Merlin

The World's Most Sustainable Data Centre

Contents

Merlin, Swindon, UK

Introduction

In September 2010, Capgemini's new data centre, Merlin, came online. Located in Swindon, Wiltshire, UK, this state-of-the-art, 3,000m^2, Tier 3 facility will set a new global standard for energy efficiency, with an industry-leading Power Usage Effectiveness (PUE) rating. With significantly lower running costs than comparably sized data centres, Merlin still meets all of its original criteria:

- Sustainable
- Recyclable
- Energy Efficient
- Resilient
- Modular

For service providers, creation of new data centre capacity has historically been a lengthy process, usually driven by specific client need. The traditional construction approach, in which lead times are typically around 18 months, increases risk for service providers and limits their responsiveness to changing client needs. With Merlin, Capgemini has created a facility with the flexibility and responsiveness to cope with the fast-changing data management needs of the future. In doing so, it has effectively turned its back on many of the assumptions and limitations within which data facility designers have traditionally worked.

By taking a totally fresh approach, identifying the right suppliers, utilising the best available technologies and selecting the optimal location, Capgemini was able to focus on using smart design, with sustainability at the core, to create a new standard for modular data centre design and build. Capgemini not only addressed the need to use power more efficiently, but also considered how a range of other green imperatives could be met and costs reduced for itself and its clients. As a result, it has created a model which will enable future data centres to be more sustainable, operate with significantly more efficiency, be located more flexibly, and make high-end data management services accessible to a wider range of organisations and enterprises. It is a model which is more cost effective to implement than traditional data centres, minimises CapEx and reduces running costs, generating savings for the end client.

The new design uses innovative engineering solutions for the most power-hungry components of a data centre, such as cooling, Uninterruptible Power Supply (UPS), lighting and electrical infrastructure. The highly flexible modules can be configured to exactly match the needs of the client with implementation in as little as 22 weeks. The resulting innovations deliver real efficiency and green benefits while maintaining or improving on standards for data centre security, power management and resilience. A data centre of this specification is expected to be quickly subscribed, such is the demand for sustainability from existing and potential clients, but this is equally matched by the speed with which new capacity can be provisioned.

Capgemini's strategy is to continue to roll out its solution globally, linking strategically paired sites with high bandwidth synchronous fibre, providing client business continuity failover. Merlin is already twinned with its Bristol Flagship List X data centre.

Inside the 3,000 square metre Merlin facility

It is now widely accepted that data centres account for a significant proportion of global CO_2 emissions.

Capgemini recognises that it is imperative to make data centres use less power

The problem with data centres

Fuelled by Internet growth, the demand for power from the world's Information and Communication Technologies (ICT) is doubling every five years[1]. Global data centre power demand in 2005 was already approximately 1% of the world's total electricity usage, about one-third of the energy consumed by India, the world's sixth-largest energy consumer. In 2006 the US Environmental Protection Agency reported to Congress that data centres were draining 1.5% of the nation's power.[2] It is now widely accepted that data centres account for a significant proportion of global CO_2 emissions, similar to that of the aviation industry.

There are many reasons why this is likely to continue: the demand for high-intensity computing is still growing and governance models increasingly dictate total ongoing storage of corporate data. The growing economic and industrial strength of countries such as China will have an as yet unknown additional impact on the world's use of IT power. Virtualisation and the growth of cloud computing will go some way towards offsetting this but it remains almost inconceivable that the net use of power can do anything but continue to grow. The EU recognises this and continues to develop its EU Code of Conduct on Data Centres. Independent research firm Gartner Inc. summarised the situation in March 2010, stating, "In 2009, the biggest issues faced by data center managers were power, cooling and space problems as a result of equipment sprawl". In addition, Gartner Inc. predicted that, "Through 2013, data center power, cooling and space problems will increase rapidly as a result of high-density infrastructure deployments."[3]

Against this backdrop, Capgemini recognises that it is imperative to act right now to make its data centres far more efficient in power usage.

Putting sustainability first

Capgemini took a 360-degree view of the efficiency and green imperatives for the new facility, including the desire to select a sustainable, brown-field site and avoid unnecessary construction activity that would in turn cause additional pollution and environmental damage. The Swindon site was selected from a large number of candidates based on a wide range of criteria including:
- Reuse of an existing building
- Renewable power provision
- Availability of appropriate telecommunications
- Climate factors (e.g. wind patterns)
- Proximity to existing facility for synchronous replication
- Natural security, flood safety and other location attributes.

The infrastructure design was strongly influenced by resource efficiency constraints such as the need to minimise the use of water, optimise energy performance and heat management, and use reusable, recyclable and renewable materials and resources. For example, no lead acid batteries will be used for short-term power within its UPS configuration. By using flywheel UPS technology, which uses stored kinetic energy to replace the role of batteries, Capgemini has delivered an innovative solution built on recyclable components that fully supports it sustainability goals.

Given this committed approach to sustainable design, Capgemini will apply for Merlin to be accredited as a green building by Leadership in Energy and Environmental Design (LEED). LEED accreditation covers a rigorous six-point review of energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts.

A module being fitted inside Merlin

Merlin's industry-leading PUE has proved that Tier 3 topology can be extremely power-efficient

Pursuit of efficiency

The accepted indicator of a data centre's power efficiency is the PUE or Power Usage Effectiveness. This measures the total power to a data centre and divides it by the power consumed by the IT equipment. This measurement should be taken over a 365-day period to account for variation in outside operating ambient temperatures which, in this instance, relating to the Merlin data centre in Swindon, could vary from -15 to 34 degrees centigrade. These temperature variations influence how much power the cooling systems will use in an annual cycle. The data centre industry average PUE is approximately 2.5. There is an industry-wide effort to reduce this, with a 'best practice' target of around 1.3 PUE.[4] Only a handful of providers are capable of achieving a PUE of less than 1.2. According to their own figures, Google's E data centre (1.12 PUE)[5] and HP's Wynyard facility (1.16 PUE) have achieved this.

The Merlin data centre is a unique design with modules that are pre-assembled and tested in a factory environment. During controlled factory testing, under the full range of specified environmental conditions, the data centre modules achieved a PUE of 1.08. Under operational conditions, with the additional calculated electrical and UPS losses, Capgemini fully expects to achieve a data centre PUE of 1.10.

Ensuring resilience

The Merlin facility is designed to meet energy-efficiency targets without compromising N+1 resilience (ensuring availability in the event of component failure with at least one independent backup component). Many UK data centres are designed around concurrent maintainability but do not have generators capable of continuous running and have not been audited for full certification. Merlin will be a Tier 3 facility designed for a minimum life of 30 years, one of only three Tier 3 data centres operating in the UK with full certification by the Uptime Institute. Certification by the Uptime Institute is regarded as the definitive classification of a data centre's infrastructure resilience.

The question of whether Tier 3 facilities can truly be energy or resource efficient has been settled. The PUE achieved buy Merlin has proved that with the right design, Tier 3 topology can achieve an extremely high level of energy efficiency.

Driving business benefits

The cost of providing data centre facilities to clients includes the provision of physical space and facilities in addition to technical services. Data centres traditionally carry high capital cost, and depreciation starts from the first day of production. By focusing its approach around standard and modular components, Capgemini has created a model within which costs only grow in line with utilisation and CapEx depreciation is managed in stages as the facility fills. Further reductions in running costs are derived from the significantly improved power efficiency over standard data centre models, within which power can account for up to 50 percent of running costs. Reduced running costs therefore benefit the end client.

1 23rd September 2008 : Jonathan G Koomey, Lawrence Berkeley National Laboratory, USA and Stanford University, PO Box 20313, Oakland, CA 94620, USA

2 www.energystar.gov/ia/partners/prod_development /downloads/ EPA_Datacenter_Report_Congress_ Final1.pdf

3 Gartner Inc.: "Data Centre Power, Cooling and Space: A Worrisome Outlook for the Next Two Years" Rakesh Kumar, 03 March 2010

4 Google Efficient Data Centres web resource and research: www.google.com/corporate/green/ datacenters /index.html

5 1st April 2009: Google disclosed an average PUE for its six company-built data centres of 1.15 in Q1 2009. According to Google's Chris Malone, the most efficient individual data centre (described as "Data Centre E") has a PUE of 1.12

Data centres traditionally carry an extremely high capital cost, and depreciation starts from the first day of production

Putting innovation to work

Capgemini's Merlin modular data centre is fundamentally different from similarly sized facilities. Capgemini is a service provider rather than a technology manufacturer, so its design team did not fixate on invention, but instead on technology innovation and application. Its design team re-examined, reconsidered and redesigned almost every aspect of the "traditional" data centre model. For example; how air comes in, how it is cooled, how racks are arranged and where cables run.

Capgemini sought out the best solutions to problems, taking the time to consider not just aspects such as how to use water in its evaporative cooling system but also how to minimise the waste of that water. Identifying a modular build for the data centre room and the plant was very important. Standalone units based upon mobile hospitals and laboratory solutions, which could be independently managed, powered, cooled, fitted out, and secured, were reviewed in detail. The key objective was to develop a facility that could come on stream in stages exactly matching client demand, rather than becoming a depreciating financial asset from day one.

Capgemini's consultants worked with a global Building Management System (BMS) company to design an entirely new independent BMS for the modules. The BMS was designed to deliver an ultra-efficient climate control engine. This engine ensures that the containment of hot and cold air is managed with precision and accuracy to use minimal power from the 12 variable-speed fans that move the air around the modular computer hall. A three-stage cooling system unit is dedicated to each module. The cooling unit uses primarily fresh air cooling for external temperatures up to 24 degrees centigrade, with secondary evaporative cooling controlling temperatures up to 34 degrees centigrade. However, the system has been tested up to 48 degrees centrigrade. Direct Expansion (DX) refrigerant cooling provides final backup for temperatures exceeding 34 degrees centigrade. DX cooling is also used during full re-circulation mode should the outside air become contaminated, or to contain the fire-extinguishing gas system in the event of an internal fire.

The climate control air optimisation module has "Expert System" software which has the capability to protect itself against all temperature and humidity conditions.

The net result is close to 100% fresh air cooling.

In order to deliver a sustainable solution, Capgemini considered the full lifecycle of the data centre. Since the modules are factory-built and can be transported to site for installation there is no construction impact at the start. Modules are constructed of 95% recyclable materials which have very low embedded carbon. Their lifecycle can be extremely long, with a structural life of up to 60 years. Since the modules are effectively independent and self contained buildings, not requiring an external building to protect them, a client can purchase and remove modules at the end of a services contract. Alternatively, the modular data centre can be moved to a new location or added to an existing site and be fully re-commissioned in three months, assuming all the necessary power and services are available.

The low-energy data centre solution now has more scope for deployment in areas where primary sub-stations struggle to support the business community

Capgemini's design team re-examined, and redesigned almost every aspect of the traditional data centre model

Overcoming challenges

Not surprisingly, Capgemini had to overcome many challenges during the design and build of the Merlin data centre. The selection of data centre sites is often difficult owing to utility power limitations, coupled with practical constraints such as the requirement for Merlin to be paired with a second data centre for synchronous data replication. Swindon was one of 360 potential sites that were considered and was ultimately selected on the basis of power availability, telecommunications, facility and environmental factors. It is entirely fitting that thanks to Capgemini's ground-breaking modular approach, the low energy data centre solution has scope for deployment in areas where primary sub-stations struggle to support the business community.

Client benefits

Capgemini's data centre modules offer a range of potential benefits to clients, including:

Total flexibility

Clients can specify exactly what they require for their data management: either rent space or racks within multi-client modules, or specify the configuration of a dedicated module. The duration of the contract can be varied to the length that fits the client's business need. The power provision can be doubled without disruption, and the cooling adjusted to suit. In effect, each module is a data centre in its own right and built specifically to order for the client.

Corporate Social Responsibility

Merlin offers clients the opportunity to host their data in a sustainable environment with greater power efficiency and with less impact on the environment than comparable facilities.

It offers clients the opportunity for their data storage and management to contribute to their environmental targets and carbon footprint reduction.

Peace of mind

A complete module comes with a full range of flexible security packages. As well as a dedicated multi-access level, biometric security system, access can be controlled as the client requires without the need for building escorts or physical access controls and barriers that are customary in normal shared data centre facilities. Clients can even assign their own data management teams to oversee their dedicated modules. Merlin's security classification and Security Equipment Assessment Panel (SEAP) ratings give peace of mind, and physical security aspects such as radiation and blast proofing can be upgraded to suit individual needs, for the whole or only part of a module.

Speed to implementation

Thanks to the modular design and off-site build a client can have its dedicated and fully customised data centre up and running in 22 weeks, as opposed to the typical 12 to 18 months.

Cost effectiveness

Merlin's unique modular design means no additional cost overheads for total building power will be passed on to the client. The client can purchase as much or as little they wish, meaning no charges for under-utilised space.

Technical specifications

Certified Tier 3
Merlin will be certified as an Uptime Institute certified Tier 3 data centre, one of only three such sites in the UK.

Total capacity
Merlin is capable of delivering 3,000m² of available technical floor space, comprising 12 modules each of 250m², containing 1,248 racks sized at 800mm x 1,000mm x 46U.

The modular data centre comprises:

- A Climate Control Air Optimiser module
- A power delivery module housing A&B Bus Bar terminations at the distribution panel, BMS & CCTV services, fire extinguishing gas bottles and release mechanism
- VESDA & fire alarm detection systems
- 4 sections making up the 250m² technical floor for each module.

Highly secure with enhanced options
The site has been built to a security level compliant with a List X audit, for example, Ministry of Defence and Police Authorities. The modular computer halls can deliver Intrusion Level 3 (IL3) and 4 (IL4) rated security to suit the client by applying different build options. Each module can also be upgraded to include a High Intensity Radiation Screening shell to meet the requirements of the UK government's Security Equipment Assessment Panel for data security.

Flexible power options
Each module offers a minimum of 1,000Watts/m² as standard. This can be upgraded to 2,000Watts/m² through the addition of a second cooling unit either at the start or during operation, without any service disruption. Individual racks can be expanded beyond 10kW.

Power resilience
Two diversely routed 7MVA (Mega Volt Ampere) supplies are connected to the on-site substation, rising to 14MVA when required. One supply is always active, the other would be energised in the event of a primary sub-station failure. This power is backed up by continuous rated generators that can deliver power indefinitely. The containerised flywheel UPS system and fast-start generators ensure uninterrupted power supply in the event of grid failure. Each power unit contains 3 generators, in an N+1 configuration supporting 1,000m². When upgraded to 2,000watts/m² density, 6 x generators in an N+2 configuration per 1,000m² would support the load.

Innovative cooling system
Each module is equipped with a highly efficient dedicated Air Optimiser climate control cooling unit which cools air in three stages, with primary "fresh air" cooling, second-stage evaporative cooling and backup third-stage cooling through Direct Expansion R410a (DX). If upgraded to the higher 2,000Watts/m² density, an additional Air Optimiser can be added without any service disruption. This represents a reduction in cooling energy of 92% compared with a conventional data centre of nearly 50%.

Cooling system

Perimeter fencing

Power generators

Cold aisle

Warm aisle

Rack space

Louvered doors

Modular BMS and climate control
The Trend Building Management System is the most sophisticated and energy-efficient ever designed.

Fully managed hot and cold air flows enable constant peak operational efficiency. The use of Computational Fluid Dynamics in the design of the modular data halls has enabled the designers to plan and control every aspect of air path. The entire air path from the air optimiser, through the cold corridors into the servers then out to the hot aisle, prevents recirculation of hot air and improves efficiency. The climate control system is virtually maintenance-free. The Energy Reducing Cold Aisle containment system ensures that the corridor is sealed and pressurised with a blanking panel system to stop cold air loss.

The cold aisles feature motorised louvered doors which adjust the air volume appropriately for the number of powered servers.

This sophisticated BMS features hundreds of sensors continuously monitoring the air temperature and quality, and able to make very fine adjustments. Thermal imaging is used to monitor constantly for any hot air leakage into cold aisles, while sensors in the hot aisles monitor for temperature, humidity and air pressure and velocity.

Power efficiency
Each 250m^2 modular room with a full technical floor load at 1,000Watts/m^2 will use 232kW of energy for the IT equipment with only 10kw of power used to cool the servers – a reduction in cooling energy of over 92% compared with a conventional data centre using chilled water, and 75% compared with a high-efficiency modern data centre with free cooling. The energy losses in the transformer and UPS are very low at only 60kw per 1,000m^2. Bus Bars feed racks via 16 Amp and 32 Amp snap in commando boxes. No Large Scale Power Distribution Units (PDUs) or electrician required.

Dedicated security and fire detection
Each unit has a dedicated CCTV network of cameras with audio links to enable contact between engineers and the control room. Fire detection systems include Very Early Smoke Detection Alarm (VESDA) which provides continuous air sampling for maximum early warning and detection and all fire and security panels are configured N+1 redundancy for resilience.

Clean build rooms
Four client build rooms are available for secure tech refresh activities. These rooms can be patched via fibre to any modular computer hall network.
This facility can be booked by the client and Capgemini will provide varying levels of security depending on the nature of the client's business, for example, Government IL3 security.

Meeting and presentation suites
A range of client facilities for meetings, presentations and conferencing are available on the upper floors and fully equipped with state-of-the-art equipment.

Conclusion

In creating the Merlin data centre Capgemini has pushed back the boundaries of resource, power, and cost efficiency – creating an improved technical facility, a more effective business model and the most sustainable data centre in the world.

In September Merlin became available to current and future clients in the commercial and public sectors. The innovations and adaptations behind the creation of the Merlin data centre avoid "bleeding-edge technology," but the application of business and common sense has changed the landscape nonetheless. One of the most significant innovations is the first of its kind modular concept, which may help others to overcome a stumbling block to data centre location – the availability of sufficient power for a large facility. It breaks down the traditional data centre concept into smaller, more efficient, cost-effective and sustainable modules.

The near-total fresh air cooling system developed by Capgemini is a real green innovation which is both resource- and power-efficient. Driving out dirty battery-based UPS systems as part of Merlin's approach to electrical efficiency is something which the industry should have addressed long ago.

Merlin has achieved all that it set out to do to become the world-leading model in sustainability and data centre power efficiency. With a factory tested PUE rating of 1.08 across all loads and ambient operating temperatures and humidity, Merlin will deliver the best PUE rating gained industry-wide and is testimony to its achievement in energy efficiency. All energy-efficiency targets were met without compromising N+1 resilience, in a facility designed to last for a minimum of 30 years.

The benefit to clients is clear: the massive cost savings, business efficiency and environmental benefits without any diminishing of space or technical services.

Merlin will be certified Tier 3, highly resilient, extremely green and ultimately secure. It will be the most energy-efficient data centre in the world, which can track the changing needs of enterprises, governments and other organisations. It is far more cost-effective to commission and operate, enabling significant cost savings to be passed to clients. The Merlin project is a success on all fronts.

Executive Summary

Energy usage is the single largest environmental factor for modern-day ICT services. The situation is set to intensify given two key factors:

- At a macro level, the continuing growth in demand for technology fuelled by Internet growth and commerce
- The micro factor of greater need for computing power.

Existing data centre facilities struggle to gain optimum efficiency; although recent advancements have enabled them to reduce energy usage, inherent design challenges prevent them from achieving truly power-efficient benefits. Capgemini has recognised that the commissioning and management of data centre services will require a new approach for the future.

Through the application of new pragmatic and innovative thought leadership, coupled with significant investment, Capgemini has revolutionised this approach. Its development in the design and deployment of new data centres will result in facilities that are more sustainable, energy-efficient, flexible, highly secure and far less costly to use.

About Capgemini and the Collaborative Business Experience™

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Capgemini Outsourcing Services (OS) draws on the expertise of more than 28,000 employees to manage, innovate and improve the IT systems and business processes of its clients. Capgemini OS offers a full spectrum of services including Applications Outsourcing, Infrastructure Outsourcing, Business Process Outsourcing and Transformational Outsourcing.

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