CASE STUDY

Reduce the speed, reduce the cost: variable speed drives on pumping systems lead irrigation efficiency measures for Gunnedah cropping enterprise

Working with the NSW Farmers' Energy Team, the Kensal Green farm in Gunnedah identified significant energy savings opportunities over the short, medium and longer term. Heading the list of opportunities was the use of variable speed drives (VSDs) on pumps, as well as proper ballasting of the farm's new tractor.

Pilot site: 'Kensal Green' and 'Gruen Park' (owned by Tagmor Ag), Masman Rd, Gunnedah, NSW 2380
Date of visit: 26 November 2013
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Just south of Gunnedah is Kensal Green, an irrigated farming property that grows cotton, wheat and other grains. Owned by Tagmor Ag and managed and operated by farmer Scott Morgan, the farm uses no-till planting and is located on a historic flood plain. 460ha of the 720-ha property are irrigated. During periods of flooding, or when there is sufficient moisture in the soil, the farm implements 'double cropping', meaning that after harvest, a crop is planted directly on top of the previous crop to take advantage of the latent soil moisture.

As in much of the country, water is a scarce resource at Kensal Green. To maximise his water allotment and minimise costs for water use, Scott uses moisture probes to prevent overwatering and has undertaken work to ensure low seepage from his dams and reservoirs. Scott also uses as much water as possible from the free-flowing river adjacent to his property when this water is available.

With a longstanding interest in energy efficiency, Scott retrofitted a variable speed drive (VSD) on his number 1 bore and installed two 10kW solar PV systems. To drive further cost reduction opportunities, Scott contacted the NSW Farmers Energy Team to participate in the energy innovation program.

Working with Scott, NSW Farmers' team developed an energy profile of Kensal Green's operations, then identified and prioritised efficiency opportunities and, finally, created a plan for implementing efficiency projects over time.

Energy profile insights

The property uses approximately 160,000 kWh of electricity and 40,000 litres of diesel per year for tractors, other vehicles and pumps (used to run various bore, transfer, and storage and lift water pumps for irrigation).

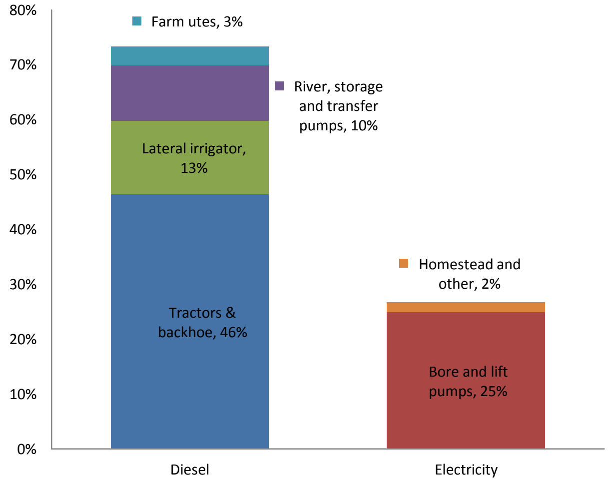
Table 1: Kensal Green's energy breakdown by energy type

Fuel Type	Consumption (p.a.)	Units	Conversion to GJ factor	GJ	Cost	Cost per Unit	Cost /GJ
Diesel	41,759.00	litres	0.0386	1,611.90	$62,220.91	$1.49	$38.60
Electricity	163,228.63	kWh	0.0036	587.62	$42,500.00	$0.26	$72.33
Totals/Averages:				Total: 2,199.52	Total: $104,720.91	Average: $0.88	Average: $55.46

Table 2: Kensal Green's energy breakdown by end-use purpose

Fuel Type	Purpose	Energy Used (GJ)
Diesel	Tractors & backhoe	1,021.086
Diesel	Lateral irrigator	294.055
Diesel	River, storage and transfer pumps	221.024
Diesel	Farm utes	75.733
Electricity	Bore and lift pumps	548.023
Electricity	Homestead and other	39.600
Totals		Total: 2,199.52

Figure 1: Kensal Green and Gruen Park Energy Use by Type and Purpose



Scott assembled information on all of the farm's energy-using equipment and estimated fuel/energy use per year. This information is shown in the table below.

Table 3: Kensal Green's register of energy-using equipment

Equipment Description	Energy/Fuel Type	Qty of Energy /Fuel use p.a.
JD 8130 235 hp (5 years old)	Diesel	13,560.00 Litres
JD 8235R 235 hp (new)	Diesel	NA (not used yet)
JD 7800 120 hp (95 model)	Diesel	3,744.00 Litres
JD Header 9500 120 hp (98 model)	Diesel	2,921.00 Litres
JD Picker 9970 120 hp (98 model)	Diesel	5,981.00 Litres
Sub bore pump electric motor #1 75kW (4 years old)	Electricity	75,812.33 kWh
Sub bore pump electric motor #2 75kW (3 years old)	Electricity	63,551.06 kWh
Re-lift pump China 16" electric motor 37kW (8 years old)	Electricity	12,865.24 kWh
Homestead and other (20 yrs +)	Electricity	11,000.00 kWh
Storage pump 20" axial flow Volvo a100 !00 hp (8 years old)	Diesel	1,908.67 Litres
Storage pump 12" china Deutz 60 hp (3 years old)	Diesel	1,908.67 Litres
River pump 20" china Volvo TD100 140 hp (8 years old)	Diesel	1,908.67 Litres
580K BackHoe	Diesel	247.00 Litres
Lateral irrigator (2 years old)	Diesel	7,618.00 Litres
Farm utes (12 years old)	Diesel	1,962.00 Litres

The farm has three John Deere tractors: a new 235hp, a five-year-old 235hp and a 120hp from 1995. It also uses six pumps. Two of these are bore pumps (both 75kW, both electric); two are used for storage (a 60hp and a 100hp, both diesel-powered); and there is a 140hp diesel-powered river pump and a 37kW electric re-lift pump.

Figure 2 depicts the diesel pump on the Mooki River (left) as it pumps water into the channel (right) leading to crops or to the lift pump for it to be stored in the reservoir.

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Figure 2: Mooki River pump and transfer channel

Kensal Green has a roof-mounted PV system (on a barn) and uses conventional silicon cells, while another PV system is ground-mounted beside an irrigation channel and uses thin film amorphous silicon cells. The figure below shows one of these systems.

Figure 3: Ground-mounted 10kW amorphous silicon (thin film) PV system provides an opportunity to offset peak load on 3 electric pumps

> **"Having invested in solar to reduce my electricity costs I was open to investigating other areas to improve farm efficiency."**
>
> Scott Morgan

Identifying and prioritising cost-saving opportunities

Scott referred to the fact sheets provided by the NSW Farmers Energy Team and, with assistance from energy consulting group Energetics, generated a list of potential cost-saving opportunities. This list, shown in the table below, includes simple paybacks that were quantified using calculators available through the Energy Innovation Program.

Table 4: Identified efficiency opportunities and their expected savings/costs

Measure	Energy savings	Energy cost savings ($)	Up-front cost ($)	Payback (years)
QW: Adaptive driving	2,194	$3,272	$0	0
QW: Ballasting & tyre pressures	1,141	$1,701	$851	1
QW: Vehicle maintenance	1,316	$1,963	$982	1
Diesel to electric pump	10,087	$2,774	$0	0
VSD on pumps	33,289	$9,154	$22,886	3
Voltage optimisation	20,000	$5,500	$110,000	20
Power Factor Correction	0	$2,750	$6,875	3
Solar PV	13,820	$3,801	$25,080	7
Solar pumps	7,960	$11,871	$75,471	6
Wind	16,200	$4,455	$68,493	15

Although more than $40,000 in potential fuel and electricity savings were identified, it was unrealistic to expect Scott and his small team to be able to progress every opportunity. Therefore, a prioritised list of projects was developed using business criteria that reflected Scott's farm plan. The criteria included cost reductions, decreasing his use of diesel, and having a seven-year maximum payback period for any investments. The figure below shows the prioritisation matrix.

Figure 4: Prioritisation matrix for Kensal Green

Variable speed drives (VSDs)

Prior to his involvement with the Energy Innovation Program, Scott Morgan retrofitted a VSD on one of his bore pumps in pursuit of energy savings. The energy consumption of this bore pump will be analysed regularly with a view to refining the specific savings it enables (compared to the previous operation). However, expectations are that **slowing the speed of the motors by 20% has the potential to save Scott 50% of his pumping costs.**

Extending the use of VSDs to two additional electric pumps, in addition to the one that Scott has already modernised and is using, is another opportunity for him to make energy savings on-farm.

Variable speed drives on electric 75kW bore pump and 37kW electric re-lift pump

VSDs reduce power draw at times when the pumps do not need to run at full power. The identified energy savings are outlined below.

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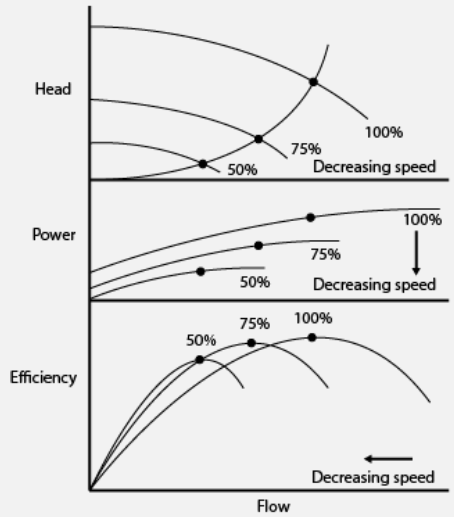
Did you know?

Pumps that experience highly variable demand conditions are often good candidates for variable speed drives (VSDs). Variable frequency drives (VFDs), a common type of VSD, use electronic controls to vary the frequency and voltage supplied to the motor, which regulates the motor speed and, in turn, adjusts the pump's output. As opposed to common flow control methods such as throttling valves or bypass systems, the principal advantage of VSDs is that they better match the fluid energy that the system requires with the energy that the pump delivers to the system. The pump's power is proportional to the cube of speed; therefore a significant reduction in power (and energy savings) can be achieved by reducing the speed of the motor. **In fact slowing the speed by 20% can save up to 50% of the electricity**. This can be seen in the diagram below:

Figure 5: With decreasing speed (100%->75%->50%), disproportionally lower power and energy is required (100%->56%->25%) [Energy Technology Support Unit (ETSU), Harwell, 1998]



A VSD can alleviate the need to throttle the flow (and lose energy) or allow the water to be pumped more slowly and reduce the frictional energy loss. Soft start and stop capabilities also reduce mechanical and electrical stress as well as the risk of water hammer.

VSDs are not practical for all applications. For example, adding a VSD to a system with high static head or one that needs to operate for extended periods under low-flow conditions will not provide great energy savings.Energy savings can vary significantly depending on the system characteristics and the type of operation; typically, they range from 5% to 50%.

Table 5: Expected savings and costs for VSD opportunity

Estimated up-front costs	$22,886 (inclusive of purchase of new variable speed pump drives & labour and installation costs)
Expected yearly savings	$6,963.81 (expected 35% savings from current pumps' operation)
Simple ROI	3.3 yrs
Notes	The ROI and savings figures are based on existing electricity prices and do not take into account future price fluctuations or the opportunity for eventual electric generation from non-grid sources (wind, biogas, solar). For more information on this measure, please see the NSW Farmers fact sheet on variable speed drives on pumps.

Tractor optimisation (ballast and tyres)

Currently, Scott is setting up a new spray tank for his tractor. Given the current driving practices of his operators and management of tyre pressures and ballast points, it was estimated that savings in fuel consumption of approximately 10% could be made to his fleet of tractors.

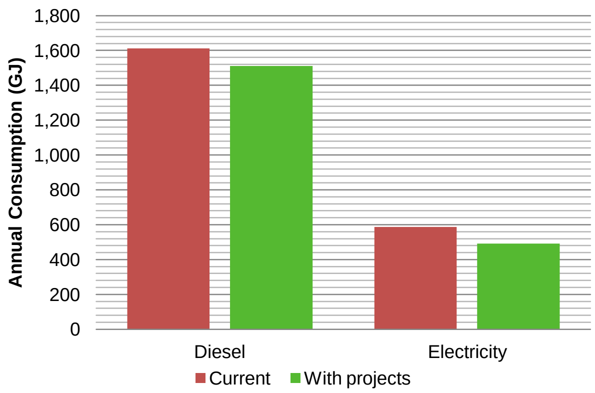
Table 6: Expected savings and costs for ballast & tyre optimisation opportunity

Estimated up-front costs	~$1,000 (estimated costs of courses, labour, tyre pressure gauges and leasing tractor weigh pads)
Expected yearly savings	$3,919.92
Simple ROI	2 months
Notes	The ROI and savings figures are based on existing fuel prices and do not take into account future price fluctuations For more information on this measure, please see the NSW Farmers fact sheets on tyre pressures and ballasting for efficiency.

Total potential savings

Figure 6 illustrates the savings available to Scott and his team.

Figure 6: Expected savings from selected efficiency opportunities



Savings per year (GJ)	197.83
Savings per year (%)	9%
Savings per year ($)	$10,883.72

Scott's team used the energy innovation templates provided by NSW Farmers and Energetics to develop an action plan to progress his priority projects.

Figure 7: Experts from Energetics and NSW Farmers helping complete the plan of action for Kensal Green

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Embedding energy efficiency into farming operations

The action plan Scott intends to implement at Kensal Green identifies energy-efficiency opportunities and allocates projects over the short, medium and long term.

Incremental steps are the key to a workable action plan

In the **short term** (within 12 months), Scott will pursue adaptive driving practices, ensuring that all the farm's tractor tyres are inflated adequately and that the ballast set-up of tractors is optimal for critical operations.

Like 50% of farmers questioned under this program, Scott believed his operators could do more to apply adaptive driving practices, such as using 'Gear-Up-Throttle-Down' to maximise efficiency and engine RMP. He will also begin to log fuel use in order to understand better where and how fuel is being used. Training courses with a potential return of $2,200 (given Scott's current tractor use) are available for less than $200. Other savings are available in proper ballast set-up and tyre pressure adjustments that would bring potential savings of $1,700. This compares with a cost of around $800 in additional maintenance and ballast adjustments when switching implements (spraying to sowing, et cetera).

Medium-term opportunities (2-3 years) include advanced water-monitoring controls to improve irrigation effectiveness, and blending natural gas into diesel-driven pumps and tractor engines to help them run more efficiently and on a lower-cost fuel mix. VSDs in this case are considered medium-term as Scott prepares his budget for next season. Voltage optimisation is also considered a medium-term opportunity, as investigation into the power rating of all equipment, especially motors, will be necessary to ascertain potential savings.

Long-term opportunities (8-10 years) include incorporating localised solar PV into power pumps, and examining the potential of powering pumps and engines using biogas or biofuels sourced from local on-farm waste or from nearby agricultural operations.

Evaluating the potential of solar power

Pumping water for irrigation is an energy-intensive process and requires a large supply of available power. Offsetting a portion with solar can provide energy cost savings and reduce farm reliance on traditional fossil fuels. Depending on pumping schedules and requirements, pumps may be able to run on either 100% solar power or a combination of solar/diesel or solar/grid electric power, with options to include battery storage. Estimated upfront costs for Scott's pumping needs are $100,000.

For Kensal Green, existing solar panels generate electricity which is fed back to the grid under the NSW feed-in and tariff solar scheme. Additional solar PV could help offset diesel costs for irrigation pumping. Expected yearly savings of approximately $11,871, with a simple ROI of 8.4 years, are possible.

Because of the nature of pumping demands on Kensal Green farm, these numbers would likely include a much longer payback period, as pumping demand is very energy-intensive but is limited to approximately three months of the year. At this point, because of the nature of solar power offsetting demand loads, this measure is less financially viable.

Another consideration for solar-based pumping is that water must be used immediately or there's a risk that significant amounts will be lost via evaporative effects or seepage losses from the current water reservoir. Additional costly remedial works may be possible to allow greater storage times but still leave evaporative losses as a key concern, especially when water pumped from the bore is subject to the site's yearly water allocation.

For help in identifying ways to reduce your energy costs, contact the Energy Team at NSW Farmers:

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 This activity received funding from the Department of Industry as part of the Energy Efficiency Information Grants Program. The views expressed herein are not necessarily the views of the Commonwealth of Australia, and the Commonwealth does not accept responsibility for any information or advice contained herein.

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