Building Data Centres

From power and cooling to layouts and budgets, this article explores the practical trade-offs behind every SUB 1 build.

SUB1's speciality is taking existing buildings with the opportunity of connecting suitable power and retrofitting them into data centres. We've been having some interesting discussions internally as we're designing custom layouts for customers, and we thought it would be fun to peel back the curtain and give some insights into what that process looks like.

Where do we start?

It sounds simple. We understand the customer's requirements then we research solutions.

Simple, yes?

No. Not simple.

First of all, most of our customers aren't data centre experts. A small minority have operated one before. Most haven't built them.

Of the already infinitesimally small number of people who have built data centres, most have done so on greenfield sites and have had years, often decades, to go from concept to design to build to go-live.

Designing the data centre internally, and building the facility accordingly – a pure greenfield environment – is, frankly, easier. The only trade-off is money versus ambition.

In our world – brownfield sites and sub-optimal structures – the challenges are way more interesting.

The first things we have to establish are: what does the customer want to do, why do they want to do it, and how much are they willing to spend on it.

What are the Requirements?

Some things are relatively straightforward and binary in nature. Others are a bit more nuanced and a matter of opinion.

Typical requirements include:

- Power requirements
- Expected IT load
- Levels of redundancy
- Fibre density
- Air or liquid cooling or both
- Green credentials
- Desired PUE
- Floor strength and cabinet weight
- Floor to ceiling height
- Space for cooling equipment
- Noise combinations

The theoretical permutations on just these 11 items are already considerable. BUT WAIT. There's more.

Somebody has just mentioned the B word. Budget.

Moving the sliders around on redundancy options alone changes the spend profile a lot. You're not going to get 2N redundancy for N+1 money.

Already, we're horse-trading on fundamentally important items. Already, it's complicated.

And nobody has changed a single thing... yet.

Small Changes = Big Impacts

We recently had a customer who had spec'd to bring in dual 3.3 MW power feeds for full redundancy. Then they decided to light up both and run the data centre at 6.6 MW, not 3.3 MW. Easy-peasy, and now they've doubled the size of their facility.

But, of course, it's not that simple.

Doubling the power means doubling lots of things. There's a lot more power to distribute, for one thing. You've got to double the UPS capacity and possibly double the size of your backup generators too.

Have you got enough space for double the IT load? Have you still got the space when you double the cooling infrastructure?

Sadly, unless you have unlimited budget, there are always resource constraints and trade-offs that have to be made.

Trade-offs and the Laws of Physics

There's a legendary Internet Engineering Task Force (IETF) Request for Comments (RFC 1925) called "The Twelve Networking Truths".

It was published on 1st April, so its tongue is firmly planted in its cheek, but there are some definite nuggets of fact in the humour.

It has just celebrated its 30th birthday, which makes your author feel old. You can read it here – unlike me, it hasn't aged a day.

Arguably its most famous truth is (7a).

Good, Fast, Cheap: Pick any two (you can't have all three).

There are plenty of variations on this theme out there but the core message is clear. You have to compromise somewhere.

Sadly, the world of data centre design must, like all worlds, obey the laws of physics. Sir Isaac Newton has a lot to answer for. Or, to borrow from a less well-regarded scholar (Homer J Simpson): "in this house, we obey the laws of thermodynamics!"

And that means trade-offs. Especially when combined with networking truth #10:

One size never fits all.

There's nothing saying we can't get your PUE to start with "point one something". But is the juice worth the squeeze to get from 1.2 to 1.15? The customer may desire exceptional environmental credentials until they see the cost of doing so. Maybe "really good environmental credentials" will be sufficient after all.

An alternative trade-off is to move the cost around. If the data centre owner doesn't fancy forking out the capex for ultra-efficient cooling via expensive hardware, maybe they change the cooling plan, make it an opex cost, and pass that along to the tenants' bills.

DLC requires less power than air cooling so a higher percentage of the total power can go to the IT load. But a traditional air-cooled rack draws 5-15kW of power but DLC racks can be 10x that with significantly heavier cabs, 2-4x more.

So you have to know, or have a good idea, what's going to go in the cabinets,

and therefore how they're going to be cooled, before you can establish your minimum power requirements and how that power is divided up.

Let's explore a few of these potential areas of conflict and the sorts of trade-offs we have to make in the design process.

Inside the Building

A brownfield site means we're dealing with a building that wasn't built to be a data centre.

Space is literally money. We want to maximise its use. As we're looking at the options for layout, we're immediately jumping to these kind of questions:

- Can we add floors to the existing roofspace?
- Can we build upwards?
- Can we extend outwards?
- What does the customer need in terms of offices, meeting rooms, lavatories and kitchens?
- If there are existing floors, can they handle the weight of the cabs and kit?
- If we can't build new floors for data centre space, can we build a mezzanine to handle all other room types?

We just had a customer where the floorspace dimensions suggested that we'd have no problems with putting in the sorts of pod layouts they wanted. But then we fired up the CAD software and added in the pillars. Old building. Lots of pillars. Now the space doesn't work. The jigsaw puzzle pieces of the layouts don't fit around the pillars.

Obvious questions pop up. Can we get rid of the pillars? Can we build a new, steel-based frame to hold up the roof instead? Will we gain enough space to make the juice worth the squeeze?

Increasingly, we're designing a lot of data centres for AI applications, and that means next generation GPUs and some serious hardware. With some serious weight. Liquid cooling, by definition, means moving a lot of liquid around. That has to be planned... carefully.

What is the total load on the floor? What's the spot loading requirements of a DLC rack? How much will it cost to reinforce the floor?

Then we have to think about what we're cooling and how? Building an air-cooled facility is, prima facie, simple enough. But for liquid cooling? Different game. Not all GPUs are DLC. And it's not just GPUs that run hot. With DLC, we have to have some liquid cooling and some air cooling.

Ideally, we'd use evaporative cooling because it's cheaper and more efficient, and we all want to lower our PUE, especially in large facilities.

Compressing anything is energy intensive and is therefore more expensive and less efficient, but often necessary depending on external factors. Which leads us, quite literally, to external factors.

Outside the Building

The inspiration for this article was the challenges associated with working on a design for a customer in Tornado Alley in the US. Every building in that State, regardless of use case, needs to be built with a twister in mind.

That means we can't just build a glorified aircraft hangar type space and stuff as many cabinets in as we like. The building itself has some physical restrictions thanks to the weather.

That same customer, like a lot of customers, is in a hot and humid area. That means more DX cooling as just using evaporative cooling won't do the job.

A similar challenge exists with location. Cities tend to be warmer, more humid and have lower water availability than rural locations. Again, that means more DX and less evap.

Brownfield sites tend to have decent parking, as that factory or office block had a lot of people working in it. Data centres, by comparison, are quite light on people. How many parking spaces do we need?

Can we steal some parking spots and use them for generators?

Can we expand the building a bit without increasing the total site footprint?

Loading bays are needed too, as we've got some large equipment, both M&E and IT, coming to the building. All that has to be factored into the equation.

Designing the Solution

As you can imagine just by thinking about the things we've outlined already, there's no such thing as a static spec. The above isn't an exhaustive list either. There are some things that can be set in stone but that means there must be trade-offs elsewhere.

We use so-called "test fits" using some cool 3D CAD-style software to build the physical dimensions and limitations of the building, and then start working on some layouts.

Test fits aim to solve the following sorts of design and layout challenges:

- How many racks?
- What power density?
- What rack/pod layout?
- Hot aisle/cold aisle?
- What power distribution?
- What cooling strategy and layout?
- Redundancy requirements?
- Other room needs?

Often, customers need to "greenline" and "redline". In other words, tell us the "absolutely must haves" (greenline) and "absolutely cannot haves" (redline). Once we know those, everything else is an exercise in fit and trade-offs.

Our aforementioned customer with the pillars? Once we had exhausted all potential layouts to meet the minimum number of racks and the pre-determined power availability, the only conclusion was that the building had to be extended. Something had to give, and if the customer didn't want a smaller facility then they needed a larger footprint.

It's a simple ROI approach. If you want X amount of racks, you need to increase the square footage by Y, which will cost Z. But Z will pay back within an acceptable timeframe based on the income from the additional number of racks.

Ultimately, a test fit is kind of like one of those puzzles where you're sliding things around until they all fit in the right place. Except there might not be a solution.

Sometimes the solution is to do something else. Maybe its more like 4D chess.

Either way, it's an immersive and fun project. If you're in the market for a data centre, and you'd like to learn more about the process, we'd happily walk you through a demo test fit and chat through all the options and considerations we go through.