Hydro Tasmania
Consulting

Energy Self Audit Tool
for Tasmanian Farmers

NRM
North
Natural Resource Management
in Northern Tasmania

Australian Government
Department of Agriculture, Fisheries and Forestry

Dairy Farm input supported by:

DairyTas

LANDCARE
AUSTRALIA

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List of Abbreviations

J	joule basic unit of energy
kJ	kilo joule 1,000 joules
MJ	mega joule 1,000,000 joules
GJ	giga joule 1,000,000,000 joules (1000 MJ)
W	watt basic unit of power = 1 joule per second
kW	kilowatt 1,000 watts
kWh	kilowatt-hour (1 kWh=3.6 MJ)
MWh	mega Watt hours (1 MWh=1000 kWh)
GWh	giga Watt hours (1 GWh=1000 MWh)
kPa	kilo Pascals (1 kPa= 1m head of water * 9.81)
psi	pounds per square inch (1 psi= 6.895 kPa)
ha	hectare 10,000 square metres
kg	kilogram
t	tonne 1,000 kg
ML	mega litre 1000 litre
$CO_{2\text{-}e}$	carbon dioxide equivalent (Greenhouse gas emission unit)
CPRS	Carbon Pollution Reduction Scheme (Proposed emission trading scheme)

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Executive Summary

Energy efficiency is becoming increasingly important in agriculture, particularly as energy prices continue to rise and farm energy consumption becomes a significant operational expense. To date there is limited public domain information about farm energy consumption in Tasmania. In light of this, NRM North commissioned a series of eight energy audits of representative farms across the NRM North region in Tasmania.

This self audit tool is an attempt to highlight some of the most common energy saving opportunities identified for those farms, and to provide some guidelines and references for other farmers who wish to conduct an energy self audit of their farms. The action plan below may be used in combination with the relevant sections in this manual along with the References and Checklists provided, to conduct an energy self-audit as part of a farm energy management plan to identify energy use, set benchmarks and targets, and implement energy and cost saving measures.

√	**Proposed Action Plan**	**Comments**
☐	Establish an Energy consumption History for the farm (minimum 2 years of energy history)	
☐	Establish annual energy use and energy costs (kWh/Yr, $/Yr)	
☐	Develop Energy Benchmark for the farm (e.g. kWh/ha or GJ/ha, kWh/ML water etc.)	
☐	Improve instrumentation and metering of main energy users (water flow meter, pressure gauges, smart meters, etc.)	
☐	Conduct an Energy Audit (use this self audit tool, and the checklist I Appendix A)	
☐	Add an Energy Efficiency Program module to your PMP	
☐	Set energy reduction targets for each year (e.g. 15% reduction of total energy costs for 2010/11, or %10 reduction in kWh/ha etc.)	
☐	Implement cost effective energy saving measures identified during the audit.	
☐	Monitor progress towards meeting your targets (quarterly, 6-monthly, and annual reviews).	
☐	Include energy efficiency requirement in your purchasing policy.	
☐	Continually improve energy efficiency.	

1. Introduction

Hydro Tasmania Consulting (HTC) was contracted in August 2009 by Tasmania's NRM North to carry out walk-through energy audits of eight representative farms within Tasmania's NRM North region. The audits were part of a larger project by NRM North, HTC, and Agricultural Resource Management (ARM) developing a Climate Change module for inclusion in the existing Property Management Planning (PMP) framework.

The Climate Change module for PMP project included a series of workshops with farmers in the NRM North region, followed by field trips in July and August 2009, and eight property specific energy audits in September and October 2009. This energy efficiency self audit tool is based on the findings from those audits.

The energy efficiency self audit tool is aimed at enabling farmers to conduct a basic energy audit of their farm, establish their historical energy use, develop energy use benchmarks, set energy saving targets, and identify and implement energy saving measures to meet those targets.

1.1 Disclaimer

Energy and cost savings measures discussed in this document are aimed at highlighting the main areas of energy saving opportunities. Detailed financial and technical investigation should be carried out for specific projects prior to any implementation.

1.2 Acknowledgment

The funding support from Tasmanian government and Commonwealth Department of Agriculture, Fisheries, and Forestry for this project is acknowledged.

2. A Summary of Farm Energy Audits in NRM North Region

As part of Climate Change Module for PMP project eight representative farms in NRM North Region were audited. Three of those farms were dairy farms, with the remaining five being a mix of irrigated cropping with grazing, forestry and other activities. All farms with the exception of one used electricity as their main energy source for irrigation.

The total areas of the audited farms varied from 200 ha to over 1,000 ha with average area for the eight farms being close to 600 ha per farm. The irrigated portions of those farms varied from 29% to 92%, with average irrigated area being 45% of the total property area.

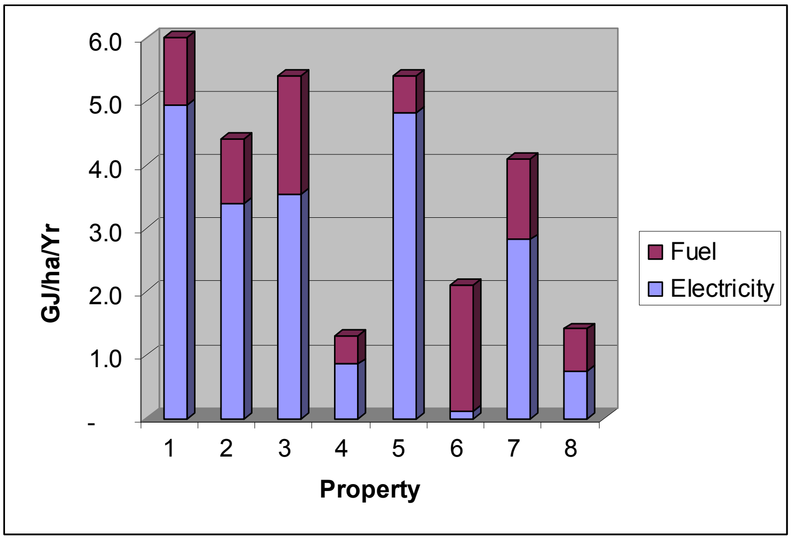
The total energy bills (electricity +fuel) for the audited farms varied from $35,000 per year to $156,000 per year, with average being just over $80,000 per year. Electricity bills accounted for an average 64% of the total energy bill or nearly $52,000 per year.

2.1 Farm Energy Use Benchmarks

Significant variations were found between energy use benchmarks for the audited farms primarily due to different pumping requirements and the irrigation system used.

Figure 2-1 shows gross energy indices in giga joules (GJ) for the total property area (including irrigated and non-irrigated areas).

Figure 2-1 Energy Indices in GJ/ha for gross areas of the 8 audited farms



As can be seen from **Figure 2-1**, the gross energy indices for the eight farms vary from a low 1.4 GJ/ha to a high 6.0 GJ/ha. An average gross energy index of 4.0 GJ/ha/Year was calculated for the eight participating farms.

More useful energy indices for irrigated areas of those farms were also calculated. For the seven all-electric farms that energy index varied from a low 315 kWh/ha (at 2008/09 cost of $56/ha), to a high 2,065 kWh/ha (at 2008/09 cost of $350/ha). An average energy index of **1,268 kWh/ha** of irrigated area (at 2008/09 cost of **$216/ha)** was calculated for those farms.

The accuracy of the above energy index can be improved by a survey of all farms in the NRM North region in the future. The above index however, can provide an early reference for the purpose of comparison with the farm specific energy indices developed as part of this self audit.

Ideally, irrigation energy use indices should be linked to the amount of irrigation water used. However, the absence of flow meters on nearly half of the irrigation systems audited did not allow development of that index for those farms. For those irrigation systems with flow meters installed, energy indices of between 200 kWh/ML to 500 kWh/ML corresponding to $35/ML to $85/ML could be calculated. Those variations depended primarily on pump/irrigation sets efficiencies and the Total Dynamic Heads (TDH) for those pumps.

For dairy sheds on the three dairy farms audited, an average energy index of **168 kWh/cow** was estimated. That is close to a recent New Zealand study which estimated an energy index of 160 kWh/cow in New Zealand dairy sheds. (See Reference 7)

2.2 Greenhouse Gas Emissions

Energy use, enteric emissions from livestock, and fertiliser use, were the main emission sources for the audited farms. Those farms however, offer many emission sinks in the soil and in plant biomass.

Under the proposed Carbon Pollution Reduction Scheme (CPRS) agriculture is exempted from an emission trading scheme.

Early estimates of greenhouse emission sources for the audited farms showed average emissions of less than 1,500 tonnes of CO_2 equivalent per farm. Nearly 85% of those emissions could be attributed to enteric emissions from livestock.

2.3 Energy Saving Opportunities

Potential energy cost savings of between 10% to 30% were identified for the audited farms, with average energy cost saving potential of 16% or $12,500 per annum per farm.

The bulk of those potential energy costs savings were based on targets of between 30 to 50% reduction in peak hour (High Rate) irrigation outside the peak irrigation periods. Some of the common energy and cost saving opportunities for those farms are discussed in this self audit document.

3. How to Conduct a Walk-through Energy Audit

An energy audit is not dissimilar in principles to a financial audit. It is essentially a review of energy purchases (incoming energy) versus energy expenditure (outgoing energy). An energy audit is often a cost effective way of bringing focus on the way energy is used and finding alternative more efficient ways of providing the same services with reduced energy expenditure.

The incoming energy metered by electricity meters or invoiced by fuel suppliers is relatively easy to determine. The energy expenditure side is usually more difficult to accurately determine.

Use of sub-meters (currently less common on farm equipment) is one option of measuring consumption by different equipment. Preparing an inventory of all energy consuming items and their rate of energy use, which can be obtained from nameplate readings multiplied by operation hours of that equipment, provide reasonable estimates of energy expenditure by those equipment (See Section 3.5 below).

Australian Standards AS3598:2000 provides the outlines and requirements for three levels of energy audits, with the level of detail and complexity increasing from Level 1 to Level 3. AS 3598 can also be used for specifying requirements and consultant’s briefs if an external auditor is used to conduct those energy audits.

3.1 Energy Consumption History

Preparing an energy consumption history is often one of the first steps in an energy audit. A minimum of 24 months is usually required to determine annual energy consumption and costs and analysis of energy use patterns such as seasonal variations, annual increase or decrease in energy use.

In case of fuel use, constructing an energy consumption history is a matter of simply entering amounts and cost of fuel purchases from past invoices into a spreadsheet.

In case of electricity consumption history, the on-line services available from Aurora Energy’s website include full access to all historical energy consumption and billing data. Subscribing to those services is simply a matter of contacting Aurora on 1300 13 2003, or registering on line using the following link; www.auroraenergy.com.au/online_services

Most farms have multiple electrical installations for various pumps and buildings. Therefore it is useful to build a separate energy consumption history for each installation individually on an Excel worksheet to enable charting and analysis of those historical data. A typical energy consumption history is shown on the accompanying Example Farm workbook.

The quarterly billing data would enable analysis of energy use for each separate installation over the years and during different seasons. However to establish an annual total for energy consumption for the farm the data needs to be aggregated for each calendar or financial year. **Table 3-1** shows a typical summary of annual electricity use for the Example Farm.

Table 3-1 008/09 Electricity Consumption Summary for Example Farm

Installation	2008/09 electricity use (kWh)	2008/09 electricity cost ($)	$/kWh
Dwelling	29,506	$4,309	$0.15
Misc. building	2,556	$890	$0.35
Pump 1	-	$880	
Pump 2	94,200	$17,502	$0.19
Total	**126,262**	**$23,581**	**$0.19**

As can be seen from **Table 3-1**, the annual electricity use for Example Farm amounts to just over 126 MWh at 2008/09 cost of $23,581. The annual energy consumption and costs can then be used to determine energy benchmarks (See Section 3.4 below) and for estimating energy savings.

Another useful tool to show the relative consumption and costs of each installation is to prepare pie charts for both energy consumption and energy costs as shown in Figure 3-1 and **Figure 3-3** respectively. (Note that the percentage costs and percentage consumption for each item can be different due to different electricity tariffs).Figure 3-1 2008/09 Electricity Consumption at Example Farm.

Figure 3-2 2008/09 Electricity Consumption at Example Farm

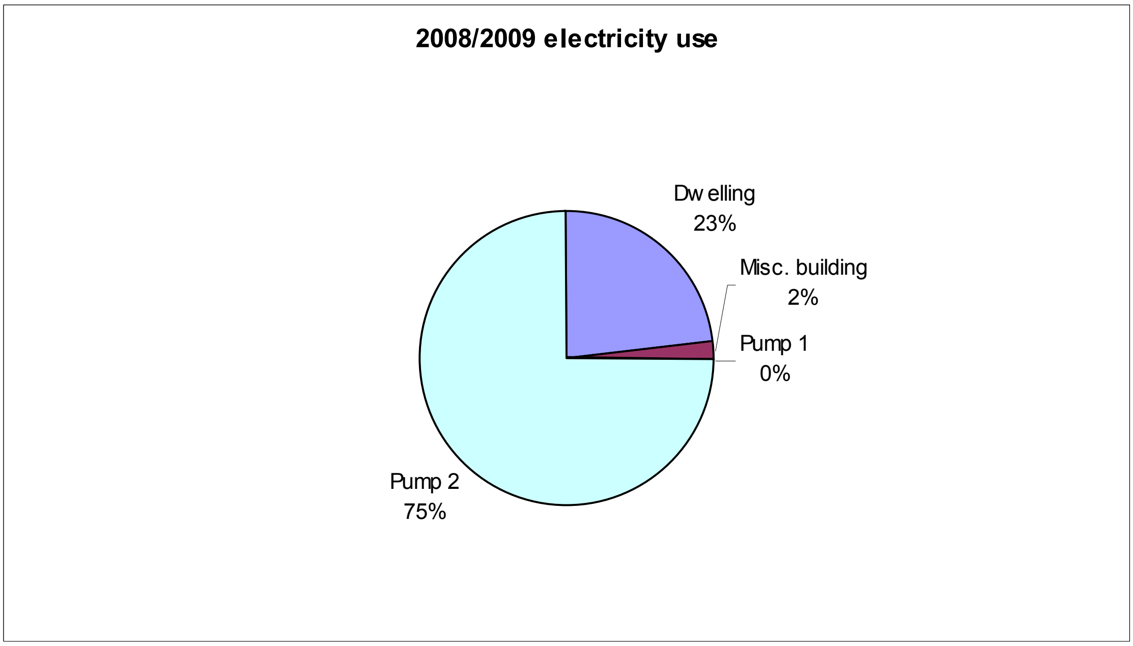
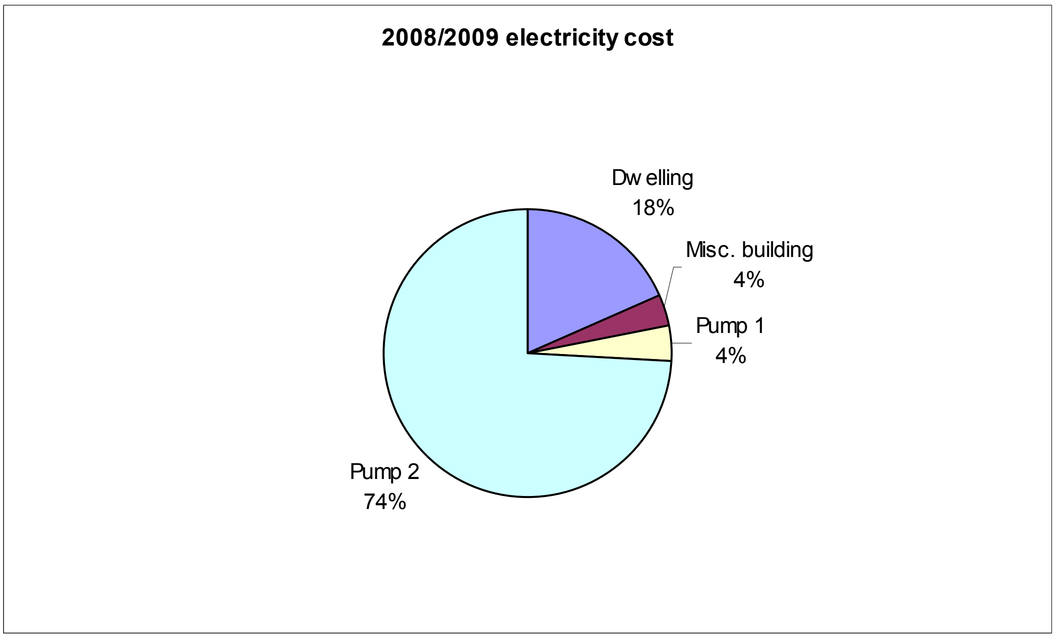


Figure 3-3 2008/09 Electricity Costs* at Example Farm



** based on latest 2009/10 Tariff Rates (see Appendix C)*

3.2 Diesel and Other Fuels Use

In addition to the electricity use, there are also fuel purchases for use in farm machinery, tractors and vehicles, and in a minority of cases for diesel pumping.

In cases where historical records are available only for fuel costs (and not fuel volume), an estimated fuel price may be used to convert those cost data to volumes of fuel in litres.

To convert fuel volumes to raw energy data, a calorific value of 38.3 mega Joule per litre (MJ/l) for diesel, and a calorific value of 34.2 MJ/litre for petrol may be used.

If the Example Farm above uses $12,000 worth of diesel at pre-rebate of $1.2/litre, an annual diesel use of 10,000 litres per year may be estimated. From that an annual energy use of 383,000 MJ (or 383 GJ/Yr) may be estimated.

To obtain a single figure for energy use, electricity consumption can be converted to the same energy unit for fuel by multiplying the total kWh electricity by 3.6 to obtain equivalent energy in MJ units.

For example the total electricity use of 126,262 kWh for Example Farm above is equivalent to 454,543 MJ which can then be added to the above Diesel use of 383,000 MJ to obtain a total energy use of 837,543 MJ/Yr (or 837.5 GJ per Year).

3.3 Tariff Analysis

The majority of Tasmanian farms use regulated tariffs published annually by Aurora Energy for their electricity bills. The larger contestable customers have individual contracts with Aurora or other electricity retailers based on rates and terms and conditions negotiated between those customers and their suppliers.

3.3.1 Understanding Tariff Rates and Charge

Appendix C gives a summary of 2009/10 Tariffs rates for most commonly used Tariffs for farms in Tasmania. Details of Tariffs for Agribusinesses and their rates and charges can also be found from Aurora’s web site:

http://www.auroraenergy.com.au/small_business/rates_and_charges/agribusiness.asp

A good understanding of the energy rates and fixed daily charges for the few main tariffs used in most farms in Tasmania is essential in determining whether or not each installation is on the most cost effective tariff.

For example, Aurora's Irrigation Tariff 73/74 includes an attractive Low Rate component (Tariff 73) which has energy rates of less than half of its High Rate (Tariff 74) component. However, at the relatively high fixed charges of ($2.42/day in 2009/10) this tariff could end up costing more than a general tariff such as Tariff 22 if used for small stock pumps or pivot's motive power with small annual consumption during peak hours.

A comparison of annual costs under each tariff can be performed using the current tariff rates and latest historical data. Calculating average unit costs in cents per kWh discussed below offers a good opportunity to check appropriateness of each tariff.

3.3.2 Average Unit cost ($/kWh)

The annual summary of energy use and costs such as those in **Table 3-1** would enable calculation of an average cost per kWh for each installation which can assist with a quick Tariff check and diagnosis of high fixed charges.

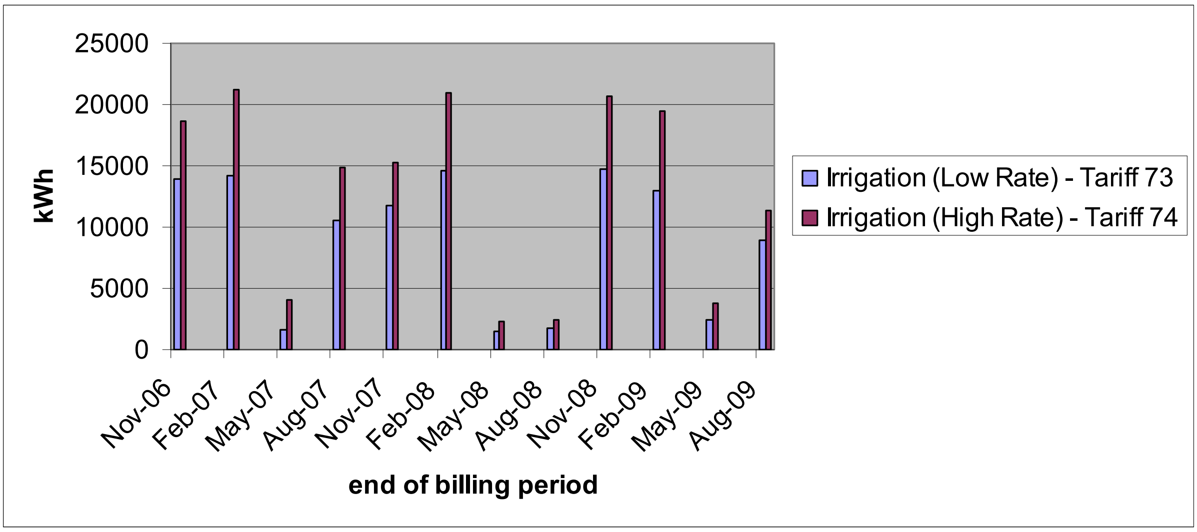
For example, the last column in **Table 3-1** shows average energy costs from 15 cents per kWh (for the Dwelling) to 35 cents per kWh (for the Misc. building-due to high fixed charges relative to consumption). In case of pump 1, the fixed charges make up the entire annual bill of $880 which has zero consumption.

Cases like that may prompt such assessment as disconnecting a disused installation, changing to another tariff with lower fixed charges, etc. They can also assist with determining how effectively the off peak tariffs are used.

3.3.3 Maximising Low Rate (Off Peak) Energy Use

Examining energy consumption for each installation separately would enable charting of those historical data as shown in **Figure 2-1** for Pump 2 at the Example Farm.

Figure 3-4 Energy Consumption Histogram for Pump 2 in Example Farm



As can be seen from **Figure 3-4** , energy use under High Rate Tariff 74 is consistently higher than consumption under Low Rate Tariff 73 even during shoulder and off peak irrigation seasons of Autumn/Spring and Winter. As can be seen from May and August consumptions on **Figure 3-4**, 100% of irrigation in those quarters could have been done during off peak time.

Whilst the existing irrigation capacity constraints force most farmers to operate their irrigation pumps continuously during the peak irrigation season, with careful planning especially during shoulder seasons at the beginning an end of the irrigation season, most farmers can shift significantly more irrigation to off peak hours. Use of irrigation scheduling based on actual soil moisture can also reduce water demand and energy whilst ensuring that plants have always access to their required moisture.

3.3.4 Extended Off Peak Hours

The Low Rate (off peak) components of Aurora’s Irrigation Tariff 73/74, has a standard night rate available for 10 hours. However subject to lack of local network constraints and at Aurora's discretion, an 11 hour extended off peak may be available on request.

This request is often in the form of an inquiry followed by signing of a standard contract with Aurora. It is therefore recommended for all farms using Irrigation Tariff 73/74 to check and see if they are already using the extended 11 hours per day off peak rates.

3.3.5 Multiple Connection Discount

According to Aurora’s web site if there are more than one connection from a high voltage distribution line at a site or property, there may be a Multi-connections Discount available. Under that discount, the full fixed charge is only payable on the tariff with the highest fixed charge (the principal tariff) with all other fixed charges capped at a maximum of 50% of the principal tariff.

See: http://www.auroraenergy.com.au/small_business/rates_and_charges/agribusiness.asp

Aurora can be contacted through their Business Line 1300 13 2045 for further queries about availability of this option.

3.3.6 Electricity Retail Contestability

Electricity users in Tasmania are progressively becoming ‘contestable customers’ where they can negotiate individual contract with any of the electricity Retailers operating in Tasmania. Tranche 4 customers; the latest group of electricity users to become contestable in Tasmania are defined as those customers using more than 0.15 GWh (or 150 MWh) of electricity per year.

Whilst there is an option of aggregating multiple installations at one site, a ‘customer’ in the above definition corresponds to a separate Installation. In case of the Example Farm as can be seen from Table 3-1 the largest Installation; Pump 2 has used only 94.2 MWh of electricity in 2008/09 and is well below the 150MWh threshold for Tranche 4 customers. All of the installations at Example Farm including the house are considered Tranche 5 installations which can become contestable in July 2010. However Tasmanian Government is yet to make a decision on extending contestability to this group of consumers which includes mainly residential customers and small businesses.

Normally, after a group of customers become contestable, there is a 12 month grace period when those customers can remain on their existing tariffs (if they wish) before negotiating a contract.

A typical electricity contract has 2 main components of energy and demand charges. (under current irrigation tariff only the energy or kWh components is billed). The contract prices are also determined by the time of use.

A download of electronic interval meters (if installed) can reveal both Maximum demand (in kW or kVA), as well as time of use of electricity. The bidding retailers can then offer prices based on those half hourly load profiles.

For a low cost electricity contract, an installation should ideally have a high load factor (which is a ratio of average demand and maximum demand), and a low percentage of energy use during peak hours. Those data are usually used as initial parameters for starting contract negotiations.

As the incumbent Retailer, Aurora can be contacted through their Business Line 1300 13 2045 for a contract quote. For further information on contestability refer to: www.power.tas.gov.au

3.4 Energy Intensity Benchmarks

Energy use is often closely linked to the production or services for which energy is used (e.g. milk or crop productions, or water pumping in Agriculture). Developing an energy intensity benchmark (or energy index or energy KPI) can provide a better indication of energy efficiency of a farm compared with the total annual energy use figures which can vary depending on such factors as irrigated area each year, volume of water used, different crops, etc.

A benchmark for energy used for each mega litre (ML) of water pumped such as kWh/ML (provided that water pressure variations are not too large) is often a useful benchmark for irrigation pumps. Such benchmark can also be used to compare different Irrigation systems and estimate potential savings (See **Figure 4-1**).

An accurate water flow meter can provide the basis for an irrigation index which can then be used to develop irrigation energy efficiency targets. Most Irrigation schemes in Tasmania require Irrigators to report their water usages. Increasingly Telemetry devices such as Ajenti developed by Hydro Tasmania Consulting are used to automatically report water extractions. Those data are also stored and can be accessed by farmers from Ajenti’s web site for use in developing Irrigation energy use benchmarks in combination with electricity use data which are readily available.

In the absence of water flow meters, a more crude benchmark of kWh/ha of irrigated area may be calculated. For example, the 94,200 kWh annual energy consumption by Pump 2 at Example Farm corresponds to 1,256 kWh/ha for the 75 ha irrigated area of the Example Farm.

A broader energy index can also be developed to incorporate diesel and other energy use. For a total of 837.5 GJ calculated for Example Farm above, a gross energy index of 4.2 GJ/ha for the 200 ha property may be developed.

Energy benchmarks are useful as part of an energy management module for PMP where annual reduction targets in energy intensity can be set and monitored independent from the total energy use of the farm, which can vary from year to year.

3.5 Conducting an Energy Survey

Having established the annual energy consumption using the historical data as discussed above, an energy survey of the farm can be carried out. The purpose of the energy survey is to:

- Balance the energy purchases against energy expenditure (energy balance)
- Apportion energy use by function (e.g. irrigation, dairy, etc.) and physical location

- Observe the operation of the main equipment from an energy use point of view
- Identify energy saving opportunities

A paper copy version of the Table 3-2 below can be used to survey all the equipment and their operating schedules. Those data can be entered into an Excel spreadsheet at the end of the energy survey for further analysis. Appendix D gives a blank one page version of Table 3-2 which can be printed in multiple copies for use in the energy survey.

The easiest way of determining kW or Power rating of each equipment is to read their nameplate rating which is given in kW or horsepower hp (1 kW=0.75 hp). However, most electric motors driving irrigation pumps are oversized by up to 70% or more. Reference 3 provides a step-by-step guide for measuring the actual power using an electrical energy meter. As a ball park estimate, the nameplate ratings multiplied by annual operation hours (kW x hrs/year=kWh/Year) should give an estimate for annual energy use of each equipment and ultimately the whole farm which can then be compared against billing data.

Table 3-2 A basic template for conducting an Energy Survey

(a) Equipment/Device Name	**(b) kW**	**(c) Operation Hrs/Day**	**(d) Operation Days/wk**	**(e) Operation Wks/Yr**	**(b*c*d*e) Estimated kWh/Yr**
Total					

The above energy survey provides a systematic way of looking at each piece of equipment and gaining some insight into its annual operation and energy costs. Such deliberate effort can highlight the main energy users at the site which can then be the subject of a focused investigation for alternative technologies and/or operating regimes that can deliver the same service at lower energy costs.

References listed at the end of this document can also be used for the initial research into different areas of energy efficiency relevant to the rural sector. A general self audit guide developed by Aurora Energy (see below) may also used along with other energy efficiency resources on Aurora’s website:

http://www.auroraenergy.com.au/save_energy/business_energy_saving_tips.asp

A more focused research using the internet and Suppliers' literatures can help with the understanding of the specific energy systems and equipment on your farm and their corresponding energy conservation options.

Below is a broad discussion of some of the common energy and cost saving opportunities observed in most of the audited farms.

4. Identifying Energy/Cost Saving Opportunities

4.1 Irrigation Systems

Photo: Courtesy of Electric Farm, Aurora Energy

Irrigation typically accounts for 70-80% of farm energy use so energy savings in the irrigation system are a priority for reducing overall farm energy consumption.

Installation of a new irrigation systems often involve significant amount of capital and is often based on a decision that takes into account such factors as return on investment, water use efficiency, degree of automation, maintenance requirements, durability, and energy efficiency.

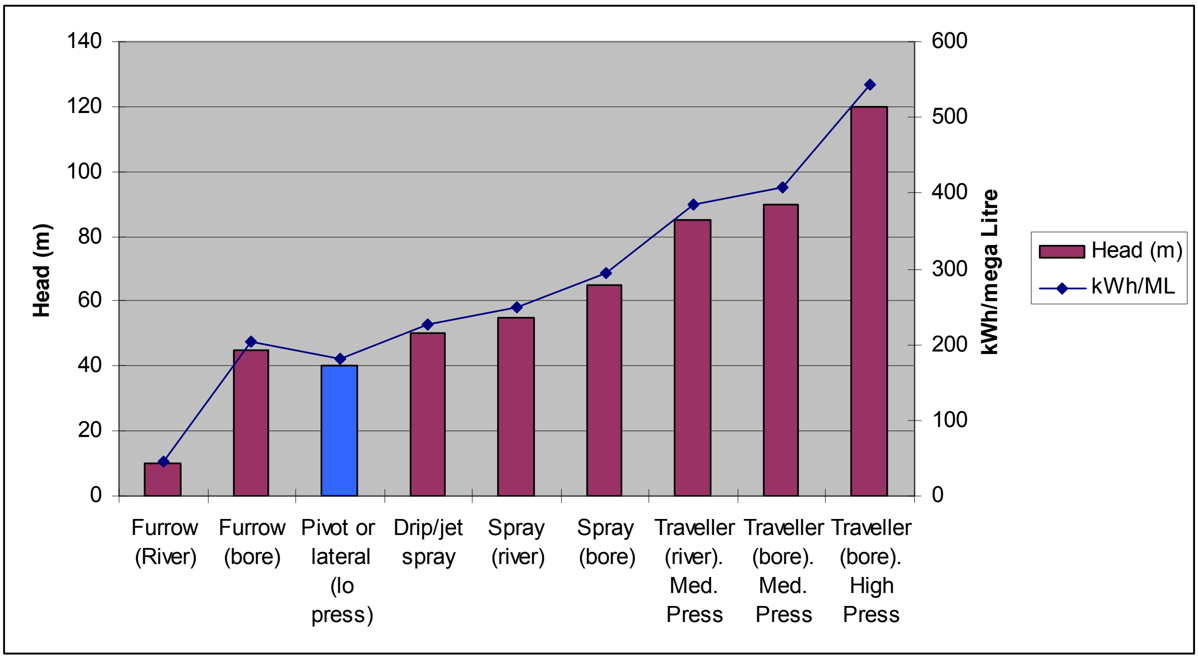
Therefore choices made based only on the least capital cost options (such as small diameter mains, high pressure irrigators, etc.) at the outset of a development can have ongoing cost penalties in higher energy use and other costs for many years to come.

Reference 1 gives a brief description of some of the main irrigation systems used in Tasmania. However, it is important to consult an independent Irrigation specialist or insist on lifecycle costing of different systems from the suppliers rather than only the initial costs when deciding on a new irrigation system installation or major upgrades.

Different irrigation systems have different pressure (head) characteristics which determine their energy use for a given volume of water. **Figure 2-1** shows an example of typical heads (in meters) and typical energy use benchmarks (kWh/ML) expected for some of the common Irrigation systems.

Section 4 of Reference 7 also gives a list of energy saving opportunities for an existing Irrigation system.

Figure 4-1 Typical pressures and energy requirements for different irrigation systems



Data Source from NSW AgFActs 2003

4.2 Pumps

Irrigation pumps are often the largest energy user in a farm. By far the majority of the pumps used in Tasmanian farms are centrifugal pumps powered by electric motors.

Those pumps when selected correctly and well maintained, are relatively trouble free and efficient.

Possible causes of inefficiency in pumps include (but are not limited to):

- Poor initial pump selection
- Pump selected for a duty that is not the present situation.
- Poor motor efficiency (possibly due to failing windings, bearings, etc.)
- Pump friction (bearings, seals, wear plates)
- Excessive hydraulic loss (though pump, adjacent fittings, check valves, etc.)
- Internal recirculation (excessive clearance between impeller rotor and pump casing)
- Foreign material in pump

- Pitted impeller or pump casing
- Poorly mating pump casings and/or internally protruding gaskets
- Cavitation

Whilst for a large pump it may be cost effective to conduct a detailed pump test, having some basic instrumentation on the pump such as a working pressure gauge, a flow meter, and an electricity meter (or sub meter) can often identify deterioration in pump performance and such issues as blockages and leaks etc. Reference 3 and Example below illustrate how you can carry out a basic pump efficiency test at your farm.

Example:

Flow Rate: 60 l/s (converted from 3.6 Kilo Litres/min or m^3/min read from flow meter)

Head= 90 m (Read and converted from pressure gauge showing 883 kPa or 128 psi)

Pump Efficiency: 0.75 (or 75% read from the pump curve)

Motor Efficiency: 0.9 (or 90% read from motor nameplate or assumed)

kWh (Power)= Flow rate in l/s x head in kPa/(pump efficiency x motor efficiency)/1000

kWh (Power)= 60*90*9.81/(0.75*0.9)/1000

kWh (Power)= 78.5 kW

You can then compare the calculated power against actual power demand from your Electricity Meter (see Ref. 3)

References 2 to 7 provide useful resources for selecting and maintaining pumps for maximum efficiency.

Photo: Three Centrifugal pumps in parallel driven by electric induction motors

4.3 Electric Motors

Electric Motors where they can be installed economically (depending mainly on the availability of the electricity supply infra-structure) are often the most reliable, convenient, and cost effective options for providing motive power for irrigation pumps, pivots, and many workshop and other equipment used on a farm.

The use of high efficiency motors (HEMs) and use of Variable Speed Drives (VSDs) for motors with variable demand (e.g. pumps with varying heads or flow rates) are other main areas of energy efficiency discussed briefly below.

4.3.1 High Efficiency Motors (HEMs)

HEMs are usually manufactured from materials which result in lower energy losses compared with standard motors. High Efficiency Motors can offer 3% to 5% more efficiency than standard motors at a slightly higher capital cost.

The use of High Efficiency Motors (HEMs) as replacements for existing motors that are still in good working order may not be justifiable financially given that the total operation hours for irrigation pumps are often limited to the irrigation season. However, it is important to ensure energy efficient motors are considered for new installations or when motors are due for replacement.

4.3.2 Variable Speed Drives (VSDs)

Variable Speed Drives (VSDs) also known as Variable Frequency Drives (VFDs) work by converting AC signals to DC using rectifiers and then inverting these DC signals back to AC at the required frequency and speed for the task being performed. Normal speeds of electric motors are based on the frequency of the electricity supply and the motor's number of poles. For example a 2 pole motor has a nominal speed of 3000 RPM (50 hz supply x 60 seconds/min). A VSD can offer any speed required although for centrifugal pumps a speed reduction of less than 20% is likely to cause issues with pumping.

In cases where there are varying pump duties because of changing terrain and pipe lengths (friction) for different pivot sites and especially in cases where the pumps are throttled for significant number of hours, a VSD may be cost effective. VSDs can also provide soft starts for cases where there are capacity constraints for the brief but very high in-rush current when electric motors start.

VSDs are expensive devices and their implementation would need to be the subject of a detailed assessment of capital costs versus energy savings and other benefits. There will be little or no savings from VSD installation on a properly sized motor operating at full load.

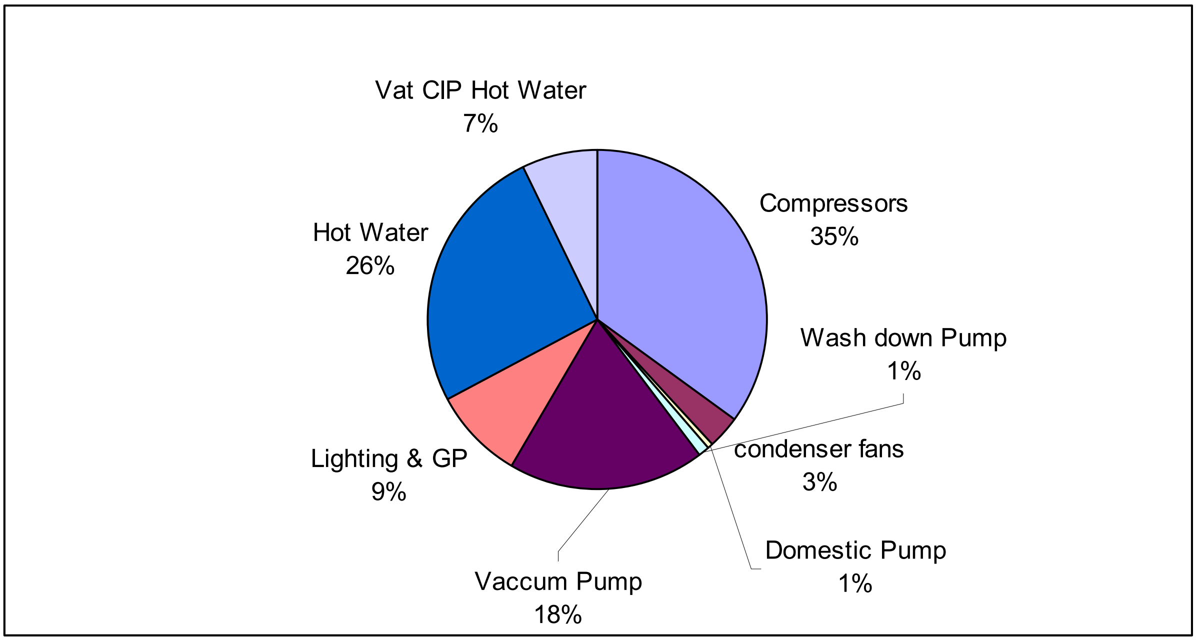
4.4 Dairy Sheds

Dairy sheds on the three dairy farms audited accounted for between 25% to 30% of the total electricity use for those farms.

The main electricity tariff for Dairy sheds is Aurora's General Tariff 22 (See Appendix C). A cheaper hot water tariff (Tariff 43) is used for billing of hot water heating which often amounts to about 40% of total electricity consumption of the Dairy shed.

Figure 4-2 shows an estimated apportioning of energy use in one of the audited dairy sheds.

Figure 4-2 Approximate apportioning of electricity use at a dairy shed



4.4.1 Dairy Shed Benchmarks

A useful benchmark for dairy sheds' energy consumption can be established by dividing the total annual energy use at the dairy shed by the number of cows milked during that year to obtain kWh/cow.

For the three dairy farms audited an average energy index of 168 kWh/Cow was calculated. As a comparison a recent New Zealand study estimated an energy index of 160 kWh/cow (See Reference 7)

4.4.2 Hot Water Heating

Hot water heating is often the largest energy (electricity) user in a dairy shed accounting for between 30 to 60% of total energy use. Although at lower tariff rates the share of hot water costs are often less than refrigeration costs which are billed under a higher tariff.

Hot water heating energy requirement depends on the temperature difference between the hot water temperature required and the incoming feed water, as well heat losses from hot water tanks, pipes etc.

Below is a worked example for estimating hot water energy requirements.

Example:

Daily hot water demand; 1,000 l/day

Hot water Temperature: 85 Deg C

Average feed water temperature: 15 Deg C

Hot Water Heating Energy in kWh/day =1000 l/day*4.2 kJ/kg/Deg C*(85-15)/1000/3.6

= 81.7 kWh/day

Heat Losses from hot water tank and pipes: say18 kWh/day (assumed)

Estimated Cost/day=100 kWh*$.12/kWh=$12/day

Apart from the well known energy saving measures such as pipe insulation, hot water conservation, and hot water reuse, below are a number of options which could be considered for reducing hot water energy costs. References 7 and 8 also provide useful resources for identifying hot water energy efficiency opportunities.

4.4.3 Hot Water Heat Pumps

Hot water heat pumps such as Quantum heat pumps have average efficiencies of more than 2.5 times the efficiency of direct element resistive heaters which have a theoretical Coefficient of Performance or COP of 1 (i.e. 1 kWh of heat is produced for every 1 kWh of electricity).

Hot water heat pumps can be used as pre-heaters as they are able to reach temperatures of 60-65 Degree C which can then be boosted in a conventional hot water cylinder to reach the higher temperatures required for hot rinse and sterilisation. Pre-rinse and warm water can also be directly supplied from hot water heat pumps.

Typical installations of heat pump hot water heaters at dairy farms include up to 4x315 litre storage heat pumps in series with the main hot water tank. Spreading the preheating time throughout day and utilising existing or new hot water storage capacity can reduce the number of required heat pumps by half or less hence reducing the upfront capital costs.

As an example, assuming 800 l/day hot water use at 85 Deg in a dairy farm, an annual energy demand of 65 kWh/day at cost of $2,234 per year may be estimated.

800 l/day *4.2 kJ/kg/Deg C *(85-15)/1000/3.6 = 65.3 kWh/day

65.3*285 days/yr*$0.12/kWh = $2,234/Yr

Pre-heating that water to 65 Degree C using hot water heat pumps (at COP 2.5) can reduce that cost to 36 kWh/day at cost of $1,230 resulting in savings of nearly 45% or **$1,000/Yr**.

4.4.4 Waste Heat Recovery from Refrigeration

A vat refrigeration system works by removing the heat from the milk inside the vat through its evaporator and rejecting that heat to the atmosphere via its condenser or outdoor unit (See Reference 9 for details of a typical refrigeration system). Inserting a heat exchanger upstream of the compressors to remove the heat from superheated refrigerant can reclaim most of that waste heat which can be used for hot water heating.

Mahana Blue developed by Danfoss in NZ is one such product using refrigeration waste heat for hot water heating. See: http://www.meridianenergy.co.nz/YourFarm/Products/Mahana++Blue.htm

According to a CAENZ trial, the Mahana Blue achieved savings of 56% in hot water use for a typical NZ midseason day reducing water heating electricity usage from 88 kWh/day to 39 kWh/day (See Ref. 8). However such units may not be currently eligible for Renewable Energy Certificates (REC’s) which are available for hot water heat pumps. Mahan Blue is said to reach higher temperatures of 85 Deg C compared with Quantum heat pump maximum temperature of 65 Deg. C.

Heat recovery from the hot water being disposed at the end of a washing cycle is another option for preheating feed water. ‘Retriever’ which is basically a heat exchanger inside a plastic tank is one such heat recovery system developed in New Zealand. Retriever is claimed to achieve 30% or so savings in hot water heating energy costs.

See: www.eecabusiness.govt.nz/sites/all/files/heat-recovery-cuts-hot-water-bill-for-diary-farm.pdf

4.4.5 Reducing Heat losses from hot water cylinders

Despite being fairly well insulated, all hot water storage tanks continually lose heat to the atmosphere. That heat loss is increased at lower outdoor temperature and higher tank temperatures.

Added insulation in the form of thermal jackets for the hot water cylinders and hot water pipes often is a cost effective investment.

Switching hot water heaters off during the 80 or so non milking days each year can also help with reducing those heat losses which can amount to savings of over $100 per tank per year.

Un-insulated plastic or metal tanks often used for temporary hot water storage during wash downs can also result in a significant amount of heat loss.

4.4.6 Increasing Refrigeration Efficiency

Refrigeration is often the second highest energy user after hot water heating and the biggest item in terms of energy costs in a dairy shed due to the higher rates of electricity tariffs used for refrigeration and general light and power.

Refrigeration system is amongst the more expensive installations in a dairy shed and generally can not be replaced economically based on energy efficiency gains alone. It is therefore important to select equipment based on their lifetime running costs and not just the upfront capital expenditure.

Reference 7, 8, and 9 provide useful resources for identifying and implementing energy efficiency measures for the refrigeration system.

4.4.7 Maximising pre-cooler efficiency

Milk pre-cooler heat exchangers, now a standard feature of most dairy farms, provide the first stage cooling of milk using water from a bore or a dam at ambient temperature. The pre-cooler can reduce the demand on a refrigeration system significantly by reducing milk temperature to within a few degrees of cooling water temperature. The effectiveness of the pre-cooler therefore is determined by cooling water temperature and flow rate, as well as milk flow rate through the heat exchanger and the heat exchanger’s efficiency.

For a Dairy shed with 650 cows milked daily, the difference between a scenario of a pre-cooler working to reduce milk temperature to an average 18 ºC, and not having a pre-cooler is close to 22,500 kWh per year or nearly $4,500 per year in added refrigeration costs. That is a difference of 55% in annual refrigeration costs of initial milk cooling. However, there may be issues with the existing pre-coolers preventing them from working optimally. Those include issues such a cooling water source that is subject to solar and other heat gains (e.g. un-insulated tanks), high temperatures, low flow of cooling water, clogged and fouled heat exchangers, etc.

Efforts therefore need to be made to reduce milk temperature through pre-cooler as much as possible as there is an estimated 1,200 kWh or $240 per year (in 2009 rates) cost reduction for each 1 ºC milk temperature reduction through a pre-cooler.

Monitoring of entering and leaving temperatures of both milk and water under different milk flows and cooling water temperatures can highlight potential improvements through adjustment of flow, supply of cooler water, cleaning of heat exchanger etc.

Another effective method of improving pre-cooler performance is through fitting of VSDs to milk pumps as discussed below.

4.4.8 Milk Pump VSD

The milk pumps operate using float switches in the milk tanks. That results in periods of no flow, followed by periods of high milk flow through the pre-cooler heat exchanger reducing the efficiency of this free cooling option.

A more uniform flow through the pre-cooler through installation of VSDs to milk pumps is likely to increase effectiveness of the pre-cooler hence reducing refrigeration costs. For further details for such retrofits refer to the following document: http://www.sce.com/NR/rdonlyres/025AEFAD-1BFB-46CA-852D-64B5B1E9BBAF/0/Dairy_Farm_Milk_Cooling.pdf

4.4.9 Vacuum Pumps and VSDs

Vacuum pumps are often the third highest energy users in a dairy shed after hot water heating and refrigeration. Vacuum pump designs include water ring, lobe rotor and rotary vane etc. each with different advantages and disadvantages). In terms of energy efficiency water ring designs are least efficient and rotary vane pumps most efficient.

In a trial discussed in Section 2 of Reference 7, the use of a rotary vane pump in place of a water ring pump reduced energy use of the vacuum pump from 71 to 44 kWh/day. That is a 38% reduction in energy use. Table 3-2 in Reference 7 lists the advantages and disadvantages of each vacuum pump design.

Use of a VSD as an alternative to conventional air bleed vacuum regulators can also result in energy savings of between 30 to 60%. Figure 2.3 in Reference 7 gives a comparison of energy savings using a VSD for different vacuum pump designs.

4.4.10 Scroll Compressors

Scroll compressors can be between 15 to 20% more efficient than reciprocating compressors. With fewer moving parts they are also less noisy and more reliable.

Replacing an existing reciprocating compressor with a scroll compressor on energy savings alone might not be justifiable. However, this option should be considered at the end of compressor's life or at the outset of a dairy shed design.

Photo: A rotary milking platform in operation

4.4.11 Chilled water or Ice Storage

Use of a chilled water storage tank as a second stage cooling can also help with increasing the peak capacity of an existing refrigeration system in an expanding dairy farm.

An electricity contract with an off peak component can also make the option of off-peak chilled water storage at lower rates more attractive than the existing flat rate tariff (Tariff 22) which does not differentiate between peak and off peak rates.

A future refrigeration system may also include a heat recovery system (See 4.3.2 above) to not only improve refrigeration capacity but also provide free preheating of hot water.

4.4.12 Refrigeration Troubleshooting

Table 2.1 at the end of Reference 9 provides a useful chart for diagnosis and troubleshooting of dairy refrigeration problems. Reference 7 and Reference 8 also provide useful resources for energy saving opportunities at a typical Dairy farm.

4.5 Domestic Energy Efficiency

Dwellings on the eight farming properties audited accounted between 1% to 23% of annual energy costs of those farms. The average share of domestic energy use for the audited farms was just under 10% of annual energy costs.

Typically the main dwelling on farms had a higher energy use up to three times higher than an average all-electric Tasmanian home of 12,000 kWh per year. The main reasons for the high energy use included mainly the large size and age of those houses.

Improved insulation and draught proofing of houses therefore can assist with reducing their heating costs significantly.

Use of compact fluorescent lighting can also reduce lighting costs by up to 80%.

Depending on the extent of the current use of plug-in heaters, there may be also be cost saving opportunities for installation of hard wired electric heaters which enable use of Hydro heat Tariff (Tariff 42). Hydro Heat tariff has similar rates and charges to Hot water Tariff and is about 40% cheaper than the General Light and Power Tariff (Tariff 31).

Use of Heat pumps with efficiencies in excess of 250% can also assist with further reduction of plug-in heaters costs.

4.5.1 Solar Hot Water Heaters

Use of evacuated tube solar hot water systems or hot water heat pumps (see below) may also be considered when replacing existing direct element electric hot water cylinders.

A hot water heat pump at an estimated post-rebate installed cost of $2,500 would only be $1500 or so more expensive than a conventional hot water cylinder but can save up to $500 per year giving a 3 year pay back period depending on household’s hot water use. There are commonwealth rebates of up to $1,600 as well as Renewable Energy Certificates (RECs) of up to $1000 which can be claimed for installation of a solar hot water heater or hot water heat pump.

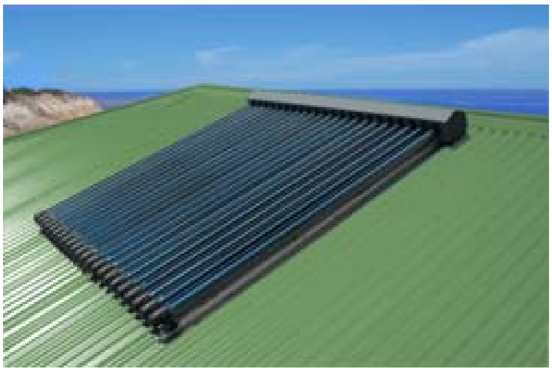


Photo- Evacuated Tube Solar Collectors -Appricus (left), and Hills (right)

Photo: A Quantum Hot Water Heat Pump

4.6 Tractors and Diesel Engine Efficiency

Diesel costs for the seven all-electric farms audited accounted for between 13% to 47% of annual energy costs or between $8,000 to $24,000 per year. The average diesel cost for all audited farms was close to 25% of total annual energy costs or nearly $17,000 p.a.

Whilst a discussion of minimum tillage and direct drilling are outside the scope of this report, those options considered by farmers for reasons such as reduced labour, reduced soil erosion, and recycling of plant nutrients, etc. can also offer significant energy savings. Direct drilling for example can offer up to 80% savings in MJ/ha fuel use compared with conventional cultivation.

In tillage operations, correct size of the tractor as well as optimum wheelslip are important factors for tractor energy efficiency. A survey by NSW Department of Agriculture some years ago, found that wheat farms with tractors larger than 90 kW (120 hp) use an average 11.6 litres of fuel per hectare for disc laughing compared with 16.3 l/ha for tractors smaller than 60 kW (80 hp).

Some operators try to eliminate wheelslip altogether (through ballasting) thinking that wheelslip is always bad. However, 'tractive efficiency' rather than traction can result in better fuel efficiency.

For example, a 100 kW 2WD tractor with 12% slip (at about 9.8 tonnes weight) can have up to 14% more power at drawbar compared with a 15.7 tonne tractor with only 7% slip (too heavy) or a 7.2 tractor with 25% slip (too light).

Table 4-1 Optimum wheelslip levels for different tractors on different soils below shows some optimum wheelslip levels depending on soil and tractor types:

Table 4-1 Optimum wheelslip levels for different tractors on different soils

Tractor	Firm Soil	Cultivated Soil
2-WD	7%-11%	10%-15%
4-WD	6%-10%	8%-12%

Source: Saving Energy in Agriculture, Aust Dept of Primary Industry and Energy

The Nebraska Tractor Tests http://tractortestlab.unl.edu/testreports.htm can be used to compare tractors on the basis of energy and power performance. Information on any specific tractors can be used to determine proper operating conditions such as correct ballasting and operating speeds. The fuel efficiency information in the tests can also be used to estimate average operating costs.

A sample tests report for a 100 hp John Deer tractor can be found through the link below. Note the significant efficiency losses at low part-load performance of diesel engines.

http://tractortestlab.unl.edu/Deere/JD_6615.pdf

5. Developing an Energy Management Action Plan

Energy management is an on-going and active ‘management’ of energy use and costs which needs to continue through improved metering and measurement, settings of benchmarks and annual targets, identifying and implementing energy saving measures, and reviewing progress.

As an energy management adage goes: *you can not save what you can not measure!*

Installation of flow meters and pressure gauges along with the existing electricity meters for the main pumps can assist with a more active management of energy and water, and settings of benchmarks such as kWh/ML, or kWh/$ revenue, etc. Those measurements can in turn enable setting of annual energy saving targets and monitoring of progress towards achieving those targets through regular reviews.

Other irrigation benchmarks such as ML/ha for each crop can also assist with monitoring of water and energy use efficiencies.

An energy management module linked to the Property Management Plan (PMP) can assist with the ongoing focus on energy and water use benchmarks and enable setting of reduction targets for each year.

Appendix A gives the outline of an action plan for developing an energy management plan linked to your PMP.

6. References

1) Energy Efficient Irrigation, Aurora Energy,

http://www.auroraenergy.com.au/save_energy/pdf/AUAGF1021_irrigation_FS.pdf

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http://www.dpi.nsw.gov.au/agriculture/resources/water/irrigation/systems/pumps/selecting

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http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/164418/pumping-costs.pdf

4) How Efficient Is Your Pump, NSW Agriculture,

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/165196/efficient-pump.pdf

5) Is your diesel pump costing you money?

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/165217/cost-diesel-pump.pdf

6) Maintaining Irrigation Pumps, ATTRA

http://www.attra.org/attra-pub/summaries/maintaining_pumps.html,

7) Energy Use and Efficiency Measures For the New Zealand Dairy Farming Industry, Agrilink

http://www.agrilink.co.nz/Portals/agrilink/Files/Dairy_Energy_Efficiency_Stocktake.pdf

8) Improving Dairy Shed Energy Efficiency, CAENZ

http://www.caenz.com/sustain/Downloads/Farmers_Report.pdf

9) Milk Cooling, Southern California Edison

http://www.sce.com/NR/rdonlyres/025AEFAD-1BFB-46CA-852D-64B5B1E9BBAF/0/Dairy_Farm_Milk_Cooling.pdf

Appendix A: Energy Management Action Plan

√	**Proposed Action Plan**	**Comments**
☐	Establish an Energy consumption History for the farm (minimum 2 years of energy history)	
☐	Establish annual energy use and energy costs (kWh/Yr, $/Yr)	
☐	Develop Energy Benchmark for the farm (e.g. kWh/ha or GJ/ha, kWh/ML water etc.)	
☐	Improve instrumentation and metering of main energy users (water flow meter, pressure gauges, smart meters, etc.)	
☐	Conduct an Energy Audit (use this self audit tool, and the checklist I Appendix A)	
☐	Add an Energy Efficiency Program module to your PMP	
☐	Set energy reduction targets for each year (e.g. 15% reduction of total energy costs for 2010/11, or %10 reduction in kWh/ha etc.)	
☐	Implement cost effective energy saving measures identified during the audit.	
☐	Monitor progress towards meeting your targets (quarterly, 6-monthly, and annual reviews).	
☐	Include energy efficiency requirement in your purchasing policy.	
☐	Continually improve energy efficiency.	

Appendix B: Energy Self Audit Checklist

√	**Action**	**Comment**
☐	Register for Aurora's on-line Services (www.auroraenergy.com.au/online_services)	
☐	Download Electricity Consumption Data	
☐	Compile historical records for Diesel, Petrol, and other fuel uses on farm	
☐	Establish an Energy consumption History for the farm (min. 2 years)	
☐	Establish annual energy use in kWh/Yr and energy costs in $/Yr	
☐	Develop Energy Benchmark for the farm (e.g. kWh/ha or GJ/ha, kWh/ML water etc.)	
☐	**Tariffs and Rates**	
☐	Calculate average Rate in Cents per kWh for each installation	
☐	Check average rates in cents/kWh and compare with different tariffs	
☐	Check if there are abnormally high average rates (these could be due to low consumption, or incorrect tariffs)	
☐	Check that you are using the right tariffs (e.g. Irrigation tariffs used for very small pumps and pivots' motive power can be more expensive than General Tariff 22	
☐	Check if you are using the full 11 hr/day under Low Rate tariff of Irrigation Tariff 73/74 (standard hours are only 10 hrs, but that can be extended to 11 hrs by signing a standard contract)	
☐	In Excel, chart Low and High rate consumptions for all your irrigation tariffs and check if you are utilising the low rates effectively-Shoulder irrigation seasons should enable most farmers to irrigate only during low rate periods at night.	
	Energy Survey	
☐	Estimate annual energy use of all equipment by reading their nameplate ratings in kW multiplied by number of hours per year (kWxHrs=kWh).	
☐	Estimate annual energy costs of each item by multiplying kWh by relevant tariff rates for that equipment	
☐	Examine energy saving opportunities for each piece of equipment	
	Irrigation	
☐	What type of irrigation system do you have?	
☐	Do you know how many kWh you use to pump one ML of water?	
☐	Do you use soil moisture monitoring devices?	

☐	Do you use Irrigation Scheduling?	
☐	Is your irrigation system energy efficient (check total pressures and compare with Fig. 5)	
☐	Is there a flow meter installed for your main pumps?	
☐	Measure flow rate in l/s (l/s=m^3/ minute or kL/minute/(60*1000)	
☐	Is there a working pressure gauge installed?	
☐	Do you have access to your pump curve?	
☐	Can you read pump efficiency figures from the pump curve?	
☐	Calculate kW power requirement by the pump (See example in Section 4.2)	
☐	Is the actual kW reading from electricity meter the same as the calculated kW power above?	
☐	Do the actual flow rate and pressures correspond to those used for selecting the pump?	
☐	Is the pump throttled?	
☐	If so, have you assessed impeller size reduction or VSD?	
☐	Does the pressure (head) vary significantly for your pump due to terrain, different irrigators etc?	
☐	If so, have you assessed a VSD?	
☐	Can you establish a kWh/ML benchmark?	
☐	Can you read your electricity meter? (See Ref. 3 and 4- Electronic meters scroll through different rates continually)	
☐	If you have to report your water usage to DPIW, do you use Ajenti?	
☐	If you have Ajenti installed, do you monitor your water use on Ajenti's web site?	
☐	Can you monitor your kWh/ML consumption using your electricity meter and water flow meter? (see Ref. 3 and 4)	
	Dairy Shed	
☐	Do you know the annual energy use and energy costs for the dairy shed?	
☐	Do you have a low rate hot water tariff?	
☐	Have you calculated an energy or cost index for dairy shed (e.g. kWh/cow, or cents/litre milk)?	
	Hot Water Heating	
☐	Do you know how much hot water you use each day?	
☐	Are your hot water tank and hot water pipes insulated?	
☐	Have you considered using hot water heat pumps?	
☐	Have you considered preheating cold feed water with hot water you dispose of?	

☐	Do you switch off your storage hot water heaters during non-milking months?	
	Refrigeration	
☐	Do you have a milk pre-cooler?	
☐	Does the pre-cooler work effectively (monitor milk temperature drops)?	
☐	Are the cooling water sources adequate (check for excessive solar gains and low flows)?	
☐	Is the milk flow through pre-cooler uniform? (consider VSD on milk pump)	
☐	Have you considered scroll compressors for the next upgrade?	
☐	Does liquid line sight glass show bubbles during normal operation? (check if refrigerant charge is low)	
☐	Have you considered chilled water storage? (for added capacity for growing demands and in combination with off peak contracts)	
☐	What type of vacuum pump do you use?	
☐	Have you considered a rotary vane vac pump for next upgrade?	
☐	Have you considered VSD for your vacuum pump?	
	Domestic Energy Use	
☐	Do you know the annual energy costs of your house?	
☐	Do you have adequate insulation? (rebates up to $1600 available)	
☐	Do you have heavy curtains for windows (drawn at night time)?	
☐	Do you need to heat the whole of house?	
☐	Do you have adequate thermostats?	
☐	Do you use compact fluorescent lamps?	
☐	Do you use low flow shower heads?	
☐	Do you use many plug-in heaters? (cheaper hydro heat tariffs and heat pump options available)	
☐	Have you considered solar hot water heaters or hot water heat pumps? (Rebates and Renewable Energy Certificate or REC’s available)	
	Tractors	
☐	Have you established your annual diesel use?	
☐	Do you monitor your tractors’ fuel use?	
☐	Are your tractors suitable for the work they do?	
☐	Do you use ballasts for traction efficiency?	
☐	Have you checked the extent of tractor's wheel slip?	
☐	Have you consider low tillage and direct drilling?	

☐	Is there a Nebraska Lab. Tractor Test available for your tractor (check http://tractortestlab.unl.edu/testreports.htm)	
☐	**Energy Mgt program**	
☐	Do you have a Property Management Plan (PMP)	
☐	Can you add an Energy Efficiency Program module to your PMP?	
☐	Do you know your annual energy uses and energy costs?	
☐	Have you developed energy use benchmarks for your farm (such as kWh/ha irrigated area, or kWh/ML water etc.)	
☐	Have you set an energy reduction targets (e.g. % of total, or % reduction in kWh/ha etc.)	
☐	Do you monitor how you are progressing with those targets (quarterly, 6 monthly and annual reviews)	
☐	Have you included energy efficiency requirements in your purchasing policy?	
☐	Are you continually researching ways of improving efficiency?	
	Other Energy Saving Measures	
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Appendix C: 2009/10 Rates and Charges for Commonly Used Tariffs for Farms

residential light and power - tariff 31					**irrigation - tariff 73/74**				
fixed charge			69.685	c/day	fixed charge			241.874	c/day
energy			19.646	c/kWh	energy - night rate			10.095	c/kWh
					energy - day rate			22.975	c/kWh
hot water supply systems - tariff 41									
fixed charge			13.497	c/day	**business hot water supply system - tariff 43**				
energy			11.847	c/kWh	fixed charge			13.497	c/day
					energy			11.847	c/kWh
general - tariff 22									
fixed charges			73.847	c/day	**hydroheat - tariff 42**				
first 500 kWh per quarter			26.285	c/kWh	fixed charges			13.497	c/day
remainder			19.296	c/kWh	energy			11.847	c/kWh
offpeak with afternoon boost - tariff 61									
fixed charge			17.102	c/day					
energy			9.538	c/kWh					

Source: Aurora Energy , Ref.

http://www.auroraenergy.com.au/small_business/rates_and_charges/agribusiness.asp

Appendix D: Energy Survey Template

(a) Equipment/Device Name and Location	**(b) kW**	**(c) Operation Hrs/Day**	**(d) Operation Days/wk**	**(e) Operation Wks/Yr**	**(b*c*d*e) Estimated kWh/Yr**
Total					