Meeting 2030 energy-efficiency targets by optimising pumping systems

Key pledges from the recent COP28 in Abu Dhabi include tripling the world's renewable energy capacity by 2030, while doubling the rate of global energy-efficiency improvements from 2% to 4% per year over the same period. Harry Rosen of TAS Online argues that as far as energy efficiency is concerned, this can be achieved comfortably by paying closer attention to our pumps and pumping systems.

One of the key pledges announced at COP28 was to double the global rate of energy-efficiency improvements from 2% to 4% per year between now and 2030. The IEA (International Energy Agency) measures this rate in terms of global energy intensity improvements. As the IEA's Head of Energy Efficiency, Brian Motherway explains: Doubling energy efficiency progress going forward means increasing this rate of improvement twofold, to just over 4% on average every year between now and 2030. This would mean that in 2030, one unit of energy used will generate 40% more economic output ;[Ref: *https://www.iea.org/commentaries/a-global-target-to-double-efficiency-progress-is-essential-to-keep-net-zero-on-the-table*]

The other massive target was to triple renewable energy capacity by 2030, a pledge that is estimated to cost the world's nations US$6-trillion per year if we are to stay on the pathway to net zero emissions target by 2050. For South Africa and other developing nations, meeting this target is just not feasible. But can we double our rate of energy intensity improvements every year between now and 2030? I believe we can.

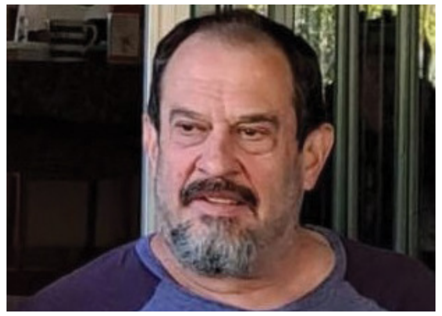
According to IEA, around half (47%) of the electricity used globally is consumed by electric motor systems, and this number rises to about 70% in industrialised nations such China, USA, EU, India and Japan. Of this, in the US for example, pump systems account for about 40% of the total, followed by compressed air systems at 22% and fan systems at 20%; [Ref: *https://www.globalefficiencyintel.com/new-blog/2017/infographic-energy-industrial-motor-systems*].

All these industrial systems have long been identified as presenting significant opportunities for energy efficiency savings. In most cases, the investments required to achieve savings are relatively low, and, in almost all cases, the bottom-line payback far exceeds that of installing a renewable energy plant.

In the pump industry, optimising pump systems to achieve rapid and lasting energy intensity improvements is not new, while the benefits go well beyond the environmental ones: efficiency optimisation also improves pump reliability and wear life, and can significantly improve productivity.

In my role as an International UNIDO pump expert, I get to go across the world to do pump system audits and to present training on the optimisation of pumping systems. Based on my experience, the energy efficiency of an installed pumping system can easily be improved by 20%, mostly by changing how the pumps are managed. And by investing a little more in monitoring and control equipment, savings can be significantly higher.

Eskom's Demand Side Management (DSM) energy efficiency initiative, which began back in 2003 and paid out major financial incentives to companies for saving energy, was premised on the fact that the cost of saving energy through implementing energy saving systems and technologies was five to ten times less expensive than investing in new generation capacity. But where is the money going to come from to incentivise companies now? The costs associated with reducing the energy used by pumping systems are, in most cases, easily justified based on traditional return-on-investment calculations. And we get to save the planet as a bonus.



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A bulk water supply company pumping station that uses pumps in parallel to deliver water to multiple destinations. Each destination change results in changes to the system pressure profile and the operating points of all the pumps.

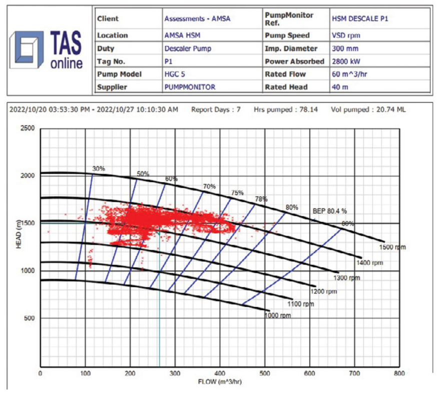
50% energy savings for bulk water supply pipeline

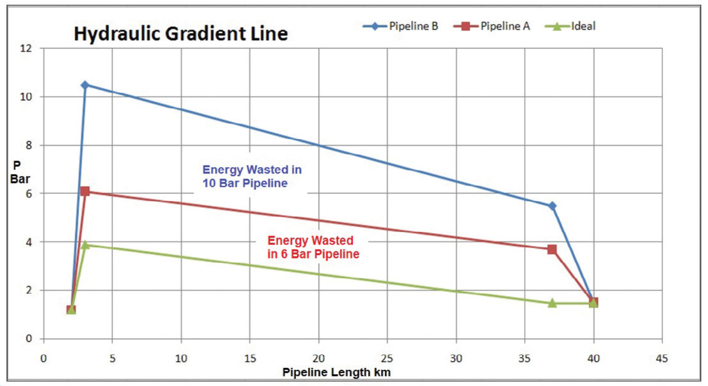
One pump station I looked at as part of the UNIDO programme was a 40 km water pipeline across the desert from the point of production in Abu Dhabi to several different cities and villages. "We identified between 1 000 and 1 500 kW that could be saved in this application, around 50% of the electricity drawn by the original system.

Several changes made this possible: Water transport systems have always been – and continue to be – over designed to make sure that any future demand issues can be met without having to further invest in the system. That often means that control valves – throttling or a bypass valves, for example – must be used to reduce flow to match demand. The result is that the pumps continue to run at full power, but at a greatly reduced volume. The specific energy, that is the power required to pump one unit of flow, is much higher when compared to a system designed to be most efficient at the actual duty.

Another type of flow control involves a bypass loop or recirculating valve, where a significant percentage of water is simply pumped back to suction, obviously a great waste of energy. And in cases of day- to- day demand varying, variable speed drives are a cost effective option to match system flow to changing demand, still resulting in significant savings.

Understanding the nature of the demand is vital and if the system is not designed correctly, there will be a massive opportunity for optimisation once the plant is in service. For one of the water pipelines, a small percentage of water was required to be tapped off by villages en route. Some villages were in the mountains, so the water needed to be pumped at a much higher pressure. But most of the flow did not require the higher pressure to reach the final destination, and increased pressure directly relates to increased power. By splitting the requirement, only 3 000 out of every 10 000 m^3 is pumped at high pressure, while the remaining 7 000 m^3 can be pumped at much lower pressure. This operational change – optimising each flow rate and pressure to match the actual requirements – is what made the biggest difference in terms of energy efficiency. In the original design, all the pumps were able to deliver at a much higher pressure, making the case for adding variable speed drives or possibly downsizing some of the pumps. And in terms of network design, it is more energy efficient to pump at the lowest possible pressure over the long distances. Another solution would have been to add a booster pump at each water offtake and only boost pressure of the smaller required flow rate to reach the higher altitude village.





Left: A PumpMonitor graph showing the actual performance of a pump used for descaling in a steel mill over a one weekone-week period. As can be seen, the pump seldom operates near its best efficiency (80.4%). Right: A comparative chart showing the energy consumption of a 10 Bar bar pipeline compared to a 6 bar pipeline. Almost twice as much energy was wasted in the 10 bar pipeline due to the higher pressure required to feed remote villages. A 50% energy savings for this bulk water supply was identified.

Pumping and load shedding

In South Africa, our bulk water supply is being affected by loadshedding, We have a system designed to pump water continuously from huge water reservoirs, dams or water treatment plants into municipal storage facilities for distribution to consumers. Keeping these municipal facilities full requires pumping on a well-planned 24- hour schedule from purpose designed pumping stations.

Loadshedding has introduced a regime of constant variability. When electrical power is only available for 18 hours or less a day, the demand cannot be met without pumping at higher flow rates, for which the pumps were not designed, pushing them away from their best efficiency. When reservoirs run dry, valves are opened and closed to allow different pump combinations to pump through pipelines to different locations. This changes the system pressure profile and the operating points of all the pumps, so the whole system quickly becomes chaotic.

The only way to handle this complexity is to install online monitoring equipment to measure and track the pressure, flow and power consumption of every pump in the system. Then, using real time analyses, losses and inefficiencies across the system can be identified and a clear idea of best possible energy savings can be established.

Instrumentation on its own is not enough. Unlike temperature or vibration, which immediately tell us whether a component is about to fail, pressure and flow rate on their own tell us very little about the condition of the pump. Even calculating the pump efficiency is only useful if we can relate it back to the pump's performance curve. Only then can we calculate how much energy can be saved – or is being wasted – and more importantly, what needs to be changed to achieve savings. Ongoing performance monitoring can be used to accurately track efficiency and to calculate the real savings against a baseline. Further adjustments can be made to achieve maximum possible pumping effectiveness and energy efficiency. Pump and system changes, once highlighted by monitoring, are often obvious and simple to rectify. It may be better, for example, not to switch on all the pumps to fill a reservoir, and, in some cases, one dedicated pump with all of its flow control valves fully open will perform better than several worn pumps pumping in parallel. Monitoring will tell you this and help to operators to optimise pump combinations and maintain the optimum flow, pressure and power consumption.

Generally speaking, though, there is no simple component- based approach to improve the energy efficiency of large pumping systems. It is easy to replace 100 W incandescent light bulbs with 3.0 W LED bulbs, and you will get 97 W of savings for each light used. Pumps don't work like that. If you replace pump A (78% as new efficiency) with pump B (85% as new efficiency), Pump B only delivers the improved efficiency if operating at its Best Efficiency Point or BEP. This is rare in most systems I have encountered in my travels as the changing dynamics of the system affect where the pump operates on its curve. Significantly.!

Sophisticated pump monitoring

TAS online's Pump Monitor, for example, uses data from suction and discharge pressure gauges, flow and power meters to determine exactly where a pump is operating on its pump curve, so it can determine how efficiently or inefficiently every pump in a system is performing. This enables complex pump and system changes to be highlighted, offering operators the information they need to respond quickly to the demand-side variations for effective and efficient end results.

Some pump operators are becoming aware of the need for energy management and are calculating the specific energy for each pump – how many kilowatts their pumps are using per unit of production. If this goes high, then it tells them something has gone wrong, but it doesn't help to identify what has changed. Pump Monitor offers a much more sophisticated view that can quickly identify pump and system wide problems and offer several solutions. For pumping plants using many millions of kWh of power to produce, every 200 kg of gold or 70 000 t of steel, for example, it becomes possible to determine accurately how efficient a plant or an area of the plant is, where the efficiency loss is coming from: if the pumps are worn, if a valve has been left shut, if pipe has become blocked, etc.

Pump monitoring enables operators to react quickly to changes to keep the pumps at their best efficiency; to plan for the best time to refurbish every pump and, over time, to right size the whole network. If done on most pumping systems in the world, this can deliver a step-change in efficiency levels, which I believe can, on its own, deliver the 4% year-on-year energy intensity improvements pledged at the end of COP28.

And while the costs of implementing pump monitoring are very easy to justify in terms of direct payback savings, proper implementation will need to be managed and overseen by a professional in the energy-efficiency field. Over the plast 15 or 20 years, a lot of training of these professionals has been done, for the pump and other industries. There are programmes all over the world for training people to do system-wide energy management audits to reduce the energy intensity of industrial processes. All that is needed is commitment from industry and plant operators. First to start measuring and then quantifying savings opportunities: of the pumps, compressors and fans used for heating, cooling, or processing.

A steel or petrochemical plant cannot run without cooling systems that consist of water feed pumps, fans and heat exchangers. It is impossible to optimise these systems without sophisticated monitoring and experienced professionals, who are out there ready and waiting to deliver. In addition to the environmental and the direct economic benefits of taking this approach, it can also significantly reduce daily demand from Eskom and overcome the need for load shedding. The reduced energy demand achieved by properly optimising a typical large pumping station of 1 500 to 2 000 kW can avoid loadshedding inconvenience in 1 000-odd households.

Let's attack the energy efficiency problem where we can make the most significant difference: in industry. It is the most cost effective and sensible way to solve the environmental and energy challenges we face.

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Average pump duty		Calculated wastage	
Flow (m³/hr)	265.4	Wear loss (%)	10.07
Head (m)	1 502	Duty loss (%)	23.88
Efficiency (%)	55.48	Total loss (%)	33.95
Power (kW)	2 088	kW wasted	710
Qbep %	48.92	**Savings Opportunity**	
Utilisation (%)	46.5	Energy savings	8,940,000 kW.h
Specific Energy (kWh/Ml)	8 267	Cost savings	R 10,726,000

The total kWh wastage over a year for a single descaling pump in a steel mill, showing the massive potential for energy savings by optimising the pump to operate at its duty point.