WHITE PAPER

How To Build A Real Green Data Centre

Part 1: Drivers for Data Centre energy efficiency

February 2008

Contents

NORMAN DISNEY & YOUNG

WHAT'S THE PROBLEM?

Data centres are the work horses that support internet connectivity, and they are massive power users. Few people understand the real impact that the computing world makes on our collective carbon footprint. To put the issue in perspective it is often quoted in terms of "equivalent houses". A typical medium size 2000m^2, 4000 kilowatt (kW) load, 2005 build Data Centre has an annual energy consumption equivalent to about 3000 2-3 bedroom homes.

This paper is part 1 of a series for IT and Property professionals who are concerned about energy consumption in Data Centres (whether due to the environmental or hard dollar costs). It is about why you should be planning to reduce your Data Centre carbon footprint, and your annual energy bill.

In this paper, you'll gain an understanding of the key drivers for Data Centre energy efficiency. In parts 2 and 3, you'll find out how to achieve greater energy efficiency in your Data Centre spaces in the order of 40%, using simple and sound engineering and management practices.

THE BIG PICTURE – GRID TO CHIP

KEY ISSUES

Viewed from the outside, your Data Centre looks a lot like a big carbon factory doing important but relatively small amounts of useful work compared to the energy going in to get it done. This is an unsustainable scenario for an increasingly environmentally aware world.

CARBON UN-FRIENDLY DATA CENTRES

A high density computing system rack of 5 kW load produces about 100kg of carbon in one week, somewhere in the environment. In IT terms, each week the rack produces 7RU of carbon in volume; in seven weeks it produces its own volume in carbon. The only reason that it is not widely recognised as a problem is that we cannot see it.

A whole Data Centre full of these is making a big dent in your carbon footprint reduction strategies! Your 2000m^2 Data Centre is producing, within its own walls, in excess of 3,000 tonnes of carbon annually! In August 2007, the US EPA published their report on trends in Data Centre energy usage and set targets for what our industry colleagues in the US need to aim for.

DATA CENTRE POWER INPUTS

Devices like blade servers are doing the useful work in your Data Centre. Your devices include chips, chassis, servers, and their power supplies.

You have control over a series of systems that support your IT devices to make that all that kit work smoothly:

- UPS / DC / Battery
- Switchboards and cabling
- Cooling plant – air and refrigeration
- Generators
- Transformers.

All of these incur losses in energy efficiency as they perform their roles. Outside your control, and outside your front gate, you rely on elements including:

- Zone Substation
- Transmission
- Power Station

YOUR DATA CENTRE'S CARBON FOOTPRINT

Whilst your CHIP might require only 1kW to keep it ticking over; that 1kW means about 10kW back at the Power Station. The rest is "losses" along the way – not the useful work of your Chip, just what's needed so that useful work can be accomplished. While your 5kW rack is making it's 100kg carbon block per week, other support elements are generating another 900kg of carbon, per week! Figure 1 shows the situation.

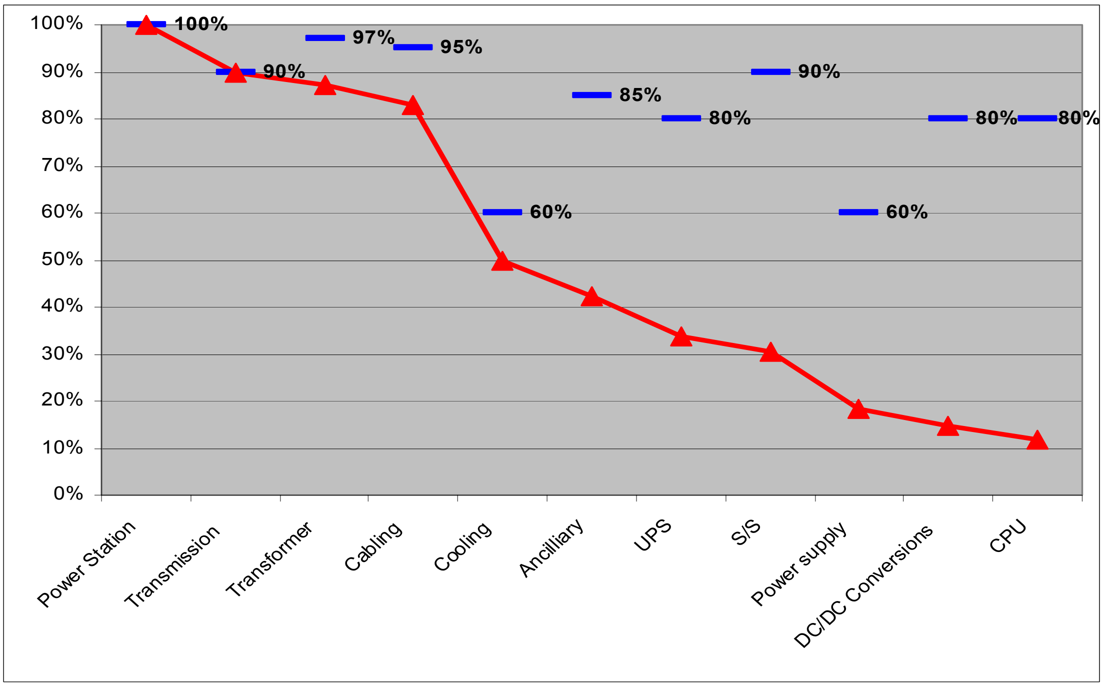

Figure 1 - Elemental (blue) and cumulative (red)losses in the Chip to Grid chain

One small change in this cumulative stack of losses has a knock-on effect up the line. For example, an improvement in server power supply efficiency from 60% to 80% in Figure 1, AND corresponding adjustments in the upstream equipment to take advantage of this, generates an overall reduction in cumulative losses of about 25%. Now, your 1kW rack needs 7.5kW at the Power Station, instead of 10kW.

Beyond the Grid and Chips

Beyond the Grid are the losses incurred in obtaining and using the fuel for the Power Stations; mining, transport, construction, and so on. Below the IT components, losses occur at the operating system, application, and software levels. So 900kg of carbon is not even the limit of the problem – it's just a starting point in our understanding of the extent of the whole issue.

You can begin to see how significant a carbon footprint your Data Centre has. Within the Data Centre, your 5kW rack is producing its own volume in carbon in about 7 weeks, and you are creating over 3000kg per year across a 2000m² facility. At this rate it will take about 2.6 years to fill your 2000m² to the rooftops with carbon; include the losses outside the Data Centre walls, and that becomes less than 2 years.

Buying green credits to offset this impact is not a sustainable approach, even if they were available in such quantities!

DATA CENTRE ENERGY PERFORMANCE

KEY ISSUES

Where do you believe you are in the spectrum of "Data Centre Greenery"?

Data Centre benchmarking in the US and Australia has found that an average of around 50% of the power input is used for IT load. Best Practice approaches that were available in 2005 are not implemented in many Data Centres, but provide the opportunity to enhance energy efficiency on a Power IN / Power OUT basis significantly, with further improvements available from IT equipment side efficiencies.

Improvements may or may not save you money when measured in isolation. If the cost reductions alone are not sufficient incentive, the capacity recovered for additional IT load may be.

METRICS FOR PERFORMANCE COMPARISON

To understand how to improve your Data Centre's energy performance, a consistent metric is necessary. A number are available. Some are referred to by more than one name or acronym. In this White Paper series, we will compare system performances using the overall measure of Data Centre efficiency illustrated in Figure 3 below, namely:

PUE = Power In / Power Out

(PUE means Power Usage Effectiveness)

This same metric is sometimes referred to as PUI or PUC (Power Utilisation Index, or other related terms). Irrespective of what name is used, the purpose of the metric is to express:

- how much energy has to put IN to the Data Centre through the incoming power supply, in order to
- deliver a given power into the IT equipment to enable the useful work to be done.

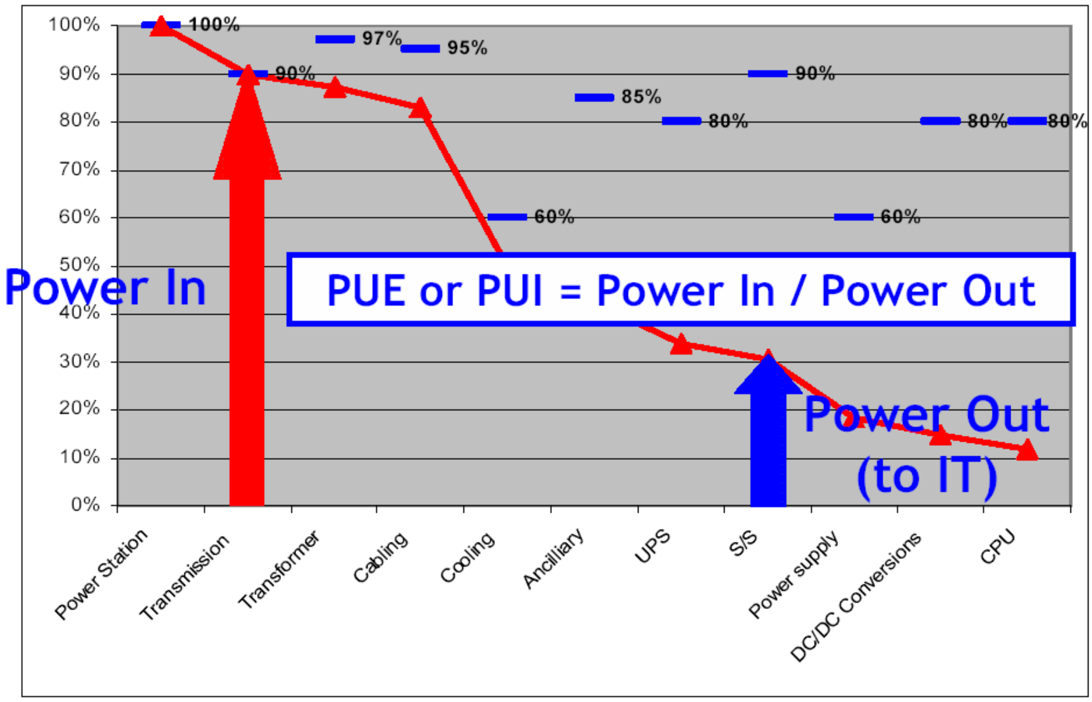

Figure 2 - A Metric for Data centre Energy Efficiency – PUE (or PUI)

You'll notice that Figure 3 shows this metric relating to the power going into the IT racks, which is something that you can readily measure, and hopefully are able to control using engineering and facilities management external to the IT function. However, that IT equipment is not as energy efficient as you'd wish once the power gets into the kit. We're going to cheat a little in Part 2 by looking at some techniques to reduce the Power "Out". Why? Because the impact on the overall energy efficiency of your data centre is SO significant.

Performance Benchmarks

A study published by Lawrence Berkeley National Laboratories (LBNL) in 2003 examined the efficiency for a number of Data Centres in the US, and found a PUE range of:

- Best: 1.5
- Good: 1.7
- Average: 1.9 to 2.0
- Fair: 2.2
- Poor: 2.4
- Worst: 2.7

Source: Data Centre Energy Benchmarking Study, Berkeley Labs, Feb 2003

Discounting the best and worst leaves a grouping around 2 or just above.

Our own analysis of a client's Australia-wide facilities in field capacity audits conducted between 2001 and 2003 found PUE in the range:

- Best: 1.75
- Average: 2.1
- Worst: 2.49

These 12 facilities range from 300 to 1700m^2 floor area size. They incorporate some of the techniques described in the later parts of this White Paper series.

Facilities loaded to or near their design capacity will operate more efficiently than those which are significantly under-loaded, since elements of the plant (including in particular UPS and Generator sets) suffer lower nett efficiency at lower loading.

We're going to assume that a "typical" facility starts at a PUE of 2 for the purposes of comparison of energy efficiency techniques in the next 2 parts of this series. Your facility may be better or worse than this now. To achieve our 40% improvement target, we'll reduce the IT load by 20% and achieve a PUE on the balance of 1.6.

TARGETS FOR A GREEN DATA CENTRE

With growing concern about the energy usage consumed by Data Centres, the US EPA were tasked to prepare a report dealing with the historical trends and future energy scenarios. Released in August 2007, the report included a forecast plot (shown in Figure 2) for various scenarios of energy efficiency development in Data Centres. These include two possible energy savings scenarios that are our target:

- The "Best Practice" brown line represents an estimate of what's possible, by applying the best combined commercially available 2007 practices for a new build
- The "State of the Art" blue line sets estimated targets for beyond this timeframe, using best-of-class solutions that were in focus, but not necessarily commercially available or accepted, at the time of the EPA report.

  Click here to find out more about these future trends

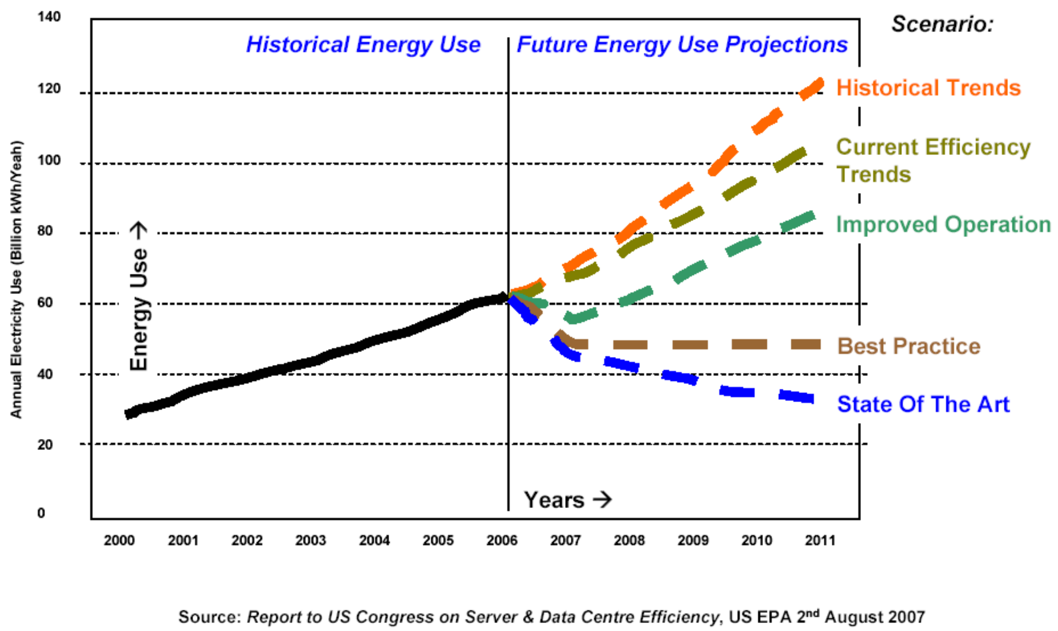

Figure 3 - Forecast USA Annual Energy use in Data Centres

In this White Paper series, we demonstrate how to get to the "Best Practice" target scenario. A large number of Data Centres do NOT incorporate the techniques we describe, and we'll discuss some of the reasons why this is the case.

Where is the Energy used?

Within your data centre, energy is used for IT load (part of which is the useful work), cooling & air conditioning, and lighting. Losses occur within these systems, and in the UPS or DC plant. Figure 4 indicates a typical energy usage profile across a total 2MW load (serving a 1MW IT load). Chilled Water close-control air conditioners (often referred to as CRACs) are used for the air conditioning system.

You can see that only 50% of the total power being consumed is being used within the IT racks. You can also see that the "IT Losses" (which are due to power conversions within the racks, primarily) account for about 25-30% of that IT rack load.

We'll use this model to compare the impact of various changes later on. We'll also assume that the load is constant over the whole year, and that the energy cost is 5.7 cents per kW hour (kWh – a kW used for 1 hour). At this energy rate, the electricity bill for our sample Data Centre is $1,000,000 per annum. Conditions in your Data Centre may vary from this sample model, or the plant systems employed may use differing portions of load for different aspects. The principles remain valid, even although some of the details vary.

It's important to note that as plant utilisation for some equipment falls as a portion of their intended maximum load, their inefficiency gets worse. This is especially so for UPS, chillers, fans and pumps if they are not designed for "turn-down" capability.

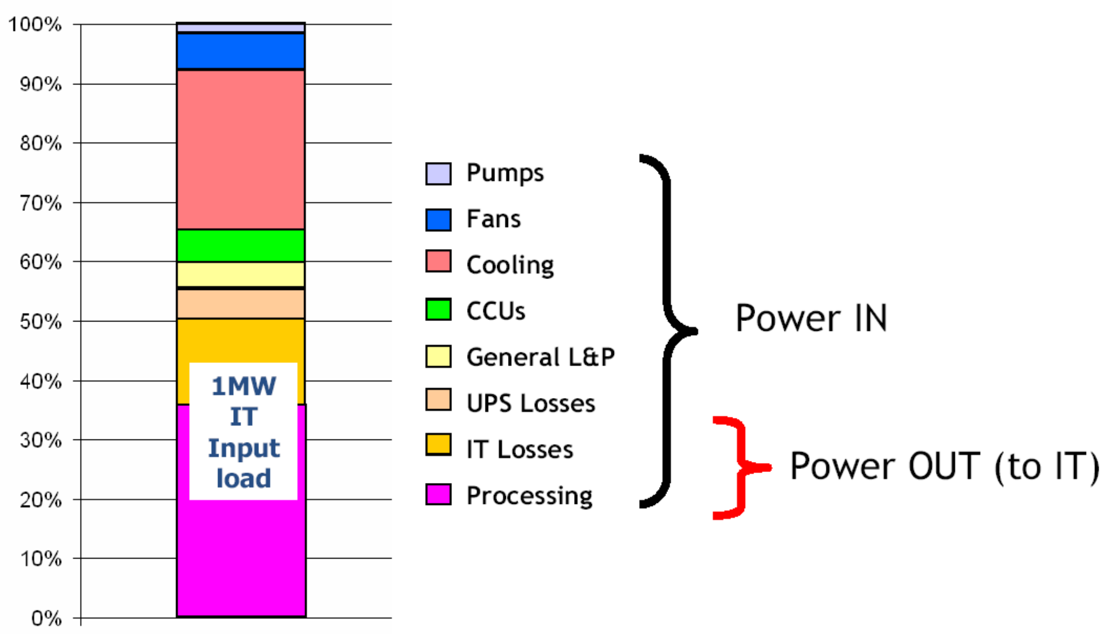

Figure 4 - Energy use in a sample Data Centre – 1MW IT load, PUE = 2

Load categories shown in Figure 4 are:

- Pumps – for circulating coolant
- Fans – for circulating air used in air conditioning and ventilation systems
- Cooling – for the refrigeration plant selected to remove heat from coolant to the outside of the Data Centre
- CCUs – Computer Cooling Units (CRACs etc) where used locally in raised floor areas or to serve specific equipment racks, excluding fan and cooling components
- General L&P – the lighting and general power loads
- UPS Losses – conversion losses between the input to the UPS (or DC) and the output to the IT equipment racks
- IT Losses – conversion losses, primarily, within the IT equipment racks between the power input and the power used for processing
- Processing – the power actually used for useful work by the IT equipment.

IS AN IMPROVEMENT WORTHWHILE?

Check your latest Data Centre energy bill, compare it to your other costs. Chances are that your electricity charges are already a significant portion of your operating expenses. Even if you continue to enjoy some of the low energy cost regimes that have been available since about 2000 (when a large stock of Data Centres were designed and built), it's likely that those energy costs will increase by about a factor of 2 by 2010. You may already be planning for such cost increases, or may have seen them already. Bottom line – the days of relying on cheap energy from the grid to feed a hungry Data Centre are behind us.

As corporate awareness of ESD matters has grown, and political interest along with it, you've probably been asked by current or potential customer representatives for your "green" credentials in energy and water savings. If your facility includes a co-locate offering, this could be a deal-breaker.

Those two factors may be enough to convince your business that an improvement is valuable to you. Until the general ESD mindset improved, this was rarely true; any energy efficiency measures had to have payback within a few years measured in hard dollar terms alone. Sometimes that's still the case for improvement strategies, but there is another compelling argument for energy efficiency – infrastructure utilisation. Your expensive Data Centre has capacity limits at some point; if you can reduce the usage of that capacity, you have more capacity. More capacity means more equipment that your Data Centre can support, at the cost of the energy and water use only. That's an argument any of your IT staff who are allocating valuable space will understand.

CONCLUSION

Data centres are massive power users. A typical medium size 2000m^2, 4000 kW, 2005 build Data Centre has an annual energy consumption equivalent to about 3000 2-3 bedroom homes. For an outsider, the energy usage looks a lot like a big carbon factory using large amount of energy, inefficiently, to support IT functionality.

A majority of Data Centres of the 2000-2005 era are environmentally unsustainable models for the next build cycle.

Data Centre benchmarking in the US and Australia has found that an average of around 50% of the power input is used for IT load. Best Practice approaches that were available in 2005 are not yet implemented in many Data Centres. They provide the opportunity to enhance energy efficiency on a Power IN / Power OUT basis significantly, with further improvements available from IT equipment side efficiencies.

Improvements may or may not save you money when measured in isolation. If the cost reductions alone are not sufficient incentive, the capacity recovered for additional IT load may be.

FURTHER READING

The authors recommend:

- Lawrence Berkeley Laboratories resource centre at http://hightech.lbl.gov/datacenters.html
- *High Performance Data Centers – A Design Guideline Sourcebook*, January 2006, Pacific Gas & Electric Company

CONTRIBUTORS

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Since 1995, Rowan has been key contributor within NDY's Data Centre design teams, with over 125,000m^2 of new or upgraded Data Centre space to his credit across primarily Australia and New Zealand locations. Prior to his Data Centre design days, Rowan was Data Centre Facilities and Operations Manager for a multi-national firm's facility in Australia for 4 years.

Patrick Fogarty – Director

Patrick leads NDY's UK operations and is a prominent figure in Data Centre projects across Europe, with experience in over 150,000m^2 of new or upgraded Data Centre space. His application of ESD design principles has seen Patrick drive the debate on the realistic applications of technology to the "greening" of Data Centres.

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