PUMPING ENERGY AUDIT CASE STUDIES (Metric)

Quantifying pumping energy efficiency (aka sustainable pumping) in an irrigation system has long been understood to be made with a simple pump test.

Ignored was the significant additional potential energy savings available in irrigation system pipelines due to legacy hydraulics designs. In the past, pipeline design never considered energy efficiency, only irrigation efficiency.

The WATER PUMPING INSTITUTE's aim is to educate water engineers in the art and science of identifying hydraulic in-efficiencies in irrigation (and other water) systems.

This is achieved through its training course "Sustainable Pumping for Irrigation (Metric)" using "Fit for Purpose" software which comes with the training course.

These case studies have been compiled as living proof of the feasibility and practicality of identifying (or incorporating into new systems) up to 50% hydraulic savings from pumping system energy audits.

CASE STUDY			Annual Cost $$ Pumping	PUMP EFFICIENCY ONLY		HYDRAULIC EFFY		TOTAL SAVINGS		Remedial Cost	
Case Study	ML/yr	Irrigation Type		$$/yr saving	Saving %	$$/yr saving	Saving %	TOTAL saving $	TOTAL saving %	$$ Total	ROI
1	140	LM Turf	13,700	$1,800	13%	$5,900	43%	$7,700	56%	$45,000	6.7
2	100	Boom Turf	10,700	$2,900	27%	$3,500	33%	$6,400	60%	$10,000	1.7
3	100	LM Vegies	5,500	$315	6%	$1,085	20%	$1,400	25%	$1,000	1.5
5	470	CP Dairy Pasture	35,900	$6,850	19%	$11,960	33%	$18,800	52%	$48,000	2.4
6	100	CP Dairy Pasture	9,100	$715	8%	$2,400	26%	$3,115	34%	$2,000	<1.0
		TOTALS	$74,900	$12,580	16.8%	$24,845	33.2%	$37,425	50.0%	$106,000	2.8 Ave

The 16.8% identified pump efficiency changes is usually not achievable because of the +/- 9% tolerance on pump manufacturers original performance data.

The 33.2% identified hydraulics savings, however, are 100% achievable.

These case studies demonstrate the importance and savings advantages of quantifying <u>hydraulic efficiencies</u> when conducting pumping energy audits.

See below for more details of these case studies.

 Rev02 1/5/25

Case Study 1: Windsor NSW, Turf farm 1

May 2014 Tallemenco was contracted by NSW Dept Primary Industries to conduct a detailed pumping energy efficiency audit on a well-managed turf farm in the Hawkesbury District.

A new 203m long Lateral Move (LM) irrigator had recently been installed on the privately owned farm. A belt driven 45kW electric pump delivered 28 l/s from the Hawkesbury River to the LM approx. 1000m away via a 150 PVC pipe plus 130m of 100 lay flat hose.

The audit measured pump efficiency plus friction losses across each major pipe and irrigation equipment sector. The system pumped 140 ML /yr, $13,700/yr electricity cost at an ave 24c/kWh and pumped head was 84m.

Lateral Move irrigator on the turf farm

Testing the pump

FINDINGS

It was found that the pump was running left of BEP at 65% and the 150 PVC rising main was fouled with iron hydroxide unbeknown to the farmer, causing the extra 36m of friction loss greater than new pipe friction.

The pump losses accounted for 13% or $1,800pa.

The hydraulic losses accounted for 43% or $5,900pa.

The following table summarises the findings in terms of $$/ML attributed to deficiencies in the irrigation system.

Component	Pump efficiency	Lift, m	Residual Head m	TDH m	$$/ML annual pumping costs	Achievable saving
Measured	65%	6m	15	84	97.5	
Achievable	75%	6m	15	48	48.3	**56%**

Restoring the pipeline was attempted with pigging, but the iron hydroxide has crusted in the 15 yr old pipe and little improvement was made.

Replacing the 1000m of pipe with new 150 PVC and replacing the pump with a lower head direct drive 30kW pump with correct BEP would have saved $7,700pa, or 56% of present pumping costs.

Remedial costs of pump and 150 pipe replacement amounted to $45,000, with a ROI of 5.9 years.

However, the farmer chose to upgrade the rising main with an DN250 poly pipe to facilitate additional irrigation capacity.

If a simple pump test only had been carried out on this property, $5,900 (43%) of recoverable annual energy savings due to the high friction losses in the rising main would have been overlooked.

Indeed, two previous audits by local irrigation consultants did just that, conducted a pump test only, gave the pump a tick of approval, but failed to identify the larger hydraulic losses.

Case Study 2: Windsor NSW, Turf farm 2

May 2014, Tallemenco was also contracted by NSW Dept Primary Industries to conduct a detailed pumping energy efficiency audit on a second turf farm in the Hawkesbury District.

However, this farm was known to be in a run down state, with energy savings likely to be identified.

A 48m long Soft Hose Boom irrigated turf on the farm. A direct driven 37kW direct drive electric pump took 12 l/s from the Hawkesbury River and delivered it to the Boom approx 1,300m away via 200/150 PVC pipe.

Soft Hose Boom, with 200m ft of 75 layflat hose

The audit measured pump efficiency plus friction losses across each major pipe and irrigation equipment sector. The system had 100 ML /yr usage, approx $10,700/yr electricity cost at ave 30c/kWh and pumped head was 55m.

Measuring residual pressure on the Boom.

The soft hose boom above was the emitter in this audit. Water was supplied with 200m of 75 lay flat hose. Friction across the layflat hose was measured at 28m. A 90 hose would have had only 10m loss.

The resulting energy savings from using the larger hose would have paid for the larger diameter hose in 2 years.

FINDINGS

It was found that the layflat hose supplying the boom irrigator was undersized and incurring a 28m head loss, 18m over and above achievable losses.

In addition to the large layflat hose friction losses, there was excessive residual pressure on the Boom, and the pump was considerably down in performance and running well off BEP, resulting in a combined operating cost of $108/ML.

Assuming the layflat hose hydraulics is restored with a larger hose, and the pump was replaced with the correct size and BEP, the system would then run at $4,330pa and $44/ML, a saving of $6,370.

That's a full 60% annual energy saving.

In this case, the replacement of the layflat hose firstly would yield 33% energy saving (based on reducing pumped head from 55m to 37m).

The pump would then need to be replaced with a lower head pump with correct BEP (or fitted with a VFD) to potentiate those savings, resulting in a further 26% saving.

33% + 26% = ≈ 60% identified achievable saving.

The following table summarises the findings in terms of $$/ML attributed to deficiencies in the irrigation system.

Component	Pump efficiency	Lift, m	Residual Press m	TDH m	$$/ML annual pumping costs	Achievable Saving %
Measured	45%	6m	15m	55m	108	
Achievable	75%	6m	15m	37m	43	**60%**

Had a pump test only be carried out here, a further 33% energy savings ($3,500pa) would have been overlooked from upgrading the layflat hose from 75 to 90mm.

In this case, since the pump was operating to the left of BEP, the existing pump could have been fitted with a VFD to potentiate the energy savings from upgrading the layflat from 75 to 90mm.

Estimated remedial costs were $5,000 for hose upsize plus $5,000 for VFD, resulting in a ROI of 1.7 yrs.

Case Study 3: Lindenow, VIC, vegetable farm

In Sept 2013, Tallemenco was contracted by the Victorian Dept Primary Industries to conduct a detailed pumping energy efficiency audit on a modern vegetable farm in the Gippsland District.

A 6 yr old 200m long Lateral Move (LM) irrigated mixed vegetables on the privately owned farm. A 37kW direct driven electric pump pumped 42 l/s from the Mitchel River and delivered it to the LM approx 500m away via an 200nb PVC pipe.

The audit measured pump efficiency plus friction losses across each major pipe and irrigation equipment sector. The system had 100 ML/yr usage, approx $5,500/yr electricity cost at ave 25c/kWh and pumped head was 51m.

Checking end of LM residual pressure

FINDINGS

Excessive residual pressure (25m) was found at the end of the LM, plus high hydraulic losses on the layflat hose, and the well maintained 35yr old pump, in otherwise good condition, was running left of BEP.

The Lateral Move was supplied with 100m of 4" layflat hose. Misting was evident at the nozzles, potentially indicating high residual pressure.

The following table summarises the findings in terms of $$/ML attributed to deficiencies in the irrigation system.

Component	Pump efficiency	Lift, fm	Residual Press m	TDH fm	$$/ML annual pumping costs	Achievable Saving %
Measured	68%	6m	25m	51m	54.9	
Achievable	75%	6m	15m	41m	40.0	**25%**

Whilst the pump was satisfactory, the hydraulic losses were a combination of the layflat hose and excessive residual pressure.

In this case, the 4" layflat is the optimal size lay flat connection from rising main to LM.

However, the residual pressure at the end of the LM was excessive and could be reduced by 10m.

This would result in an annual energy saving of $1,080pa.

In this case, a trimmed impeller would achieve the required pressure reduction, with minimal cost.

By reducing LM residual head, the system could run at 41m TDH and $40/ML, with a $1,080 pa savings and a payback period of 1 year.

However, with 68% pump efficiency, there would be no economic advantage from pump overhaul.

If a simple pump test only had been carried out on this property, approx. $1.080 of annual electricity savings would have been overlooked, or 16% of annual electricity usage.

An impeller reduction would cost about $1000 in labour, resulting in a ROI of about 1.0 yr.

An alternative would be to fit a VFD to the pump to reduce the pumped head. This would cost about $5,000, with a ROI of 5 yrs.

However, the VFD has a 5% energy efficiency penalty, negating some advantage from using a VFD in this case.

Case Study 4: Hay, NSW, flood irrigation

The NSW Office of Water (NOW) contracted Tallemenco (via a third party) to conduct a detailed pumping energy efficiency audit in Aug 2010 on a large flood irrigation farm in the Riverina district of NSW.

A 175kW submersible (motor=0.83% effy) flood pump lifted water from the Murrumbidgee River into an earth channel from where it gravitated a couple of kilometres to irrigation outlets.

One of the submersible flood pumps audited for pumping energy efficiency.

The audit measured pump efficiency plus friction losses across the lift pipe to the channel. The system pumped 5,600 ML/yr, approx $23,000/yr electricity cost at ave 10c/kWh and TDH was 5.4, with a lift of 5.1m.

Measuring flow at the flood irrigation site audit. A stream velocity meter was used to measure a water velocity profile, hence flowrate, since the station's propeller actuated flowmeter was considered in-accurate.

FINDINGS

It was found that the pump efficiency was well down, in addition to running off BEP.

Once overhauled, this pump would operate with a $9,270pa electricity saving.

OFF BEP component has not been considered since that is not recoverable in this instance.

The hydraulic losses from the pump discharge to the discharge channel were approx 0.3m head. This is considered optimal.

Head loss in this system is critical, since every additional 0.3m head loss results in $800pa, or 5.5% additional cost with an overhauled pump.

The following table summarises the findings in terms of $$/ML attributed to deficiencies in the pumping system.

Component	Pump efficiency	Lift, fm	Residual Press m	TDH m	$$/MLannual pumping costs	Achievable Saving %
Measured	43%	5.1m	0	5.4	4.1	
Achievable	72%	5.1m	0	5.4	2.46	**40%**

Measuring static lift at pump site using survey equipment. Pump suction in background.

Case Study 5: Sale, VICTORIA, Dairy Farm

SUSTAINABILITY VICTORIA contracted Tallemenco to conduct a detailed pumping energy efficiency audit in Jan 2018 on a modern 350 head dairy farm in the Gippsland District.

An 8 yr old 500m long Center Pivot (CP) irrigated mixed pasture on the dairy farm. A 55kW submersible pump on a VFD lifted 36 l/s, 20m from the underground aquifer and delivered it across level ground to the CP approx 650m away via a 150nb PVC pipe.

The audit measured pump efficiency plus friction losses across each major pipe and irrigation equipment sector. The pumped system had 470 ML/yr usage, approx $35,885/yr electricity cost at ave 20c/kWh and pumped head was 63m.

The residual pressure at the end of the CP was 7m.

The CP was also supplied from another pump 1600m away.

Photo below showing well head

<u>FINDINGS</u>

The old and tired submersible well pump was down 10% on efficiency and running well to right of BEP, at 57% effy.

The 650m of 150nb rising main from the bore/well had a H&W C Value of 112 and was undersized, resulting in 25m friction to the CP.

Replacement of the 150nb PVC pipe with 200nb would result in only 4m head loss, a saving of 21m friction.

Optimizing the pipeline would result in saving $11,960 pa, whilst replacing the pump with a lower head pump operating at BEP would save an additional $6,850 pa.

Total savings would be 52%. or $39.2/ML.

Ultimate pumping cost would be $37.2/ML

The following table summarises the findings in terms of $$/ML attributed to deficiencies in the irrigation system.

<u>SUMMARY OF FINDINGS</u>

Component	Pump efficiency	Lift, m	Residual Press m	TDH m	$$/ML annual pumping costs	Achievable Saving %
Measured	57%	20m	7	63m	76.4	
Achievable	78%	20m	7	42m	37.2	52%

To potentiate the savings, the pump needed to be changed out to a lower head pump with the same output 36 l/s, but with the correct BEP.

This was conveniently facilitated 12 months after the audit when the pump motor failed.

The pump was downsized from 55 to 37kW at 36 l/s, at the same time the pipeline was replaced with a 200nb PVC.

ROI for the upgrade was 2.4 years, saving $18,800 pa energy costs.

In this case, a pump test only would have missed the extra $11,900 pa (33%) attributed to the optimization of the hydraulics.

Case Study 6:

Fleurieu Peninsula, SA: Dairy Farm

Tallemenco was contracted to conduct a detailed pumping energy efficiency audit in Sept 2020 on a modern 100 head dairy farm in the Fleurieu Peninsula, South Australia.

An 8 yr old 190m long Center Pivot (CP) irrigated mixed pasture on the dairy farm. A 15kW vertical multistage pump on a VFD lifted 16 l/s gpm, with a TDH of 53m to the CP approx 520m away via a 150nb PVC pipe.

The audit measured pump efficiency plus friction losses across each major pipe and irrigation equipment sector. The pumped system had 100 ML/yr usage, approx $9,100/yr electricity cost at ave 37c/kWh and pumped head was 53m.

The CP operated over a considerable land undulation, ranging from 28m lift at its highest, to 2m lift at its lowest, making an average lift of 15m.

The residual pressure at the end of the CP was 7m at its highest point.

FINDINGS

The pump was found to be 8% down on efficiency, amounting to about $1,000pa additional electricity cost.

The pump was a higher head than required and was fitted with a VFD which was set for the optimum Hz to give optimal residual pressure at the CP's highest elevation.

However, the system was not configured to take advantage of the elevation drop as the CP moved to its lowest elevation.

All it required was a Radio Pressure Transmitter at the end of the CP, telemetered back to the VFD input.

This modification would cost around $2,000 installed, including aerials.

The savings from this alone will amount to $2,400 pa, or an additional 26% saving.

This represents a ROI of about 1.0 yr.

The following table summarises the findings in terms of $$/ML attributed to deficiencies in the irrigation system.

Component	Pump efficiency	Max Lift m	Residual Press m	TDH m	$$/ML annual pumping costs	Achievable Saving %
Measured	67%	28	7	53m	91.2	
Achievable	75%	28	7	39m ave	60.0	34%

In this case, a pump test only would have missed the extra $2,400 pa (26%) attributed to the optimization of the hydraulics.