CASE STUDY
Solar vineyards in the Central Tablelands

NSW Farmers’ Energy Innovation Program has triggered a discussion with Justin and Pip Jarrett about what to do after the solar feed-in-tariff ends in December 2016. Jarrett’s Wines has the potential to invest in battery storage or electrification of its farm vehicles to help build a sustainable brand image.

Other initiatives include a review of energy-efficient design options for a new coolroom as part of their business expansion and integrated solar pumping option to reduce irrigation energy costs.

Jarrett’s Wines energy profile

Table 1: Jarrett’s Wines’ energy breakdown

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Purpose</th>
<th>Energy Used (GJ)</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>Motor bikes</td>
<td>166</td>
<td>548</td>
</tr>
<tr>
<td>Diesel</td>
<td>Tractors</td>
<td>345</td>
<td>85</td>
</tr>
<tr>
<td>Diesel</td>
<td>Harvester &amp; Excavator</td>
<td>56</td>
<td>54</td>
</tr>
<tr>
<td>Diesel</td>
<td>Other vehicles (utes)</td>
<td>270</td>
<td>48</td>
</tr>
<tr>
<td>Diesel</td>
<td>Unspecified</td>
<td>193</td>
<td>54</td>
</tr>
<tr>
<td>Electricity</td>
<td>Pumping</td>
<td>95</td>
<td>60</td>
</tr>
<tr>
<td>Electricity</td>
<td>Climate Control (office)</td>
<td>20</td>
<td>54</td>
</tr>
<tr>
<td>Electricity</td>
<td>Refrigeration (Wine store)</td>
<td>58</td>
<td>54</td>
</tr>
<tr>
<td>Electricity</td>
<td>Lighting</td>
<td>44</td>
<td>60</td>
</tr>
<tr>
<td>Electricity</td>
<td>Homestead and other</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>Petrol</td>
<td>Motor bikes</td>
<td>68</td>
<td>54</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>7,867</strong></td>
<td><strong>1,957</strong></td>
</tr>
</tbody>
</table>

The farm’s largest energy expenses are diesel-using pumps and tractors, and other vehicles.

Figure 1: Jarrett’s Wines’ use ‘baseline’ by type and purpose

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Pilot site: ‘Jarrett’s Wines’ – Orange, NSW 2157
Date of visit: 21 May 2015
Authors: Gerry Flores, David Hoffmann, Leigh Rostron & Phil Shorten

Justin and Pip Jarrett run Jarrett’s Wines, a vineyard to the west of Orange, New South Wales. The property grows a variety of horticultural crops and was once an egg farm. The farm incorporates three different properties at various altitudes ranging from 700 to 900m above sea level. Altitude changes impact grape yields and flavours, and the Jarretts tend to specialise in varieties that flourish at these altitudes, including shiraz, chardonnay and sauvignon blanc.

**Energy needs and planning for the future**

The Jarretts took advantage of the ‘solar bonus scheme’ and installed four 10kW solar arrays on their associated properties. Currently, the solar arrays are generating revenues through the feed-in-tariff of $0.60/kWh, but they will be used to provide power to the farm when the scheme ends on 31 December 2016. In addition to growing grapes, the Jarretts have two sheds with coolrooms to store wine. Some wine is produced on the farm; however, much of it is shipped in from other local vineyards before being distributed to retail outlets and online customers.

The Jarretts are looking to expand their wine production and to promote their brand as a boutique wine label. They are also interested in redesigning their coolrooms so that they are more functional and energy-efficient.

**Sustainability, farming and the land**

In the world of wine, labels generally need to work to distinguish themselves from competing brands. Justin and Pip are interested in running their business and marketing their label as ‘carbon-negative’: a product and means of production that actually removes carbon from the surrounding area. To this end, the Jarretts are working on reducing their existing energy needs through efficiency and upgrades, and supplying whatever they can through renewables, such as their existing solar PV installations. Additionally, the farm employs methods of creative cross-cropping and natural fertilisers to ensure the soil in their vineyards is healthy and has higher-than-average carbon levels, which in turn helps that soil to retain moisture and reduces irrigation needs.

The Jarretts are also exploring a number of other areas in which energy efficiencies might be made, including redirecting the solar energy their array generates from the grid to charging batteries and powering vehicles for use on the farm. They are investigating the idea of electric forklifts or quad bikes, which could operate off the solar electricity, and reduce current diesel and petrol costs.
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Cost reduction opportunities
A total of 11 energy savings opportunities were identified by the team, with the potential to save the Jarretts more than $10,000 in energy costs. Five opportunities have been prioritised for investigation by the Jarretts with assistance from NSW Farmers, as highlighted in Table 3.

Table 3: Full list of opportunities. Note: ‘UI’ indicates ‘Under Investigation’.

<table>
<thead>
<tr>
<th>Opportunity</th>
<th>Description</th>
<th>Savings</th>
<th>Capex</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractor set-up and operations</td>
<td>Ensure tractor is set up with correct ballast requirements for application.</td>
<td>$1,000+</td>
<td>6</td>
<td>&lt;1yr</td>
</tr>
<tr>
<td>Electric pump maintenance (dam 2)</td>
<td>Electric dam pumps are approximately 10 years old and have never been pulled up and serviced – primarily due to difficulty in extraction. Savings to be achieved by ensuring pumps and motors are well maintained.</td>
<td>$275</td>
<td>$1,375</td>
<td>5</td>
</tr>
<tr>
<td>Diesel genset pump maintenance (dam 3)</td>
<td>Dam pumps haven’t been inspected or had maintenance performed in 5-10 yrs.</td>
<td>$350</td>
<td>$1,750</td>
<td>5</td>
</tr>
<tr>
<td>Integrated solar for diesel genset</td>
<td>Current diesel and genset is oversized for pumping requirements. Existing infrastructure means that it may be possible to readily integrate solar PV + storage system to operate pumps as needed. Given limited use of pumping (~3 months/yr), need to explore options as to what to do with excess PV power when not pumping, including electric conversion of farm vehicles for free charging; and retrofitting existing panels on site to be relocated to a trailer system that can be manoeuvred to suit needs. Further savings to be achieved, potentially, through installation of new VSDs on the existing system and lower overall power requirements.</td>
<td>&lt;$7,000</td>
<td>$20,000+ (UI)</td>
<td>5-10 yrs</td>
</tr>
<tr>
<td>Storage options onto existing solar PV after NSW feed-in tariff expires at end of Dec 2016</td>
<td>Currently 4 x 10kW systems located on site across 4 different accounts. After Dec 2016, system will go to a net metering arrangement where the greatest gain would come from offsetting on-site use. Consider storage potential and offsetting homestead electricity use and potential chock expansion.</td>
<td>Under Investigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Produce on-site biodiesel for use in farm equipment.</td>
<td>Explore potential of creating biodiesel from grapes and understand relative energy content value of grapes vs grape mash and other sources.</td>
<td>Under Investigation likely &gt; 10 yrs payback</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load shift electric pumps (dam 2) from peak to shoulder</td>
<td>Opportunity to reduce operating costs by shifting pumping outside of peak energy using times (7am-9am, 5pm-8pm). Some difficulty in not wanting to pump through heat of day.</td>
<td>$500</td>
<td>&lt; $500</td>
<td>1 year</td>
</tr>
<tr>
<td>Power Factor / Voltage Optimisation</td>
<td>As part of future farm upgrade considerations -&gt; upgrade if load is expected to increase substantially. Possible to be pushed onto a demand-based tariff, which could create opportunities for PF correction.</td>
<td>Under Investigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar pumping at dam 5</td>
<td>Currently not pumped at all -&gt; no actual savings. Consider potential for installing low flow/high head pump connected up with level switches on dam so that it will pump whenever dam is too high.</td>
<td>Under Investigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coolroom package design considerations</td>
<td>Farm considering new refrigeration skid installed on large coolroom. Should make consideration of the following options: - High Eff Compressor (7%) - VSD to the compressor (14%) - EC Motor for evaporative fans (5%)</td>
<td>S-10% Ul</td>
<td>S-10 yrs</td>
<td></td>
</tr>
</tbody>
</table>

Totals (where costed): $9,125 $28,125 1.3 yrs

During a two-hour discussion with the Energy Team in the farm’s converted egg-laying shed, now used as an office and farmstay facility, Justin and Pip discussed their business plans and their energy innovation priorities.

The priorities include:
1) hybrid power for pumping water to dams and drip-feed irrigators
2) energy storage for general use around the farm including electric vehicles
3) refrigeration upgrade for the coolroom
4) correct tractor setup and operation
5) redirecting electricity generated from solar panels to another use on the property

Hybrid power for pumping saves $7k in diesel per year
A walk around the property identified a diesel genset (55kVA) being used to power three 7.5kW electric pumps, with VSDs installed.

Variable speed drives (VSDs) reduce electric pump requirements further so the diesel genset may only be 30% loaded, which is generally an inefficient operating load point for diesel gensets. Diesel engines typically run most efficiently when operating at loads of 70% or more. In this case, the optimal sizing would be in the order of 25kVA.

Figure 2: Main irrigation pump servicing the vineyards delivers multiple megalitres of water to the vines via drip feed and is used for around 3 months of irrigation per year. Hence the opportunity to consider a mobile solar rig that can be transported to other pumps that feed the storage dam or even run the coolroom when no irrigation is required (e.g. in hot, wet seasons)

Such a set-up is not common but has its advantages, says Leigh from Energetics – “The more common set-up is to see diesel engines connected directly to pumps; however, having a generator creates opportunities for much easier integration of solar PV straight onto existing wiring systems, together with the possibility for batteries to be wired in for storage, coupled with the diesel genset to control the speed of the motor as the pumping and subsequent electrical load varies.”
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Justin and NSW Farmers discussed the preferred configuration: “It could look like electric pumps being driven by a combination of solar and battery power with fallback onto diesel when sun/battery is not available.” Further analysis is required to determine if this configuration will enable the genset to load-share with any new solar PV system. Depending on the size of the solar PV array, the genset will go from running at about 30% load down to 20% or less, which could result in the genset needing to operate at below its minimum operating limits. This could drop further when pumping loads are reduced.

To ensure the most efficient set-up, Justin would likely need to replace his existing diesel genset with a much smaller one so that the genset operates at its best efficiency point.

Energy storage, for general use as well as for electric vehicles, makes energy independence a reality
Jarrett’s Wines has three 10kW solar PV arrays across its three properties. Currently, these arrays are earning income under the NSW Solar Bonus Scheme Feed In Tariff, which is due to expire by the end of December 2016. The array sizes are greater than the business’s current electricity requirements. The Jarretts want to understand all suitable options available to them after the tariff finishes. This is a wider question with several layers of complexity, which NSWF will address in a dedicated study. For now the focus is on storage options and how the Jarretts could best arrange their systems so as to deliver ongoing cost savings.

This investigation will include exploring the following ideas:

- using battery-powered vehicles, with batteries charged from surplus solar PV output, as vehicles are the primary energy consumers on site (How much battery power will be needed, to power vehicles travelling for what distances? At what point do the size and weight of the batteries become a problem?);
- rigging up a solar PV array on a mobile trailer and then moving the trailer around to supply power to the operation’s various electric pumps. (See Figure 6, below);
- installing a stationary battery bank near the solar PV array (close to the Jarrett homestead); and
- relocating the array to the potential new coolroom, which will be better placed to utilise excess power from the system.

The vehicles that could be converted to or replaced by electric vehicles include a diesel-powered gator, a 230hp tractor (for spraying and slashing), two motorbikes, a ute and two quads.

Local electric tractor proves it can be done
Just down the road, near Bathurst, Nuffield Scholarship-holder Michael Inwood has developed an all-electric ‘tractor’ using a 200hp (144 volts DC-to-DC motor) Mitsubishi ute with dual range (standard) gearbox and a retrofitted heavy-duty clutch. The battery pack, charged by the 10kW solar array on the Jarretts’ shed, comprises 45 x Thunder Sky TS-LFP200AHA 3.2-volt lithium-ion cells with a Café Electric Z1K LV 1,000-amp, 156-volt controller.

While this ‘electric tractor’ saves diesel costs and enhances the properties’ carbon balance, the current ‘fuel’ range of around 3-4 hours of sowing has its limitations, says Michael.

“If (says Mike) I could drive back to the shed at lunchtime, drop off one battery pack and pick up another at the flick of a switch, I would use this tractor as my only tractor for sowing and spraying.” (Mike has also reduced demand for tractor use on the property: he applies a no-till and biodiversity policy on his fine-wool merino sheep farm near Bathurst, NSW).

The benefits of electric vehicles include less noise pollution, maintenance and emissions as well as cost savings.

Jarrett’s wines would likely look at ATVs or other electric vehicle options. John Deere currently offers a small 6 horse power ATV with a hatch in the back for transporting items around the farm. These types of vehicles are still new, and relatively rare in the Australian marketplace, but new developments in battery storage and charging technology should make electric vehicles more commonplace in the coming years.
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Wine storage profitability dependent on coolroom efficiency
The Jarretts are expanding their coolroom facilities to provide a storage service for local wine producers. Great idea, but if the cost of energy and materials handling exceeds the modest storage charge, they will be carrying the cost burden. In fact, the electricity load alone is expected to double once the neighbours’ wine begins to roll into the storage facility. In order to provide an affordable service, it’s important that coolroom renovators and designers ensure, when ‘spec’ing’ skids (refrigeration plant) to consider long-term operating costs as well as upfront costs to maximise the use of new energy-efficient refrigeration components. The kinds of things the Jarretts will need to consider include:

- high-efficiency compressors: up to 7% savings;
- variable speed drives on compressors to slow the speed of the motor when the cooling load reduces: 15-20% in savings;
- an electronically commutated (EC) motor for evaporative fans: 2-5% savings; and
- screens or rooms with staged compressors: 5-15% savings, depending on occupancy rates and subsequent cooling loads.

The Jarretts contacted their supplier to cost the first three components needed to retrofit their existing system. Based on forecast storage levels, the payback period was 5-7 years.

Of course, there is a risk that the forecast storage levels won’t be achieved, but the pay-off is very attractive: perhaps as much as $5,000 p.a. (compared with a $10,000 p.a. operating cost without retrofits) over the first five years of the life of the refurbished coolrooms.

Maintenance on dam pumps
Submersible pumps, while relatively small, often run for long periods of time, left unseen, untouched and unmetered. That may seem like a good thing but it could end up being a real problem. Pumps that are excessively worn in the impellors can use 30% or more energy to deliver the same amount of water before they fail completely. For this vineyard, one set of pumps was last checked around 10 years ago. With no monitoring systems in place, it is difficult to determine how the current pumping performance is tracking against expected performance.

This pump uses about 14,000kWh/yr, costing, say, $4,000 a year, given the operating hours. If there is a major hole in the impeller it may have been using as much as 4,000kWh of extra energy a year – throwing away $1,200 per year.

Where possible, farmers should consider their ongoing maintenance and monitoring systems when making new installations, to enable more accurate tracking of performance and early identification of pump performance problems, rather than ‘letting it go’ for a five- or 10-year period.

It is entirely possible that when or if the pump is pulled out, it will be in a reasonable state and simply in need of a general service; however, it is impossible to know this in advance.

Outcomes for the vineyard
Solar PV pumping, an upgraded refrigeration plant and better pump maintenance could save Jarrett’s Wines just under $10,000 a year in electricity and diesel savings, or 16% of their energy use.

The bigger prize will be the electrification of all farm vehicles after 31 December, when the Jarretts are planning to redirect their solar-generated electricity from the grid to a bank of batteries. With this change, they’ll be able to power their vehicles.

Savings could be in the order of $30,000 or 40% of the business’s total energy bill (and perhaps 90% of its diesel fuel bill, depending on a large range of variables including number of days of sunshine, the technology available in two years’ time, battery sizes, etc).
Planning for the new world of energy storage

Justin, with the assistance of NSW Farmers’ Energy Innovation Program, will continue to explore energy-generation and energy-efficiency options that secure the future of his vineyard in Orange and increase the export potential of its wines, especially if the business’s ‘low-carbon’ story evolves. This story could be well received in European markets, where ‘green’ credentials are highly valued.

In the short term, in addition to converting the existing diesel pump to an electric one powered by a solar PV array, Justin will begin monitoring the amount of electricity and water used by his submersible pump with a wireless meter (an example of which is shown in Figure 6).

In the medium term, the business case for upgrading the coolroom refrigeration will be developed and a decision made to invest in lowering operating costs and de-risking the wine storage venture.

Long-term opportunities include large savings from electrifying all or most farm vehicles, reducing energy costs by an estimated 40% or more. The cost savings could be as much as 100% if the investment in batteries capable of storing solar-generated energy for evening use and use on no-sun days can be justified.

NSW Farmers will be monitoring innovation in battery storage and releasing information to help inform these decisions as we get closer to December 2016.