AUSTRALIAN PORK LIMITED

Understanding Energy in Pig Production

May 2018

PROJECT TITLE:

Understanding energy in pig production

DISCLAIMER

AUSTRALIAN PORK LIMITED

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1. Understanding energy in piggery production

1.1 Introduction

Energy is an important cost for pork production, with electricity, fuel and gas prices in pig production areas rising by 25-40% in recent years. Energy sourced primarily from limited fossil fuel reserves also has an environmental cost, contributing greenhouse gas (GHG) emissions to the atmosphere. Alternatives for reducing energy use can include; choosing the best tariff, managing power usage and considering alternative power sources can substantially improve the bottom line for both the piggery and the environment. By understanding the components of energy used in piggeries, producers will be better able to understand, compare, analyse and determine measures to reduce or improve consumption.

The following booklet details information collated by the Energy Guys for Australian Pork Limited over the period 2013-2017. The intent is to provide information regarding energy use in the pork industry. An energy audit program was completed and a total of 42 piggeries participated. As a result of this audit, key benchmarking data was developed to assist producers' measure and manage their energy use.

Information presented in this booklet will cover:

- Monitoring energy use
- Electricity tariffs
- Heating benchmark data
- Pumping benchmark data
- Ventilation benchmark data
- Lighting benchmark data
- Case study – boilers & LPG
- Biogas as an alternate energy source
- Solar PV as an alternate energy source

Total direct energy usage is the combination of shed lighting, heating, ventilation, water supply, feed supply, effluent management, administration and minor activities such as repairs and maintenance and pig management. Energy is also used indirectly through the transport of incoming and outgoing pigs and feed.

2. Monitoring energy use

Measuring actual energy consumed by equipment in the piggery can assist in understanding the cost effectiveness of any proposed changes to reduce energy bills and should be conducted in consultation with the supplier or qualified tradesperson.

2.1 Single phase monitors

Simple single phase plug-in monitoring units are inexpensive and can be installed by piggery operators in their sheds at low cost (see Figure 1). They can assist in understanding energy consumption by specific equipment in the sheds, including:

- Heat lamps
- Heat pads
- Lights
- Small pumps

The outputs are most useful if they can be compared to the temperatures in the farrowing room and creep areas. Monitoring units can be used to compare energy use per day over a farrowing period for different times of the year. For example, the monitoring data could be compared as follows:

- same types of equipment in the same shed, e.g. 100W lamps in different locations
- same types of equipment in different sheds, e.g. 100W lamps in insulated and curtain shed
- different types of equipment in the same shed, e.g. 100W versus 175W
- different types of equipment in different sheds.

Monitoring results of electricity consumed in two sheds at a piggery in Western Australia:

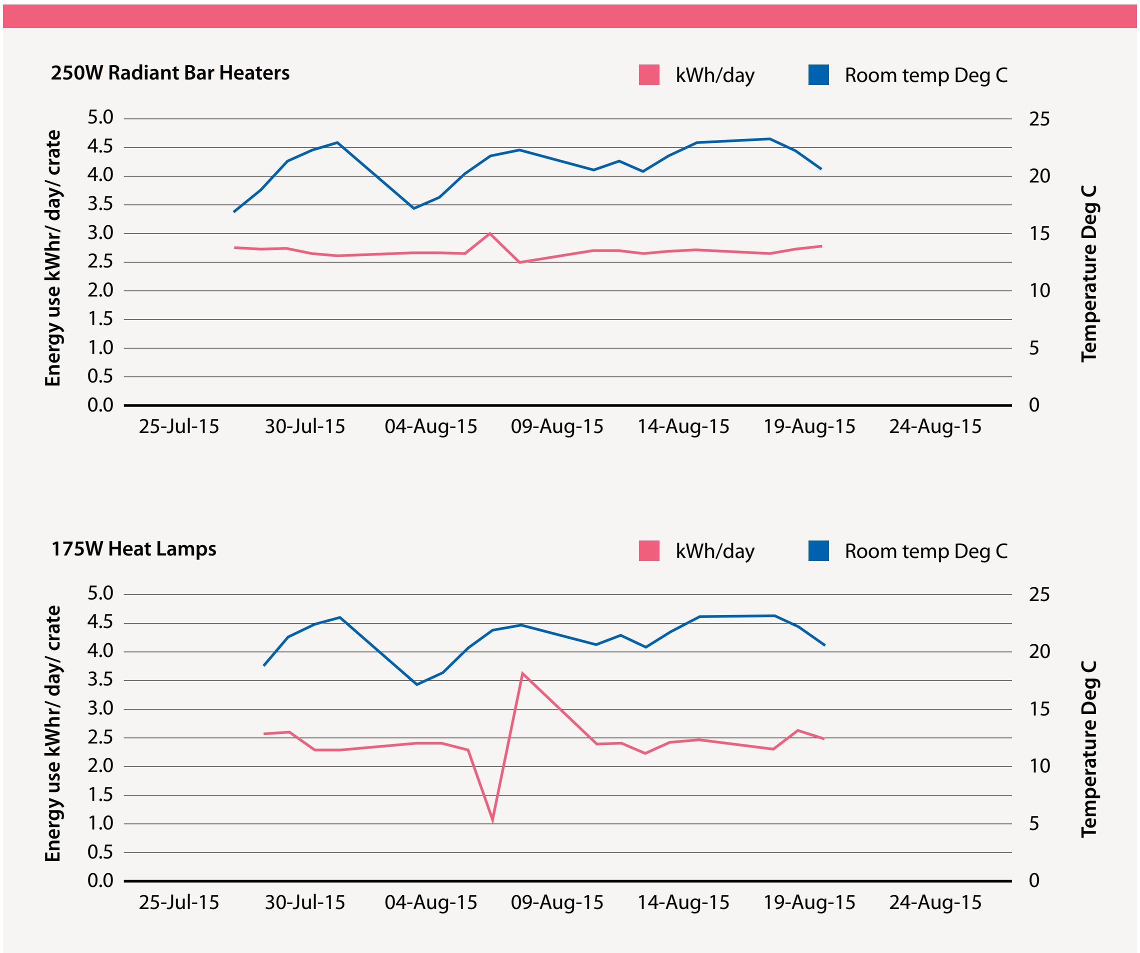
- 250W radiant bar heaters used for 2 crates
- 175W heat lamps used for one crate

The sheds were open with curtain sides and with creep covers in farrowing areas.

The results are summarised in the graphs below and show that on average for the winter period monitored:

- The 250W radiant bar heaters consumed **2.7 kWh** per crate per day
- The 175W heat lamps consumed **4.0 kWh** per crate per day.

Figure 1. Energy used by different heating methods and intensities



The table below summarises the costs for each type of heating for a range of typical tariffs ($/kWh).

Table 1 Cost of heating farrowing crates

			$/kWh	
	WINTER		0.20c	0.30c
	kWh/day	kWh/90days	$/90 days/crate	
250W heaters per 2 crates	2.7	243	49	73
175W heat lamps per crate	4.0	356	71	107
	No. crates		$/90 days	
250W/2	250		12250	18250
175W	250		17750	26750
	Saving over 90 days		5500	8500

2.2 Circuit board monitoring

The circuit board monitoring units provide data on the electricity consumption for a whole circuit. For example, this might include 25 heat lamps, rather than a single piece of equipment. With these units, comparisons are made between sheds.

Types of circuit boards:

- The "Auzimax" energy monitor (pictured right) was installed at 9 pig sheds http://auzimax.com/
- Another type of circuit board monitor is the "Enviovision" energy monitor http://www.envirovision.net.au/

Circuit board monitors cost between $1,500 – 2,500 plus installation costs and need to be installed by an electrician at the electricity meter or sub-board.

During the energy audit, split CT's were installed on the main circuits at the meter board to measure power consumption of critical equipment, such as heat lamps, lights, feed augers, fans.

- Monitoring temperatures in shed and creep areas can assist in the analysis of the outputs
- Units normally have a modem to transfer data directly to the cloud for remote analysis. This means 4G signal at the location is needed.

An example of CT monitoring output available on-line is included at Figure 2&3 below.

The circuit board units have a number of advantages over the simple plug-in units:

- They are automatic and provide an ongoing data stream for analysis of electricity consumed
- Minute or hour data can be used for detailed analysis of electricity consumption
- Temperature probes can be installed to provide a continuous stream of data but must be calibrated to reflect the length of cable from unit to the probes.

Figure 2. Energy allocation

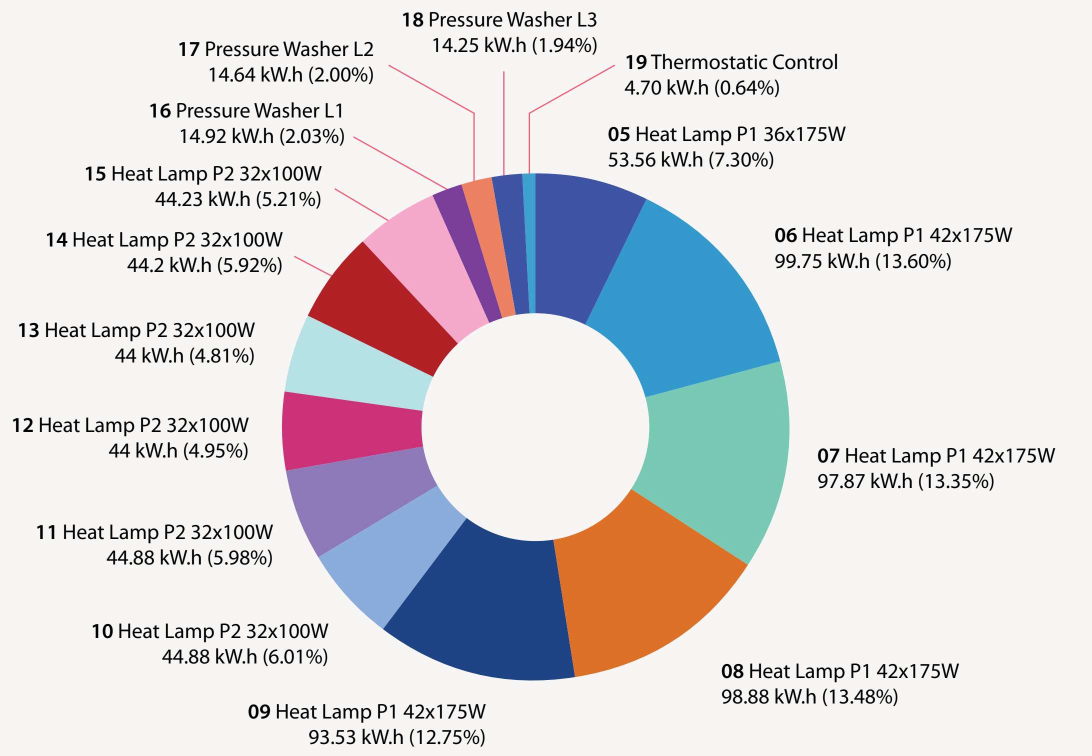
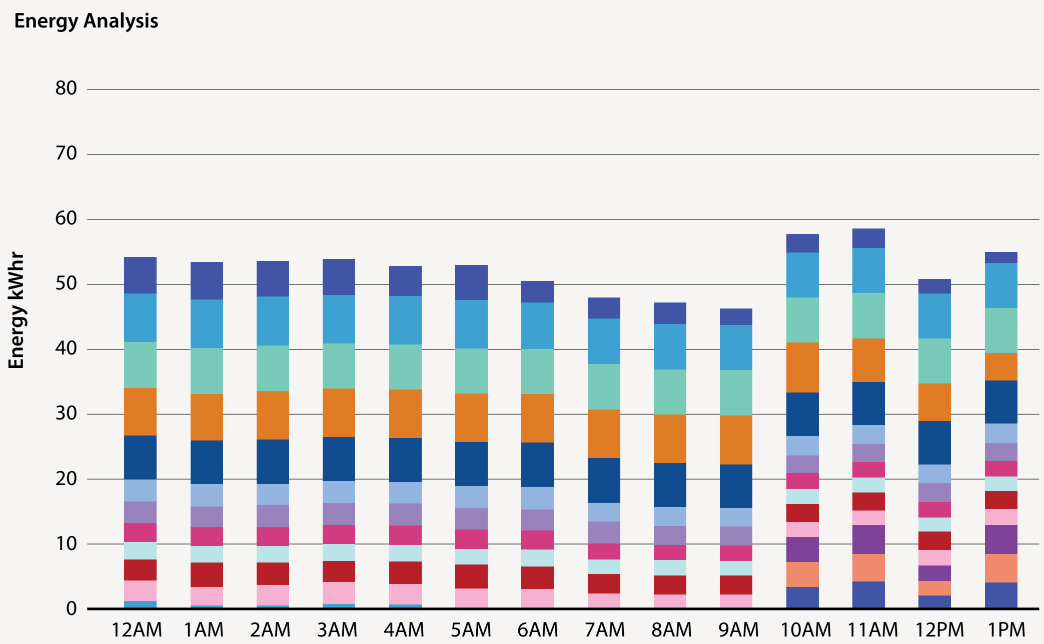


Figure 3. Energy analysis



Example circuit board monitoring:

- Circuit board monitors were used to compare electricity consumed in an environmentally controlled shed at a piggery in NSW. There were no creep covers in the farrowing areas.
  - 100W heat lamps
  - 175W heat lamps
- The results are summarised in the graph below and show that on average for the winter period monitored:
  - The 100W heat lamps consumed 1.9 kWh per crate per day
  - The 175W heat lamps consumed 3.0 kWh per crate per day.

The impact on the electricity bill depends on the tariffs. Table 2 below summarises the costs for each type of heating for a range of typical tariffs (cents/ kWh).

Figure 4. Energy use comparison between two circuits

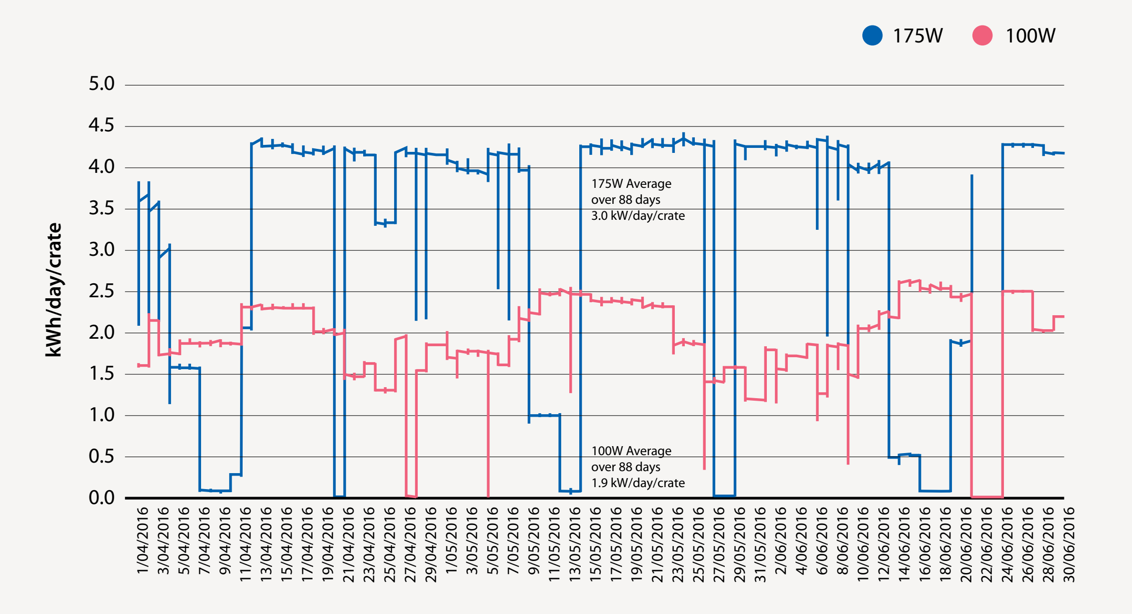


Table 2. Impact of heating costs per tariff

Cost of heating for a range of typical tariffs			$/kWh	
	WINTER		0.20c	0.30c
	kWh/day	kWh/90days	$/90 days/crate	
100W	1.9	171	34	51
175W	3.0	270	54	81
	No. crates		$/90 days	
100W	200		6800	10200
175W	200		10800	16200
		Saving over 90 days	4000	6000

3. Electricity tariffs

A tariff is the amount charged for providing energy under the energy contract. It includes both fixed and variable charges. It is important to understand all of the costs associated with the energy contract. Electricity tariffs can be complicated, particularly for large consumers. In addition, the structure of the market is changing in different states in an attempt to make the electricity market more competitive.

3.1 Retailer categories

It is important to know which retail category the piggery is allocated.

3.1.1 Small retail customers

Piggeries are defined as small retail customers when they use less than:

- 40,000 kWh/year in Victoria
- 50,000* kWh/year in WA (*in SW Interconnected System). In WA customers consuming between 50-160,000 kWh/year can choose to pay either capped rates or another retailer at negotiated tariffs
- 100,000 kWh/year in NSW and Queensland
- 160,000 kWh/year in South Australia.

These tariffs are relatively simple with a kWh usage charge and access charge. Some retailers offer a percentage discount by signing onto a 2 or 3 year small (simplified) market contract with an energy retailer.

3.1.2 Large retail customers

Piggeries are defined as large retail customers if they use more than the listed thresholds in 3.1.1 and are required to be on a "Contestable" large market contract – named because different retailers can "contest" for their business by offering them contracts. Large retail customer billing is more complicated and includes itemised electricity costs including:

- **Retail energy charges** (often termed "energy"). These are the contestable components of your bill and are set out in your contract. Retail charges are calculated on kWh consumption.
- **Network charges.** These are costs associated with the transmission of electricity from the power station to your site. These costs are passed on from the network and not negotiable, but there are different types of network charges which can have a large effect on your bills. These charges can be based on kWh or kW/kVA or a mixture of both.
- **Environmental charges.** These are state and federal charges based on kWh consumed.
- **Market Operator charges (AEMO).** These are based on kWh consumed.
- **Metering charge.** This is an annual charge for metering services and data collection.
- **Service charge.** This is an annual charge for the retailer's services and is negotiable.

3.2 Price comparisons

There are websites that offer price comparisons, and these can be an excellent starting point to identify alternative retailers. A useful government site is **www.energymadeeasy.com.au**

General or TOU Tariff?

Time of Use tariffs (TOU) may reduce costs

- if your site uses more than 50% of electricity during the off-peak periods (generally 9pm to 7am (SA)/10pm to 7am (NSW/WA)/11pm to 9am (Qld/Vic) Monday to Friday, and all day on weekends) then TOU tariffs may be worthwhile
- TOU have higher service fees and need a smart meter
- Most piggeries reviewed were better off on TOU
- In NSW the Small Retail Customer tariffs are currently now more complicated as there is no regulated price, and each retailer sets their own tariff rates. Qld, SA & Vic have been this way for years.
- Previously energy retailers would offer a % discount off the regulated tariff, but retailers now offer a % discount off their tariff rates.
- Each energy retailer's tariff rates are different. Therefore it doesn't matter how big the % discount, what matters is the combination of discount and base offer, e.g. 10% off 25¢/kWh = 22.5¢/kWh is a lower effective rate than 20% off 30¢/kWh = 24.0¢/kWh.
- To properly assess offers from energy retailers you need to assess the price sheets. Look at all the individual charges, retail rates & charges.

Brokers may be able to assist you to work out

- **your best tariff type**
- **your best offer from different retailers**
- **SEE ON PAGE 4**

Figure 5 below shows an example of a contestable bill format for a large consumer. A large consumer is required to have a communications smart meter. These meters record electricity consumption and peak demand every 30 minutes and produces a stream of data called "interval data".

Energy efficiency upgrades should consider all charges. An example is provided in Figure 5. The contestable bill in Figure 5 comprises $8,800 in costs associated with the consumption of 91145 kWh, which is an average charge of $0.097/ kWh. It is this tariff rate that should be used in considering efficiency upgrades. The remainder of the bill comprises demand charges and fees, not impacted directly by kWh consumption.

Alternative energy sources have the capacity to reduce Peak demand, so may reduce the demand charges. However, depending on the location, solar PV is generally not relied on to reduce total demand as a single day with poor solar PV generation can determine the peak demand charged.

Figure 5. Sample contestable bill format (large consumer)

Pricing Details			Account:	
charges	Usage	Unit Price	Loss Factor	Total Price (excl GST)
Retail Energy Usage Charges				
NSW Peak	13,739.800 kWh	5.2562 c/kWh	1.05657	$777.56
NSW Off Peak	49,588.100 kWh	3.4978 c/kWh	1.05657	$1,832.61
NSW Shoulder	27,816.900 kWh	5.3993 c/kWh	1.05657	$1,586.88
Network Charges				
BLND3AO Service Charge	31 Days	13.9462 $/Day		$432.33
BLND3AO Peak	14,940.000 kWh	4.7329 c/kWh		$707.10
BLND3AO Shoulder	30,459.400 kWh	4.7329 c/kWh		$1,441.61
BLND3AO Off Peak	45,761.200 kWh	2.8950 c/kWh		$1,324.79
BLND3AO Peak Demand	177.000 kVA	14.2316 $/kVA/Mth		$2,518.99
BLND3AO Shoulder Demand	195.000 kVA	14.2316 $/kVA/Mth		$2,775.16
BLND3AO Off Peak Demand	171.000 kVA	3.2528 $/kVA/Mth		$556.23
Environmental Schemes				
NESC	91,144.800 kWh	0.1612 c/kWh	1.09240	$160.50
LRECs	91,144.800 kWh	0.4411 c/kWh	1.09240	$439.19
SRECs	91,144.800 kWh	0.4192 c/kWh	1.09240	$417.38
Market Operator Charges				
AEMO Ancillary Fee	91,144.800 kWh	0.0213 c/kWh	1.09240	$21.21
AEMO Market Fee	91,144.800 kWh	0.0358 c/kWh	1.09240	$35.64
Service and Meter charges				
Meter Charge		4,240.00 $/mtr/pa		$360.11
Service charge and supplementary meter fees				$100.00
GST				**$1,538.72**
Total (excl GST)				**$15,387.29**
TOTAL				**$16,926.01**

Negotiable rates (Retail Energy Usage Charges)

Depending on tariff can be: kWhr, kW or kVa or mixture

Negotiable rates (Service and Meter charges)

Costs for kWh use total $8,800 for 91,145 kWh, average charge $0.097/kWh

Both energy efficiency upgrades and alternative energy sources can reduce TOTAL ANNUAL CONSUMPTION so that it falls below the threshold for that state, changing the tariff structure. In this case, the new tariff structure can be used to assess the savings.

3.3 Energy contract renewal considerations

It is important to review energy contracts prior to renewal. This is particularly important for managing large contracts. If you do not renew a contract prior to its expiry you may be charged spot prices or default rates, which can be significantly more expensive. The timing of renewing contracts is important in order to take advantage of dips in the electricity market. Forward contracts can be drawn up to 12 months in advance and can provide significant savings.

3.3.1 Brokers and energy management specialists

Brokers can help you negotiate small and large market contracts and arrange the tender and assess pricing proposals. In addition, brokers are continually assessing electricity markets and they can arrange forward contracts to take advantage of low market prices, while keeping an eye on contract expiry dates.

Energy Management Specialists (EMSs) perform the functions of energy brokers in purchasing electricity, but also can assist pig operators manage the consumption and peak demand to ensure the tariffs used are working most effectively. For example, EMSs can regularly review consumption and demand and provide warnings or alerts when demand has peaked beyond expectation.

Selecting a broker is not straightforward as there is no industry body. Recommendations from other pig operators are a good place to start. However, you should check the terms and conditions from 2 or 3 brokers before signing up.

- Brokers should provide a quote that explains all fees and commissions and clearly state what is included in their fees and what is not (e.g. processing and analysis of interval data, renegotiating forward contracts).
- Energy Brokers may require you to use their metering agent rather than using the energy retailer's preferred metering agent. This can be add a significant cost. When assessing a broker check the savings on retail rates are not offset by increased metering charges.

4. Heating benchmark data

The largest energy consumed in piggery sheds is for the heating of farrowing sheds and crates. Results from the APL Energy Audit program indicate that heating farrow rooms comprises:

- 69% total energy use for farrow to wean units
- 49% total energy use for farrow to finish units

4.1 Farrow room heating benchmark

Farrow room heating consumes an average of 10 kWh/pig/year with a range of 5 – 25 kWh/pig/year. Figures 6 and 7 illustrate the energy consumed by farrow units

Figure 6. Farrow to Wean

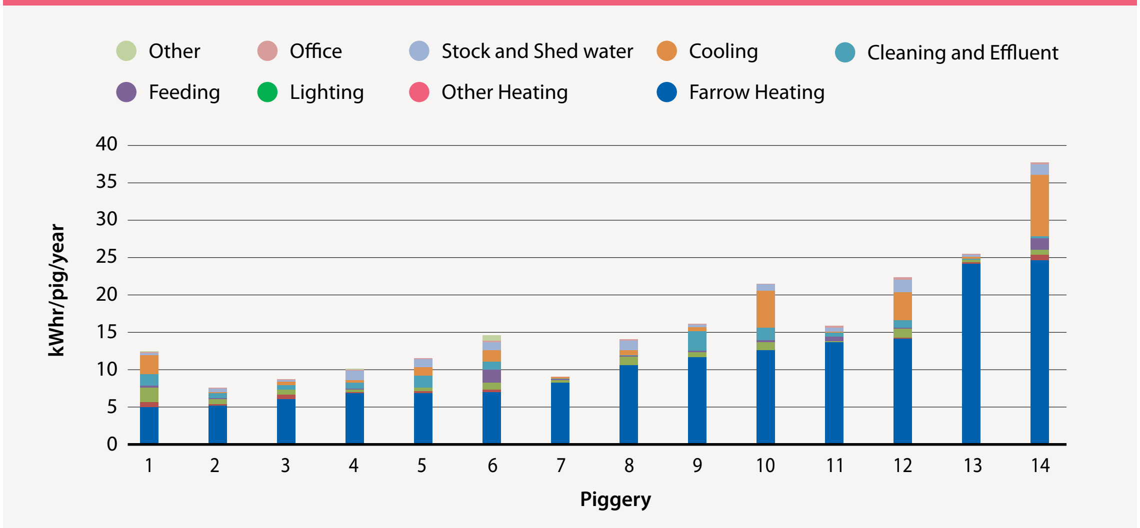
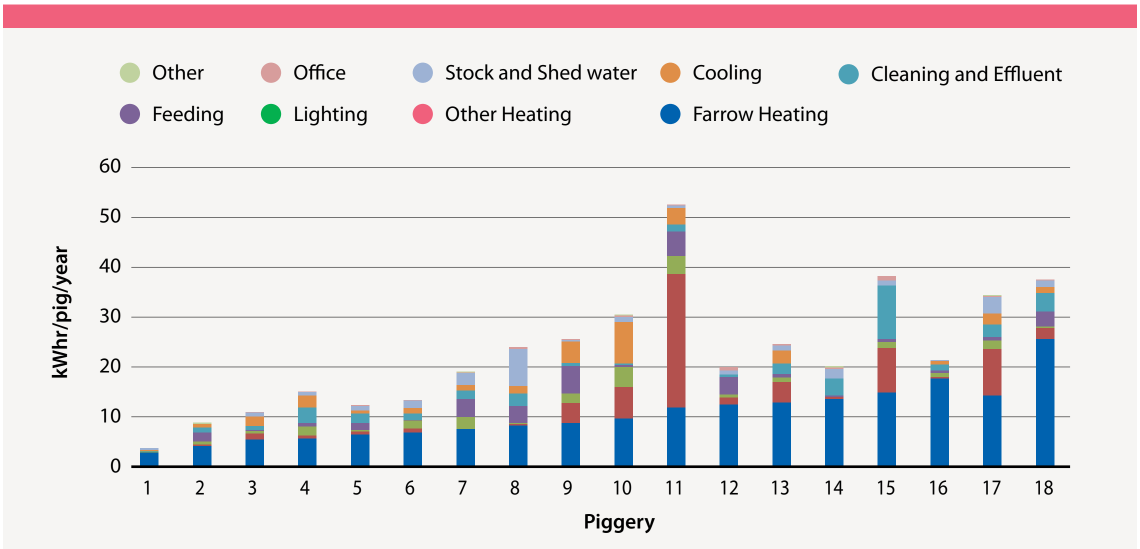


Figure 7. Farrow to Finish



4.2 Type of heating used in farrow sheds

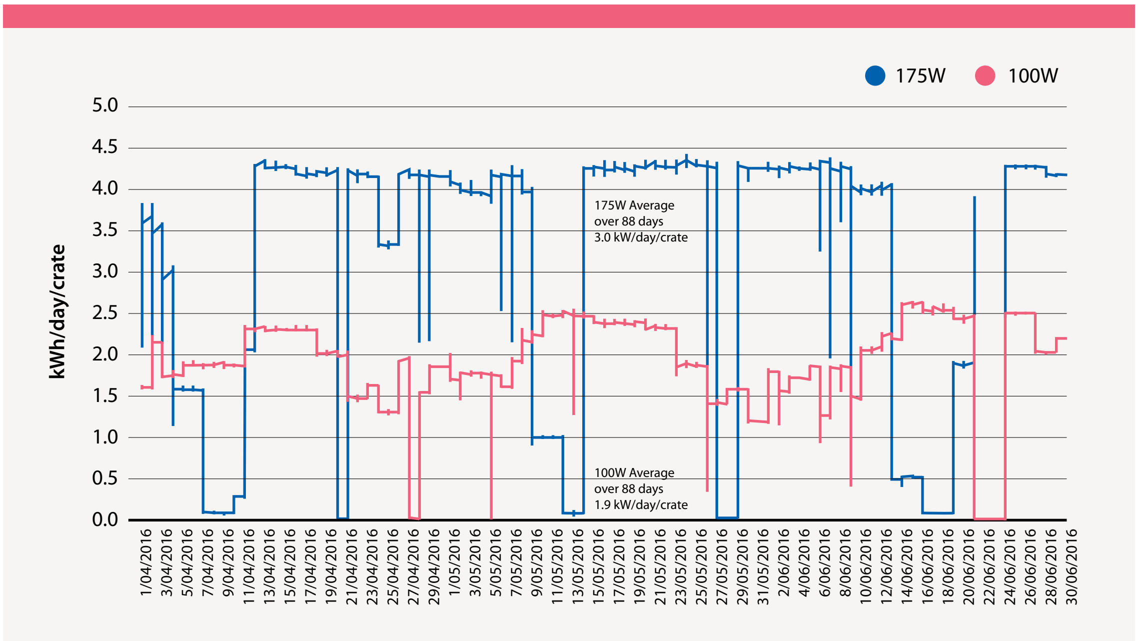
Piggeries participating in the APL Energy Audit program used a range of heating in farrow sheds. Table 1 summarises the types of heating used for crates and proportion of piggeries using each type.

- The most common heating were 100W and 175W heat lamps
- 100W heat lamps were more common in warmer climates, such as Queensland
- 175W heat lamps were more common in cooler climates, such as Victoria.

4.3 Comparison of heating types

Monitoring of farrow crate heating was carried out as part of the APL Energy Audit program. The results of this monitoring illustrated that, for similar sheds on the same farm, there is significant variation in energy consumed depending on the type of heating source and controller. Figure 8 provides a snapshot of these results for different heat sources.

Figure 8. Comparison of energy consumed per heat lamp



4.4 Heat source selection factors

Factors that influence the selection of heat source include:

- shed insulation, draft exclusion, creep covers, climate and aspect, other heat sources, thermostat control, interval between farrowing
- to minimise energy costs, the lowest Watts per crate should be selected that also provides adequate heating for the piglets
- When selecting heating type, consider shed management and specific site requirements

4.5 Strategies to manage energy efficiency in farrow sheds

Improving energy efficiency in farrow sheds is a complex balance between costs and production. Energy efficiency in farrowing sheds can be managed by three factors under the producer's control:

Table 3. Energy efficiency factors in farrowing sheds

Component	Strategies
Heat source	Can heat source with a lower kW rating be used?
	Can a different method of heating be adopted with lower kW per crate?
Temperature control	Are thermostatic controllers used?
	Are there more effective controllers?
	How is the controller managed?
Heat losses	Are there any obvious heat losses that can cost effectively be eliminated?
	Are creep covers feasible?
	Are temporary draft excluders possible?

Before any changes are trialled or implemented two steps should be carried out:

- Work out your total benchmark. This is a good starting point to compare your costs to other piggeries. It may be your costs are low and there is little to be gained.
- Understand your energy costs and the monetary value in saving energy consumption.

The following strategy is suggested to better understand the energy efficiency changes that could be worthwhile in farrow sheds:

- Monitor shed or specific equipment BEFORE trying any changes
- Implement changes on small scale
- Monitor shed or specific equipment AFTER implementing change on small scale
- Assess costs and savings achieved
- Implement in other sheds if worthwhile.

4.6 Factors for consideration

- Generally lower Wattage results in lower cost, but the heat source must be adequate to provide adequate heat for maximum piglet production. Considerations include:
  - Is it possible to use 100W lamps in summer, 175W lamps in winter?
  - Can you install "High/ Low switches" to reduce output when not required?
- Have you investigated alternate controllers and thermostats that may improve temperature control in the shed?
- Is the installation of creep covers feasible in your sheds?
- Is it feasible to adopt different heat sources in environmentally controlled sheds and curtain sided sheds?
- Have you considered the lowest Wattage heat source for crates and supplement with LPG room heaters during cooler temperatures?

- When constructing new sheds, energy efficiency equipment can be more cost effective than when retrofitting.
- LPG can be a cost effective heat source when compared to electricity, depending on the price of gas and efficiency of boiler or heater, and other heating losses.

4.7 LPG as an energy source for heating

- 1 litre of LPG has 6.9 kWh energy value
- With boiler operating at 90% efficiency, this delivers 6.2 kWh/L
- When LPG costs $1.00/L, this is equivalent to $ 0.16/kWh
- With a boiler at 80% efficiency, 5.5 kWh/L is delivered, at $ 0.18/kWh.

This compares to average electricity prices in the APL Energy Audit group of $0.20 to $0.25/kWh.

5. Pumping benchmark data

Pumping water can be a significant energy use on piggeries. In the APL Energy Audit program pumping was between 1% and 37% of total energy consumption, with an average of 10%.

5.1 Energy benchmark for pumping

Energy benchmarks for pumping ranged from 0.5 to 7.6 kWh/pig/year, with an average of 1.2/kWh/pig/year

Many pumping systems do not work as efficiently as they could. The most common factors that impact on the efficiency (i.e. cost) of pumping are:

- Pump efficiency
- Pump suction line
- Motor efficiency
- Pipeline friction
- Fittings friction losses
- Leaks

5.2 Pump Efficiency

The most common type of pump is the centrifugal pump. These pumps can operate between 60-75%, but many efficiencies of 30-50% have been measured. These inefficiencies can be the result of incorrect pump selection, wear of the pump impeller and housing.

For these pumps the actual operational efficiency can be calculated using 4 factors that can be readily measured in the field:

- Flow rate - using a flow meter
- Total head - using a pressure gauge
- kW drawn from grid recording kWh on the electricity meter over an hour
- motor efficiency recorded from plate on motor

Pump efficiency calculation:

$$\text{Pump efficiency (\%)} = \frac{\text{VOLUME (L/s)} \times \text{Total HEAD (m)}}{\text{kW drawn from grid} \times \text{motor efficiency (\%)}}$$

Example of pump efficiency calculation:

DATA recorded

1. Flow	=	38 L/ s
2. Total head	=	pressure gauge at pump + estimate of suction head
	=	91 m
3. kW draw from grid	=	67 kWh consumed in 1 hour operation (from meter)
4. Motor efficiency	=	90 % (from name plate on motor)

$$\text{Pump efficiency} = \frac{38 \times 91}{67 \times 0.90} = 57.4\ \%$$

5.3 Pump suction line

The most common problems with pumps are reported as being from suction issues. Further detail is provided in this section.

5.3.1 Excess suction lift

Pumps rely on atmospheric pressure to "push" water into the pump housing. The "Net Positive Suction Head" of any pump is a measure of the ability of the pump to draw water from a source, and is provided by manufacturers on each pump's performance curve.

As a general rule, locate the pump as close as possible to the surface of the water. Typically pumps should not be located more than a maximum 3-4 m vertically above the surface of the water, less for some pumps.

5.3.2 Poor configuration of pipework into the pump

Pumps work most efficiently when the fluid is delivered in a surge-free, laminar flow. Any form of turbulence reduces efficiency and increases wear and tear.

- There should be at least 5 diameters of straight pipe connecting directly to the pump.
- Typically, suction pipe should be at least 2-3 times the pump inlet diameter to maintain inlet velocities 1.0- 1.5 m/s
- An eccentric reducer should be used and orientated to eliminate air pockets
  - Flat section on top when fluid drawn from below
  - Flat section on the bottom when fluid drawn from above.

5.3.3 Entrained air

Air entrained in the fluid reduces pump efficiency, increases noise, vibration and wear and tear. Proper location of inlet pipe or foot valve should be fully submerged below the surface of the fluid and not creating a vortex, which can draw air into the pumped fluid.

- Suction pipeline should be installed with a uniform slope upward.

5.3.4 Excess blockages on filter or screen

Where a filter or screen has been installed on the suction line to protect the pump from debris in the water source, regular cleaning of built-up debris should occur in order to reduce inefficiency in pump performance.

5.4 Motor efficiency

New motors sold in Australia must conform to Minimum Energy Performance Standards (MEPS). In addition, there are high efficiency motors, and these generally can provide 2-4% improved efficiency of the standard MEPS efficiency. Table 4 below details the current standards. Note the following:

- Every motor has a plate detailing the design motor efficiency
- Compare your motor's efficiency with the current MEPS or HEPS.

Table 4. Australian Standards for motor efficiency

	Australian Standards	
kW motor	Minimum Energy Performance Standards (MEPS)	High Efficiency Motor
	%	%
22	91.2	92.4
30	92.0	93.1
37	92.5	93.6
45	92.9	93.6
55	93.2	94.2
75	93.9	94.8
90	94.2	95.0

5.5 Pipeline friction

Pipeline friction means higher pressure is required at the pump, which increases the cost of pumping.

- The larger the pipeline diameter for a given flow, the smaller the friction loss
- This results in lower pressure required at the pump
- And as a result less energy is consumed for the flow.

The selection of pipeline diameter is a balance between cost of pipe and electricity consumed.

- Typically, selecting a pipeline that provides an average friction rate of 0.8 – 1.5 m/100m of pipeline length optimises the pipe/electricity cost
- If in doubt, contact your local pipeline supplier to check the efficiency of your pipeline.

5.6 Pipe fittings and friction losses

Generally, pipe fittings should be a small component of overall "friction" losses. However, in some circumstances these losses are higher than needs be – reducing the system efficiency and costing more to operate. Examples include partially shut gate valves or failed check-valves.

- If your system does not generate as much pressure as in the past, this may indicate an issue with fittings
- Analysis of the system hydraulics may be required if fittings are a problem
- It is best to consult your local pipeline supplier who can analyse the performance of your system and identify if fitting "losses" are excessive.

5.7 Leaks

Leaks in pipelines or fittings result in extra pumping to deliver the necessary water (to stock) resulting in additional costs. Losses of 10-20% have been measured.

Water leaks in pipelines and fittings can be identified using a flow meter. A datalogger can be coupled with a flow meter.

5.8 Flow meter only

If a pipeline system has a flow meter installed, the presence of a leak can be detected by shutting off all known outlets: if the flow meter continues to tick over there is a leak.

- Monitoring the flow meter when all outlets are closed will provide an indication of the magnitude of the leak.

5.9 Flow meter with datalogger

- There is no need to shut off known outlets
- In most systems there will be some point in the day or night when there is NO flow
- Unless there is a leak, in which case the recorded flow will never reduce to zero, but to the volume of the leak.

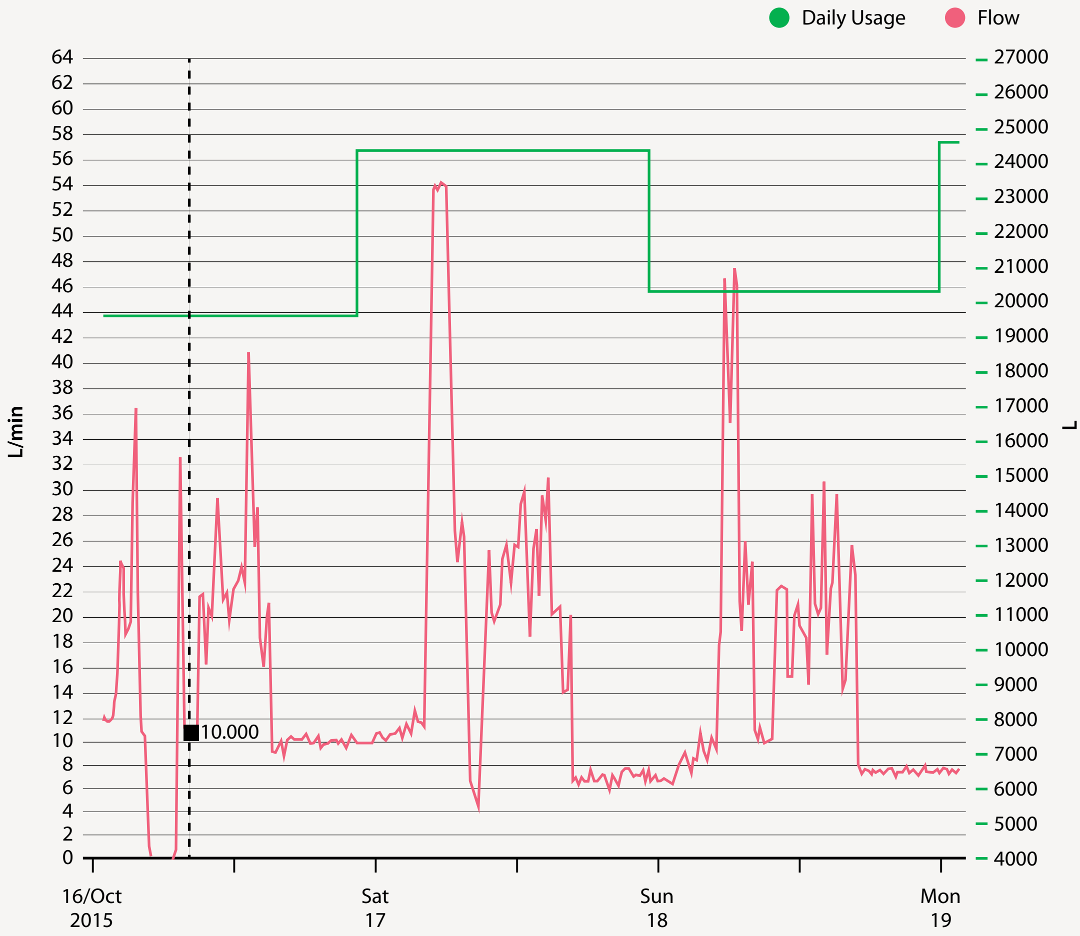
Example:

A data logger was attached to a flow meter supplying a piggery with a suspected leak using town water. The resulting graph (Fig 9) showed that the flow was never below approx. 6-10 L/ minute.

To test the logger, the inlet valve to the piggery was closed, and the logger recorded a zero flow. The leaks were costing the piggery an extra $7,600/year in water bills.

Billed	11,800 kL/yr
Water budget	8,800 kL/yr
Estimated excess	3,000 kL/yr = $ 7600
	3000 kL/yr = 5.7 L/min = shows up in Fig 9

Figure 9. Sample output from data logger



6. Ventilation benchmark data

The energy cost of ventilation in piggery sheds can be a significant proportion of total energy costs.

6.1 Energy benchmark data for ventilation

In the APL Energy Audit program:

- Ventilation made up an average 6 - 9% of total shed energy costs depending on type of production. This ranged from 0% to over 35% of total energy consumed.
- In terms of kWh/pig/year, the range was 0 – 8.3 kWh/pig/year, with an average of 1.5 kWh/pig/year

6.2 Energy efficient fans

Not all fans are equal in terms of energy efficiency. When selecting fans most piggery operators consider the air moving capacity of the fan (m3/hour or CFM, cubic feet per minute). However, fans with similar outputs in terms of air flow can have very different energy efficiencies. Two examples of 54" fans are given in the table below:

- Energy efficiency is measured in m3/h/W or CFM/W at specific static
- For tunnel ventilation, increasing static reduces the ability of the fan to move air in the shed.

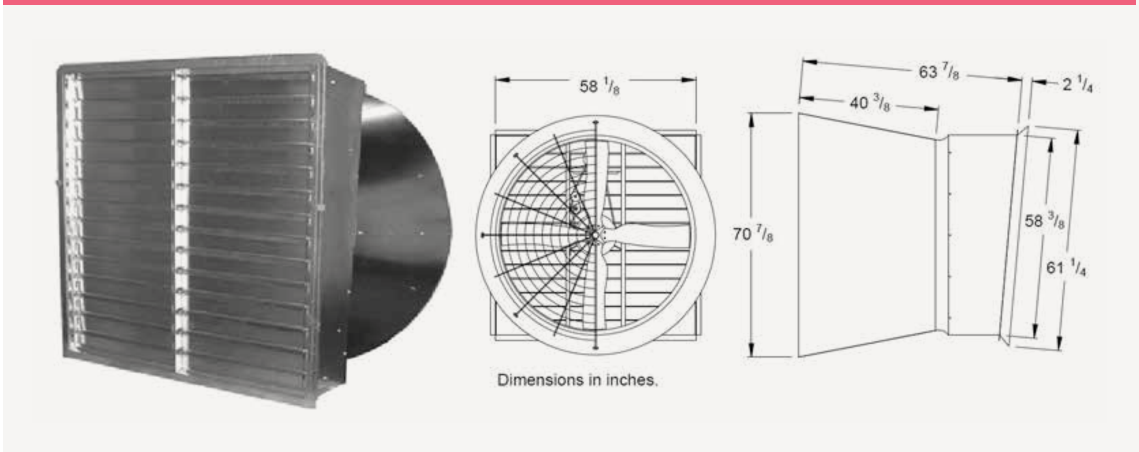
Table 5. Energy efficiency of two different fan models

Fan Model	Motor HP	Performance at static pressure (")					
		0.0		0.05		0.20	
		CFM	CFM/W	CFM	CFM/W	CFM	CFM/W
MNEF	1.0	25,800	36.3	24,500	32.6	16,300	17.9
MNBF	1.0	24,376	23.5	22,726	21.0	16,000	14.0

Typical fan dimensions are depicted in Figure 10.

Energy efficient ventilation however, is NOT just about energy efficient fans. Energy efficiency is achieved by attention to a number of factors:

Figure 10. Typical Fan cross section and dimensions



6.2.1 Energy efficient ventilation

Energy efficient ventilation = energy efficient fans + automatic controller + minimum leaks + regular maintenance

Energy efficiency + effective ventilation = managing static in shed (positive or negative)

- **If the static in the shed is sub-optimal, even efficient fans will unnecessarily use excess power and have higher running costs.**

6.3 Factors for consideration when purchasing fans

Generally, the cost to run fans over 10 years will be approximately 2-3 times the initial purchase cost. Other considerations include:

- the up-front cost of a fan
- ongoing running costs
- for every 2 CFM /Watt increase, power usage is reduced by approximately 10%.

Typically, growers should consider:

- fans with the lowest horsepower available that delivers the output required
- for tunnel ventilation: fans with exhaust cones and shutters on the inside of the fan or butterfly/dragonfly shutters in the cone.

6.4 Performance factors

There are three performance factors to consider when purchasing an exhaust fan for a tunnel-ventilated shed:

- air moving capacity (m3/ hour or CFM— cubic feet per minute)
- energy efficiency (m3/hour/ Watt or CFM/Watt)
- airflow ratio = $\frac{\text{m3/hour @ 50 Pa static}}{\text{m3/ hour @ 12.5 Pa static}}$ or $\frac{\text{CFM @ 0.20" static pressure}}{\text{CFM @ 0.05" static pressure}}$

Airflow required in a shed is extremely important and depends on the design of the shed and vent system.

The airflow ratio indicates how well a fan can move air as the static pressure increases. The higher the ratio, the greater the volume of air a fan can move.

- some fans have a very good air flow ratio but a poor energy efficiency rating
- other fans may have a good energy efficiency rating, but a poor airflow ratio.

Minimum standards have been suggested by the poultry industry. They indicate that a fan should have:

- an energy efficiency rating of at least 19 CFM /watt (0.5 " SP)
- an air flow ratio of at least 0.71.

6.4.1 Automatic controls

Automatic control systems vastly improve the efficiency of tunnel-ventilated sheds by continuously monitoring parameters such as temperature, humidity and static pressure and adjusting ventilation to best suit the conditions.

6.4.2 Minimum leaks and drafts

A shed with minimal air leaks is critical for controlled ventilation and pig performance. Sheds with air leaks can use up to 20-25% more energy and have poor temperature control. Other factors include:

- In winter, valuable heated air can leak out of the shed
- In summer warm air is drawn in increasing the load on the cooling system.
- Sidewall curtains need to be tightly closed, cracks around doors and shutters sealed and holes in ceiling insulation patched.
- Measuring the static pressure of a shed will help determine if there is a ventilation problem such as air ingress or a fan that is operating in-efficiently.

6.4.3 Regular maintenance and servicing

Regular servicing and maintenance considerations should include the following:

- fans require regular maintenance and cleaning to maintain optimum efficiency
- dirty shutters or fan blades can reduce the air-moving capacity of a fan by up to 30% resulting in higher electricity consumption
- fan belts should be regularly checked for wear and to see that they have not slipped into the v-groove of the belt wheel, which reduces tension in the belt.

6.7 Recent developments in fan technology

In recent years there have been new developments in fan technology including the use of variable frequency direct drives. These new fans have:

- potentially very high energy efficiency
- higher capital costs.

For more information contact your fan supplier or visit the websites below.

- MagFans, Denmark - www.dacs.dk/products
- EBM Pabst - www.agricool.com.au

7. Lighting benchmark data

Electricity consumed by lights in piggery operations is generally a small proportion of the overall energy bills. Typically this includes:

- 6% for farrow to finish and farrow to wean operations, and
- 2% for wean to finish operations.

Even so, as the cost of energy efficient LED (Light emitting diode) lights have reduced in recent years, there can be cost-effective opportunities for piggery operators to reduce their lighting energy costs.

7.1 Lighting rebates

Rebates are available through accredited suppliers in each state. The amount of rebate depends on energy saved, type of light, market price for energy saving certificates, and the specific scheme. Typically 20-30% of the total cost. Most suppliers can carry out all the necessary paperwork.

The Australian Government website 'Your Energy Savings' has current information on energy rebates available in your state or territory. As these are subject to change APL has opted to provide the website for reference: **http://yourenergysavings.gov.au/rebates**

7.2 Lighting types

The cost effectiveness of replacing lights with energy efficient alternatives depends strongly on:

- the cost of installation
- the operation time of the lights (where lights are only used for a few hours a day, there are unlikely to be sufficient savings to justify the costs).

7.2.1 Fluorescent tubes

By far the most common light used in pig sheds are fluorescent tubes (1.20m in length, generally referred to as "T8" tubes) and represent 70 - 85% of the lights used in the piggeries which participated in the APL Energy Audit program. See picture to the right.

T8 lights are reported to operate between 1 to 24 hours per day, but on average 7-9 hours in farrowing sheds and 5-6 hours in growing sheds.

LED tubes (pictured to the right) are an energy efficient alternative and can replace the T8 tube. However, LED tubes are relatively expensive so you need to work out if the energy saved is worth the extra costs.

7.2.1.1 Factors for consideration

- Fluorescent tubes are cheap and provide dispersed light levels in all directions
- LED tubes in comparison are more expensive and provide a more directional light source
- Fluorescent tubes have a limited lifespan, delivering 60% output after 14,000 hours of operation
- LED tubes in comparison can deliver 60% output for up to 40,000 hours of operation
- Where lights are used for prolonged periods this limited lifespan of fluoro tubes results in ongoing replacement costs, for light fittings and labour to install.

7.2.1.2 Lighting lifespan benchmark data

Table 6 demonstrates the impact of increased operation hours on the replacement frequency to achieve the same light outputs:

- Running 12 hours/day, the T8 tubes should be replaced every 3 years
- This compares to LEDs replaced every 9 years.
- 36W Fluorescent tubes can be replaced with 20W LED tubes to provide a comparable light output, a saving of 40% in electricity costs
- LED tubes can be controlled with sensors and timers, which can potentially reduce run times
- Expected lifespan of LEDs of more than 40,000 hours means three times the life of Fluorescent tubes
- Typically where lights are used for > 4 hours/day, replacement may be cost effective
- A typical cost-benefit calculation is summarised in table 6 below.

Table 6. Lighting lifespan benchmark data

	FLUORO	LED
	Lifespan (Hours) 14000	Lifespan (Hours) 40000
Hours/day	Replacement frequency (years)	
4	9.6	27.4
8	4.8	13.7
12	3.2	9.1

7.2.2 High bay lights

About 25% of piggeries participating in the APL Energy Audit program operated some form of High bay light, mostly in grow out areas. A number of farmers have switched to LED High Bay options. However, these LED lights are expensive and the savings need to be calculated to justify the installation costs.

Typically High Bay lights are reported to operate between 1-24 hours. However the average light usage time was 8-9 hours/ day.

- Non-LED high bay lights are expensive to install and run, consuming 400W for the lamp and 15-20% for the drivers.
- In addition, most Mercury Vapour or Metal Halide high bays have a limited lifespan with reports of 16,000-20,000 hours at 60% output.
- Where lights have long run times, the limited lifespan results in higher replacement costs.

7.2.3 Floodlights

Floodlights are used on 50% of piggeries participating in the APL Energy Audit program. Some producers have switched to LED or CFL (compact fluorescent lamp) floodlight options.

Typically floodlights do not run for extended periods, and reported run times of 1-7 hours with an average of 3-4 hours/ day.

7.2.3.1 Factors for consideration

LED lights do not provide the same output as existing lights and it is important to consider the specific details of the replacement so that it provides the type and quality of light of light required.

- It can be a good opportunity to review light levels in sheds, with potential to increase or decrease the light output provided.
- It can also be an opportunity to review how long lights are required to run in each shed and the possibility of using timers or sensor controls.

Further factors to consider and discuss with lighting suppliers:

- The wattage best suited to shed
- Colour temperature

- Colour Rendering Index
- Sensor controls for LED
- Batten replacement
- Ballast and wiring

7.3 Cost benefit analysis sample to replace existing lights

Table 7 below illustrates typical payback times that can be expected by replacing old lighting with LED equivalents. These payback times are based on quotes obtained from two suppliers and includes rebates available in NSW and Victoria. However, these are INDICATIVE ONLY and detailed quotes must be obtained.

Table 7. Sample cost benefit analysis for replacement lighting

Type of light	Run times		Replacement type
	8 hours/day	4 hours/day	
	PAYBACK YEARS		
Fluorescent tubes	2.4	4.3	36W fluoro replaced with 20W LED tube and batten
High bays	1.5	2.4	400W High bay replaced with 160W LED High bay (new fitting)
Floodlights	2.2	4.3	250W Floodlight replaced with 100W LED floodlight (new fitting)

Assumptions:

- replacement of whole batten
- Includes 20% rebate
- Includes estimate for reduced ongoing replacements for LED (longer lifespan)
- Includes estimated supply and install costs (indicative only)
- NOTE A detailed quote must be obtained from authorised lighting specialist

7.4 Typical lighting used in piggery operations

For some farrow to finish or farrow to wean units, lighting can be a significant energy use, particularly environmentally controlled sheds, whilst on others lighting is a small energy use.

The range of energy use and costs for farrow to finish and farrow to wean operations participating in the APL Energy Audit Program varied:

- Some sheds installed lighting with as little as 5-10 Watts per crate, whilst others used up to 40-45 Watts/crate
- Energy use ranged from 20 kWh/crate/year to 100-120 kWh/crate/year
- This compares to energy for heating
  - lighting typically 140-400 W/crate
  - consumption typically 200-4000 kWh/ crate/ year
- In grower units lights are a small proportion of the bill (1-9%) costing up to $2,000 in electricity.
- When replacing lighting or building new facilities consideration to energy efficient lighting can save on energy bills into the future and prove to be worthwhile.

8. Case study – boilers and LPG (Lindsay Walker - main piggery)

The main piggery operated by Lindsay Walker at Lindham Properties on the Wild Horse Plains in South Australia is a farrow to weaner enterprise with 1800 breeding sows.

In recent times, the Walkers have upgraded the gas boilers which heat the water that flows through the mats in the creep areas. The old atmospheric boilers have been replaced with Baxi 28 kW condensing boilers that have potential to be more efficient.

Older style boilers utilise atmospheric combustion resulting in significant heat loss up the flue. In theory, atmospheric boilers can be 80% efficient. However, dusty air intake can result in eroded jets and inefficient gas use in the boiler. Estimates of 5-10% loss in efficiency have been reported.

With condensing boilers a lower temperature exhaust is achievable, reducing heat wasted and increasing efficiencies up to 92%.

8.1 The heating system

There are two separate water systems:

- A closed circuit with a Fernox water conditioner is heated by the boilers to 50°C and pumped through to a heat exchanger.
- From the heat exchanger, water is pumped through the flow line (red blocks) of the manifolds to the heated mats in the creep areas. Water from the heat mats then flows back through to the return line of the heating system back to the return blocks of the manifold (blue blocks) and the process is repeated. One circuit from the manifold heats 4 to 5 mats.
- Air remittance valves are also added to the heating system to relieve the system of un-wanted air, which causes air pockets in heat mats, lowering the desired temperature or bursting pads.
- A water meter is also used in the system to make sure the heating system is operating at its optimum level and will pick up any potential leaks in the system which can be isolated to each individual circuit. This also greatly improves the efficiency of the system by eliminating the introduction of colder water back into the system.
- A pressure limiting valve has also been added to protect system and heat mats and is set at 1.5 bar.



The Walkers installed two boilers for each 100-150 crates. This has provided a level of redundancy. The extra boiler allowed the system to continue to operate in the event of a breakdown or when servicing is required. This is particularly important in rural areas where it is costly to get a trade's person at late notice. Lindsay now prefers this system as it provides peace of mind and ensures the system is always going to be working during that critical time when the piglets are 1-10 days old.

- The Walkers have undertaken a straight swap of the boiler as the existing pipework was intact and working well. However, on many farms, leaks in the pipework are a major issue reducing the efficiency of the whole system.
- Installing a flow meter allows leaks to be detected quickly and problems rectified (refer to section 5 of this booklet).

8.2 Cost benefit analysis

At the main piggery, the Walkers operate 520 crates and use approximately 152,000 litres of LPG each year costing $150,000 (includes GST). This equates to $290/crate/year.

The supply and installation of the new combustion boilers cost $120–150 per crate for a shed with approximately 100 crates.

Measurements on the Baxi boilers and the current heating system design of 120 crates indicate encouraging results.

- In November, with the old boilers, an average gas use of 122.4 L/ day was recorded
- Also in November, with the new boiler, an average gas use of 97.0 L/ day has been recorded
- This represents a 20.8% reduction in gas use.
- This is equivalent to a saving of 60 L per crate per year, or $60 per crate per year at $1/ L.
- For an investment of $120-150/ crate, this is a payback of 2 to 2.5 years.
- NOTE: this included the cost of an extra boiler installed as backup and peace of mind.
- NOTE: this calculation is to replace a working atmospheric boiler. For a new installation, the cost is the extra cost of the condensing boiler over the atmospheric boiler to achieve the savings. This results in a payback of 1 to 1.5 years.

8.3 Maintenance

The maintenance of condensing boilers is similar to atmospheric boilers, which should include cleaning out the heat exchanger every 6-12 months.

8.4 Managing leaks

Leaks in water pipes in farrowing sheds are a common issue and can result in significant losses of heated water. Rodents are reported to be a major cause of leaks, gnawing through pipework. A number of strategies can be implemented to minimise the risk of leaks including:

- Minimise visual attack of pipe and joints by installing ducted pipework
- Minimise use of rubber ring joints at fittings; compression joints reduce issues of hot water and rubber deterioration.
- Some farmers are experimenting with Aluminium cored pipe to discourage rats

However, leaks will always occur, and installing water meter alerts the operator when and where to look for leaks: when the water meter reading is showing a higher flow than normal, a leak is the most likely cause.

8.5 Managing other losses

Reticulation of hot water large distances has potential for significant energy losses and steps must be taken to insulate as much as possible.

- Plate heat exchanger: at the Walkers this is lagged and located inside a container for extra protection
- Pipework outside is currently partly lagged but a proportion of this is currently missing at the Walkers

8.6 Volatility of gas prices

Gas prices can at times show some volatility. However, per kWh of power available, LPG can work out to be very cost effective:

- 1 litre of LPG has 6.9 kWh energy value
- With a boiler operating at 90% efficiency, this delivers 6.2 kWh/ L
- When LPG costs $ 1.00/ Litre, this is equivalent to $ 0.16/ kWh
- With a boiler at 80% efficiency, 5.5 kWh/L is delivered, at $ 0.18/ kWh.
- In the ALP Energy Audit program group electricity has ranged in price from $ 0.20 to $ 0.25/ kWh.

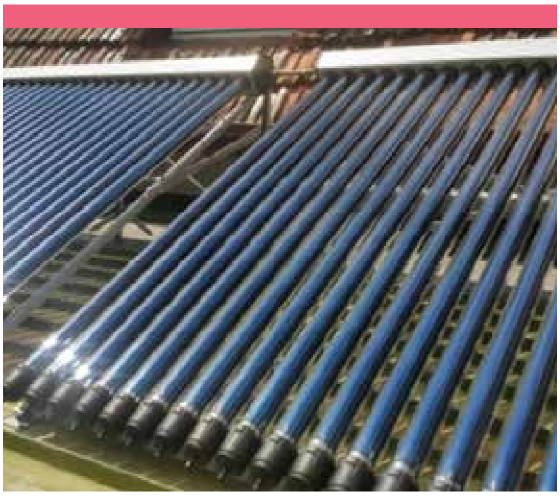
8.7 Using biogas

Use of boilers provides the potential to use biogas generated from a plant on the farm and utilising the waste stream available.

Use of the farms own biogas would eliminate the risk of price fluctuations in LPG.

8.8 Preheating water with solar energy

With a water based heat exchanger system there is potential to heat or preheat water with a solar hot water system, which generally can deliver water at 50-55°C. This could be flat panel or evacuated tube.



9. Biogas as an alternate energy source

Biogas has potential to reduce electricity bills at piggery operations and reduce the carbon footprint.

As part of the Pork PIEES program, the feasibility of installing biogas infrastructure on each participating pig operation was analysed. FSA Pty Ltd completed these analyses. Up to three potential energy generation options were investigate at each site where appropriate:

- Option 1: Covered anaerobic pond with combined heat and power (CHP) generation
- Option 2: Covered anaerobic pond with electricity production only (generator)
- Option 3: Covered anaerobic pond with heat production only (boiler).

The potential revenue included Australian Carbon Credits (ACCUs) available.

9.1 Return on investment

The results highlight that for many piggery operations investment in biogas can be cost effective with many payback times between 2-6 years.

- Figure 11 summarises the payback times for farrowing units
- Figure 12 summarises the payback times for growing units.

Figure 11. Biogas for farrowing units

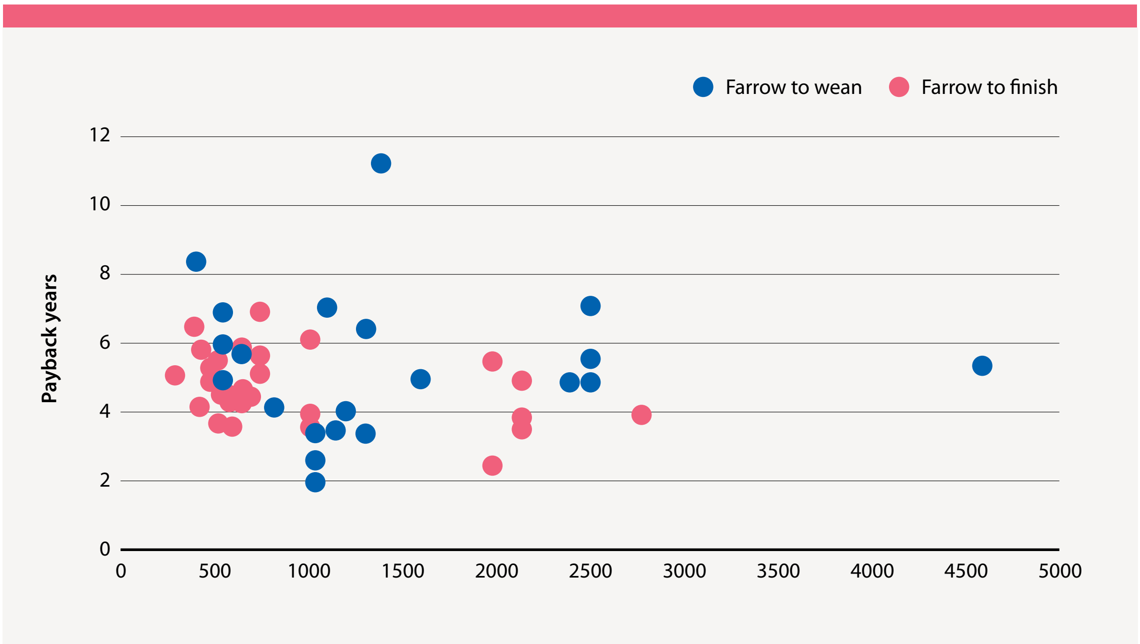
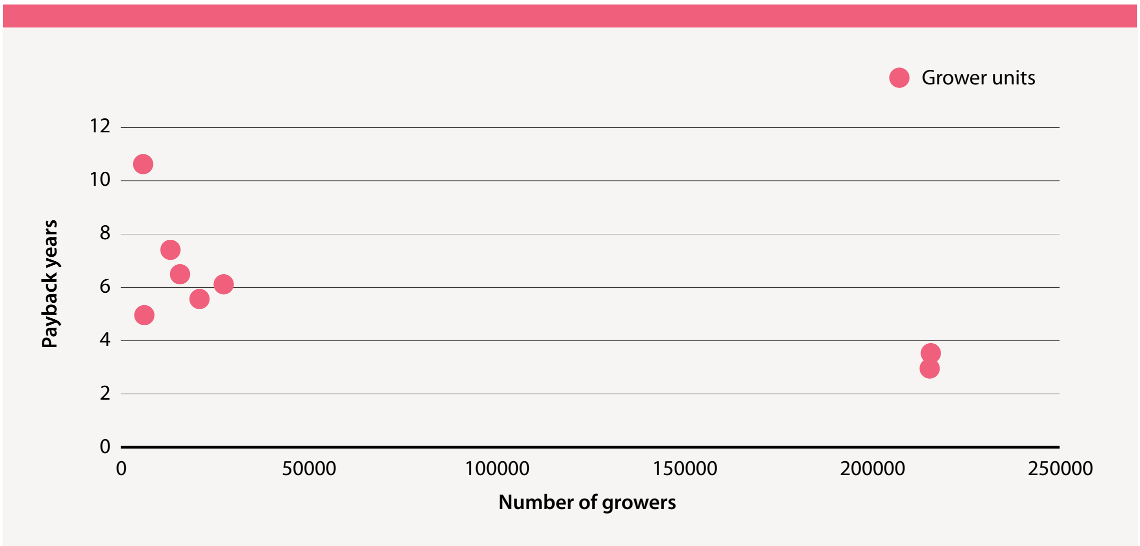


Figure 12. Biogas for grower units



9.2 Capital investment

Capital investment depends on the scale of operation and type of piggery unit. In the APL Energy Audit group, the largest investment required was 2.0 million dollars.

- Figure 13 summarises the capital investment and payback times for each type of piggery
- Figure 14 summarises the same data but highlights the Option 1, 2 or 3 considered.

The results show that biogas plants can offset a significant proportion of energy purchased, typically between 50-100%.

- Figure 15 illustrates the percentage electricity offset by the biogas plant
- Figure 16 illustrates the percentage of heat offset by the biogas plant.

Figure 13. Return on investment in biogas

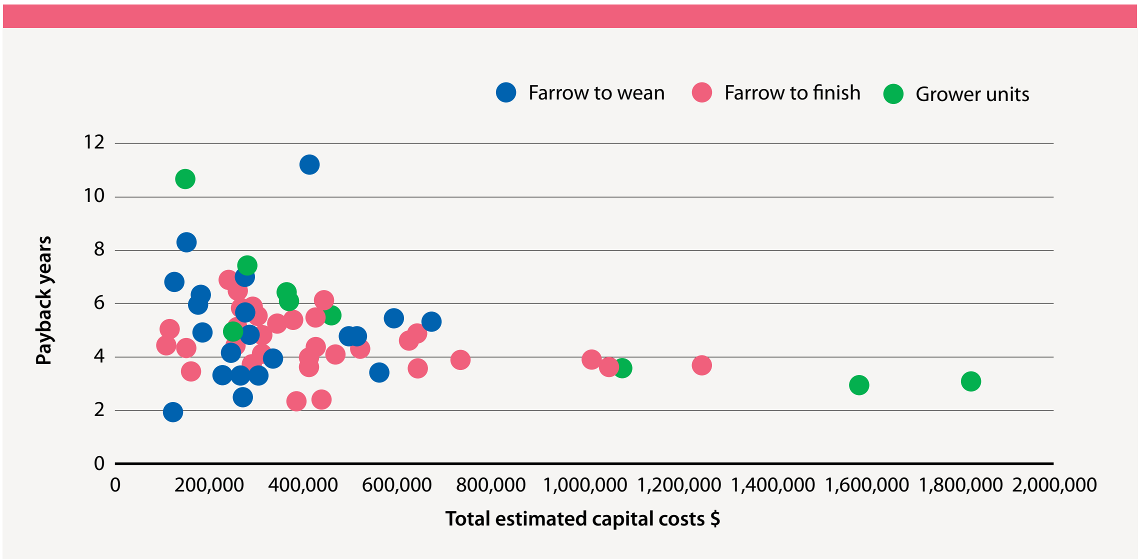


Figure 14. Return on investment in biogas in different plant and equipment

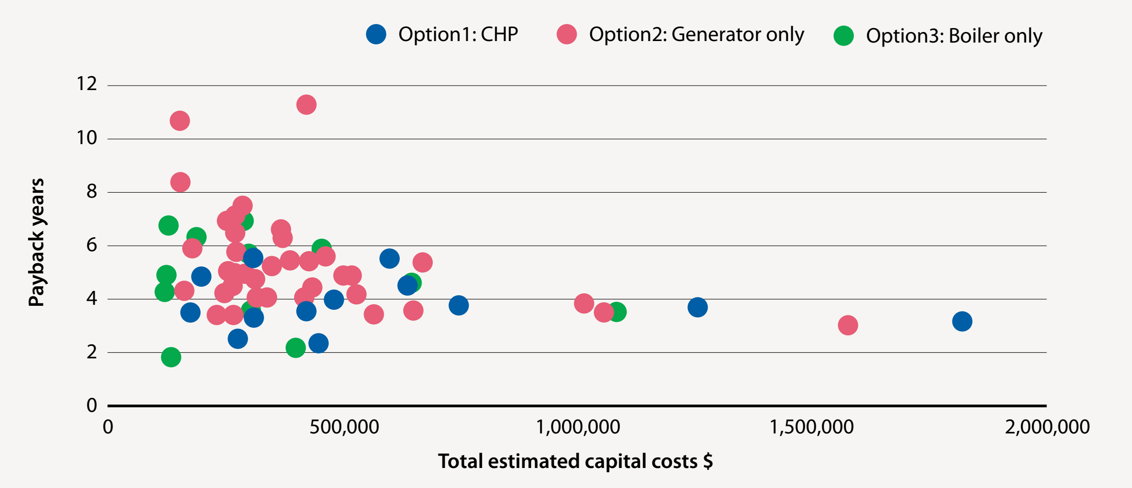


Figure 15. Electricity generation potential

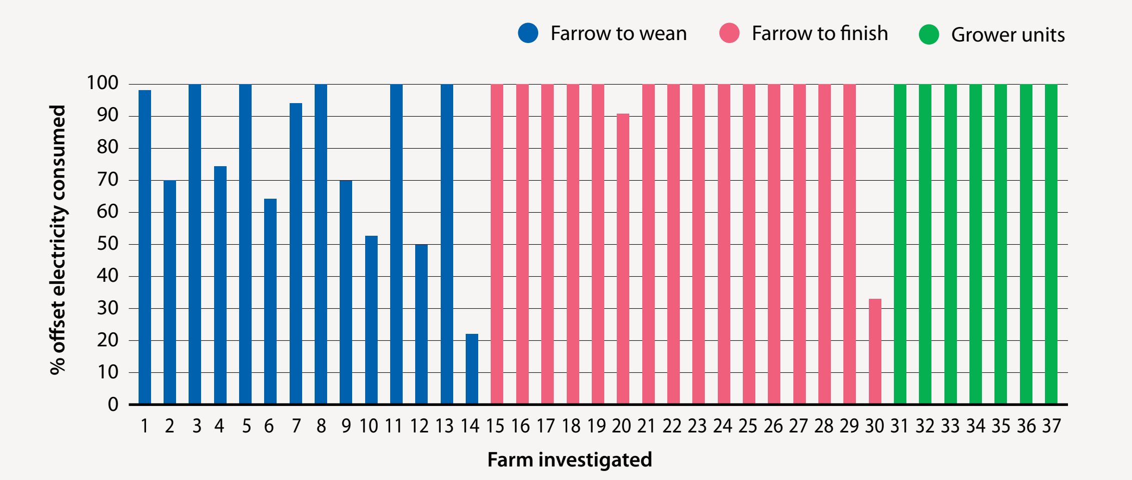
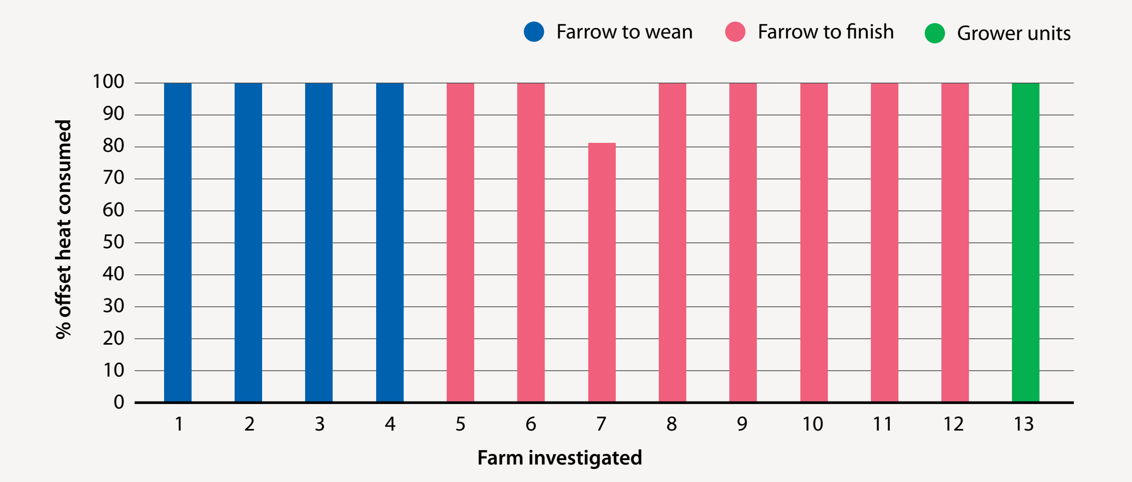


Figure 16. Heat production potential



9.3 Resources available

There are many resources available for piggery operators when investigating whether a biogas plant will be a worthwhile investment option:

- Australian Pork Limited (APL) has links to information on all aspects of biogas investments
- http://australianpork.com.au/industry-focus/environment/renewable-energy-biogas/
- Pork CRC also has information on Biogas projects.
- http://porkcrc.com.au/research/program-4/bio-energy-support-program/
- Pork CRC Bioenergy support program run by DAFF QLD can assist you review production figures for proposed Biogas Plant.

9.4 Steps to implement a biogas project

When considering biogas options for piggery operations consider the following steps:

- Gather your electricity bills for the last 12 months.
- If you have a communications smart meter you can request "interval" data from your electricity supplier. This is a record of your electricity consumption every 30 seconds over the last 12 months and will assist your Biogas designer to better analyse the savings
- Do you r research on the APL and Pork CRC websites. The better informed you are the better your understanding of your options.
- Contact Australian Pork Limited to get the latest information on where there is assistance to provide an impartial review of any proposals
- Contact your electricity distributor early to understand grid connection requirements
- Understand your local planning requirements
- Review quotes submitted. Pay particular attention to product selection, warranties and guarantees
- Be clear about rebates and who is responsible for the paperwork
- Check if there are any other state or local government grants: www.grants.myregion.gov.au

10. Solar photovoltaic (PV) energy

Solar cells, also called photovoltaic (PV) cells, convert sunlight directly into electricity. PV gets its name from the process of converting light (photons) into electricity (voltage) which is called the PV effect.

Solar PV is increasingly being used by piggeries to offset the high cost of grid electricity. Some pig farms have installed both solar PV and biogas units to reduce their reliance on the grid.

10.1 Feasibility of solar PV

As part of the Pork PIEES program, the feasibility of installing solar PV on each participating pig operation was analysed. Epho Pty Ltd completed these analyses: www.epho.com.au

Figure 17 illustrates the analysis and is based on

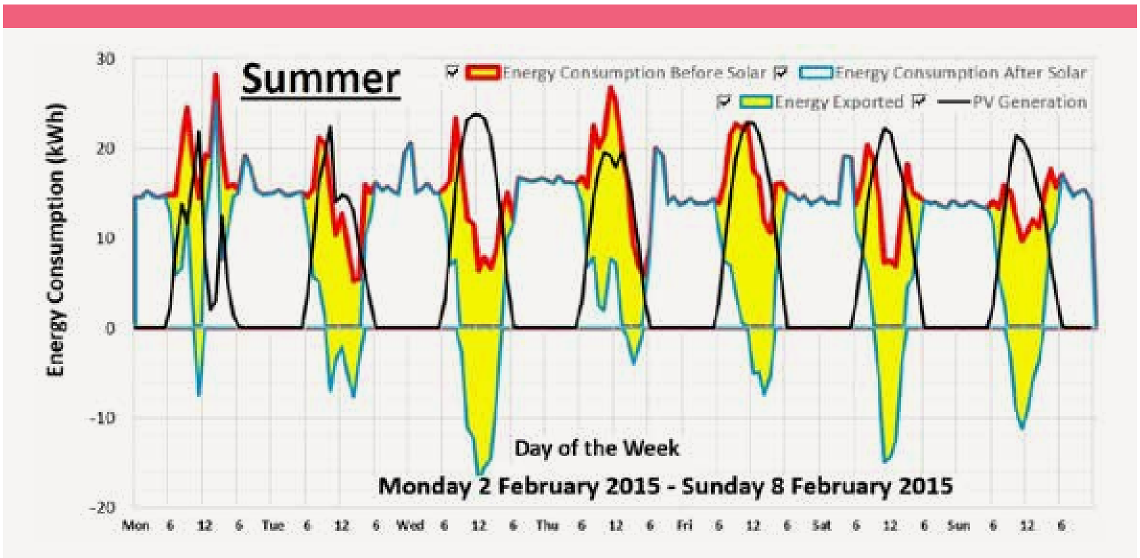
- the actual daily pattern of electricity consumption at each piggery
- the solar PV generated at the piggery location

The results of this analysis for all farms participating in APL Energy Audit program. These results (see figure 18 below) highlight that for many piggery operations solar PV is a feasible cost effective alternative energy source:

- Paybacks were typically between 2.5 and 6.0 years
- Return on investment were typically between 17- 41%
- Between 60- 90% of the solar PV generated was utilised at the pig sheds
- Electricity consumed at the pig sheds was offset by between 15-48%
- Solar PV systems between 5-100 kWp are best suited to pig operations

One distinct advantage of solar PV is the modular nature of the system: a large investment can be broken up into workable stages to spread costs.

Figure 17. Analysis of daily consumption pattern and solar PV generation



10.1.1 Example of solar PV return on investment

A 425 sow farrow-to-finish piggery in Victoria uses 127,000 kWh/ year in electricity

- The installation of a 44.5 kWp solar PV system would reduce this consumption by 34%, utilising 71% of the solar PV generated at the sheds.
- The capital cost of $64,770 (after rebates) would take 3.8 years to payback with a return on investment of 27.1%.
- Over 10 years savings of approximately $182,800 would be achieved.

Sizing a solar PV system is a balance between

- a system large enough to offset a significant proportion of grid electricity consumed AGAINST
- a system that utilises a high proportion of the electricity generated

10.2 Solar PV implemented by APL Energy Audit program group

In the APL Energy Audit group three farmers have already invested in solar PV at a total of 6 sites, installing systems that range from 5kWp to 90kWp. However, five of the installations were delivering significantly less electricity than expected, with actual generation 12-82% lower than expectations.

- Regular monitoring of system performance is offered as a service by some suppliers of solar PV and is highly recommended for larger systems.
- The table below illustrates the systems installed, expectations and recorded performance

Table 8. Results of Solar PV installation

Type of production	Farm No.	Number of sows	Solar PV system size (kWp)	Expected kWh/ year	Recorded kWh/ year	% gap: expected & recorded
Farrow to Wean	Farm 1	700	60	93,440	53,251	-43%
	Farm 2	1000	60	96,360	84,456	-12%
	Farm 3	1300	60	95,995	61,310	-36%
	Farm 4	2600	90	154.760	27,093	-82%
Farrow to Finish	Farm 5	400	40	71,175	44,146	-38%
	Farm 6	850	5	9,600	9,366	-2%
Wean to finish	None to date					

The performance of the solar PV systems already installed on piggeries were analysed on the basis that the expected or designed electricity generated was delivered:

- Between 62-100% of the solar PV generated could be utilised at the pig sheds
- Electricity consumed at the pig sheds would be offset by between 5-39%
- Farm 6 had additional capacity to utilise solar PV and an additional 30kWp system could be installed to offset 27% of electricity utilising 99% of the solar PV generated.
- The table below summarises these analyses.

Table 9. Analysis of Solar PV installation at various sites

Farm No.	Number of sows	Solar PV system size (kWp)	Assuming solar PV generates as designed		
			% Offset	% Utilised	Payback Years
Farm 1	700	60	37%	66%	4.9
Farm 2	1000	60	39%	62%	4.8
Farm 3	1300	60	36%	80%	4.8
Farm 4	2600	90	31%	92%	4.8
Farm 5	400	40	34%	69%	4.6
Farm 6 existing	850	6	5%	100%	2.5
Farm 6 additional	850	30	27%	99%	2.9

10.3 Resources available

There are many resources available to help you assess if a solar PV system is worthwhile for your sheds and in the implementation phase. A good place to start is the Clean Energy Council (CEC) website which provides a "Guide to Installing Solar PV for Business and Industry" (www.cleanenergycouncil.org.au). This site has information on:

- CEC accredited designers and installers
- Questions you should ask designers and installers
- Questions for your electricity provider
- Applications for rebates, connections and approvals
- A useful checklist.

10.4 Steps to implement solar PV

When considering solar PV for your piggery operation you need to follow a few steps to make sure you get the result you want:

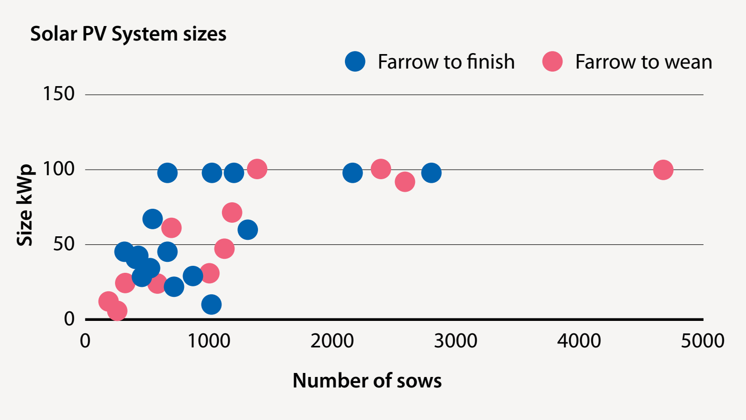
- Gather electricity bills for the last 12 months.
- If you have a communications smart meter you can request "interval" data from your electricity supplier. This is a record of your electricity consumption every 30 seconds over the last 12 months and will assist your solar PV designer to better analyse the savings
- Contact a CEC accredited designer/ installer for an on-site assessment
  - Look for a company that has strong experience in installing commercial solar systems (>30kW), not necessarily your local residential solar installer
- Do your research using the CEC website: work out the important questions to ask
  - the designer
  - the installer
- Contact your electricity distributor early to understand grid connection requirements
- specifically ask the quoting installer if all grid-connection and metering costs are included

- Understand your local planning requirements
  - In some states, a complying development certificate (CDC) is required between 10- 100 kWp and development application (DA) over 100 kWp
  - In some states a structural engineering certificate is required
- Review quotes submitted. Pay particular attention to product selection and warranties
  - In particular, compare the warranties on each of the major components (eg Panels, inverters, mounting structure)
  - Look closely at the workman warranty offered by the installer
- Be clear about rebates and who is responsible for the paperwork
- Check if there are any other state or local government grants: www.grants.myregion.gov.au

10.5 Feasibility of solar PV in piggery operations

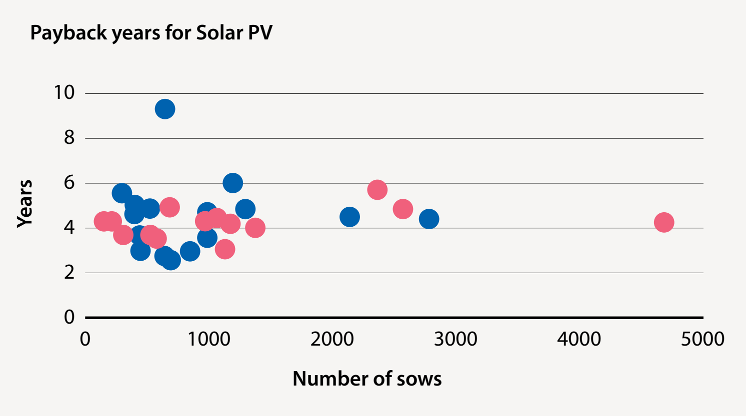
Figure 18. Feasibility of Solar PV in piggery operations Feasibility of Solar PV in Pig operations

(a) Farrow to Wean and Farrow to Finish piggeries
Results of Solar PV analysis for participants of APL's "Energy Audit Program".



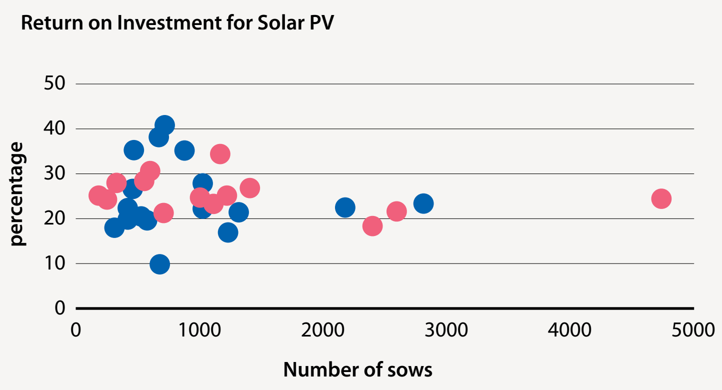
Solar systems range in size from 5 kWp to 99 kWp.

Some smaller piggeries can justify larger solar PV systems where there is high consumption from the grid.



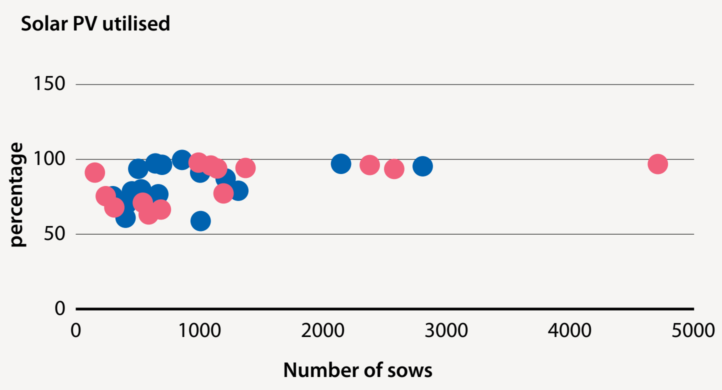
Payback periods are generally in the range from 2.5 years to 6 years with one outlier at 9.4 years.

Size of piggery does not correlate to payback.



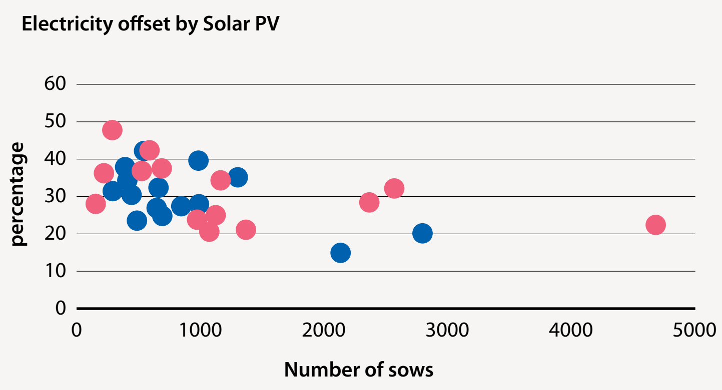
Return on Investment results are generally in the range from 17 to 41% with one outlier at 10%.

Size of piggery does not correlate to return on investment



Solar PV utilised is generally in the range from 60 to 99%.

Size of piggery does not correlate to solar PV utilised

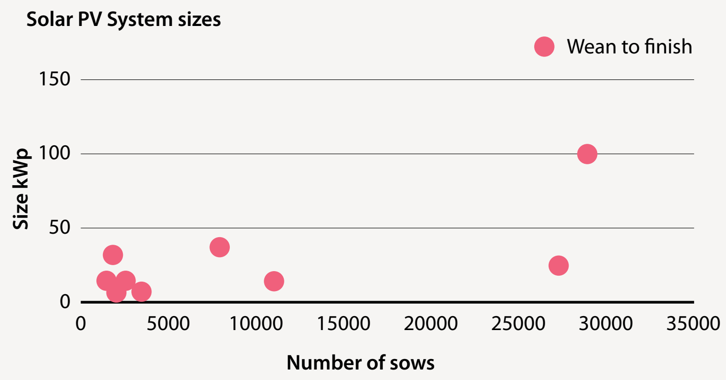


Electricity offset by Solar PV is generally in the range from 15 to 48%.

Smaller piggeries generally offset a higher proportion of electricity consumed form the grid.

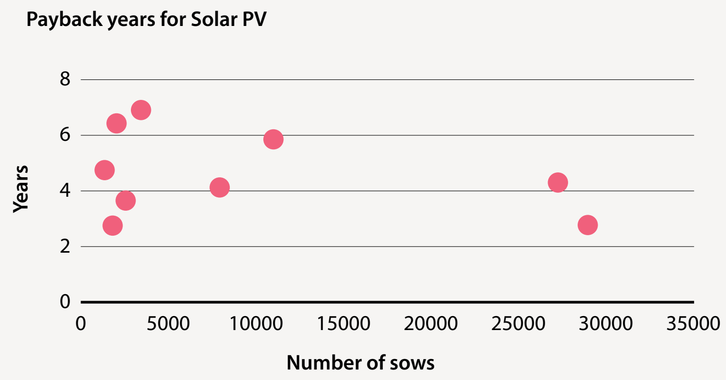
(b) Wean to finish piggeries

Results of Solar PV analysis for participants of APL's "Energy Audit Program".



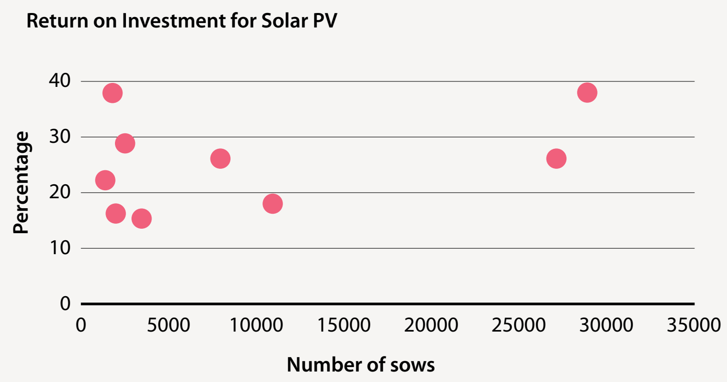
Solar systems range in size from 5 kWp to 99 kWp.

Some smaller piggeries can justify larger solar PV systems where there is high consumption from the grid.



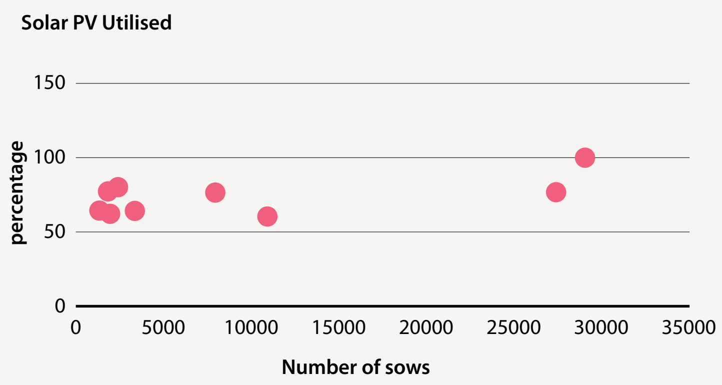
Payback periods are generally in the range from 2.7 years to 6.8 years.

The larger piggeries have slightly improved payback times.



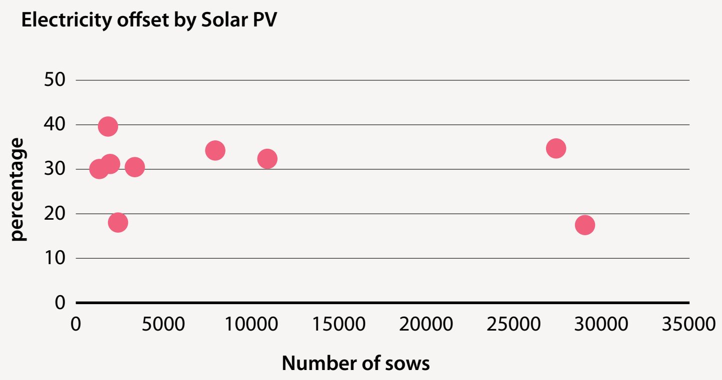
Return on Investment results are generally in the range from 15 to 38%.

Size of piggery does not correlate to return on investment



Solar PV utilised is generally in the range from 55 to 99%.

Size of piggery does not correlate to solar PV utilised



Electricity offset by Solar PV is generally in the range from 17 to 39%.

Smaller piggeries generally offset a higher proportion of electricity consumed form the grid.

Notes

Notes

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AUSTRALIAN PORK LIMITED
ABN 83 092 783 278

Level 2, 2 Brisbane Avenue, Barton ACT 2600
PO Box 4746 Kingston ACT 2604 Australia

P: 02 6285 2200   F: 02 6285 2288
E: apl@australianpork.com.au

www.australianpork.com.au