The Challenge of Energy Management "Are renewables enough to keep the lights on?"

Responsive Environments – Next Generation Datacentre's

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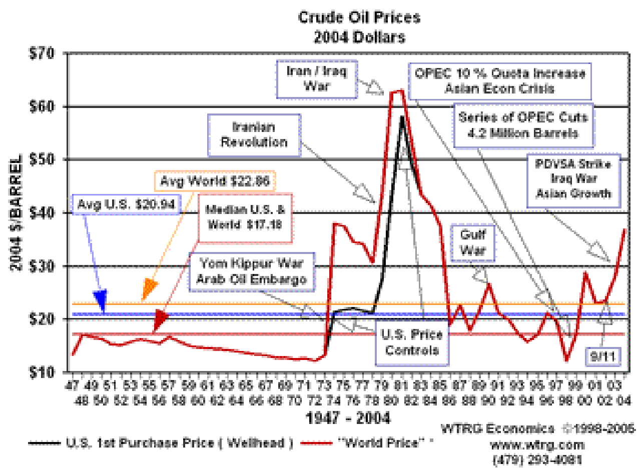
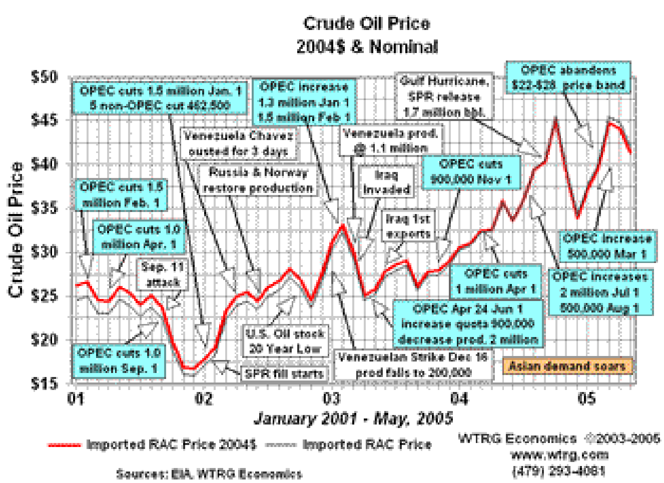
Business Drivers………

- **Technology is key** – earlier what used to be done via Human interaction has become technology driven – this is becoming a **key business differentiation**.
- Companies rely on their information systems to run their operations and **maintain business continuity.** The main purpose of a datacentre is running the applications that handle the core business and operational data of the organisation.
- Not just commercial business or industry – today all areas of human activity and endeavour are more and more **reliant on technology which somewhere in the support chain will often contain a datacentre facility………………..**

Reality check– cost, supply and demand





- The days of cheap energy are gone and there is increasing uncertainty over security of fuel supplies.
- **"The energy abundance on which this nation was built is over"** – Former Federal Reserve Chairman Alan Greenspan, Washington June 7th 2006 (Reuters);
- **"doubted producers would pump enough oil to meet future demand"** and;
- **"the buffer between oil supply and demand was razor thin"** and **"even small acts of sabotage or local insurrection have a significant impact on oil prices".**

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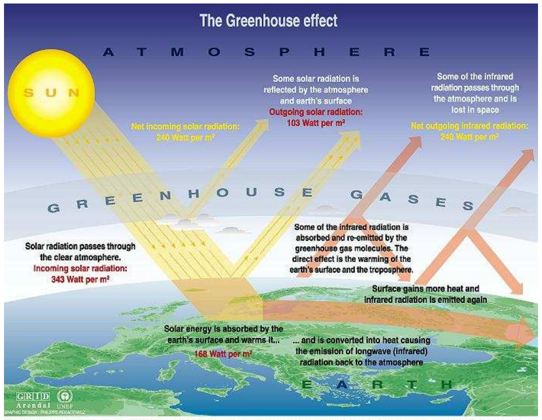
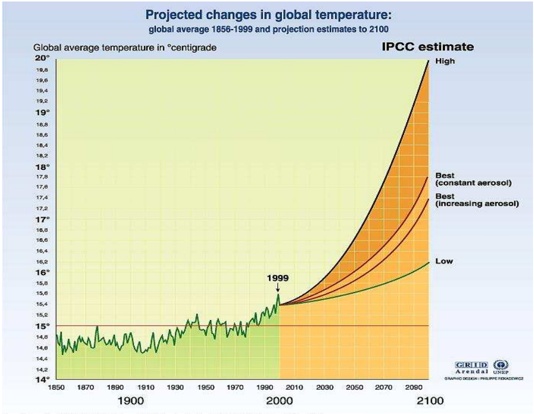
Increasing environmental focus



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.



Source : Temperatures 1856 - 1999: Climatic Research Unit, University at East Anglia, Norwich UK. Projections: IPCC report 95.

- Whatever the reason's you choose to believe in (human activity?) **greenhouse gas levels** in the atmosphere are **increasing.**
- Climate change **affects the patterns of electricity demand** and the **efficiency** of the **raw power plant**.
- **Governments** struggling to achieve publicly made **commitments to Kyoto targets look for** the areas most likely to provide a opportunity for **serious energy reduction** (and perhaps also an opportunity for a new tax revenue stream).
- The **datacentre is a prime target for "greening**" and **energy efficiency/reduction** due largely to its incessant consumption of energy.
- Public pressure – Corporate Citizen.

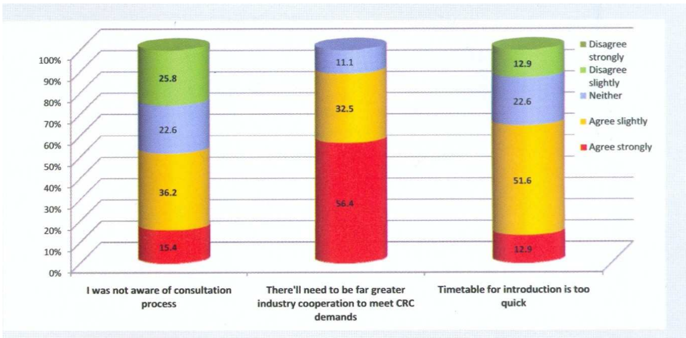
Sufficient Power and Cooling capacity are always key concerns for any datacentre

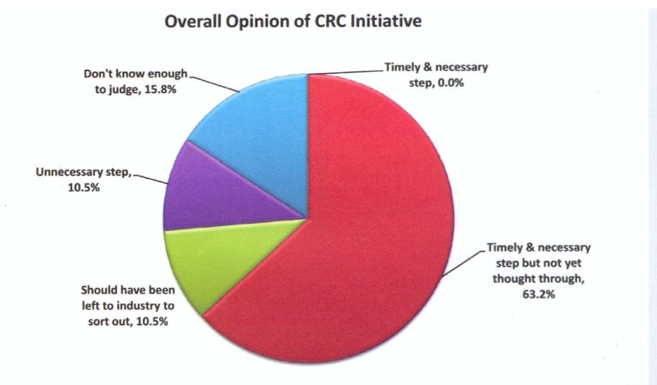
Priority for 2012 Olympic Games- "shackling the City of London, the UK's top money earner, by denying it access to the national grid"
– The Guardian, Thursday 29th May 08

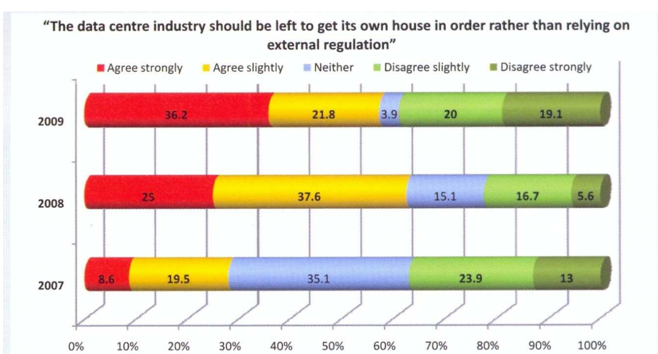
- Are we still too wedded to the Tier 1 Cities?
- While some are taking advantage of capacity off-tier others are experiencing difficulties due to their need to be in close proximity to the tier 1 markets -

  but if this critical aspect of your business only accounts for between 17% to 25% - why not move the other 80% and gain additional headroom for that which is really critical without any increase in current capacity ?

Increasing regulation & codification







- UK Carbon Reduction Commitment (CRC)
- EU Code of Conduct for Datacentre's (EU CoC)
- EU Energy Performance Building Directive
- Revision of Part L of The Building Regulations 2000 "Conservation of fuel and power
- Climate Change Levy
- F-Gas regulation
- EU Eco-design Directive for Energy Using Products, Energy Star, Eurovent certification
- BREEAM, LEED certification,
- Carbon Trust ECA Scheme
- Green Grid metrics PUE/DCIE
- BCS
- Financial instruments
- Standards ANSI-TIA-942-2005 / ASHRAE TC9.9 etc,
- **Legislators should always engage and consult with the industry to ensure the most effective means of dealing with the issues of energy consumption are implemented.**

Data havens - ways to avoid punitive legislation?

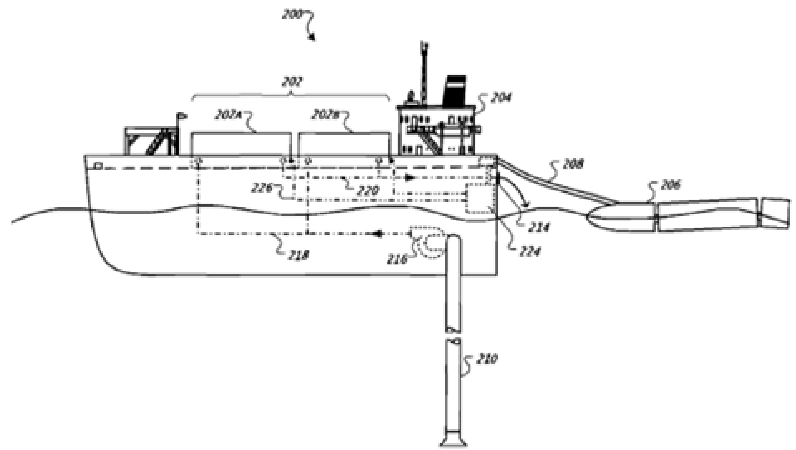


FIG. 2

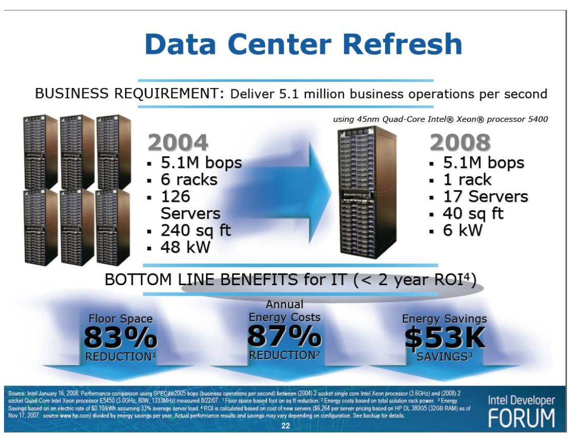
This is the side view of the data center system.

- On a sea fort 6 miles offshore a sovereign principality – Sealand.

- Containers take to sea not just for shipping purposes enroute to a site on terra firma but for deployment as a **floating DC** using the **tides for energy generation** and the **sea** as a thermal heat sink **for cooling**.
- Lots of issues around marine DC installations

denser with more frequent change, focus on efficiency and cost

- Blade technology adoption as a mainstream architecture
- Consolidation & Virtualisation
- Dynamic cooling loads
- Cloud Computing (External / Internal)
- Warehouse-Scale Computer (WSC)
- Thin-client architecture



Together with the above, the recent economic turmoil and the ever shrinking business horizon has driven the need for more flexible, scaleable, modular DC facilities

Stranded capacity = inefficiency for power & cooling

Figure 4 – *Using scalable power and cooling to minimize the inefficiency of unused capacity during consolidation and regrowth*

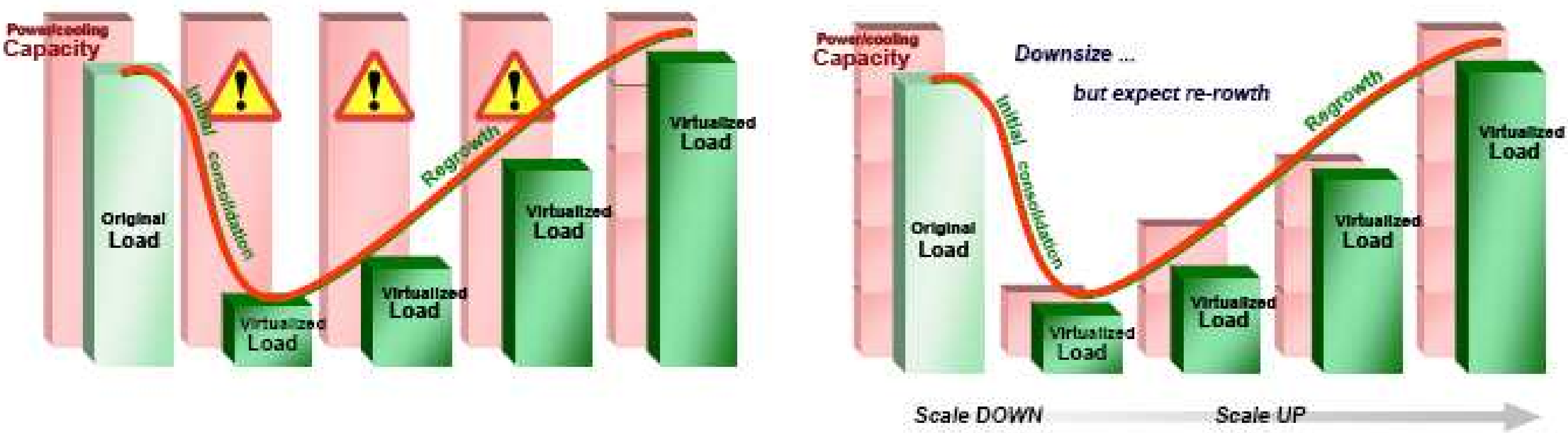
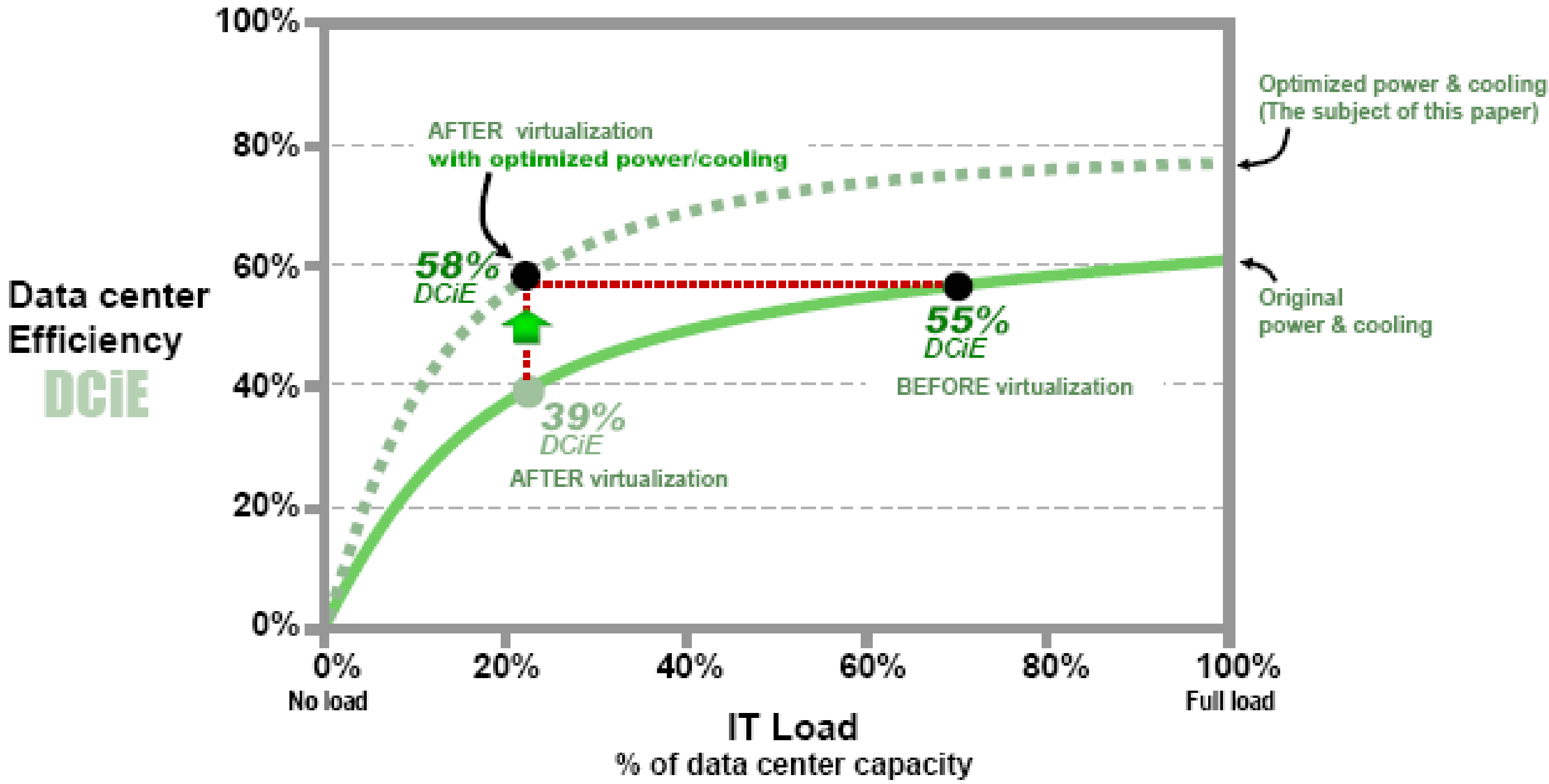


Fig 4a – Power and cooling not downsized after virtualizing
Unused capacity is a significant source of inefficiency (low DCiE)

Fig 4b – Right-sized power/cooling
Scaled capacity maximizes efficiency

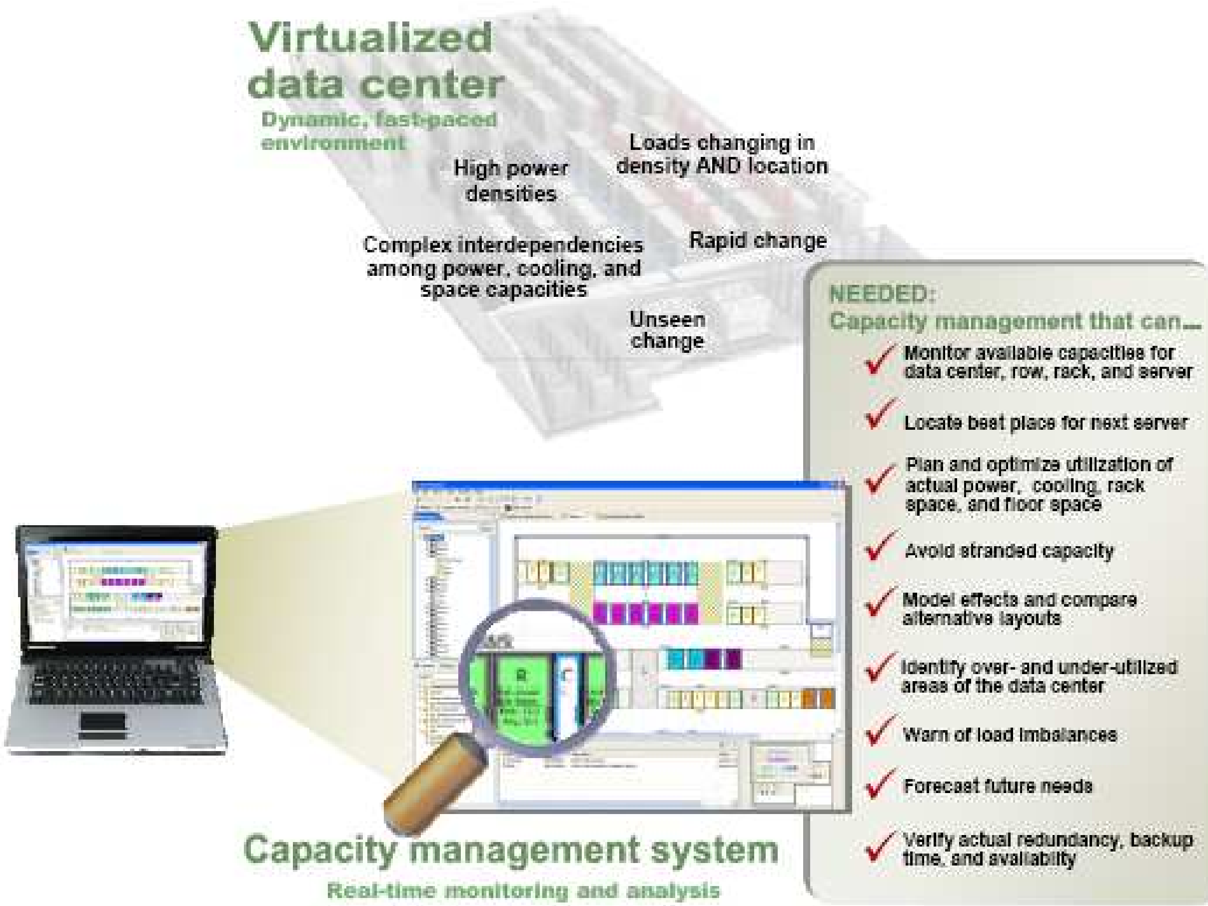
Raising the efficiency curve

Figure 13 – Optimized power and cooling raises the efficiency curve

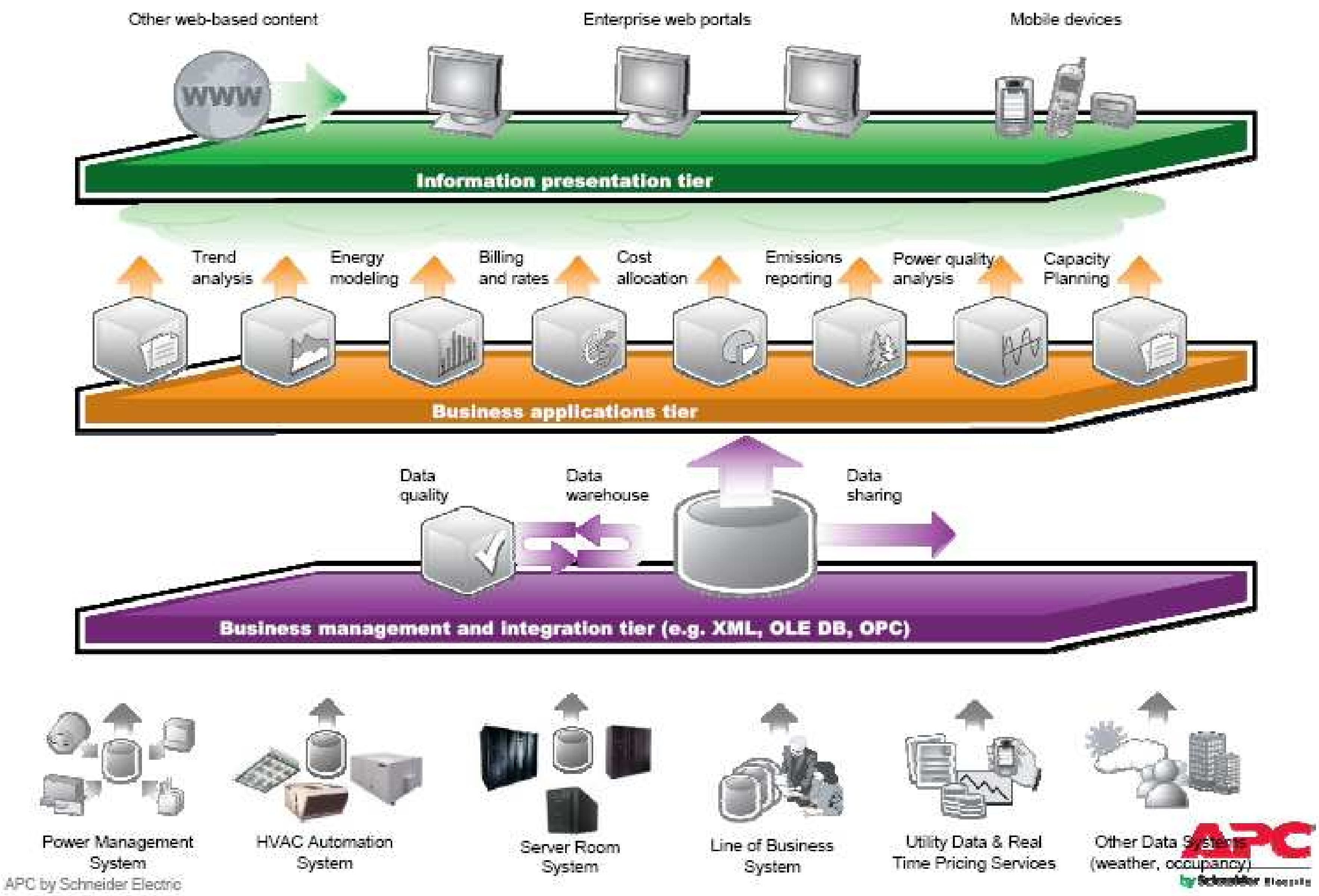


Management of a virtualized environment

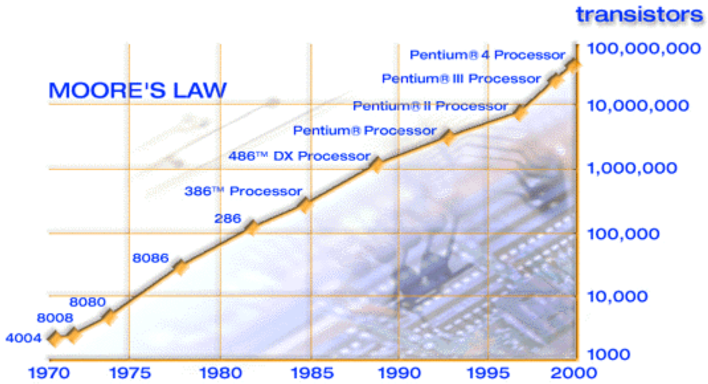
Figure 5 – Meeting the management challenge in a virtualized environment

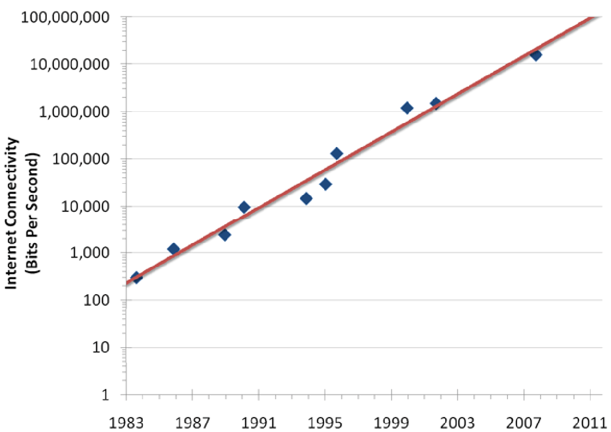


PowerLogic ION EEM software architecture



Moore's Law and Nielsen's Law





- Processing **power increases on the CPU** due to Moore's Law but without the ability to get it off the CPU fast enough due to **pipe limitations** (ISA bus late 90's). **Clock speeds** were **increased** but without great gain in data throughput, **multi-cores** introduced to help overcome **wire delay** and increase data throughput.
- Moore's Law- **computers** double in **capabilities** every 18 months or about 60% annual growth, a factor of **100x every 10 years**. Nielsen's Law relating to the speed of **bandwidth** has a 50% annual growth, a factor of only **57x** over the same timeframe.

Location, location, location.

- Traditionally the prime clients and top dollar have been obtained by those facilities located in the **Tier 1 Markets** which in EMEA are the following cities:-
- **Amsterdam**
- **Frankfurt**
- **London**
- **Madrid**
- **Paris**
- Increasing regulation, power supply issues, and environmental pressure together with technology improvements are likely to significantly impact the selection of location and the dominance of the Tier 1 markets in the future.

Needs to know basis and lost opportunity – “nobody told us”

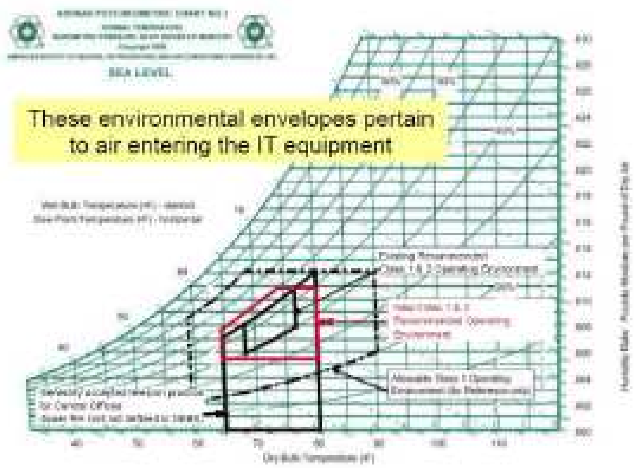
- Existing factory and offices converted to colocation facility – Amsterdam
- “nobody told us the IT industry had chosen Amsterdam as the European landing point and that you would need all this power – and would be building all these large facilities” – Chair of Amsterdam City Council 2002.

Tiering-four levels relating to availability and security ANSI/TIA-942-2005

"Is it safe?"

- Would the business not want **any** additional risk regardless of **any** potential benefits?
- **Recent trends** in an increasing power constrained and regulated market are **a move from Tier 3** or Tier 3+ **to Tier 2** and in some cases **two Tier1 or three Tier 1** facilities in a delta spaced within the latency limits.
- **The modular datacentre** (depending on the configuration of its building blocks) offers the **opportunity to have multiple tier levels within the same facility and/or use of the lower Tiers to benefit from a better PUE without any real loss in availability and security.**

2008 ASHRAE Environmental Guidelines for Datacom Equipment – Expanding the Recommended Environmental Envelope



	2004 Version	2008 Version
Low End Temperature	20°C (68 °F)	18°C (64.4 °F)
High End Temperature	25°C (77 °F)	27°C (80.6 °F)
Low End Moisture	40% RH	5.5°C DP (41.9 °F)
High End Moisture	55% RH	60% RH & 15°C DP (59 °F DP)

Table 1 Comparison of 2004 and 2008 recommended operating envelope

- **Open up the bandwidth for temperature and humidity control** to avoid wasting energy, improve the cooling plant efficiency and make best **use of "free" cooling** opportunities.
- **Don't get fixated on specific set points consider allowing these to gently "float"** within the broadest possible band – obviously within rate of change requirements.
- **Further opportunities** to broaden the operational band to save energy **requires input from all the OEM's** re their internal fan control and possible fan less versions of their boxes? – warranty issues may limit the opportunity here.

Polar research facility - to further our understanding of climate change

- Schneider Electric: Technical partner for the first zero emission polar station at Princess Elisabeth, Antarctica.
- Sustainable energy (wind generators and solar panels) and passive construction.
- Extreme conditions in which the on-board technologies must operate include violent winds, -40℃.
- Energy requirements are barely 20% of those for any other Antarctic station of comparable size.
- Handling electrical distribution, energy management, automation, supervision, and remote communication of the station (monitoring and management) during hibernation periods – March to October.

Sustainable energy –zero emissions

- Photovoltaics
- Wind Turbines
- Ground-coupled systems
- Biomass systems
- Tidal Systems
- Tri-generation
- Fuel cells
- Greywater/Rainwater recovery
- Water conservation
- Solar cooling

On-site renewable energy systems are desirable but:

1-start by reducing the loads

2-increasing the efficiency of power, cooling, lighting etc (passive design, correct design, specification, and construction.

3-reduce the carbon in the mains fuel supplies eg district biomass-CHP, off-site wind/tidal turbines community energy schemes make more environmental and economic sense than lots of separate, smaller renewable systems serving individual sites.

Passive Construction

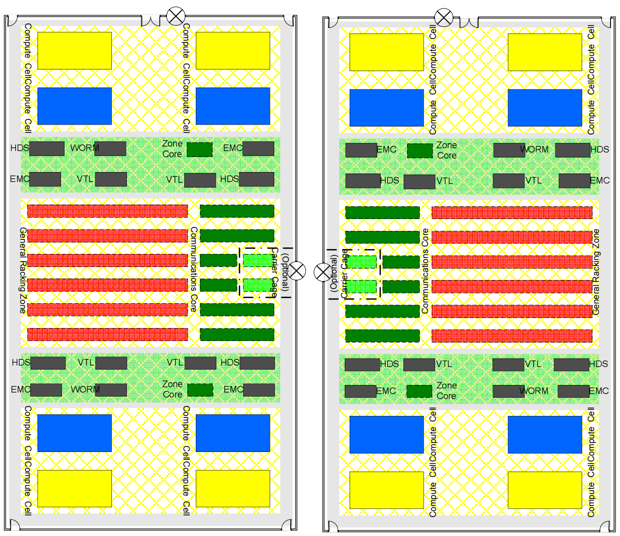
- Make maximum use of passive construction in basic design to reduce mechanical loads due to environmental gains.
- Maximise off-site work using prefabrication, standardised modular systems to better control cost, quality, and reduce or avoid the "fuzzy edge disease" of the industry (site interface issues).

DC in a tent?

- Microsoft tent in DC fuel yard from November 07 to June 08

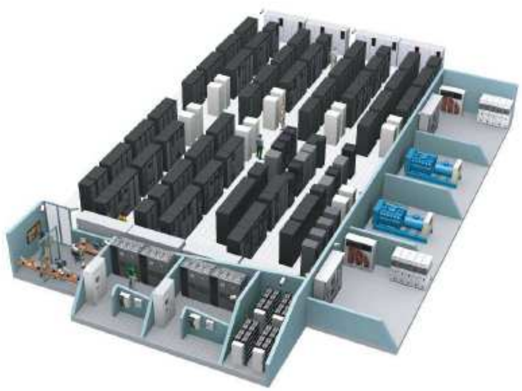
- Water dripped from the tent onto the rack.
- A windstorm blew a section of the fence onto the rack.
- An itinerant leaf was sucked onto the server facia.
- An interesting exercise to demonstrate the robustness of modern electronics but by current normal industry definition's the uncontrolled environment does not entitled this to be referred to as a datacentre.

Datacentre size



- A datacentre can occupy **one room** of a building, **one or more floors**, or an **entire building**.
- **2/3rds of US servers** are housed **in datacentres smaller than 5,000ft² (450m²)** and with **less than 1MW** of critical power.
- Most **large DC's** are built to host servers from multiple companies (colocation DC's) and can support a **critical load of 10-20MW**. Very few DC's today exceed 30MW of critical power.
- Use of empty warehouses as shell stock has resulted in **typical large DC halls of 10,000ft² to 15,000ft² (929m² to 1394m²)** which is a property development metric related to the economic span of a portal frame (27m to 30m) and has nothing to do with IT requirements. **Trends** are to breaking down DC halls **into smaller modules eg 2,000ft²**

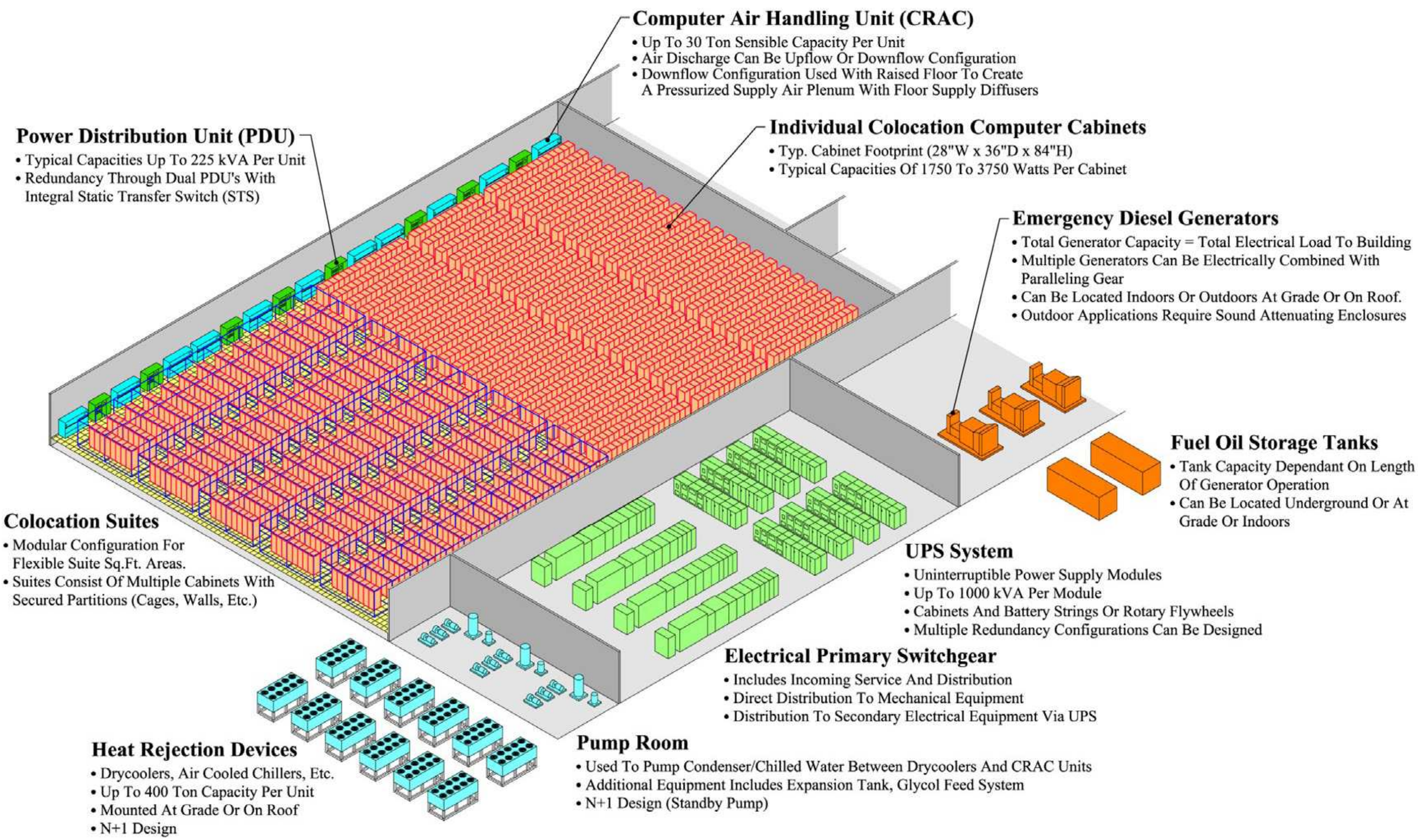
Features of the datacentre today



- Buildings where multiple servers and communication gear are colocated because of their common environmental requirements and physical security needs, and for ease of maintenance.
- typically host a large number of relatively small or medium-sized applications, each running on a dedicated hardware infrastructure that is de-coupled and protected from other systems in the same facility.
- host hardware and software for multiple organisational units or even different companies.
- Different computing systems within such a datacentre often have little in common in terms of hardware, software, or maintenance infrastructure, and tend not to communicate with each other at all.

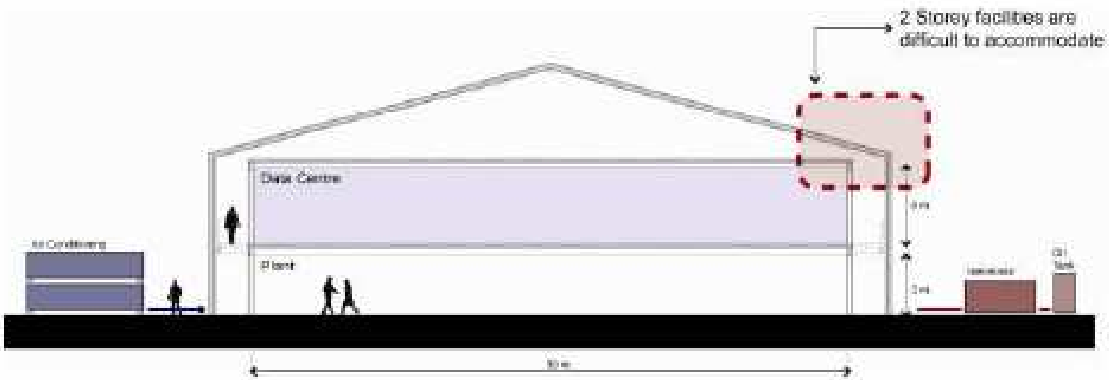
Google

Main components of a typical datacentre



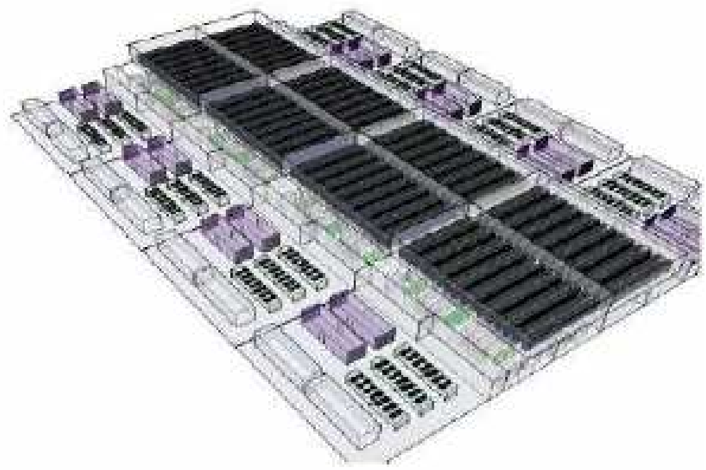
Low Cost Industrial shed construction modules relate to economic span of a portal frame- not relevant to IT needs

Two-Storey Facilities

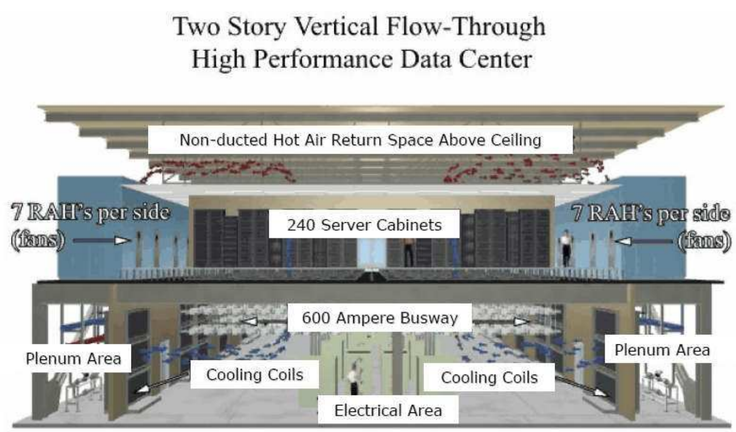


Modular build out inside traditional large halls with pods or clusters

Standardised Scalable Facilities



Topologies applicable to all DC categories in satisfying their respective requirements



- **Connectivity** – internet access and wide-area communications
- **Operational hosting** – web hosting, file storage and backup, database management, etc
- **Additional services** – application hosting, content distribution, etc
- **Failsafe power**
- **Environmental controls**
- **Fire detection and suppression**
- **System redundancy**
- **Security**

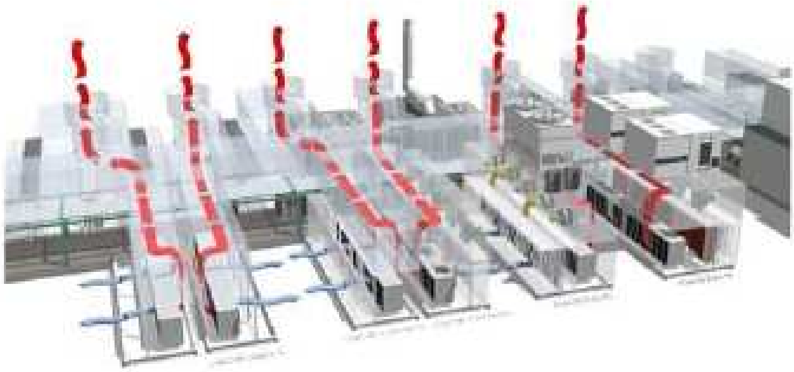
Features of Warehouse-scale computer (WSC)

- These facilities power the servers offered by companies such as Google, Amazon, Yahoo, and Microsoft's online division.
- There are significant differences compared to a traditional datacentre,

- they belong to a single organisation
- use a relatively homogenous hardware and system software platform
- share a common systems management layer
- much of the application, middleware, and system software is built in-house compared to the predominance of third-party software running in conventional datacentres
- run a smaller number of very large applications (or Internet services) and the common resource management infrastructure allows significant deployment flexibility.
- Google

Microsoft Generation IV Modular DC

Agile and adaptive architecture

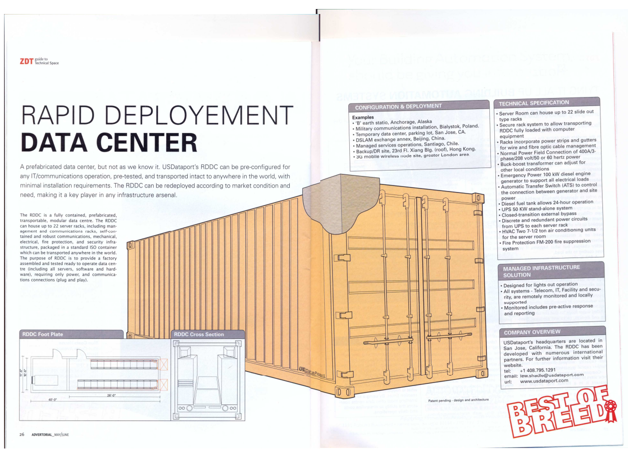


Delivering service spine corridors-2002

Construction off site

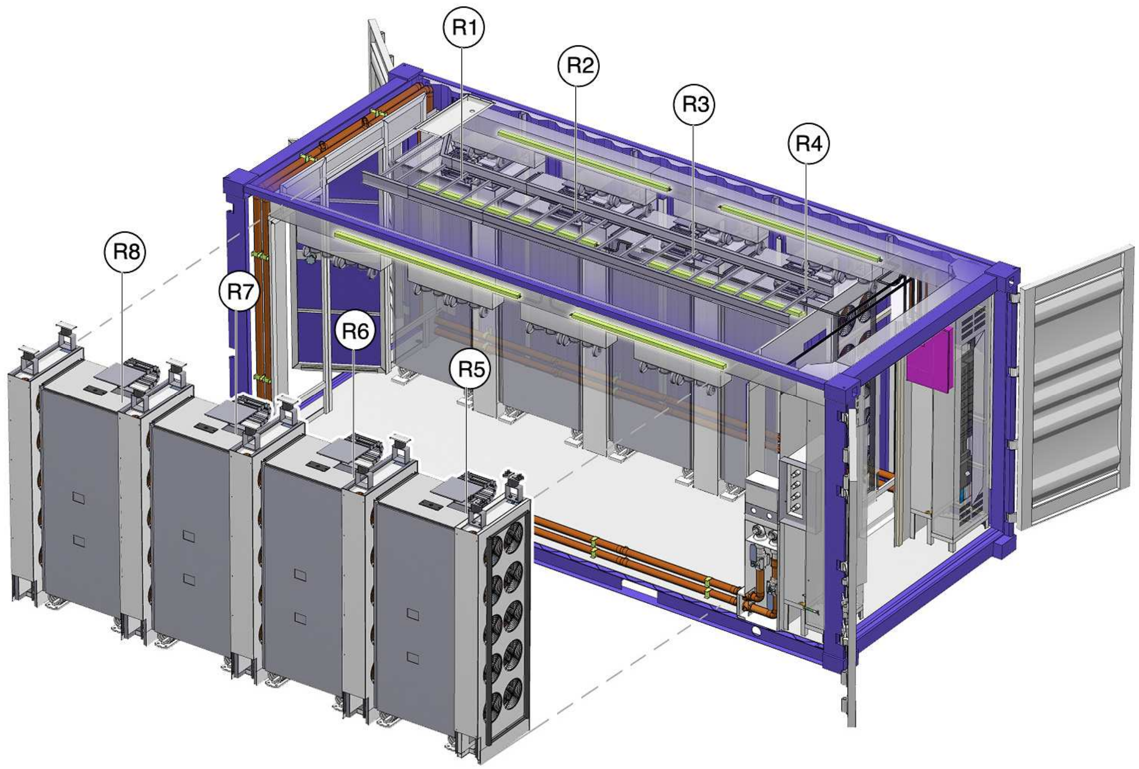
Construction off site

Containerised datacentre

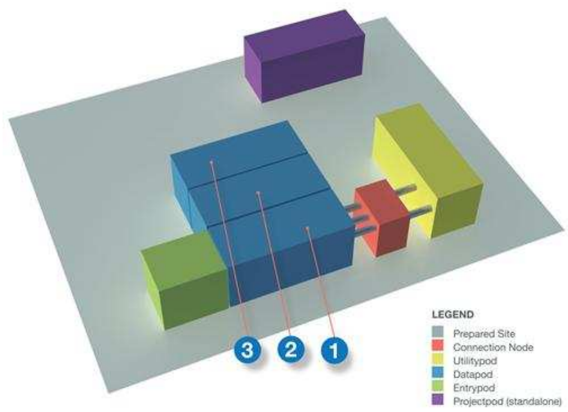


- Despite Google's patent filing in 2003 **containerised DC's are not new**, the military, oil industry and others have been using them for years, and companies like US DataPort had advertisements in DC trade magazines in 2003 for "a DC in a box" (also showed them stacked on the deck of a ship at sea).
- They provide all the functions of a typical datacentre room (racks, CRACs, PDU, cabling, lighting) even if not the physical space, in a small package. Air handling and cooling is similar to in-rack cooling and typically allows higher power densities than regular raised floor DC's.
- Rack boxes must be complimented by utility boxes containing infrastructure such as chillers, generators, UPS etc. Good PUE values.
- Google has been operating a container-based DC since 2005 and others are to be **heavily reliant on containers for new DC's – Microsoft**, **HP, IBM, Sun, Dell**, etc (**the cloud**).

Sun MDC 20



Container solution – internal/external



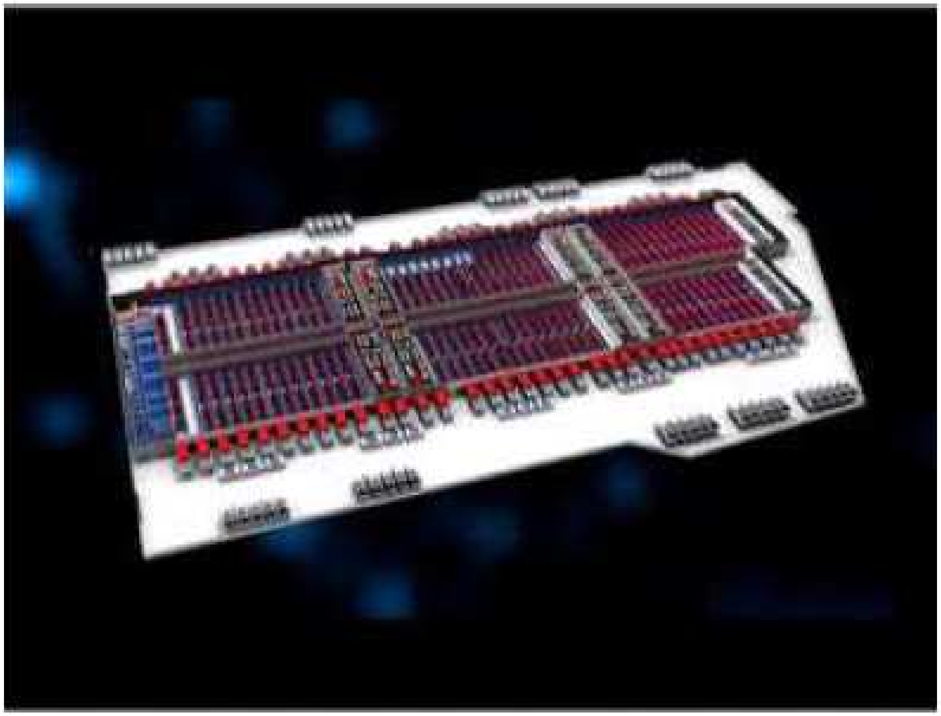
Prefabricated substation's

Prefabricated modular rooms

- Normal DC room heights – 3.8m
- Normal DC aisle widths – 1.35m
- Takes deep racks – 1.2m
- Each room with two 18m rows
- 500kW critical load per room
- N+1 cooling, dual feed power
- Weathered – use externally or internally
- Transportable

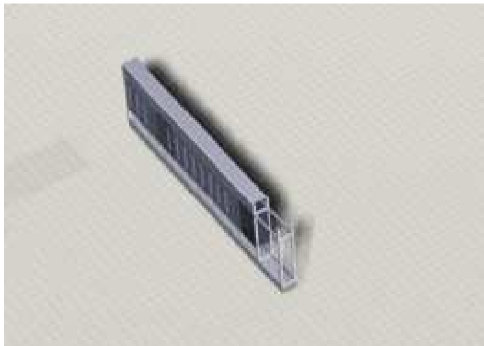
FlexDC – 2007 Prefabricated building

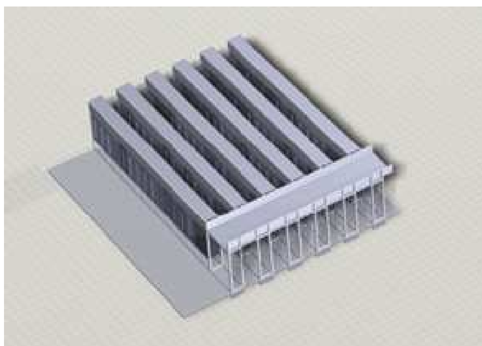
Modular DC?

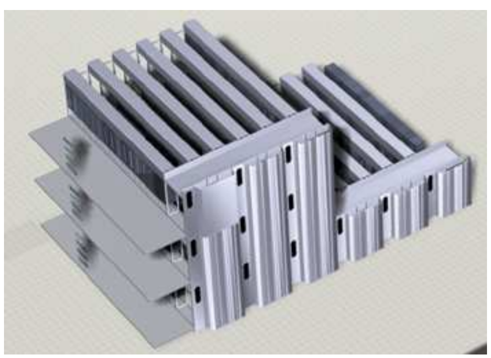


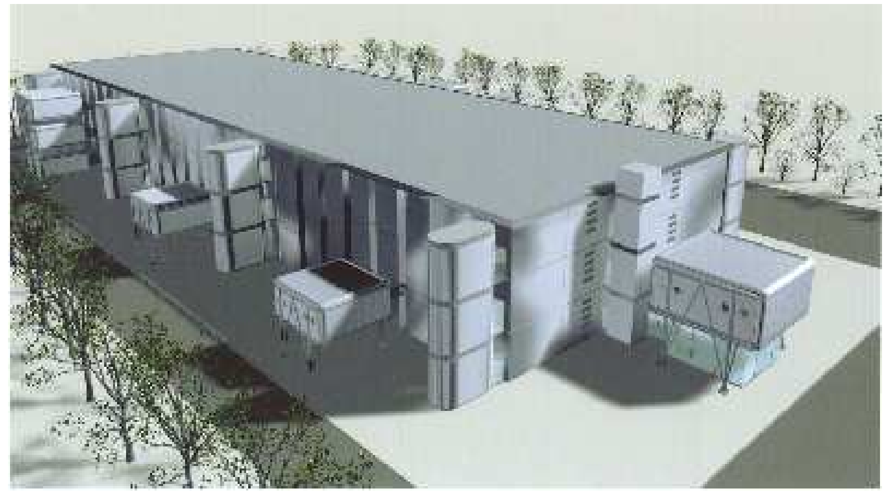
- 7000+ racks in custom ISX HACS provides secure scaleable build out in large hall deployment.
- 407,000ft² of space
- 250 MVA substation
- Modular cooling plant plugs into side of DC – all air cooling hot aisle containment maximises rack space.
- Modular generation plant at perimeter
- For security reasons the **basic construction is heavy concrete** and requires placement for whole site – **not modular scaleable in regard to the building fabric.**

The modular scaleable DC - tecnikon MDC shown at ECTA Vienna in 2000









- Tecnikon MDC 58RMU air-cooled sealed IP65 fully ducted racks12.5kW per rack
- Pre-assembled fully wired spines (rows – 20 racks per row)
- Plug-in plant modules, stair and lift towers
- Factory built/prefabricated, transported by road, - can be relocated for reuse elsewhere, fast build.

Example of concept application - ALBA 1

- **250 acre site arranged in 5 acre grid of 50 secure campus units.**
- Each campus with **IT technology space of approx 60,354 ft² to 80,472 ft².**
- Std 600mm wide x 1200 deep racks between 2,268 to 3,024 per campus.
- Std 750mm/800mm wide racks x 1200mm deep between 1,764 to 2,352 per campus.
- **Potential total site IT technology space of just over 3M ft²** with between 88,788 to 114,156 racks.
- Up to 2,114 compute cells/pods/rooms.

JIT Approach Build-out what is needed when it is needed, standardized, scalable, modular .

- **Minimum site implementation** for build out is a single **starter bay** which consists of **2 x compute cells each of 1,437 ft²** and the associated infrastructure/plant/ circulation space for rack loads scalable up to 30kW per rack (or greater if required) – **footprint 5,695 ft²**.
- Thereafter **single bays** of building structure of similar size (**2 x 1,437 ft²**) **overall 3,815 ft²** inc plant etc can be added individually or in multiples as required according to the users business need in a **step and repeat** approach.
- **Payment is only made for** the **infrastructure actually deployed** when it is deployed – not for reserved space to grow into.
- Adequate land, power and cooling resource **ensure future upgrade capability using JIT approach..**

Power and Cooling and touching earth lightly

- **Dual Grid supplies 400MW**
- **Bio-mass 2 x 50MW** from community facility using existing sustainable renewable fuel supply (waste from established industry)
- Maximising use of direct and indirect **“free cooling”.**
- Infrastructure is not just **recyclable** but more importantly **reusable**.
- **Virtually everything can be** removed from site and **relocated for reuse**.

Datacentre Scotland - Summary

- **Already has**:-
  - **abundant diverse sources of renewable power**
  - **favourable ambient climate**
  - **available reasonably priced land**
  - **a skilled workforce**
  - **favourable political climate**
- **Important to**:-
  - **acquire connectivity direct to mainland Europe and US** without having to route through London
  - **engage with industry**
  - **meet client needs** with green, energy efficient, responsive, agile and adaptive DC architectures
  - **establish centre of excellence** ("high tech cluster") around university research facilities and training for future industry requirements.

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The infrastructure must support the technology to support the business

- We require modular, scalable, responsive architectures
- An agile infrastructure adapts to the ever changing business needs