AI-driven system improves reliability and efficiency

Within the Estates Department at the Royal Victoria Infirmary (RVI) in Newcastle-upon-Tyne, a major trauma centre in north-east England, the COVID pandemic placed significant pressure on engineering services, highlighting the need to maintain and improve the resilience and reliability of all key M&E plant. Now, in 2022, the new medical gas plant, developed by SHJ Medical Gas Specialists, has 'addressed areas of energy inefficiency, vastly increased the system's productivity, resilience, and reliability', and aided carbon emission reduction. Ben Slawinski, Plant Development manager, and Katrina Robson, Marketing manager, report.

During a risk-based backlog maintenance assessment on the Royal Victoria Infirmary's medical and industrial air plant, Ian Clayton, RVI's senior specialist engineering officer, and his team identified both a need to replace the existing plant, and the key risks and areas of improvement they should look for when installing the replacement equipment – namely reliability, critical spares availability, air quality, and plant downtime. In line with Newcastle Hospitals NHS Foundation Trust's own target of achieving Net Zero carbon emissions by 2030, the team was also looking for plant that would address issues of energy inefficiency and carbon emission reduction.

After looking at potential suppliers, RVI partnered with SHJ due to the two organisations' shared vision on post-COVID resilience and innovation. RVI's original system for air delivery to the site (medical, surgical, and industrial) was broken up into completely separate plants, separate dryers, and distribution networks, that were linked. Four compressors with a total motor drive output of 165 kW (comprising a 55 kW and Triplex 37 kW medical air system) were potentially running at any one time, which was both costly and energy-inefficient. SHJ's solution was to create a system that can operate both as an individual system, supplying the industrial and medical side as two individual plants, but also in a 'global mode' that links the two plants together, allowing for optimisation of energy efficiency at any individual point.

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The Royal Victoria Infirmary in Newcastle-upon-Tyne is a major trauma centre in the north-east of England.

Hospital capacity met

To provide a more efficient HTM-compliant replacement system, three 55 kW Kaeser compressors were installed on the medical side of the plant, each able to meet the hospital's demand based on the HTM calculations. Four smaller Kaeser compressors were then installed at 11 kW and 22 kW respectively that could cope with the demand on the industrial side. A VSD (variable speed drive) compressor is then used to optimise energy efficiency.

When in separate mode, the compressors for the industrial and medical plant run independently, feeding both sides, which is not the optimal option, in terms of energy usage. However, by utilising Empower (SHJ's intelligent plant control system), the customisable and flexible system can combine the eight compressors together to consistently match the site's demands, with the optimal supply from the compressors.

Differing consumption patterns

For example, during the day, more air is used at the RVI due to use by the hospital's Dental School, and consumption of industrial air, which may require up to 40 kW in terms of power usage. However, during the evening and overnight, when both the Dental School and the Outpatients' Department are closed, the site uses considerably less air, requiring a compressor drive output of 15-22 kW. The RVI's old plant would have consistently used 37 and 55 kW, when in fact just 11 kW may have been needed – equating to a wastage of around 80 kW of energy, on a regular basis.

The RVI's new plant was configured to combine medical and industrial air plants to achieve maximum efficiency, in a system where fixed-speed compressors are employed to maintain a system base load, with the option to call on selected variable speed technology that adapts to different outputs and site demands. The use of dewpoint temperature control as part of the process of drying air reduces energy wastage. In addition, an AI-based remote monitoring system is continuously collecting data to further optimise system performance, conduct predictive maintenance, and estimate and quantify the net impact of the system.

Three driving factors

There were three main factors that drove the change at the RVI: energy efficiency, resilience, and reliability.

Energy efficiency

NHS Net Zero targets were a major factor when the Engineering team at the RVI was considering the site's future medical gas requirements. Large machines use a lot of energy; therefore if you can optimise their running, you can potentially halve your energy usage. Even though medical air is generally being used less in hospitals, HTM calculations still concluded that the plant must be able to manage 7,000 litres, where realistically the common demand is only around 3,000 litres. While to remain compliant, hospitals need to be able to accommodate a certain amount of demand, the new system from SHJ now allows the use of smaller compressors to deliver only what is actually required.

Resilience

Staff at the RVI were keen to increase the resilience of any future medical gas plant, and move away from the existing reliance on one compressor feeding the entire plant, meaning that if it were to fail, to they would no longer have air being fed to their industrial air plant. Now factored into the new plant are many more 'points of failure' that can occur before the hospital is in crisis. By utilising four compressors, should any fail, there is still medical air supply, and in the worst case, if all four were to fail, there are controllable valve arrangements that enable the 55 kW units to feed the entire site on their own.

Ian Clayton said: "In common with all areas of the NHS, we in Estates are under constant pressure to improve productivity, reduce costs, and cut carbon emissions. We must achieve all these things while maintaining the high level of service expected by our patients. By monitoring numerous parameters, SHJ's Empower system will recognise if all is not well, and will adjust the plant operation to address any issues, as well as letting let us know what has happened, and what needs to be done. This then gives us time to implement the required remedial action and ensure continuity of service. It can often allow us to rectify minor issues before they develop into a major, costly breakdown."

As part of the system, there are two dryers, eight compressors, and two control panels. The system has been constructed so that if anything fails, there are back-up failsafes, so that in

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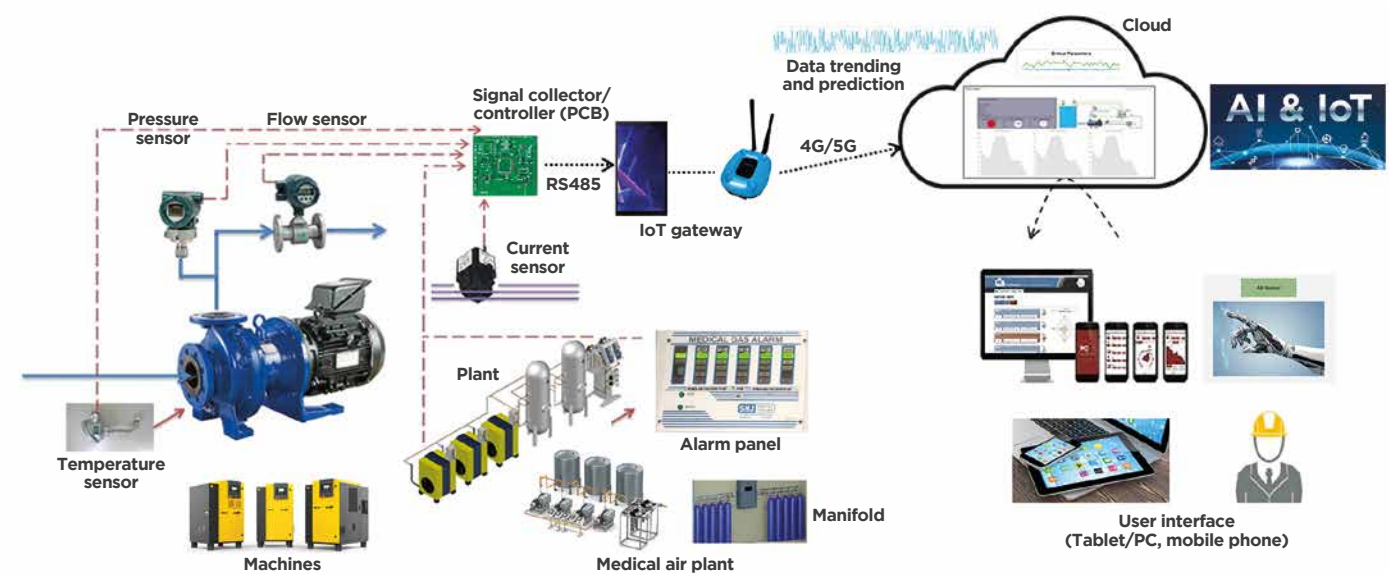
The RVI's medical gas plant room.

Professor Gaoyong Luo, SHJ's chief scientist, who has developed and led the project from the AI remote monitoring perspective.

The key benefits of SHJ's Empower system graphically illustrated.



The configuration of a real-time AI system for medical air plant.

future, they will never lose the supply of air to any part of the hospital. The new plant also uses a controllable global valve on the wet side of the system, to provide optimised control and resilience. The hospital is therefore prepared for the future, taking into consideration any further expansion, or even a future pandemic.

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Reliability

SHJ's managing director, Stafford Scopes, said: "The data we are producing is accurate down to every two seconds; we are continuously monitoring how efficiently the RVI's medical gas plant is running, in real time. No one else in the sector is managing medical gas plant with this degree of accuracy, and we are continuously looking to improve on performance."

The data

Professor Gaoyong Luo, SHJ's chief scientist, who has developed and led the project from the AI remote monitoring perspective, explained: "Through plotted waveforms, we can demonstrate how the plant is operating at any juncture, and where different usage demands are shown, the system adapts to ensure that the machines are running efficiently. The main compressor (a fixed speed machine) is always running, and is aided by a VSD machine to adjust the speed and adapt to demand variants without wasting energy – the end-goal being to contribute to the Trust's Net Zero emission targets.

Data we have gathered over the past few months has shown that the frequency of machine cut-in and cut-out has now been reduced significantly, which also helps to ensure that the machines remain in good condition, and reduces the costs associated with non-scheduled service call-outs."

The timeline for the medical gas plant scheme at the RVI spanned from the hospital's initial inquiry during the Autumn of 2021, through the research and design process, with installation commencing just before Christmas 2021. The final plant was then signed off and commissioned in early March 2022. hej

Acknowledgement

SHJ says: "Thanks for his input into this article are due to Ian Clayton, RVI's senior specialist engineering officer, who has over 18 years' experience within the NHS, and currently specialises in medical gas pipeline systems as the Authorised Person at what is a major trauma centre hospital. During his NHS career Ian has delivered a number of major medical gas schemes to ensure a resilient and robust supply for the Trusts concerned."

Ben Slawinski

Ben Slawinski, Plant Development manager, SHJ Medical Gas Specialists, graduated from Durham University with a BEng (Hons) Undergraduate Degree in Mechanical Engineering, with a specialisation in thermodynamics and fluid mechanics. He has a Postgraduate Masters (MSc) in Engineering, specialising in New and Renewable energy – specifically, power electronics, energy efficiency, low carbon technology, and optimisation. Having joined SHJ as Plant Development engineer, he was promoted to Plant Development manager, focusing on production, installation, and development of the SHJ Medical Gas Plant product line.

Katrina Robson

Katrina Robson, Marketing manager at SHJ Medical Gas Specialists, has held senior marketing roles for over 25 years within a variety of industries, including over 10 years in the healthcare and pharmaceuticals sector. Since joining SHJ in early 2022, she has been working closely with the team to raise the company's profile as a leading innovator within the medical gas industry.