Felton Valley Sustainable Energy Plan

Preliminary Report April 2010

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Executive Summary

This is an interim report to Friends of Felton and forms the first stage in developing a sustainable energy plan for the Felton Valley. The aim of a sustainable energy plan is to assess the renewable energy resource of the Felton Valley and identify appropriate renewable energy technologies that are compatible with existing farming practices. This is in response to concerns community regarding the AMBRE Energy's coal to liquid fuel project proposals and the environmental impacts and long term consequences this project may have.

To do this, research was conducted into the available wind and solar resources, and land area potentially available for a range of renewable energy technologies to be employed on both a large and small scale.

The preliminary energy output estimates for each of the renewable energy technologies of solar thermal electric (STE), wind turbine generators (WTGs), solar photovoltaic (PV) systems and solar thermal collectors, and food production are shown in table 6, page17.

The combined annual energy output is estimate at 1285 GigaWatt.hours (GWh) from a peak installed capacity of 713 MW, excluding food energy. This could supply the electrical energy needs of about 160,000 average SEQ homes, or twice that number if energy efficiency measures were employed in each home.

It was found that the Felton Valley has a number of attributes that may make it suitable for development as a smart, distributed grid area. These include:

- Access to good renewable energy resources of both wind and solar energy,
- Potential hydro storage/power sites,
- Potential usable land area that doesn't conflict with current food production on fertile soils,
- Access to large and small electrical system transmission and distribution lines,
- A supportive community looking for an alternative to coal mining,
- Proximity to a major growth corridor in SE Queensland.

It is proposed here that the Felton Valley could be used as a pilot project to support the development of smart distributed grids across rural Queensland that would negate the need for further expansion of coal fired power stations.

It is recommended that Friends of Felton assist further development of a Sustainable Energy Plan for their region by:

- Helping to better quantify the land and roof area potential for solar technologies, both on a large and small scale within the Felton region,
- Financially supporting on-site weather monitoring including solar global and direct irradiation, wind speed and direction measurements over 3 to 12 months,
- Gaining support from the Office of Clean Energy to develop the Felton area as a smart distribution grid model that could be rolled out across regional Queensland.
- Starting to approach potential renewable energy industry partners.
- Investigating a community funding model for sustainable energy deployment.

Introduction

This is an interim report to Friends of Felton and forms the first stage in developing a sustainable energy plan for the Felton Valley. The aim of a sustainable energy plan is to assess the renewable energy resource of the Felton Valley and identify appropriate renewable energy technologies that are compatible with existing farming practices. This is in response to concerns from Friends of Felton regarding the Ambre Energy's coal to liquid fuel project proposals.

This report:

- Outlines the work to date to assess the renewable energy resources of the Felton Valley,
- Gives the first estimates of an appropriate scale and energy output from a mix of renewable energy systems that could be employed across the Felton Valley and neighbouring areas,
- Identifies issues that the Felton community will need to consider in the implementation of a Sustainable Energy Plan.

Assessment of Renewable Energy Resources and Technologies to date

Resource data and potential land available for wind farms and solar farms has been collected from:

- Wind energy mapping by 3Tier, Queensland Government's wind mapping tool and Consultants Garrad Hassan Pacific Pty Ltd,
- Solar energy mapping from the Australian Solar Radiation Data Handbook (ASRDH) and NASA Surface Meteorology and Solar Energy,
- Google Earth and topographic map examination, 0n-site field visits and a survey of land owners' available land (about 20 respondents so far).

The technologies discussed in this report are:

- Wind turbine generators (WTGs), solar thermal electric (STE) and solar photovoltaic (PV) technologies for electricity generation
- Solar water heating for direct heating applications such as hot water, food processing or crop drying.

Wind Farms

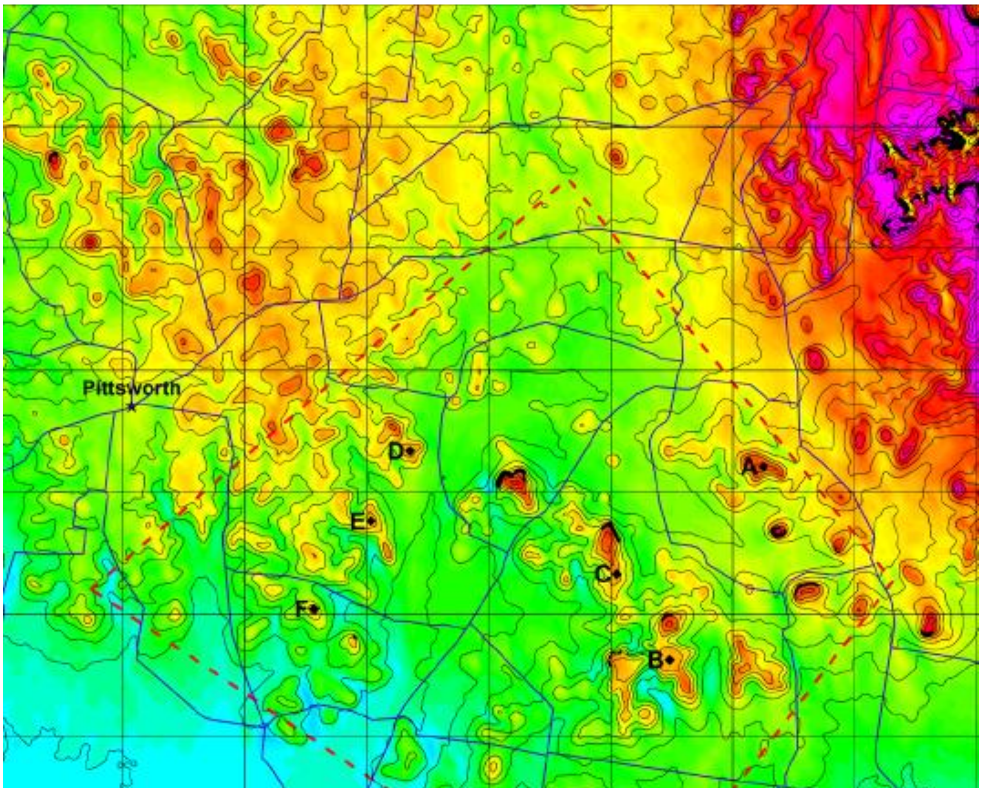
Wind farms consist of arrays of two or more WTGs that produce high voltage AC power for the electricity network. This is a well proven technology that now provides clean, renewable energy for many millions of homes around the world.

The first stage in the assessment of wind energy potential of a region is the use of a wind mapping model that predicts annual average wind speeds at a given height over a region. Three models were consulted. The 3Tier wind speed estimator, the Queensland State Government's recently released wind map and the Anemoscope model used by Garrad Hassan Pacific Pty Ltd. The 3Tier tool simply gives a wind speed range for a given height above ground level and geographic coordinates – Eg. for Prestbury Ridge site, 5.8 to 7.3m/s at 80 elevation. The Queensland Government's wind map proved to be unsuitable as it did not give the necessary level of detail.

These models use measurements of upper atmosphere wind speeds and project wind speeds downwards to the tower (or hub) height of typical wind turbines. They take into account the elevation above sea level, the shape and surface roughness of the terrain**.** This can be done on both a large (known as meso-scale) and small (or micro) scale. In this study, a large scale area of approximately 350 by 350km square was used. Wind speed projections from the model were made at 10m in order to check the model against long term, regional Bureau of Meteorology (BOM) measurements and calibrated accordingly (see full Garrad Hassan report for details). **The height above ground level at which wind speeds are shown on the wind maps provided by Garrad Hassan was 80 metres.**

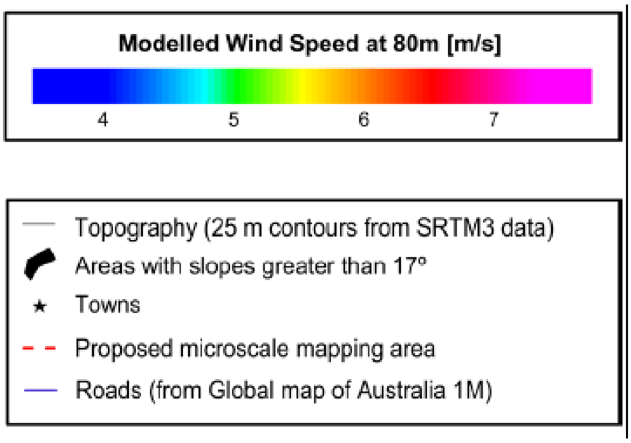
A specific target area of the Felton Valley and surrounding ridges was modelled over an area approximately 60 by 60km square to give more detail for this study. This is shown in figure 1.

Figure 1- Felton Region Wind Map (Taken from Garrad Hassan Pacific Pty Ltd report)



The legend for the wind map is shown in figure 2 below.

Figure 2 – Legend for Wind Map Figure 1



A check was also made using the author's own wind speed data analysis tool, WindPro V1, to project wind speed data measured at 10metres elevation to 80metres at two sites. One site was at the University of Southern Qld, Toowoomba. Data was collected over 2 years (1985/86) as part of a Wind Energy Survey of Southern Queensland, conducted by the University of Queensland and on which the author worked. The other site was near Ramsay School, with only 10 months of data (2002). These projections, adjusted for long term variation using BOM data, agree reasonably with the micro-scale map, with wind speeds projected in the range of 6 to 6.5m/s at 80m elevation at both sites.

Within this micro-area, the model was used to predict annual wind speed, frequency of occurrence and direction data at 80m height for 6 locations (marked Points A to G on the wind map). This data allows prediction of wind energy output from wind turbines located near these or similar wind speed locations. At this stage, an Enercon E82 wind turbine (82metre blade diameter) on 80 and 100m towers has been used for energy output predictions. The annual wind energy output of an E82 at these six sites and at two tower heights is shown in table 1.

Table 1 – Annual Energy Output in GigaWatt.hours (GWh/yr) of an Enercon E82 WTG at Sites A to G, Felton Valley.

	Location from Wind Map on Felton Valley Ridges							
	Point A	Point B	Point C	Point D	Point E	Point F	**Average**	**Tower Ht.**
Annual Wind Speed (m/s)	6.18	5.79	5.98	5.95	5.77	5.96	**5.94**	**80m**
Outut at Tower Ht. (GWh/yr)	4.91	4.24	4.56	4.54	4.23	4.62	**4.51**	**80m**
Annual Wind Speed (m/s)	6.39	5.98	6.18	6.15	5.96	6.16	**6.14**	**100m**
Outut at Tower Ht. (GWh/yr)	5.24	4.54	4.88	4.85	4.53	4.93	**4.83**	**100m**

Note: Wind speeds projected at tower ht. = 100m assumed a roughness length, Zo = 0.1

Assumption: To simplify estimation of annual output from multiple WTGs across the Felton ridges, an annual average wind speed of 6m/s (wind speed distribution with a Weibull Shape factor = 2.1) and an annual output of 4.54GWh/year was assumed for each WTG on average. Using these assumptions and the wind map data, in conjunction with topographical map and on-site observations, wind turbines were positioned across the Felton region in 4 locations as shown in table 2 in locations where the wind map indicates average wind speeds at 80m of around 6m/s.

Table 2 – No. Of WTGs in each Location

Site 1	**Highland View/Rockmount**	**Area (m2)**	
Length x Breadth	**3000 1000**	3000000	**Av. No. Of WTGs**
	Range in No. of WTGs	8 18	**13**
Site 2	**Prestbury and Neighbour**	Area (m2)	
Length x Breadth	**3000 500**	1500000	**Av. No. Of WTGs**
	Range in No. of WTGs	4 9	**6**
Site 3	**Mt Kent**	Area (m2)	
Length x Breadth	**3000 500**	1500000	**Av. No. Of WTGs**
	Range in No. of WTGs	4 9	**6**
Site 4	**Ridge to SE of Cambooya**	Area (m2)	
Length x Breadth	**2000 1000**	2000000	**Av. No. Of WTGs**
	Range in No. of WTGs	5 12	**9**

Note 1: This assumes spacing of between 5 to 7.5 rotor diameters (approx. 400 to 600m apart) across ridges for the prevailing Easterly winds to minimise shielding of one WTG by another WTG as this reduces their energy output.

Note 2: The E82 WTG is a class 2 wind turbine, ie. suited to medium wind speed sites. For comparison in the final report, a class 3 WTG, suited to lower wind speed sites, will be modelled to compare the energy production against the E82 Enercon model. This should give a higher energy yield at a similar cost.

This results in between 21 and 48 wind turbines with a total rated capacity of between 42 and 96MW. Annual energy output is projected to be between 96 and 207 GWh/year at 6m/s and 80m height. This is equivalent to supplying the electricity needs of between 11,000 to 25,000 average Queensland homes, or twice this number if the energy efficiency of these homes was improved by 50 percent. (NB. In the author's experience of undertaking detailed energy audits of homes over 30 years, this is easily achievable).

While the energy yield from wind turbines at these sites is considerable and sites with annual mean speeds of this level are used throughout Europe, it is generally recognised that the windiest sites will be commercialised first and for Australia, sites with an annual mean wind speed of 7m/s or greater give a higher commercial return on investment. Such average wind speeds may be available in parts of the Felton region by extending tower heights and/or selecting only the best sites from the wind map. This would need to be confirmed by on-site measurements. However, a range of factors need to be considered in wind farm economic viability and key factors are discussed below.

Considerations for Wind Farm Development in Felton Valley

The following need to be considered in the future development of sustainable energy from WTGs in the Felton Valley.

Economics

The economic viability of wind farming is dependent on:

- Wind speeds available at the tower height (also called "hub" height) of WTGs – The energy production varies approximately with the cube of the wind speed. A 17 percent rise in annual wind speed to 7m/s increases the energy production stated above (at 6m/s) from 207 to 328 GWh/year, a 59 percent gain. This is a large increase and therefore greatly enhances the economics of the project. Increases in wind speeds can be achieved by either greater tower heights or better sites.

- The price of Renewable Energy Certificates (RECs) - These are tradeable certificates that electricity companies are required to purchase for renewable energy generators, under the Federal Governments mandatory Renewable Energy Target, in order to increase over time their use of renewable energy generated electricity and reduce greenhouse gas emissions (See www.orer.gov.au). Each certificate represents 1 Megawatt.hour (MWh) of electricity from a renewable energy generator. These certificates vary in value over time, typically between about $20 and $50/REC, depending on supply and demand. Government policy decisions affect supply and demand and hence REC value. **It is anticipated that, under the Federal Government's revised RET for large scale renewables, the price of RECs will climb to above $50 each.**

- A price on Carbon Emissions – This is heavily dependent upon when emission trading or carbon tax schemes, that set a price on carbon emissions, will be implemented. The proven science of climate change suggests that we need to act quickly and decisively to limit greenhouse gas (GHG) emissions and stabilise emissions within the next 6 to 10 years to prevent catastrophic climate change. Australian Government action on climate change policy to date has been very slow. This is due to the delaying tactics perpetrated by vested interests, primarily the coal, aluminium and cement industries, those most affected by a carbon price (Pearse, 2009).

- A minimum acceptable commercial return on investment (ROI) – Commercial wind energy projects generally aim for a ROI, in real terms, of 8 to 10% after tax. However, community owned projects are emerging in Australia now and under these models, lower ROIs may be acceptable as long as they provide returns equal to or better than superannuation. (See: www.hepburnwind.com.au & www.centralvictoriasolarcity.com.au). There are many examples overseas of community owned wind farms. In Denmark, the 5500 WTGs are owned by over 200,000 community investors, often originally through farming cooperatives.

- Power purchase agreements (PPAs) – This is a contract between the wind farm owner and the local electricity retailers to buy the electricity generated by a power plant. These agreements are a critical part of planning a successful wind project because they secure a long-term stream of revenue for the project through the sale of the electricity generated by the project.

Changes to any of the above can either improve or worsen the economics of wind farms. However, future policy changes announced recently by the Federal Government are likely to strengthen the case for wind power. Note that many of the issues above also affect the AMBRE Energy project proposals, in particular, the price of carbon and the value of RECs.

Full Wind Energy Feasibility Study

The work to date is a preliminary assessment only. The second stage of wind farm assessment would require a full feasibility study involving:

On-site measure of wind speeds at various heights at selected sites to verify wind mapping predictions. These measurements of wind speed and direction could take place over 3 to 12 months.

Assessing road access to wind turbine sites - Sites on steep terrain with no or minimal existing road access would require road upgrading or construction for heavy machinery such as cranes and prime-mover, semi-trailer trucks carrying wind turbine parts and towers.

Assessing p**ower line access** – Existing power lines must be of a suitable size and power carrying capacity. The Felton / Pittsworth region does have two large power transmission feeders through the area of 275kV and 330kV. These feeders probably suit larger power station interconnection for power stations with a peak capacity of greater than 100MW. Smaller distribution lines or 11kV or 33kV within the area may also be useable. However, this needs to be investigated further.

Checking for likely interference with telecommunications – There are Telstra microwave repeaters at Mt Kent (northern most peak) and Mt Mallard (south of Pittsworth) that link to Toowoomba or Warwick. WTGs can interfere with microwave and radio transmissions. Initial observations from Mt Mallard and Mt Kent indicated that some interference may occur, but this needs to be investigated in detail.

Assessing noise impacts – Noise is generated mostly from the blades motion through the air and, to a lesser extent, the gearbox and electrical generator. Manufacturers have made great advances in reducing wind turbine noise. A comparison with other noise sources is given in table 3.

Table 3 – Wind Turbine Noise compared to other Noise Sources

Activity	Sound pressure level (dBA)
Wind farm (10 turbines) at 350m	35 – 45
Jet aircraft at 250m	105
Noise in busy office	60
Car travelling at 64 kph at 100m	55
Quiet bedroom	35
Background noise in rural area at night	20 – 40

Source: SDC (2005).

The effect of noise on human behaviour and health is highly complex, individual and subjective. Recent research suggests no health impacts on people living close to wind farms as noise levels are very low (Colby et al, 2009). My advice is to encourage concerned people to visit a wind farm to hear for themselves the noise levels. (See references for further reading).

Assessing Visual Amenity – "Beauty is in the eye of the beholder". Individual response to the "look" of wind farms is highly subjective. Most surveys of local residents' views about the visual impact of their local wind farm show clear support, usually greater than 70 percent (Macintosh et al, 2006). Again, my advice is to encourage concerned people to visit a wind farm to see for themselves the visual impact.

Assessing Effects on Wildlife – Impacts on local or migratory birds and bats needs to be considered carefully. Bird kills around WTGs have been recorded but are generally very low in number. Birds do learn to avoid the WTGs. There is generally very little effect on ground dwelling animals and flora. The general consensus from studies and the views of major environmental groups is that the impacts of wind farms are usually very low and that climate change poses a far greater risk.

All of these issues and other issues such as aircraft safety, blade shadow flicker, heritage and cultural issues including aboriginal land rights, are included in the planning and approval process for wind farm development and covered by industry best practice guidelines. (Auswind ,2006)

Solar Farms

The three main types of commercially available technologies are:

- **Solar Thermal Electric (STE)** – collection and concentration of direct sunlight to give high temperature heat (300 to 600C). This is used to drive steam turbines and then electric generators, similar to conventional power stations. There are three main types currently in use and they are rough classified as to how they concentrate the sunlight. These are trough, dish and power tower STE systems.
- **Photovoltaic (PV)** – conversion of sunlight directly to electricity through semi-conductor technology known as solar cells. This are the same cells used in solar electric fence panels, solar water pumps, powering homes, Telestra repeater stations etc.

- **Solar Thermal** – conversion of sunlight directly to heat through a range of collector types including the standard domestic/commercial solar water heaters. These technologies can be used for home and office heating/cooling and process heat such as crop drying.

Solar energy technologies rely on a good solar energy resource. This is discussed below.

Felton Valley Solar Resource

Australia has an excellent solar resource, as we all know from our high skin cancer rates. Table 4 shows the relative solar energy (irradiation) from the sun for Brisbane, Longreach and estimated from Felton from NASA satellite data. The table shows:

- Average Daily Global Irradiation on a Horizontal Surface – global includes both direct rays of sun's energy and rays that are scattered by clouds and dust.
- Average Daily Global Irradiation on a plane facing north and tilted at the Latitude angle of about 27 Degrees. This would be the plane used for fixed solar arrays such as photovoltaic (PV) systems or solar water heating systems.
- Average Daily Global Irradiation on a plane that tracks the sun's movement each day to keep the solar panels aimed at the sun. This improves energy output by about 30 percent on average.
- Average Daily Direct Irradiation on a plane that tracks the sun's movement each day to keep the solar panels aimed at the sun. This data is used for solar thermal systems that concentrate sunlight from the direct rays and produce high temperature steam for power generation or process heat.

Table 4 – Irradiation Data for the Felton Valley.

ASRD Handbook	**Global - Horizontal**		**Global - Fixed N Lat. Tilt**		**Global - Tracking**		**Direct -Tracking**	
Location	**MJ/m2/yr**	**kWh/m2/yr**	**MJ/m2/yr**	**kWh/m2/yr**	**MJ/m2/yr**	**kWh/m2/yr**	**MJ/m2/yr**	**kWh/m2/yr**
Brisbane - Lat -27.5deg	6606.5	1835.14	7409.5	2058.19	9672.5	2686.81	6789	1885.83
Longreach - Lat. -23.5deg	8066.5	2240.69	8760	2433.33	12045	3345.83	10366	2879.44
NASA	**Global - Horizontal**		**Global - Fixed N / Lat. Tilt**		**Global - Tracking**		**Direct -Tracking**	
Location	**MJ/m2/yr**	**kWh/m2/yr**	**MJ/m2/yr**	**kWh/m2/yr**	**MJ/m2/yr**	**kWh/m2/yr**	**MJ/m2/yr**	**kWh/m2/yr**
Felton Site - Prestbury Lat. -27.759 Long. 151.733	7121.88	1978.3	7568.64	2102.40			8304.48	2306.80
						As % of Longreach		80.11

Sources: Australian Solar Radiation Data Handbook (ASRDH) (www.anzses.org) and NASA's surface meteorological services (www.eosweb.larc.nasa.gov/sse).

This data shows that the solar energy available is very high, greater than Brisbane due to 30 percent lower rainfall and less pollution. The direct solar energy required for STE averages about 80 percent of the level in one of Queensland's (and the World's) best recorded sites, Longreach.

By current international standards, Felton irradiation is very high. For example, for direct irradiation required for STE systems, Felton is estimated to be 2307 kWh/m^2/year. The ANASOL STE system in southern Spain has an annual average direct irradiation of 2200 kWh/m^2/year. The advantage that Felton has is its proximity to large demand areas of SE Queensland and closeness to large transmission line infrastructure. Hence long distance transmission line construction costs and potential energy losses can be avoided.

Land Area Survey for Solar Farming

As part of the process of quantifying the solar resource, a survey of about 150 land owners in the valley was conducted. This survey aimed to quantify:

- The uncropped land area, on poor quality soils, with slopes of less than about 11 degrees (1 in 5), that would be suitable for STE or PV farms. This farmland will not reduce significantly the land available for food production if used for solar energy farming instead.
- Roof space with good orientation for solar PV or solar water heating technologies on farm buildings and homes.

To date, 20 respondents have returned surveys. So far about 1.47km^2 for land area and 4124m^2 of roof space has been identified. Of this, about 1.29km2 was from blocks bigger than 10ha. These size blocks were deemed potentially suitable for STE systems. Smaller blocks or steeper blocks would only be suitable for PV systems. If steeper blocks of land are used, then the total area of land available for solar generation would be significantly larger.

Solar Thermal Electric (STE)

Deployment of solar thermal electric technologies is now in a rapid growth phase around the world. This is because the technology has been proven large scale over 30 years and, coupled with high temperature heat storage on-site, can provide power into the evening and all night if necessary. Climate change policy and the inclusion of carbon costs for fossil fuel use are driving this development.

Most of the land area identified to date is scattered around the valley with the largest areas each of about 25ha. Each of these areas would provide about 15MW(peak) and 27GWh/year (assumed capacity factor of 0.2).

Through further surveying by Friends of Felton, additional available land will be identified and this will increase the potential STE capacity.

Assumption: As only 20 properties (13%) out of over 150 land owners returned surveys to date, for this report it was assumed that the total amount of land available if all land owners responded could be in proportion to that found on the 20 respondents. **This would make at least about 10 km^2 available for STE in blocks of 10ha or greater.**

Table 5 shows the estimated annual output from different STE technologies for sunny sites west of the Great Dividing Range in Queensland. This information was through obtained but web searches of existing systems and personal communication with Australian suppliers. Note that the variation in output per km^2 is heavily dependent on the packing density of the solar collectors and the overall efficiency of conversion of sunlight to electricity.

Table 5 – STE Peak Capacity and Annual Output

STE Output and Capacity		
Company	**Annual Energy Output (GWh/km2/yr)**	**Peak Capacity Rating (MW/km2)**
Ausra	175	100
CSIRO	95	54
Regenesys	53	30
Average Output/km2	**108**	**61.4**
Average Output/ha	**1.08**	**0.61**

Note1: Assumes Anticipated Direct Irradiation > 2190kWh/m^2/yr

Note 2: Assumes Capacity factor = 0.2

Using the average energy output per km^2, **the total potential output from STE systems across 10km^2 of the Felton Valley is therefore about 1080 GWh/year,** or enough energy to supply 134,500 SEQ homes. These systems are modular and would not need to be all in one area although economies of scale would apply to larger systems.

Solar PV

Photovoltaic (PV) systems are again a well proven technology. They consist of arrays of PV panels each of about 170 to 200 Watts rated peak power and about 0.8m^2 in area. These can be mounted:

- As fixed arrays facing north (NE and NW is acceptable) and tilted at about the latitude angle, 28 degrees.
- On tracking platforms that move to follow the sun. This increases the output of each panel by about 30 to 37 percent averaged over the year, as seen in the increase in solar irradiation on a fixed plane as opposed to a tracking plane in table 4 for Brisbane and Longreach. This requires tracking arrays to be spaced further apart than fixed arrays so the increase in energy output is less than this. Hence the estimated energy output increase is at about 25 percent.

For this report, the reported suitable roof areas available from the surveys will be extrapolated across the Felton Valley.

Assumption: As for STE, only 20 properties (13%) out of over 150 land owners have returned surveys to date, for this report it was assumed that the total amount of roof area available if all land owners responded would be in proportion to that found on the 20 respondents. This would make about 30,900m^2 of north facing roof area available across Felton Area, excluding more densely populated areas such Cambooya. Assuming that some of this is shaded, say 30%, this leaves about 21,000m^2 available for roof top PV or solar heating applications. As roof areas in Cambooya and other villages are excluded, this should be a conservative estimate.

This would give a PV energy output across the region of 3.6 GWh/year from 2.2 MW peak capacity from roof top PV alone. This is likely to be an underestimate of PV potential output as PVs can also be used on steeper slopes of farmland than STE which, except for power tower systems, needs nearly flat land.

Assumption: Average annual PV output per kWp is 1.65MWh, for an average Irradiation of 5.5kWh/m^2, PV systems facing between NE & NW, tilted at Latitude Angle, System Efficiency of 0.82, adjusted for module temperature de-rating and inverter losses. If tracking systems are used, then PV system output increases by about 25 percent for large scale systems on farm land.

Solar Thermal

Another well proven technology is solar collectors used for low to medium temperatures. Examples include pool heating collectors (efficient up to about 30C), domestic and commercial flat plate water heating collectors (efficient up to about 80C) and evacuated tube collectors (efficient up to about 120C).

To identify the full potential of these collector systems in various applications such as space heating and cooling, solar water heating, crop drying or food processing would require a full audit of domestic, commercial and industrial heating and cooling energy requirements across the Felton Valley. To date, some preliminary surveying incorporated in the land area survey mentioned above has shown that there is a range of applications listed in the Felton Valley. One example is to displace the need for gas for crop drying. A solar technology has already been developed and employed by a Toowoomba based company for dehumidifying crop drying air (see www.agridry.com.au).

In this study, only the potential for some solar thermal systems for domestic water heating and for commercial crop drying is included. It was therefore estimated that 150 homes and 20 businesses could use standard domestic flat plate solar water heaters for water heating and possibly contributing to some crop drying. Collector area was estimated at 1000m^2, consisting of 600m^2 for homes and 400m^2 for crop drying. **The energy displaced from fossil fuel generation is therefore 0.593 GWh/yr. This is a conservative estimate as there are some small townships in the region which are not included and where there will be demand for heating and cooling loads that solar thermal systems could provide that have not been identified.**

Assumption: Flat plate collectors are oriented on average NW at 20 tilt and energy delivery per 4m^2 of collector area was 6.5kWh/day at 60C.

Biomass Food Production

Biomass for food production is included here as it is both a renewable energy resource and is substantial in magnitude. The energy estimate is based on a survey undertaken in November, 2008, by Friends of Felton to quantify agricultural production in the area. The survey included responses from 150 households (estimated to be 75% response rate). This survey identified the total biomass food production of all crops of 31,000 tonnes per annum. **Assuming an energy content of 17 MJ/kg** (typical of oats – see www.fao.org/DOCREP/006/y5022e/y5022e04.htm), **this is equivalent to 527,000 GJ or 146 GWh/yr of human food energy.**

Energy Storage & Smart Distributed Grids

Energy Storage

The most common criticism of wind and solar power systems is, "what happens when the sun doesn't shine and the wind doesn't blow?". The answer is not simple as:

- Peak demand across the whole electrical system in Queensland for much of the year is dominated by midday to mid-afternoon air conditioning loads. Large and smaller scale solar systems may be located to generate power into local feeders to help offset this demand, particularly in commercial areas. This adds value to the solar power without needing to add storage systems.
- On average, up to 20 percent of an electricity network's generation capacity can come from solar and wind power systems without any need to add storage. This limit is restricted by the inability of large coal fired power stations to response to changes in the load Ie. To be "turned up or down " Eg. if there was lots of wind power available.
- We are already designing systems to cope with rapidly changing demand. This is accomplished with demand side management (DSM) systems that allow some loads to be switched off or rescheduled to better fit the available power generation sources and maintain quality of power. Examples of switchable loads include air conditioning, swimming pools and water heating systems.

The most common solution proposed is to add an energy storage system so that energy generated during windy or sunny times can be stored and used at later times on demand. While this adds capital cost to systems, it allows the generator to schedule power generation to times of peak power demand and hence potentially receive higher prices for their power. Storage can be in many forms, including as high temperature molten salts, ice storage (for air conditioning), chemical storage such as redox batteries or electric vehicle batteries when not being driven, flywheels and water.

The cheapest forms of storage are heat stored in molten salts and water pumped from lower to higher storage dams Eg. Wivenhoe Dam to Split Yard Creek. The Felton Valley may have potential sites to employ some pumped storage. A dam of roughly 550metres square, 10metres depth and located 100m above the surrounding valley floor dam could store sufficient water to generate 100MW for 3 hours.

STE systems are now employing molten salts in storage tanks that allow them to generate at night, up to 8 hours in some cases. The best example is the ANDASOL System in Spain. (See www.en.wikipedia.org/wiki/**Andasol**_Solar_Power_Station)

Smart Distributed Grids

A recent reports to the NSW Government (Rutovitz, 2009) and by CSIRO(Lilley et al, 2009) indicate that it is likely to be cheaper, cleaner environmentally and creates more jobs to build what are now called smart (or intelligent) distributed grids. These consist of:

- A larger number of smaller, distributed generators embedded in an electrical distribution system closer to the point of demand ie. homes and businesses. This could include wind and solar systems and combined heat, cooling and power systems from biomass and gas,
- Demand side management practices, using telecommunications and system control technologies, to help manage peak demand and maximise energy production from renewable energy sources,
- Energy storage to maximise generation potential of renewable energy sources Eg. energy storage as heat, ice, or in electric vehicle batteries etc.

This type of grid structure is now evolving in many parts of the world (see www.chpa.co.uk/news/press_releases/2009).

Felton Valley has a number of attributes that make it suitable for development as a smart grid area. These include:

- **Access to good renewable energy resources of both wind and solar energy,**
- **Potential hydro storage/power sites,**
- **Potential usable land area that doesn't conflict with current food production on fertile soils,**
- **Access to large and small electrical system transmission and distribution lines,**
- **A supportive community looking for an alternative to coal mining,**
- **Proximity to a major growth corridor in SE Queensland.**

It is proposed here that the Felton Valley could be used as a pilot project to support the development of smart distributed grids across rural Queensland that would negate the need for further expansion of coal fired power stations.

Conclusions

The work to date has identified that the Felton Valley and surrounding ridges has a very significant renewable energy resource for both electrical and heat energy, and food (human energy) production.

The preliminary energy output estimates for each of renewable energy technologies of STE, WTGs, PV and solar thermal collectors, and food production are shown in table 6.

The combined annual energy output is estimate at 1285GWh from a peak installed capacity of 713MW. This could supply the electrical energy needs of about 160,000 average SEQ homes, or twice that number if energy efficiency measures were employed in each home.

Table 6 – Combined Renewable Energy Output and Peak Capacity

RE Technology	GWh/yr	Peak Capacity (MW)
Solar Thermal Electric	1076.03	614.2
Wind Energy	207.02	96.0
PV - roof top	3.62	2.2
Solar Thermal - roof top	0.59	0.6
Biomass - food energy	146.39	
Total RE - excluding Biomass	**1287.27**	**713**

Note: Average Capacity Factor = 0.2. This could potentially double with thermal and/or hydro storage.

These results are based on a number of conservative assumptions. These are as follows:

- Solar energy land area does not include sloping land greater than 11 degrees that may be suitable for PV or Power Tower STE.
- The wind speeds predicted may well be lower or higher due to the effects of temperature inversions, katabatic flows or localised terrain shape effects.
    - Temperature inversions are common across Australia, particularly in winter due to clear sky conditions. This results in dampening of wind speeds very close to the ground, particularly at typical BOM measurement height of 10metres. At higher elevations, the wind speeds are often significantly higher than those estimated when wind speeds are projected upwards from 10m data.
    - Katabatic air movement results from cooler, heavier air flowing down into valleys from mountainous areas. The top of the Great Dividing Range is only about 10 kilometres to the east of Cambooya. A katabatic tendency of air flow into Felton is likely to exist as colder air on top of the Range falls down across the Felton area, assisted by the prevailing easterly winds. This could increase wind speeds in certain locations.
    - Localised terrain shape can accelerate or dampen winds.
- Use of a class 2 WTGs for modelling the energy output. A class 3 WTG should give better energy production.

- Output from all systems does not include the benefits of adding storage either as heat or pumped water to increase the capacity factor and allow more generation at night and during peak demand times.
- The output of PV systems is for fixed arrays only. Larger scale, tracking PV systems can increase the output by about 25 percent.

Hence, the total generation capacity may differ significantly from that estimated to date. In particular, as the output of solar farms for the Felton area is potentially much larger than wind energy, it is crucial to assess more fully the land and roof areas available for solar farming.

Key factors to investigate further to more fully develop a sustainable energy plan are:

- The need for more complete mapping of the land and roof areas available for solar technologies for both large and small scale electricity and heat/cooling generation.
- The need for on-site wind monitoring to confirm wind mapping projections.
- The need for some on-site monitoring of solar global and direct irradiation.
- Identifying support from both the renewable energy industry and the State Government, particularly the Office of Clean Energy, to undertake a full feasibility study for the Felton Valley as a pilot smart distributed grid.

Recommendations

It is recommended that Friends of Felton assist further development of a Sustainable Energy Plan for their region by:

- Helping to better quantify the land and roof area potential for solar technologies, both on a large and small scale within the Felton region. This could be done by assessing land area and roof space from Google Earth or Nearmap.com or through GIS. USQ or Government Departments may also be able to assist with GIS analysis. For example, USQ could possibly do it as undergraduate student project work or post-graduate work.

- Financially supporting on-site weather monitoring including solar global and direct irradiation, wind speed and direction measurements over 3 to 12 months, seeking financial assistance from the Office of Clean Energy.

- Gaining support from the Office of Clean Energy to develop the Felton area as a smart distribution grid model that could be rolled out across regional Queensland.

- Starting to approach potential renewable energy industry partners.

- Investigating a community funding model for sustainable energy deployment (Mallon et al, 2004).

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Glossary of Terms

BOM – Bureau of Meteorology

Capacity Factor – ratio of actual or projected annual energy output to the annual output if the power plant operated at its peak capacity all year. Typical values are:

- Coal, gas or biomass fired plant - 0.75 t0 0.85.
- Wind farms - 0.15 to 0.4. (higher value in windier sites)
- Solar Thermal Electric plant – 0.2 to 0.4 (higher value with storage or higher irradiation)
- Solar PV – 0.15 to 0.25 (higher value with more efficient panels and/or higher irradiation levels)

GWh - Measurement Unit for Electrical Energy = 1,000,000 kWh

kWh - Measurement Unit for Electrical Energy – I kWh would be consumed by a 100 Watt light bulb run for 10 hours or a 1000 Watt electric radiator run for 1 hour.

MWh - Measurement Unit for Electrical Energy = 1,000 kWh

m/s -wind speed units – 1 metre per second (m/s) = 2 knots = 3.6 km/hr

PV – Photovoltaic power generation

STE – Solar thermal electric generator