Wind Speed

Wind speed is measured by an instrument called an *anemometer* (Figure 2) which turns faster as the wind blows harder on it. A data logger can be used to record instantaneous observations of wind speed, or to store a long term record for later analysis. A wind vane indicates the direction of the wind.

Wind speed is generally reported in kilometres per hour (km/h) or in metres per second (m/s): 1 m/s = 3.6 km/h. Direction is indicated in degrees azimuth or compass points.

How much energy is in the wind?

One of the first steps in determining if a wind energy system is feasible is finding out how much wind energy is available.

To do this, wind speeds are measured over a period of time, making note of the amount of time the wind blows at various speeds. From this, an average annual wind speed is calculated. A wind energy system usually needs an average annual wind speed of at least 15 km/h to be practical.

It is also important to know the variation in wind speed.

As it turns out, the wind is almost never calm, and rarely exceeds twice the annual average speed, and then only briefly. If you call in an expert to assess the amount of wind energy at your site, one assessment tool will be in the form of a wind speed distribution curve. This is just a chart of the number of hours the wind blows at various speeds. The Rayleigh curve represents a typical distribution (Figure 3). The wind blows most often at the speed corresponding to the highest point on the curve. In the Rayleigh distribution, the most frequent wind speed is about 75 percent of the average annual wind speed.

Features on the ground will impact the speed of the wind. Hills, ridges and valleys can block the wind or create undesirable turbulence for a wind energy system. Air movement is also slowed by friction close to the ground. As you move higher, wind speed increases. For most open spaces, wind speed increases 12 percent each time the height is doubled.

Locating a wind energy system on a hill, and on a tower will increase the amount of wind energy available.

A small increase in wind speed leads to a large increase in the amount of energy available (because volumes of air are being moved, the energy available in the wind is proportional to the cube of the wind speed).

Harnessing the Wind's Energy

A wind energy system is simply a method of extracting the energy from the wind and converting it into useful energy. This conversion can be to mechanical energy, where

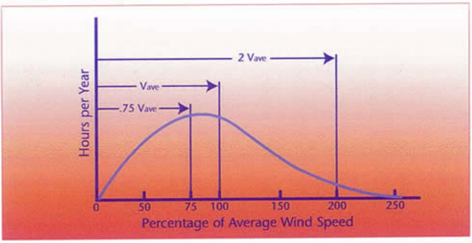


Figure 3. Annual Average Wind Speed (V_{ave})
The high point of the curve is the speed at which the wind blows most often. Such a graph is called a wind speed distribution curve – the one shown above is the Rayleigh distribution.

Wind Speed Conversions

Wind speeds are often measured in metres per second but, for simplicity, we will refer to wind speeds in kilometres per hour.

m/s	km/h
4	14.4
6	21.6
8	28.8
10	36.0
12	43.2
14	50.4
16	57.6

the wind turns a rotor which drives a mechanical device such as a gear or lever system running a water pump. The conversion can also be to electrical energy, where the rotor runs a generator.

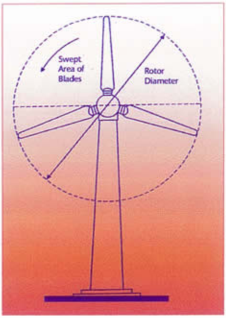


Figure 4. The "Swept Area" is the area through which the rotor blades travel.

A basic wind energy system consists of a turbine (a propeller-like rotor, a gear box and a generator), a tower, and a Balance of System (BOS) package. Components of a BOS package vary, and will be discussed further in Chapter 3.

You cannot rely on the wind, so some applications will require a battery system to store electricity, while some will be supplemented with a diesel, gas or propane powered generator which operates when the wind is not blowing.

Typically, wind speeds greater than 15 km/h are needed before a wind energy system can begin to generate electricity. This is known as the "cut-in" speed.

The "cut-out" speed, usually around 70 km/h, is where the system stalls to protect itself from damage.

The precise amount of energy that can be extracted from the wind depends on many factors, which are reflected in standard formulae. The formulae are complicated and depend on such factors as the variability and distribution of wind speed, the height of the rotor and the density of the air.

The diameter of the area swept by the rotor is also important (see box below and Figure 4).

About Wind Energy Theory

Energy production from the wind depends on several key factors:

The diameter of the area swept by the rotor blades (known as the "swept area"). The rotor blades of a wind turbine sweep through a circular area. Because we are dealing with circular area, increasing the rotor diameter, greatly increases power output. For example, doubling the rotor diameter quadruples power output.

The speed of wind. To start with, the length of time the wind is blowing above the cut-in speed is a critical factor. It is also important to remember that small increases in wind speed lead to large increases in available power. A 10 percent increase in wind speed can cause an increase in power of about 30 percent.

The variability of wind speed over time at the site. The total energy produced by a wind energy system over a period of time depends on the distribution and variability of wind speeds over time. Not surprisingly, the annual average wind speed at a site is more important than the speed at any given moment.

The density of the air. Wind power is directly related to air density, which increases as the temperature drops (warm air rises). About 16 percent more energy could be available at minus 20°C than at plus 20°C.

The Betz Limit

When energy is extracted from the wind, its speed decreases. In theory, if you took all the energy out of the wind, the wind would stop completely! In reality, however, you cannot remove all the energy from the wind. The most energy that an ideal wind energy system can extract is approximately 59 percent. This value is known as the Betz limit.

2. **Different Types** of Wind Energy Systems

- **You need different types of systems to fill different needs**
- **Systems range from very small to grid-connected**

This guide deals mainly with non grid-connected systems. That is, the wind energy system does not connect to the main electrical grid (such as a municipal electrical system). Changes in the way electrical utilities operate, however, are leading to some innovations which we will touch on briefly at the end of this section.

Terminology Issues

Wind energy systems that generate electricity are often referred to as *wind turbine generators* (WTGs). For the purposes of this guide, all systems that recover and convert wind energy will be referred to as *wind energy systems*.

Non Grid-Connected Systems

Small, non grid-connected systems can be stand-alone systems, which provide power solely from the wind, or hybrid systems, which use a combination of wind and another source of energy when the wind is insufficient to meet demand.

Stand-alone systems can generate electrical or mechanical energy and often have a method for storing energy when wind conditions are not good. A generator driven by a wind energy system can produce electricity which can be stored in batteries. Batteries are not necessary if the owner is willing to live with an uncertain supply.

Mechanical systems are relatively simple. They can be used to aerate ponds, pump water for livestock, irrigation or drainage, and to supply water to remote households, farms and small communities. You can think of a water tank as storage in a mechanical system. More than a million mechanical systems are said to be in use today, mostly on farms.

Hybrid systems are used in locations where the wind may fluctuate or where users might not want to be totally dependent on the wind. Hybrid systems can include solar energy or diesel generation. These systems can provide a reliable supply of energy regardless of wind conditions, but can also be costly and complex.

Hybrid Systems for Remote Communities

Many remote communities depend on diesel generators to provide electricity. If the site has good winds, a wind turbine can also be installed to help supply electricity for light industry, water treatment, municipal services, and other applications. Whenever the wind speed is within the turbine's operating range, the wind-generated electricity flows to the users and the diesel generator has to supply less, reducing the consumption of expensive fuel.

Wind-diesel hybrid systems are operating in several remote Canadian communities, including Kuujjuaq (Quebec), Fort Severn (Ontario) and Cambridge Bay and Igloolik (NWT).

Hybrid systems are especially useful where an existing energy technology, such as a generator, is already in use and fuel is expensive. A hybrid system may also be an option if the cost of storage (i.e. batteries) is high due to large loads.

Wind energy systems all have a power rating known as the rated output. This is the maximum power output of the system in a strong wind under ideal conditions.

For purposes of this guide, we will group systems into the following categories:

Micro Systems:
100 watts or less
They are useful for:

- portable systems for lighting and communications radios at hunting and fishing camps
- small appliances on yachts, recreational vehicles, in cabins and cottages
- electric fences
- remote area lighting
- emergency lighting
- trickle charging
- pond aeration
- navigational beacons and lights
- communications systems
- educational programs and displays

Mini Systems:
100 watts to 10 kilowatts
They are useful for

- small gas or diesel generator set back-up
- pumping water for cattle or for irrigation
- cottage and domestic water pumping
- navigational aids

▲ *Students of Assiniboine College in Manitoba install an 850 watt turbine. (Photo courtesy of Nor'wester Energy Systems Ltd.)*

- telecommunications systems
- area and emergency lighting
- refrigeration and ice making for retaining quality of fish at remote locations
- water and waste treatment
- waste water pumping
- trash rack cleaners (in irrigation systems)
- cathodic protection
- alarm systems

Small Systems:
10 kilowatts to 50 kilowatts

These are large enough to supply the electrical needs of a farm or business, and could serve as an energy supply for remote communities or camps.

Grid-Connected Systems

Canada is entering an era of change with the way in which its utilities are regulated and how they obtain or purchase electrical power from others. New regulations will make electricity more of a tradable commodity. Power markets are now opening up to private suppliers. This means that wind energy will have the opportunity to compete with conventional carbon-emitting fossil fuel and expensive nuclear alternatives. Utilities in various provinces, for example Alberta and Ontario, are already moving in this direction.

Another force at work is concern for the environment. Climate change and Canadian international commitments to reduce greenhouse gas emissions have brought attention to the carbon emissions from fossil fuel generation. Future attempts to reduce these emissions may encourage the use of "green" or non-polluting electricity. Natural Resources Canada and Environment Canada are setting an example by purchasing green power for their facilities in Alberta.

Large wind turbines that feed electricity directly into the utility grid are commercially available in sizes ranging from 300 kilowatts (kW) to 1.5 megawatt (MW). These turbines are typically installed in arrays known as wind farms, although installations of single large turbines are not uncommon. Wind farms usually become economically viable only at the megawatt scale.

Standards

The Canadian Standards Association (CSA) Standard CSA-F418-M91 *Wind energy systems – Interconnection to the Electric Utility* deals with these issues, as well as related topics such as requirements for installation and operating specifications.

It is also technically possible to connect small-scale systems to a utility grid. This allows for "net billing". In most cases, however, it is uneconomical to do so. Certain local or provincial utilities, Ontario Hydro Services Company for example, are now working to make grid-connection more attractive to owners of smaller systems. (See the box *Grid-Connect Special Programs*.)

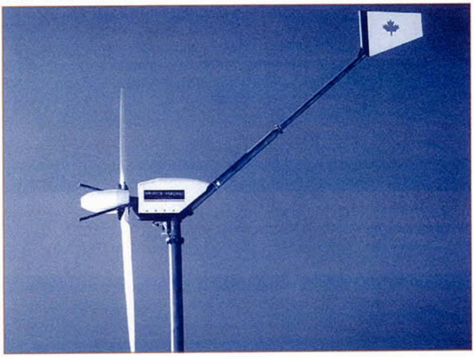
A utility's key requirements for grid-connected wind energy systems are *safety* and the *quality* of the power. The utility will require that the system meets certain standards and that it poses no risk to their personnel or equipment. Quality defines the need for the electricity generated by the wind energy system to match the characteristics of the grid electricity. This will avoid damage to sensitive electronic equipment. For small grid-connected wind energy systems, power quality problems are rarely a cause for real concern. Other issues to consider are of a legal and contractual nature, and require specialized attention.

As each utility has a different policy for grid connections, those interested should contact the customer relations or business office at the local utility for further information.

Grid-Connect Special Programs

Ontario Hydro Services Company's Net Billing Option pilot program is designed for small renewable energy generators (less than 50 kW) that are connected to the grid. Under the program, a small wind generator can supply electricity to the grid, balancing out the electricity that the owner of the system purchases from the grid. In effect, Ontario Hydro Services Company purchases electricity from the owner at the same rate at which they sell it to the household. This net billing arrangement is also referred to as "energy banking". Up to 20 renewable energy systems were to be tested in the pilot before the end of 1997.

For more information, contact Ontario Hydro Services Company toll-free at 1-877-647-3783 or visit their web site at http://www.ohsc.com.



Profile of a 25 kW Wenvor-Vergnet wind turbine. (Photo courtesy of Wenvor Technologies Inc.)

3. System **Components**

- **The components you need depend on the job you are doing**
- **Help in reading technical specifications**

Wind Turbines

The wind turbine rotor is one of the most visible parts of a wind energy system, but there's more to the turbine than just the rotor.

The most familiar turbine is the horizontal axis wind turbine, known as a HAWT. The main propeller-like rotor has an axis that is parallel to the ground, and therefore horizontal to the wind. A vertical axis wind turbine, VAWT, has an axis perpendicular to the flow of the wind.

HAWTs are most common in small applications, and can be placed on a tower which does not require a large area. If servicing has to be done to a HAWT, however, the tower either has to come down, or the service technician has to go up.

The generating equipment in a VAWT is at ground level, but VAWTs require a lot more space to be cleared for guy wires.

Because any wind turbine may be exposed to high winds, rain, snow, sun, ice, and even salty air, its parts should be made of tough, durable and corrosion-resistant materials. A well-built and well-maintained turbine should have a life expectancy of 20 years or more.

Turbines consist of several sub-components (Figure 5):

Rotor

The rotor consists of blades with specially shaped, aerodynamic surfaces. When the wind blows over the blades, the rotor turns, causing the rotation of the drive train and generator. The blades should be light-weight, strong and durable to withstand the elements. They are usually constructed of composites of fibreglass, reinforced plastic or wood. The turbine should also be designed to prevent the rotor from turning too fast during strong winds.

The diameter of the rotor blades determines how much power is generated by the system. There are usually two or three blades. Three blades reduces the mechanical stresses on the system, but increases the cost of the rotor.

Generator/Alternator

Generators and alternators produce electricity from the rotation of the turbine motor. A generator produces Direct Current (DC) power or, as an alternator, it produces Alternating Current (AC) power. Most small wind turbines used for battery charging systems use alternators generating AC power which is converted to DC for the batteries.

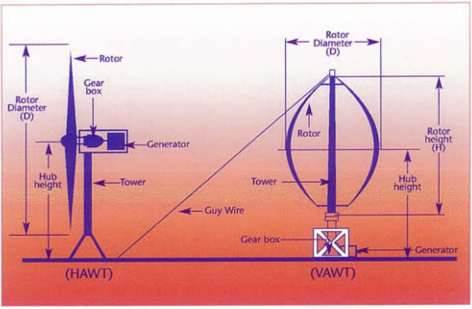


Figure 5. HAWT's and VAWT's: Horizontal and Vertical Axis Wind Turbines.

AC/DC?

Direct Current (DC) is a flow of electricity in one direction. Alternating Current (AC) flows first in one direction, then in the other. Alternating Current is used in household electricity because of AC's ability to be transmitted over long distances with minimum loss. DC, however, loses energy the greater the distance transmitted.

You do not need to know the physics, suffice it to say that the current coming from a battery is DC, while the current coming from a wall outlet is AC. Typically, DC-powered appliances run at lower voltages than AC.

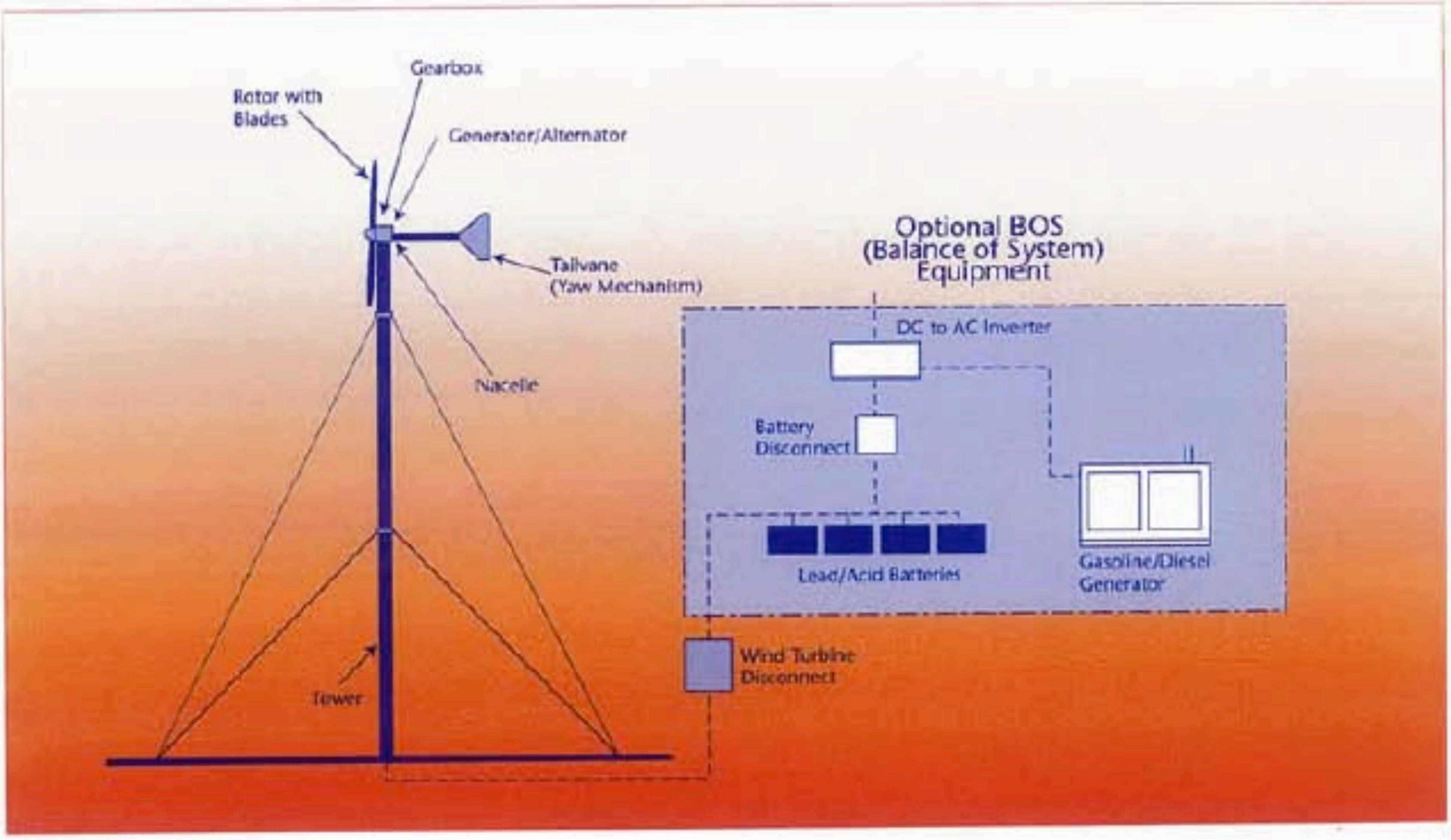


Figure 6. Wind energy system components.

Gearbox

Many turbines, particularly those above 10 kW, use a gearbox to match the rotor speed to that of the generator. Most micro and mini systems have the generator/alternator rotating at the same speed as the rotor and do not need a gearbox.

Nacelle

This is an enclosure which protects the gearbox, generator and other components from the elements. It is removable to allow for maintenance.

Tailvane (Yaw System)

A yaw system aligns the HAWT with the wind. Most micro and mini systems use a simple tail vane that directs the rotor into the wind. In some systems, the rotor is downwind of the generator, so it naturally aligns with the wind. Some yaw systems can be offset from the vertical axis to regulate rotor power and speed. Special release mechanisms can use the yaw system to turn HAWTs out of dangerously high winds.

Control and Protection Systems

Control systems vary from simple switches, fuses and battery charge regulators to computerized systems for control of yaw systems and brakes. The sophistication of the control and protection system varies depending on the application of the wind turbine and the energy system it supports.

It is important to know some key terms used in descriptions and specifications of wind turbines. On a chart on the next page, we have outlined terms for a typical mini DC generating turbine that might be found in a manufacturer's literature.

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Options

The student uses relevant research to explain how the complexities of the situation have been identified and explored.