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Example of Multiple Pump Control

Analysis of the service area of a reservoir determines that to meet forecast 20 year growth the pump station that transfers water to that reservoir will ultimately need to deliver:

Nominated Duty 222 L/s @ 61m Lift (Pump Head) with 40m Static Lift (Elevation difference) → 222 L/s = 799 m^3/Hr or 19.18 ML/Day

Efficiency is considered an important consideration and they realise that the ultimate duty will not be realised for some years, and even then it will only be on peak consumption days. So, a Variable Speed Drive (VSD) is being included in the project scope so the pump can be slowed down and be more energy efficient.

A 3 pump package with a single VSD is being considered; the VSD can control any of the pumps and allows the package to operate across the range of flow rates without valve throttling or bypass valves. The package is cheaper than including three (3) VSD's, is it better value?

Summary of Results

Assuming that the pumps were in service for 18 hours per day and lasted 20 years, and that for 40% of its service life it operated at 70% of the nominated duty (70% x 222L/s = 155 L/s), 30% at 80% (178 L/s), 20% at 90% (200 L/s), and 10% at Nominated duty of 222 L/s**, the total Lifetime energy saving by installing multiple VSD's could be 420,574 kWh.**

Figure A illustrates the energy per unit volume across the range of flow rates up to the nominated duty. It also has the flow rates used in the comparison marked.

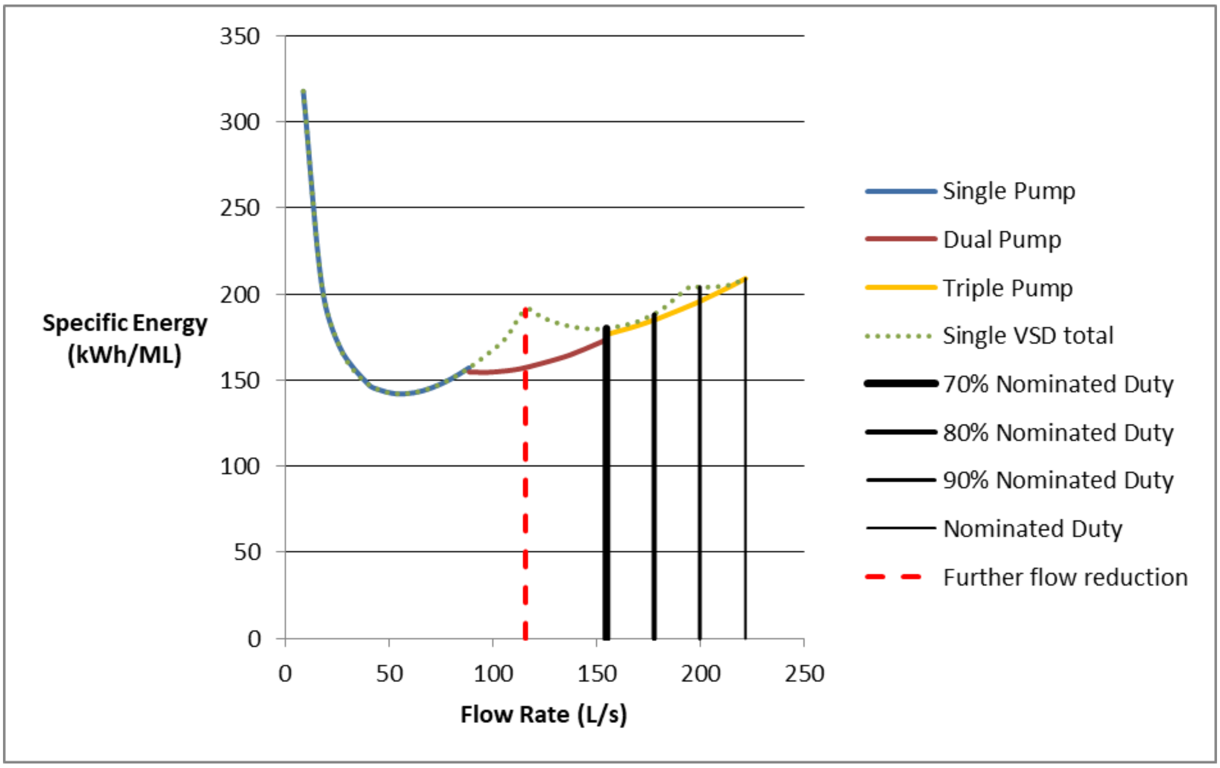

Figure A - Comparison of Specific Energy for single and multiple VSD arrangements presented

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Based on the cost of the electricity consumed, if a rate of 10 cents per kWh could be secured for the entire 20 years, the multi-VSD control presented could save $42,057. Additionally, it can be seen that if the flow rate were able to be reduced further greater savings are available. For example, instead of operating at 70% capacity for 18 hours, if the process could be run at 52.5% for 24 hours, using the multiple VSD control system presented, there is a potential saving of 12% for this duty alone. As a further comparison, this reduced flow rate with the single VSD system would actually use 6% more energy than running at the higher flow rate. This is an excellent example of why it is important to understand your pumping system.

The algorithms developed to control the pumps in the multiple VSD system to achieve this optimisation are illustrated in Figure B.

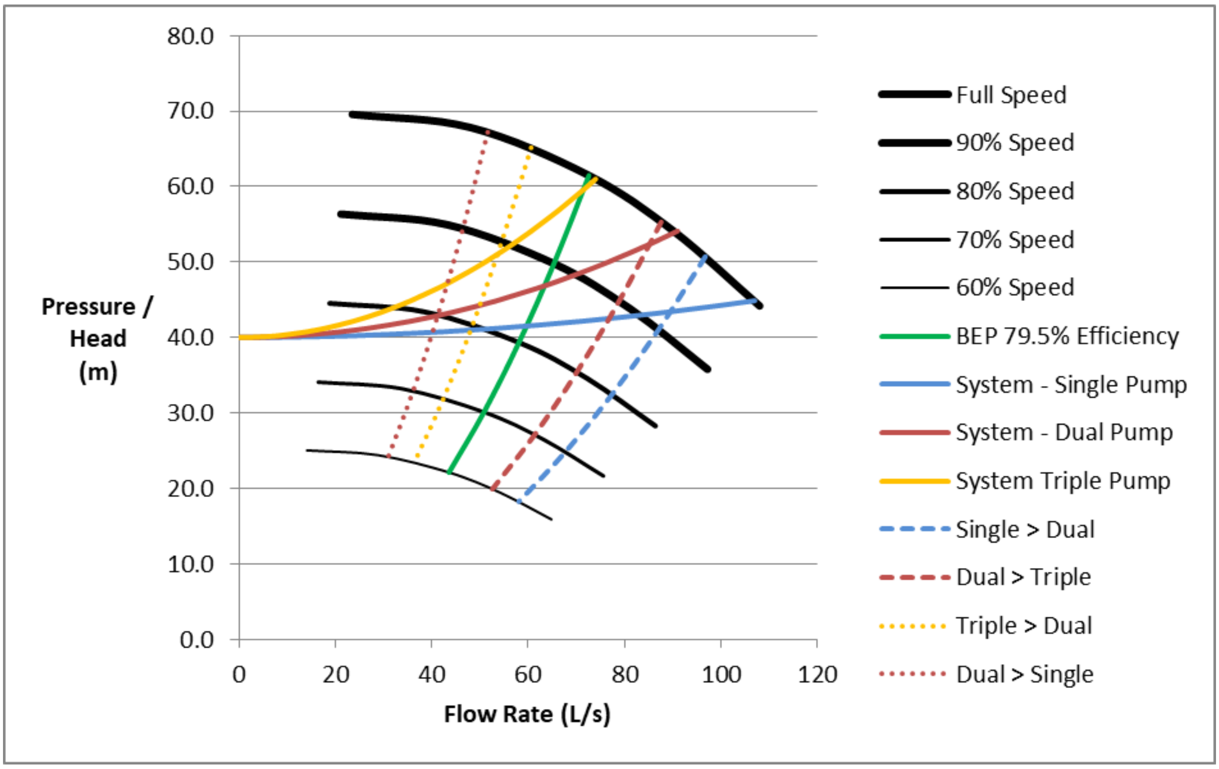

Figure B - Variable Speed Pump Curve with system and controls overlaid

The finding of this analysis is that for this scenario the multiple VSD arrangement is more efficient and robust. But, this does not mean that single VSD systems should be avoided, rather the implications on your usage needs to be understood to allow an informed decision.

Single VSD multi-pump operation

A lot of multi-pump packages utilise a single VSD. When the flow rate required needs flexibility, and may be required to operate across a range of flows these arrangements are more efficient than using throttling or bypass valves with pumps that operate at full speed only. They typically operate in a cascade effect so that the VSD can control any of the pumps, and the other pumps operate at full speed as required to make the desired flow / pressure.

Figure C illustrates the effect on the efficiency of the pump being controlled by the VSD across the range of flow rates up to the nominated duty. In the example illustrated, as the VSD controls the

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duty pump and when it is required to operate at full speed it changes to duty-assist and runs at full speed only and the VSD controlled duty pump moves to the next available pump in the array.

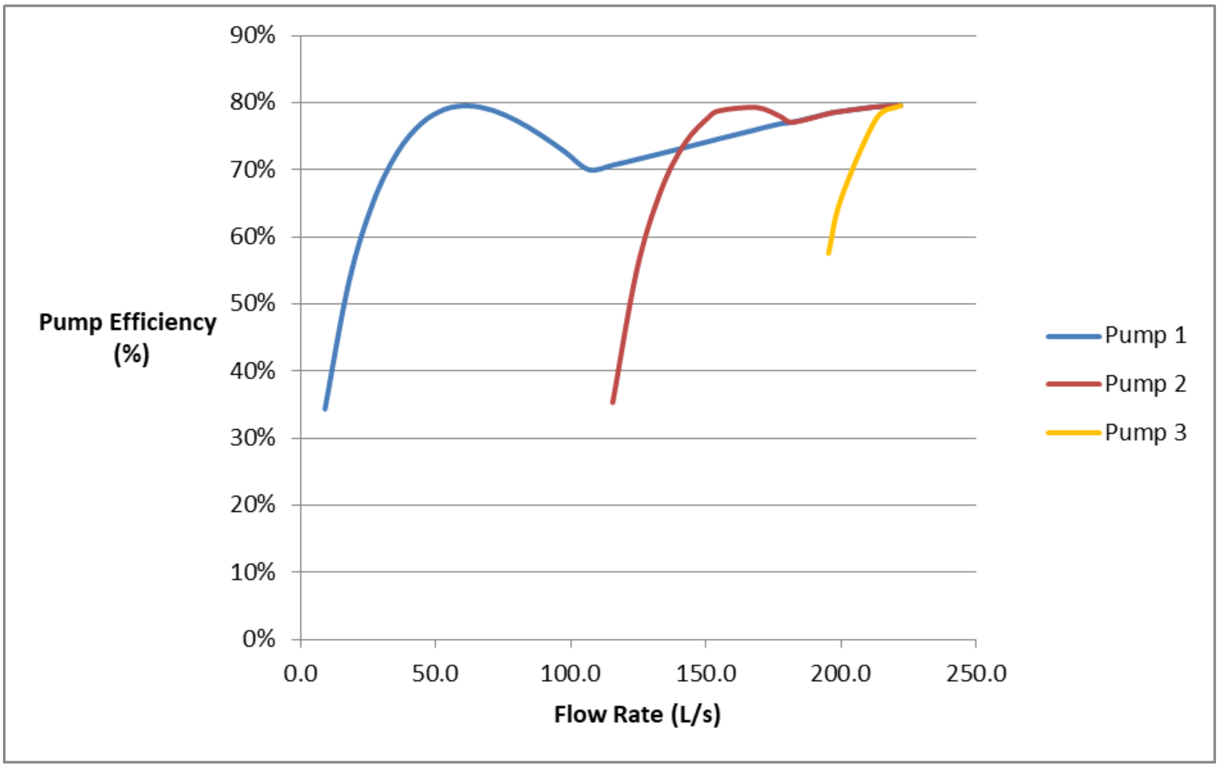

Figure C - Efficiency of each pump operating in a multi-pump arrangement with a single VSD across the available range.

As can be seen, as the duty pump moves and an additional pump is started, the pump efficiency is very low. Low pump efficiency represents more than just excess energy consumption; it also represents vibration within the pump. At the pumps Best Efficiency Point (BEP) the vibration is at its lowest. Vibration causes wear in pump seals, bearings, and wear rings; it can even be destructive and cause shaft breakages if the pump is operated too far from the BEP for extended periods.

However, in a package designed to meets the highly fluctuating flows associated with a pressure sustaining pump station, this method of control can be better than continually starting and stopping pumps trying to achieve optimal efficiency. But, in applications where the flow rate is not required to change continuously, better efficiencies can be found using multiple VSD's and running more than one pump at part speed.

Multi-VSD multi-pump operation

For the ultimate in control and redundancy the pumps can be installed with a dedicated VSD for each pump. This allows more than one pump to run at part speed simultaneously and can improve the efficiency by starting pumps earlier than would be possible with a single VSD arrangement.

Figure D illustrates the efficiency of each pump when running in single, dual or triple operation. For these arrangements each pump that is operating typically runs at the same speed.

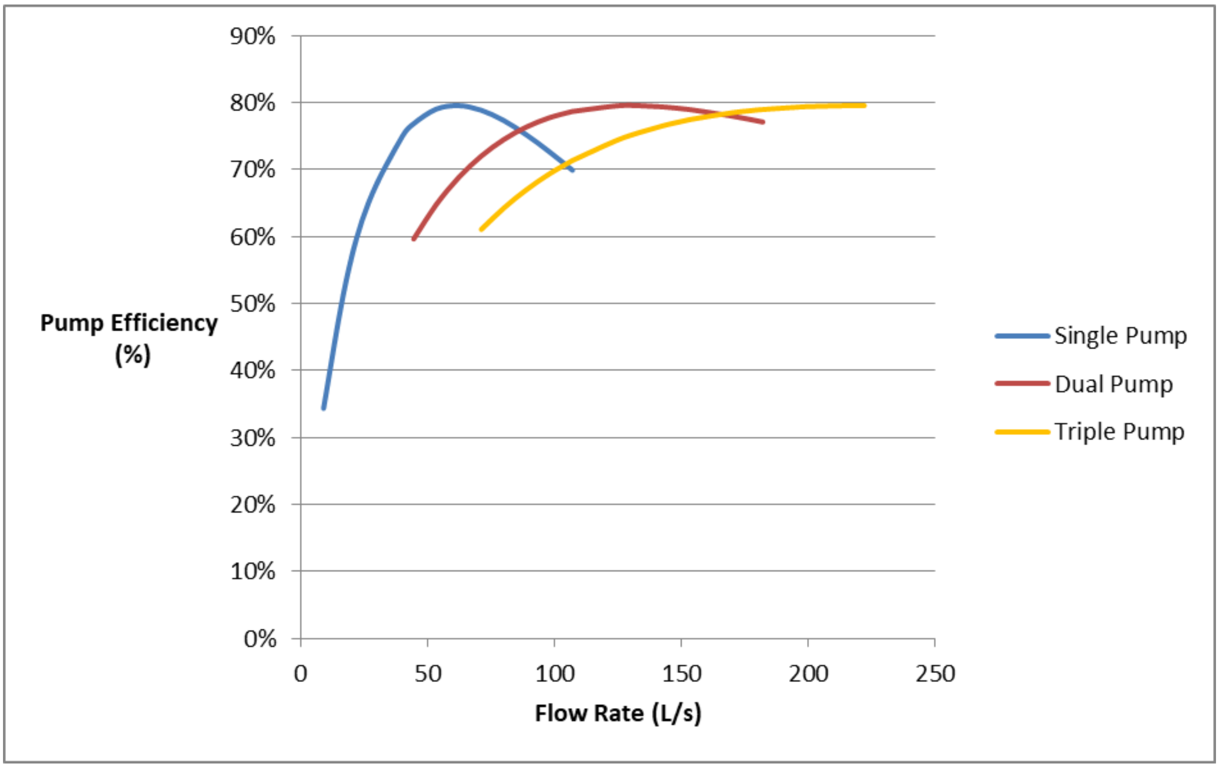

Figure D - Multiple VSD pump efficiency

As can be seen, to realise the best efficiency available the number of pumps operating needs to be monitored and controlled. This can be done in a number of ways; the pump station operator could select the number of pumps required, or it could be based on flow or pressure and incorporated into the control system.

The development of the control system is something Variable Efficiency can help optimise. For this example a system that compares flow and pressure based on the original pump characteristic curve was developed to keep the efficiency at the absolute peak. The efficiencies possible from such a control system are shown in Figure E.

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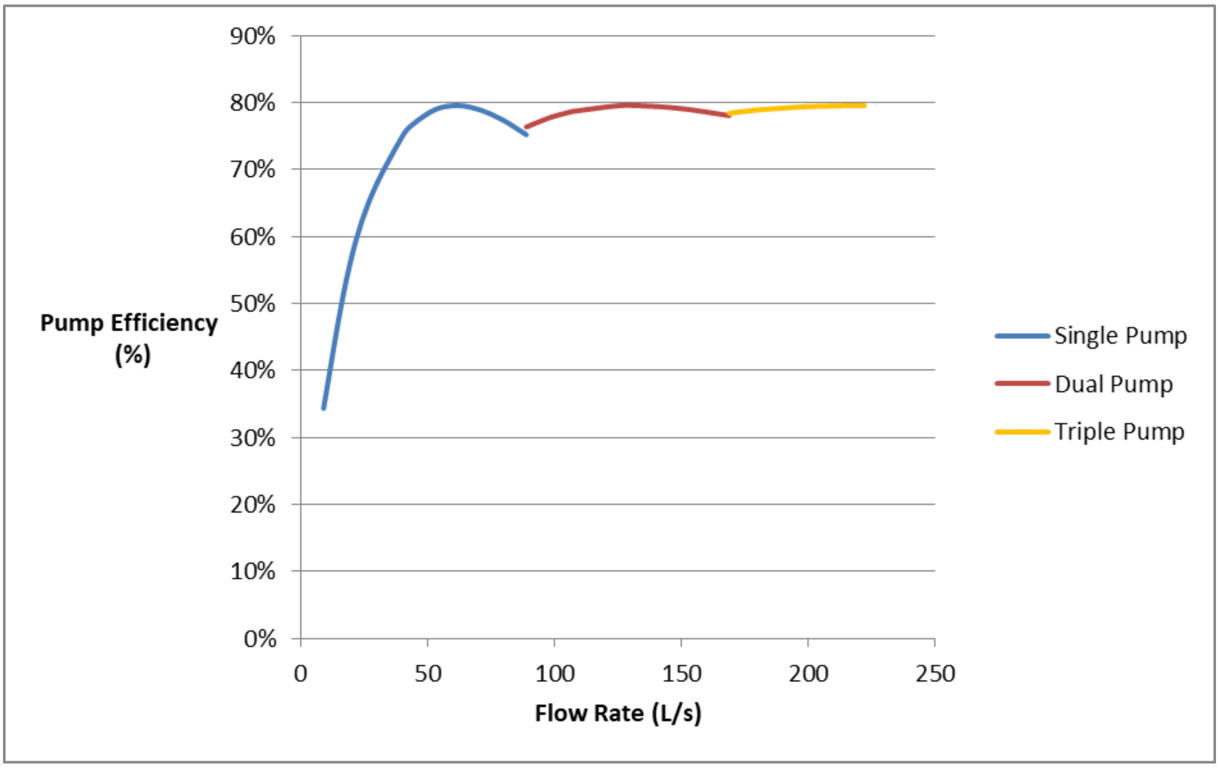

Figure E - Multiple VSD controlled pumps with tuned control system

For this arrangement, the pump efficiency is above 75% from 40 L/s and above. This consumes up to 10% less energy when compared to the single VSD arrangement. For an arrangement where the system curve used to size the pump is not continuously replicated in practice, which would be most of the time, this degree of precision that the number of pumps operating would be reduced to allow overlap. This stops pumps from continuously starting and stopping if a flow rate is selected that falls right on the trigger point for a pump to start.

Therefore, it would be expected that the pumps would experience less wear with the multiple VSD arrangement than the single VSD option due to the efficiency remaining close to the pumps VSD across the entire range of flow rates. Additionally, should a VSD fail, the remaining pumps can still operate across the range of flows without the need for throttling of bypass valves.

This makes the multiple VSD arrangement more energy efficient, require less maintenance, and more robust in the event of a failure than the single VSD system for the scenario presented. This would not always be the case, and single VSD arrangements should not necessarily be avoided.