VERTIV WHITEPAPER

Indirect Evaporative Cooling Technologies in the Data Centre

Using Hyperscale Technology for Retail Data Centres in Tropical Climates

Introduction

Traditionally, data centres are situated in regions that have cooler environments to take advantage of the outdoor climate using freecooling technology. But with the increasing need to reduce latency and establish the infrastructure closer to the customers, more and more operators are building data centres in tropical climates such as in Southeast Asia.

Singapore has been touted as a hotbed for global data centre construction, owing to a variety of factors such as a robust infrastructure, talented workforce and stable internet connectivity. Recognising the challenges of keeping data centres cool in tropical environments, Singapore set out to build a master plan called the Green Data Centre Technology Roadmap, which highlights its key initiatives and programs for a more sustainable data centre industry. The roadmap covers both physical IT and software, and hopes to reduce carbon emissions emitted by data centres in the country.

Opportunities highlighted in the program include identifying cooling technologies that would allow Singapore data centres to operate in higher temperatures without them being too energy-use intensive. While technologies such as passive cooling, direct liquid cooling and freecooling were identified, one of the technologies that can be utilized in countries like Singapore is Indirect Evaporative Cooling (IEC).

In this paper, we look at the use of a non-traditional data centre cooling technology in the Singapore climate. Drawing on current practices and government direction, we discuss the benefits that IEC brings to the Singapore market – a technology that is standard for many hyperscale users in colder climates.

Is a Tropical Data Centre Possible?

Cooling accounts for one of the biggest energy spends when operating a data centre. With increasing digitisation, data centres are becoming one of the biggest sources of energy expenditure globally. In 2018, global data centre energy demand was estimated at 198 TWh (terawatt-hour) or 1% of the world's total electricity consumption. Energy efficiency has thus become one of the top priorities for global data centre operators.

However, operating a data centre under warmer climates such as in Singapore can be a challenge. Traditionally, data centre servers must operate in a cool temperature of between 20°C and 25°C, with 50 to 60% relative ambient humidity. The need to maintain data centres under this temperature is one of the reasons why a huge amount of energy is needed to keep data centres cool.

In Singapore, temperatures range between 27°C to 32°C, making it difficult for data centre operators to capitalise on freecooling and why energy spend on cooling is one of the biggest. According to the Singapore National Climate Change Secretariat (NCCS), cooling IT equipment accounts for 37 percent of the total energy consumed in data centres. While there are several approaches to reducing energy consumption in data centres, Singapore's tropical climate can be a disadvantage. Higher temperatures and humidity make cooling data centres in Singapore significantly more energy-intensive compared to other locations in the world. Thus, the government is looking at improving cooling technologies and reducing the need for active cooling.

The Singapore government has announced a funding of SG$100 million (approximately US$74 million) for energy efficiency research and development projects to identify opportunities for energy efficiency – including cooling – that would allow data centres to operate at higher temperatures without being too energy intensive.

Singapore data centres typically utilise chilled water (CW) cooling technology. But a non-traditional approach to improving data centre cooling is **indirect evaporative cooling (IEC).** This technology can help alleviate the power consumption used by traditional cooling systems, allowing a greener data centre to operate even in tropical conditions. Below we look at the technology in greater detail.

A Look at Evaporative and Adiabatic Cooling Technologies in Data Centre Applications

Just a few years ago, the standard working temperature of a data centre white space was approximately 22 °C. Today, it is quite normal to have data centres running between 24-27 °C in front of the servers, as confirmed by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), who expanded its data centre operating temperature guidelines. The data centre environment is getting hotter and data centre management has evolved accordingly to incorporate more power and higher temperatures.

Data centre designs, in accordance with ASHRAE guidelines, have thus accepted to move to the upper limit of the recommended envelope, and in some cases, even to the allowable ranges (A1-A4), allowing data centre managers and manufacturers to be creative with cooling solutions. One of the most efficient solutions that have been introduced is adiabatic and evaporative cooling – a cooling methodology that promises to greatly increase efficiency and has been used in traditionally colder environments.

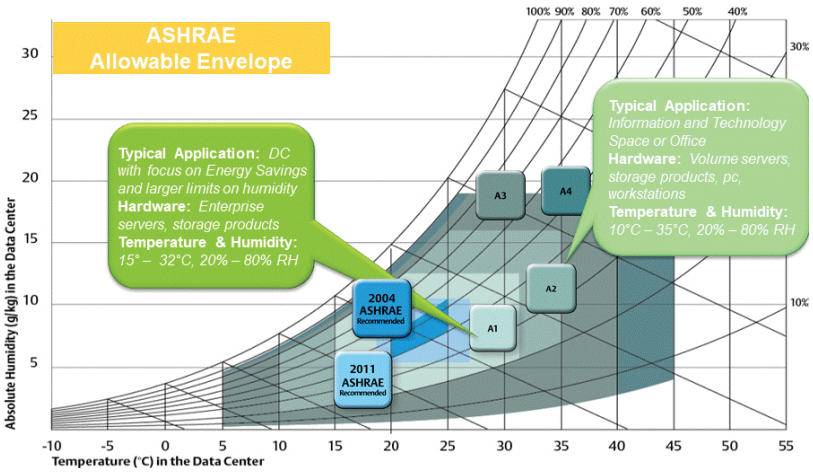


Figure 1. ASHRAE guidelines

[1] https://www.iea.org/reports/tracking-buildings/data-centres-and-data-transmission-networks
[2] https://www.nccs.gov.sg/docs/default-source/default-document-library/green-data-centre-technology-roadmap.pdf
[3] https://www.vertiv.com/globalassets/products/thermal-management/free-cooling-chillers/freecooling-evaporative-and-adiabatic-cooling-technologies-in-data-center-applications.pdf

How Adiabatic/Evaporative Cooling Works

By using a process with a heritage that can be traced back to the Roman Empire, adiabatic/evaporative cooling is a process of reducing air temperature as a result of water evaporation in the air. Over 2,000 years ago, the system was used to lower the temperature in a hot room by spraying water into the air or on the floor, which has a cooling effect on the area as the water evaporates.

Today, adiabatic/evaporative cooling uses the principles of the ancient system with the benefit of 21st century technology within the category of thermal management units. But while the adiabatic/evaporative cooling approach is eco-friendly and efficient, it would not work well in warmer, more humid climates such as those in Southeast Asia. As such, in these countries, the use of indirect evaporative freecooling units that provide high efficiency and availability all-year round is the best approach.

Indirect Evaporative Cooling in Tropical Climates

Indirect Evaporative Cooling (IEC) works on the same principle as evaporative cooling but with the use of a heat exchanger to remove heat and cooler air is re-introduced to the IT equipment room. This technology is economically viable and environmentally sustainable as it prohibits outside air and internal air to mix, reducing any contamination such as pollutants, dust and smoke. By estimates, IEC has the potential to reduce energy consumption by as much as 50 percent compared to traditional cooling approaches.

Use case: The Liebert® EFC

The Liebert® EFC is Vertiv's indirect evaporative freecooling unit equipped with the most advanced industry technology that offers indirect air-to-air heat exchange and evaporative cooling in one footprint.

The Liebert EFC can reduce air temperatures by leveraging the evaporative cooling principle through the evaporation of pressurized water which cools the surrounding air. The highly efficient evaporative system sprays water inside the unit, as well as onto the heat exchanger to enable cooling even at high ambient air temperatures, without the need for mechanical cooling.

The evaporative principle uses air to absorb water that is sprayed at high pressure. Water evaporation thus removes heat from the air and cools the outside air temperature. The use of evaporative cooling allows freecooling operation to be maximized and compressor-related cooling to be reduced to a minimum, thus optimizing operating costs even further.

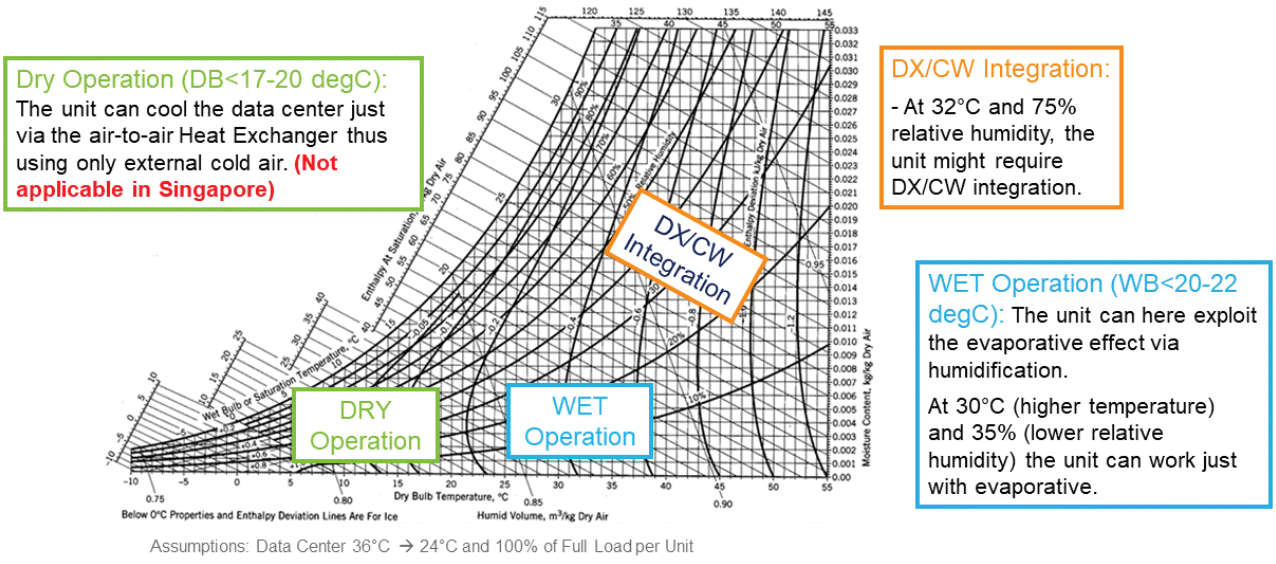
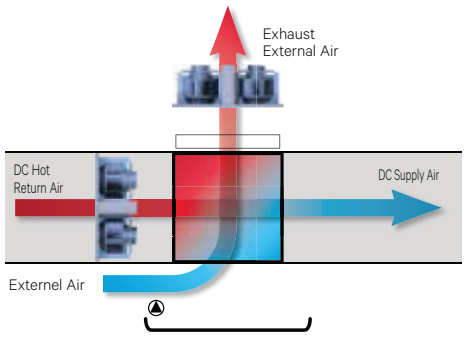


Figure 2. Psychometric Chart

In order to optimize the overall system efficiency, the Liebert® EFC unit has been designed to automatically change its operating mode according to the external environment. Higher ambient temperatures and external humidity determine unit capacity and performance as the evaporative effect is directly associated to the external air capacity in order to absorb water.

When the unit operates in environments with a higher temperature and lower relative humidity (summer operating mode), Liebert EFC works in evaporative mode. In climates featuring high levels of humidity, the unit may require the integration of a Direct Expansion (DX) system or the installation of a Chilled Water (CW) coil (DX/CW operation mode).

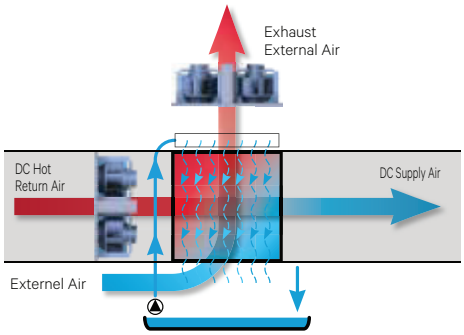
Winter



Dry Operation

Air-to-Air Heat Exchange Without Spraying Water

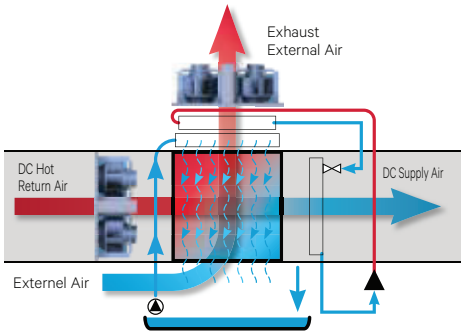
Summer



Wet Operation

Air-to-Air Heat Exchange Via the Spraying of Water to the External Air Side

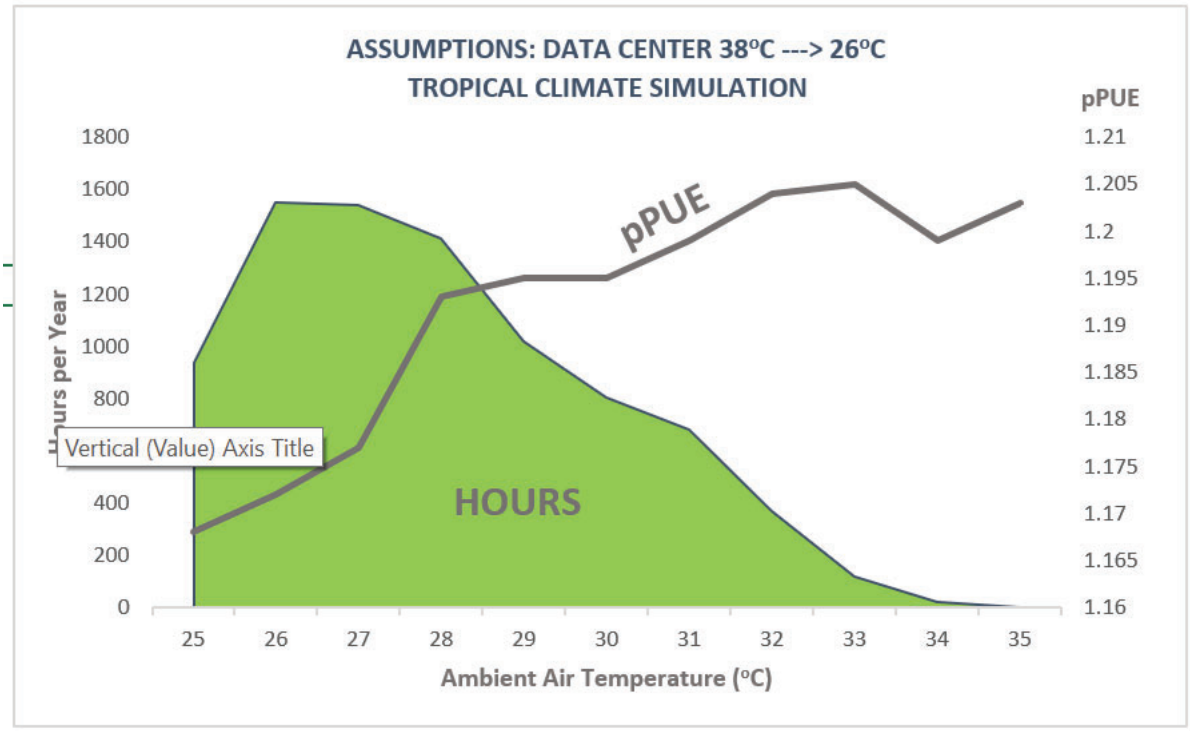
Optional



DX/CW Integration

External Air Is too Hot to Achieve 100% Cooling with Adiabatic, the DX Module Is thus Integrated to Cover the Missing Capacity

While respecting ASHRAE guidelines, the Liebert® EFC unit can be installed in hotter climates, where DX operation is reduced to a minimum and used only during extreme temperature peaks that occur throughout the year. This results in a significant reduction in electrical consumption, even at full load (reaching the highest possible savings at partial loads). Below example shows comparison among three cities and where Liebert EFC works across different temperatures:



In Singapore, the Liebert EFC operates with a combination of DX trimmed cooling at 99.5% of the time, and 0.5% in evaporative mode only. In addition, the Liebert EFC can operate throughout the year summer mode and optional mode. Dry/winter mode is not applicable.

Application Scenario

Data centres that deployed IEC technology and are situated in warmer locations have reaped the benefits of improved energy efficiency. For example, NEXTDC in Australia has received a Tier IV certification from the Uptime Institute by deploying the Liebert EFC IEC solution from Vertiv. The solution allowed NEXTDC to operate in varied environmental conditions, achieving an annual PUE average of 1.28, despite changing seasons.

The Liebert EFC 300 uses minimal amount of cooling units to meet the highest levels of cooling, saving on both capital expenditure and maintenance costs. The system includes indirect air-to-air heat exchange and evaporative cooling technology all in one footprint. The Liebert EFC can reduce air temperatures by leveraging the evaporative cooling principle. (Refer to Appendix 2 for the full customer story on NEXTDC.)

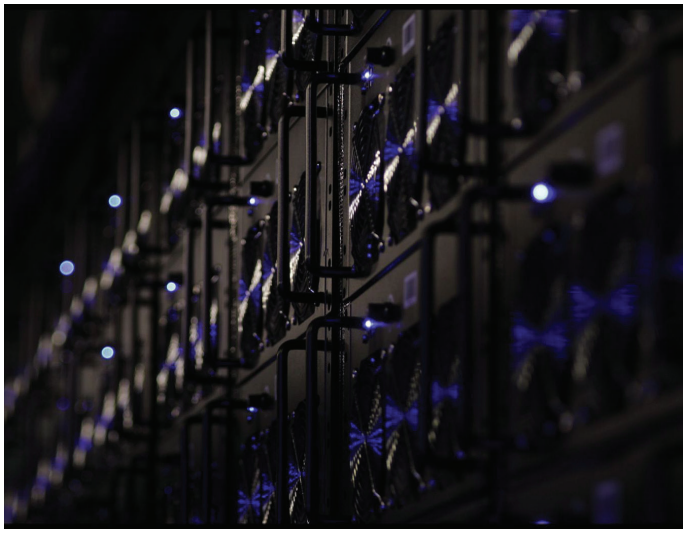
NEXTDC

Meanwhile, a cryptocurrency mining provider in Eastern Europe decided to utilise IEC technology in its data centre instead of the usual freecooling approach in the region.

"The thermal side is the hardest to deal with. We learnt this the hard way when we built our first facility as we deployed a direct expansion cooling solution which, might be perfect for a normal datacentre operation, is simply not an efficient enough technology for a constant high load as we have," said Silviu Catalin Balaci, CEO EvoBits IT.

By deploying the Liebert EFC, EvoBits was able to achieve a PUE of 1.15 even operating under external temperatures of 35 degrees Celsius. *(Refer to Appendix 2 for the full customer story on EvoBits IT.)*

Singapore typically experiences high and uniform temperatures throughout the year, including high humidity owing to its location near the equator. Mean annual humidity is at 83.9% according to the Singapore Meteorological Service. In this high humidity scenario, the Wet mode combined with the DX mode of the Liebert EFC will work for Singapore.



Is Data Centre Free Cooling Feasible in the Middle East?

This case study references Vertiv's IEC technology in Middle East setting. Download the white paper here.

Conclusion

Compared to traditional cooling approaches, IEC can provide retail data centres in Singapore significant energy savings opportunities. In summary, we can identify four advantages of IEC in tropical data centres as compared to traditional cooling approaches:

- **Efficient.** Evaporative approach sprays water onto the heat exchanger to enable cooling even at high ambient air temperatures, reducing the need for mechanical cooling. Additionally, the air-to-air heat exchanger in IEC separates external and internal air, protecting the data center air from bacterial contamination, as well as other external events such as fire and pollution.
- **Environmentally-sustainable.** As IEC uses less refrigerants for cooling, this technology is more sustainable as it contributes less to ozone depletion and global warming.
- **Substantial savings in data centre space.** IEC solutions can be installed externally, thus increasing savings on data centre construction and installation. Data centre white space can be maximised and greater savings are achieved.
- **Optimised water consumption.** The intelligent technology embedded in IEC allows the use of water as needed, thus preventing wastage and higher costs.

Given the above benefits, IEC can make for a great cooling investment for retail data centers operating in Singapore and other tropical, humid environments.

Appendix 1

The Liebert EFC Innovative Cooling Solution from Vertiv

At 100 percent load, the Liebert EFC can also achieve a PUE of 1.26 as compared to a traditional chiller plant with a PUE of 1.4. In addition, under normal operating conditions, the Liebert EFC will operate at both evaporative cooling and DX trimmed cooling.

While respecting ASHRAE guidelines, the Liebert® EFC unit can be installed in hotter climates, where DX operation is reduced to a minimum and used only during extreme temperature peaks that occur throughout the year. This results in a significant reduction in electrical consumption, even at full load (reaching the highest possible savings at partial loads).

As compared to the traditional chilled water approach, the Liebert EFC is more economical and cost efficient in cooling data centres in warmer climates. It offers:

- Faster deployment and ease of installation with less piping work;
- Scalable deployment depending on requirements;
- Minimal maintenance with lower service cost;
- High efficiency, particularly in N+1 or N+2 mode;
- Redundancy

The cost function, which is the software logic embedded in the control, optimizes running costs (water and electricity), and, according to the external dry bulb and heat load, selects the most convenient working mode (i.e. dry vs. wet). With the same logic, the cost function will also optimize the use of the optional DX mode.

One of Liebert® EFC's key differentiators is its state-of-the-art Vertiv™ ICOM™ Control which guarantees water management and energy optimization both at unit and teamwork level. The user-friendly Vertiv iCOM Control collects information from different units' key parameters and operating modes (dry, wet and DX/CW) while taking into account water and electricity costs. This allows the control to predictively calculate and implement the combination which optimizes operating costs.

Liebert EFC also offers a constant control of data centre air via its integrated control logic, ensuring dew point temperature is lower than heat exchanger surface temperature, thus avoiding unnecessary dehumidification. This occurs when the unit's unnecessary internal dehumidification can cause it to exceed ASHRAE recommended minimum humidity levels.

The Vertiv SmartAisle™ control logic, moreover, optimizes internal air volumes and temperatures according to specific server needs and allows Liebert EFC to exactly match the servers' airflow needs, ensuring that not even a single watt is wasted in moving or cooling unnecessary air.

As a result of these state-of-the-art technologies, both in terms of servers and in thermal management technologies, top efficient data centres today can also be built in warmer climates, thus contributing and leading the way to a significant reduction in global energy consumption.

Appendix 2

EVOBITS

About the company

EvoBits Information Technology SRL is a software development and a cryptocurrency mining provider based in Eastern Europe. With several facilities totalling 4.5MW, they are a rapidly growing company in this space. Having seen a gap in the market, they developed a unique model to serve their customers with greater accountability.

Background

Cryptocurrency mining is one of the genuine disruptive technologies that has exploded over the last decade. Having become a regular target for the media, it is now a well-known, but often not so well understood technology. For currency miners, there is often little or no transparency in the service provider they use, which means that the opportunity to exploit the uninitiated is high. EvoBits Information Technology SRL entered the cryptocurrency market on the programming development side, developing coins, token distribution systems and even a merchant platform. Seeing the gap in the market for a provider who could offer transparency of service, EvoBits IT set up their first 1 MW facility in 2017 and have expanded rapidly to 4.5 MW with further growth in progress.The challenges of running a professional mining operation which promises transparency in an opaque market are considerable. Located in Eastern Europe, they buck many of the trends of traditional cryptocurrency mining operations which has made their operation quite unique.

> *"We like to say we offer a little bit of transparency in an opaque market." Silviu Catalin Balaci, CEO EvoBits IT*

Cryptocurrency Technology Challenges

"Power and climate are the two main considerations when choosing a cryptocurrency mining location. Power is always your limiting factor." Says Silviu Catalin Balaci, CEO EvoBits IT. "Whatever power you have, you will use 100%, and the less power you can use on infrastructure, the more power you can use for compute, which translates to more mining, more customers and more revenue." "Add to this equation the fact your IT load runs at 100% all year round, which impacts your infrastructure decisions, not just in terms of needing reliability but more importantly regarding efficiency. Consider that cooling is traditionally the largest user of power in a datacentre, your objective is to minimise this cost while ensuring your IT hardware is kept at the optimal temperature.""While many cryptocurrency companies are based in China or the Nordics to benefit from free cooling, often people ask us why we set up our operation to Eastern Europe. There are two key reasons for this. Firstly, locating in a non-EU country where you are subject to geopolitical risks, exposes your business and customers to risks regarding changes in legislation. Secondly, while the Nordics are famed for free cooling, we believed we could build a highly efficient model with the right architecture, even in hotter climates."

Optimising Power Usage Through Efficient Cooling

"The thermal side is the hardest to deal with. We learnt this the hard way when we built our first facility as we deployed a direct expansion cooling solution which, might be perfect for a normal datacentre operation, is simply not an efficient enough technology for a constant high load as we have.

> *"We operate with external temperatures of 35 degrees Celsius and high humidity, technically the worst conditions for cooling your equipment, and we get a PUE of 1.15 which is honestly incredible."*

"When we came to building our second facility, we became aware of an Vertiv Indirect Evaporative Free Cooling technology. When I saw the modelled performance and PUE, I was sceptical that it was possible. Despite external temperatures of 35 degrees Celsius and high humidity - technically the worst conditions for cooling your equipment - we get a PUE of 1.15, which is honestly incredible."

Partnership and Growth

"The biggest challenge in this phase of our growth is finding partners who are willing to work with you, prepared to build what you need, and our requirements are quite unique to the datacentre business. Vertiv are a big company, with a start-up mentality. They're always willing to listen and work with you, and in a business, that's evolving so fast, that's critical. This is why we choose to work with Vertiv." "This is just the start, we have aggressive growth plans for EvoBits IT. We have built an eco-system which is adaptable to Hyperscale computing as it is to Cryptocurrency mining. We will diversify and adapt as we see new gaps in the market.

Vertiv Solutions:

- Phase 1 – Vertiv Liebert PDX direct expansion cooling units + Liebert MC microchannel condenser – 9 units
- Phase 2 – Vertiv Liebert Evaporative cooling EFC 320 – 6 units

Appendix 3

NEXTDC

About the company

NEXTDC is an ASX200-listed technology company enabling business transformation through innovative data centre outsourcing solutions, connectivity services and infrastructure management software.

As Australia's leading independent data centre operator with a nationwide network of Tier III and Tier IV facilities, NEXTDC provides enterprise-class colocation services to local and international organisations. With a focus on sustainability and renewable energy, NEXTDC is leading the industry with award-winning engineering solutions for energy eff iciency and NABERS 4.5 star certification.

Case Summary

Location: Australia

Vertiv Solutions: Liebert EFC300

Situation

Australian businesses are transitioning to more cloud and hybrid IT solutions to enable new and innovative digital services and take the pain away from managing IT infrastructure. NEXTDC plays a vital role in enabling that transition, satisfying the ever-growing demand for data storage, transmission and processing by providing enterprise-class colocation services to local and international organisations throughout the country.

The company recently opened its latest data centre, M2 Melbourne, which is delivering significant new capacity and access to a host of world-leading cloud services for organisations in Melbourne and surrounding areas.

Like any state-of-the-art data centre, M2 requires the highest quality in cooling to maximise eff iciency and ensure the continuous operation of the physical assets within the facility. However, NEXTDC had bigger ambitions than just a standard facility – it set out with the goal of making M2 the most reliable and energy eff icient data centre in the country built using Indirect Evaporative Free Cooling air handling units (AHUs) to International Electrotechnical Commission (IEC) standards.

NEXTDC selected the Liebert® EFC 300 solution from Vertiv and the company's dedicated service team to help it meet this goal and to achieve the lowest possible power usage eff ectiveness (PUE) numbers, ensuring maximum energy eff iciency and operational savings.

The Solution

To verify that its design for M2 could deliver as promised, NEXTDC had the facility undergo rigorous on-site audit and testing by Uptime Institute. In December 2017, M2 achieved Australia's first Uptime Institute Tier IV Constructed Facility Certification for a hyper-scale, greenfield data centre.

Uptime Institute is the IT industry's most trusted and adopted global standard for the proper design, build and operation of data centres – the backbone of the digital economy. For over 20 years, Uptime Institute has been providing customers with the assurance that their digital infrastructure can perform at a level that is consistent with their business needs, across a wide array of operating conditions. Uptime Institute helps organisations optimise critical IT assets while managing costs, resources and efficiency.

Fault Tolerance is the main feature of Tier IV certification, which also represents the highest level of availability, performance, and resilience that a data centre can achieve to support mission-critical operations. Fault Tolerance means that the failure of an individual piece of equipment or a distribution path will not impact critical IT operations. A Tier IV facility is designed eff ectively to ensure seamless maintenance, operations, and response to any fault. To achieve a Tier IV rating – the highest available rating the Institute provides – applicants must demonstrate a fault-tolerant and concurrently maintainable system, as well as continuous cooling without fluctuation of more than five degrees to critical IT equipment in any 15-minute period.

"Eff ective cooling is a vital part of meeting our critical standards," said Simon Cooper, NEXTDC's Chief Operating Off icer. "We embarked on a lengthy and thorough tender process to find the best partner to help us achieve optimal cooling across M2. After extensively reviewing all submissions, we realised Vertiv's team and its Liebert EFC 300 would fit our needs and the partnership was born."

The industry-leading solution was selected primarily due to its high capacity, low energy consumption and ability to exceed all cooling requirements, but also because of Vertiv's leadership in the thermal space and past success with other colocation providers in meeting similar rigorous standards.

The Liebert EFC 300 uses minimal amount of cooling units to meet the highest levels of cooling, saving on both capital expenditure and maintenance costs. The system includes indirect air-to-air heat exchange and evaporative cooling technology all in one footprint. The Liebert EFC is capable of reducing air temperatures by leveraging the evaporative cooling principle.

"The cooling solution uses iCOM Control to automatically and intelligently cascade units on or off to match capacity to the

internal load of the data centre," said James Miles, colocation, cloud and banking leader, Vertiv ANZ. "This means all assets are constantly monitored to ensure optimum eff iciency. This cooling is balanced between water and air cooling to again provide eff ective cooling with minimal power usage."

"Our decision to select Vertiv IECs was based on thorough, independent modelling of all cooling options on the market and comparing day one and final capex and total cost of ownership," said Jeff rey D Van Zetten, NEXTDC's Head of Engineering and Design. "Eff iciency is one of the most vital aspects to not only achieving the optimal solution, but providing best-of-breed colocation services to our customers. Optimised cooling increases eff iciency and helps us reduce our carbon footprint and lower costs, which minimises our customers' energy consumption. We're targeting an annual average PUE of 1.28 for M2. We achieved a 1.21 PUE during spring time and with tuning we expect PUEs between 1.1 and 1.2. In winter we are targeting spot PUEs of 1.09 or better.

"Vertiv's engineering and service teams worked alongside NEXTDC and a number of design and construction teams to complete the project. M2 is now able to meet the rigorous standards required by modern IT and welcome the growing number of organisations in Melbourne and surrounding areas looking to invest in colocation and cloud services.

The Benefits

The M2 data centre's Uptime Institute Tier IV Certification for Constructed Facility wouldn't have been possible without the fault tolerance, eff iciency, redundancy and capacity of Vertiv's indirect cooling system, the Liebert EFC 300."There are a lot of moving parts involved in the design and construction of any colocation centre, let alone one with the highest standards ever achieved in Australia," added Van Zetten. "Our goal was to simplify the design to increase reliability and the Vertiv IECs helped minimise the moving parts and interfaces. Key to our decision to select Vertiv is the fact that prefabricated modular construction with units like the Liebert EFC 300 helps minimise site installation time and cost."

"We would not have met the tough sets of criteria we were up against without Vertiv's incredibly smart, hard-working service team, which handled extreme pressure and worked with us through unexpected hurdles along the way. The team understood the importance of meeting our strict certification schedules and didn't rest until the job was done.

"NEXTDC M2 is now the only Australian data centre – not to mention one of a select number in the entire APAC region – to meet both Uptime Institute and IEC standards. This means maximum reliability and energy eff iciency and with it cost savings are in place at the centre, and has meant a significant reduction in the data centre's expected power usage eff ectiveness (PUE) numbers.

"Enhancing the strategies used in their Tier III data centres, in M2, NEXTDC has achieved Australia's first Uptime Institute Tier IV Constructed Facility Certification for a hyper-scale, greenfield data centre and globally, the first with a Fault Tolerant N+1 redundant IP-DRUPS electrical system," said John Duff in, Managing Director, South Asia, Uptime Institute.

"We estimate data centres now account for almost four per cent of power usage in Australia," said Robert Linsdell, Managing Director, Vertiv ANZ. "Any reductions you can make here mean massive savings in terms of energy eff iciency and cost, savings now more important than ever with the recent rise in electricity prices across Australia.""We had a very specific goal in mind, and Vertiv got behind that and worked with us to achieve it. We worked tirelessly together and reaching this achievement has given us a unique off ering to provide to our customers in Melbourne," said Cooper.

For more information visit **www.VertivCo.com**.

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