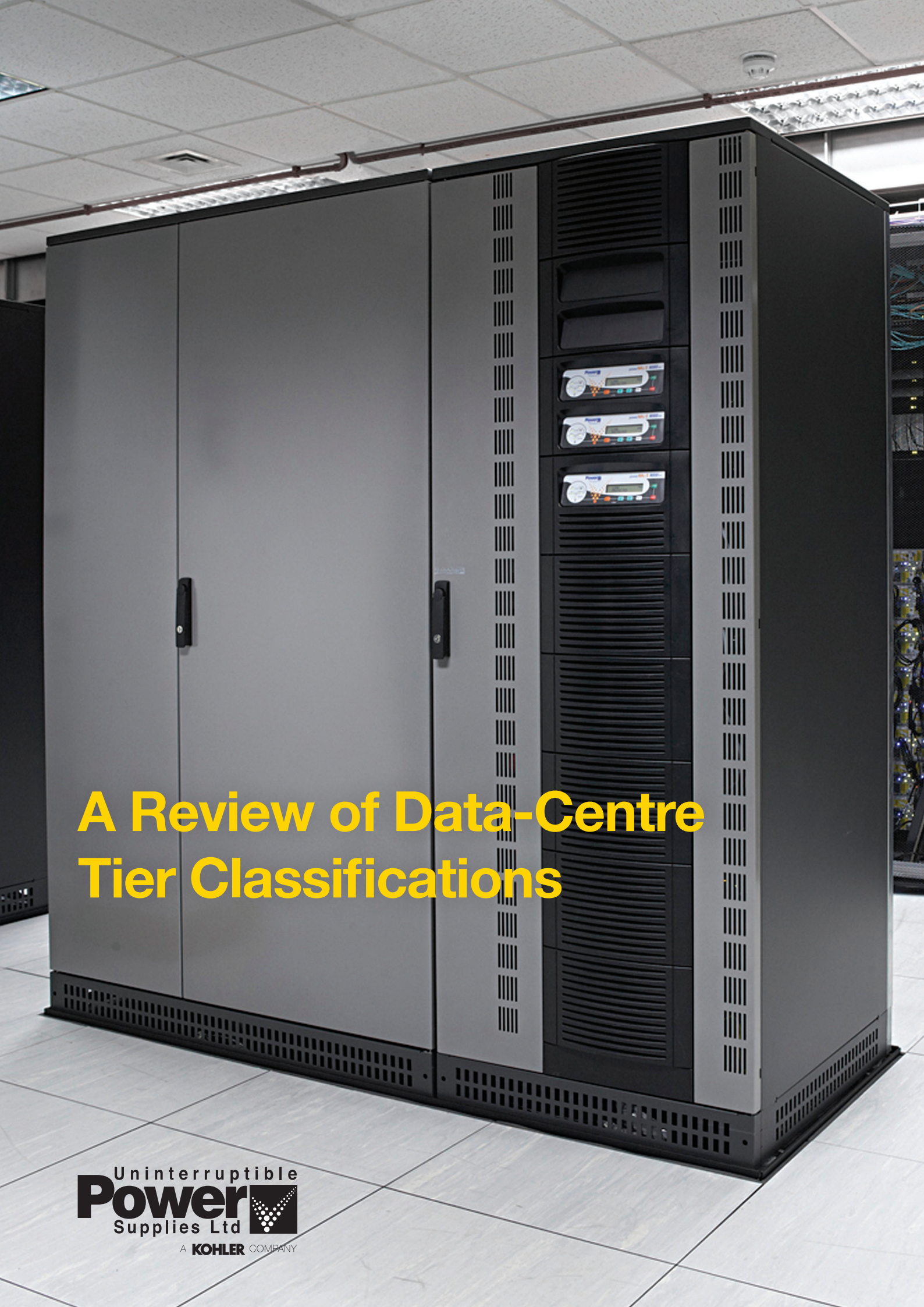


A Review of Data-Centre Tier Classifications

Uninterruptible Power Supplies Ltd

A KOHLER COMPANY

Information technology clients expect an Availability of 99.999%, 'Five-Nines'

The substantial investment that a business makes to achieve Five-Nines in its computer hardware and software platforms is unlikely to be sufficient unless matched by a site mechanical & electrical infrastructure that can support their availability goals. Data-centre's are classified by their Availability which comes down to their capability to achieve concurrent maintenance and fault tolerance but their overall site 'Tier' rating is dependent upon all aspects of the site infrastructure and will be the lowest of the individual sub system ratings covering such aspects as power, cooling and connectivity etc. It is important to be aware that operational issues (how the site is operated once constructed) also plays a significant role in what site availability is actually achieved. All too often it is assumed that installing a UPS is the end of any problems but, if the overall design, installation and ongoing service support is handled badly it could just be the beginning of the problems. For example, it is vital to ensure that the Mean-Time-To-Repair (MTTR) of the system is kept to a minimum if the highest overall availability is to be achieved. Nowhere is this more important than in the design of data-centers.

Each business has a unique Availability target driving the site infrastructure Tier level requirement

After careful alignment of IT availability objectives with site infrastructure performance expectations, an informed client may select a site infrastructure based on one of the Tier classifications. Data centre owners/ operators have the responsibility to determine what level of functionality and resilience is appropriate or required for their sites. As such, it is a business decision to determine the Tier classification necessary to support site availability objectives. Part of this decision is to balance the IT operational practices with the facility practices that support the IT infrastructure but once selected the desired Tier should be uniformly implemented across all systems.

The benchmark Tier standards

The Uptime Institute[1] has, for nearly 20 years, sponsored research and practical studies into data centre design, operation and resultant resilience and developed a Tier Classification to describe and differentiate facilities from an availability standpoint. A White Paper[2] from the Institute (authors of which include the originator of dual power supplies in IT equipment and the Tier system itself) is the basis of this review of the facility and operational concepts. The Uptime classification system describes four levels of Availability for the overall site, from the basic Tier I to the ultra-available Tier IV.

A later addition to TUI is a data-centre 'standard' in ANSI/TIA-942-2005 Telecommunications Infrastructure Standard for Data Centers, issued by Telecommunications Industry Association[3]. This follows the same Tier I-IV format and draws heavily on The Uptime Institute publications but extends the detail, especially in connectivity, and is more proscriptive. It is entirely a USA centric ANSI specification, but can be used as a very useful guide outside of the reach of ANSI. One point worth noting is that TIA-942 was specifically written for telecom related data-centre environments of a power density up to 2.7kW/m2.

Another US-centric design guide was published by BICSI[4] which introduced a 'fifth' Tier but this was Tier '0' and described a data-centre without UPS or generator support that most observers would not classify as a data-centre in the first place.

CENELEC[5] is preparing a new European Standard, EN 50600, for data-centre infrastructure which will also be based on four levels (Classes rather than Tiers) of Availability.

1 The Uptime Institute, Building 100, 2904 Rodeo Park Drive East, Santa Fe, NM 87505, USA. www.uptimeinstitute.org

2 Industry Standard Tier Classifications Define Site Infrastructure Performance; Turner, Seader & Brill, © 2001-2005 The Uptime Institute, Inc

3 TIA, Standards and Technology Department, 2500 Wilson Boulevard, Arlington, VA 22201, USA. www.tiaonline.org

4 BICSI, (Building Industry Consulting Service International Inc) 8610 Hidden River Parkway, Tampa, FL 33637. www.bicsi.org

5 CENELEC, European Committee for Electrotechnical Standardization is responsible for standardization in the electrotechnical engineering field. CENELEC prepares voluntary standards, which help facilitate trade between countries, create new markets, cut compliance costs and support the development of a Single European Market. www.cenelec.eu

Why only four levels?

It was the founders of The Uptime Institute that innovated the concept of the 'dual-cord' IT load and then went on to produce a classification system to take advantage of that feature. Prior to the dual-cord load there was only two options for feeding the power to a load: With a single-bus power system that comprised a unitary string of conditioning components that needed to be shut down for maintenance and should a single failure occur, disconnect the load. An improvement on this was to introduce redundancy in the components (e.g. N+1) that gave protection from a single failure and a degree of concurrent maintenance. Although not described as such at the time these two options covered Tier I and Tier II.

Adding the second power-cord to the load introduced the concept of the dual-bus power system, with an 'active path' including the redundant components of Tier II and a 'passive path' enabling a wrap-around power connection, for truly concurrent maintenance operations. This describes Tier III.

Tier IV, with a physically segregated 'active-path/active-path' topology comprised of two independent Tier II systems, was a very short step to very high availability, concurrent maintenance and near total fault tolerance. It is hard, if not impossible, to describe a 'fifth' Tier unless the load was triple-corded, with only one out of three cords needing power for 100% compute operation.

	Tier I	Tier II	Tier III	Tier IV
Number of delivery paths	Only 1	Only 1	1 Active 1 Passive	2 Active
Redundancy	N	N+1	N+1	S+S or 2 (N+1)
Compartmentalisation	No	No	No	Yes
Concurrently Maintainable	No	No	Yes	Yes
Fault Tolerant to Worst Event	None	None	None	Yes

Getting to Five-Nines?

Concurrent maintenance and fault tolerance is the key to the Tiers and the table (above) shows the progressive level of redundancy and resilience required and how it might be achieved. This table refers to each of several key systems that are identified by TUI as critical to the operation of a specific data-centre. For a facility to achieve a Tier classification it must achieve the benchmark in all the criteria and critical power is just one of those (sixteen) criteria.

Tier	Site A%	Nines	MDT h/5y
I	99.670	2	144.54
II	99.750	2	109.50
III	99.980	3	8.76
IV	99.990	4	4.378

Availability – a measure of 'goodness'?

To achieve a high-percentage Availability is simple – achieve a long MTBF (Mean Time Between Failure) and a very short MTTR (Mean Time to Repair), the calculation simply being:

$$Availability = \frac{MTBF}{MTBF + MTTR} \times 100\%$$

TUI has assigned a target Availability (A%) to each of the Tiers (table above) and sensibly recommend to measure the downtime (MDT) over at least a five-year period rather than over just one year.

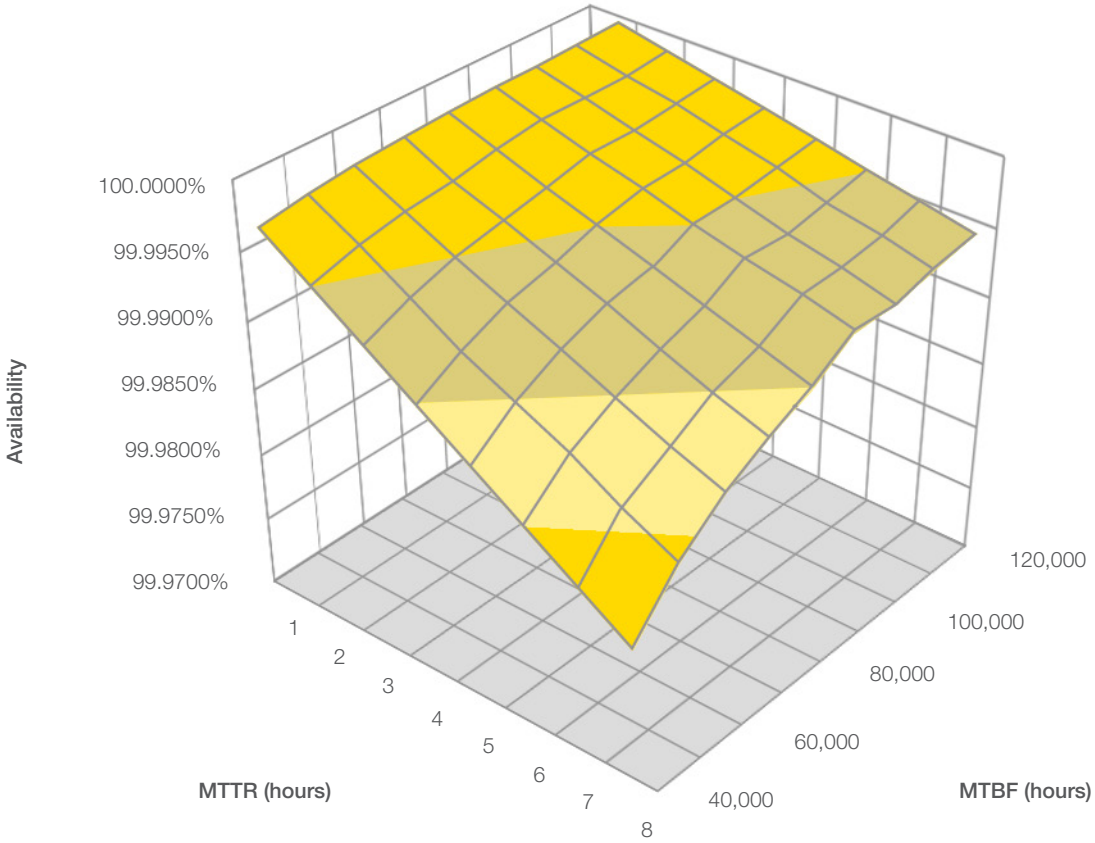
It will be immediately apparent to the reader that to achieve a defined overall site Availability then each of the sixteen sub-systems must achieve much higher performance (e.g. A% raised to the power of sixteen). For the ultimate Tier IV site this means that every sub-system (e.g. power at the load terminals) has to achieve 99.9994% - the magic Five-Nines.

The importance of a short MTTR

Clearly a wide range of 'answers' can be generated by varying combinations of MTBF and MTTR (see right) but the reality is that only an emergency service back-up that can minimize travel time to site, have comprehensive spare-parts availability and excel in first-time fix rate will achieve the sort of MTTR's needed to push the Availability to the required level for the higher Tiers. Indeed it is quite easy to demonstrate that Tier III cannot tolerate travel times of more than 4 hours to site if the system is to achieve the desired Availability performance – even with MTBF's in the 200-400,000h range.

This conclusion highlights the need for 24x7 remote monitoring, diagnostics and tele-assisted service via data-connectivity and a first-class service support organization.

Availability: MTBF Vs MTTR



Higher Tier power systems don't come cheap...

Comparing systems is rather complicated when taking into account the type of load (single-corded or dual-corded) and the scale of the system with its redundancy plan. In the strict definitions Tier III & IV are only intended for dual-cord loads without Static Transfer Switches (STS). However at the most fundamental level we can take Tier I as the base cost and MTBF (=1) and make relative comparisons:

Tier	Load Cording	Concurrent Maintenance	A% Power System	MTBF Index	COST Index
I	Single	No	99.98333	1	1
II	Single	Limited	99.98547	1	1.6
II	Dual	Partial	99.99965	45	1.8
III	Dual	Yes	99.9983	45	2.2
IV	Dual	Yes	99.9999	2,450	3.0

Partial load problems with legacy UPS systems in Tier IV architecture

Legacy UPS, particularly large monolithic systems, suffered from very low efficiency at partial load. When this characteristic was overlaid with a Tier IV dual-bus 2(N+1) architecture and the usual partial load of data-centers the result can be a load per UPS module of lower than 5%. Under these circumstances it was only to be expected that very poor power system efficiency was a result.

Four developments have mitigated the traditional downside of Tier IV:

- The Uptime Institute 'reduced' the requirements of Tier IV from the double-redundant 2(N+1) to 2N (where each system is 100% redundant for the other) and raised the UPS module load by several percentage points
- Modern IGBT/IGBT transformer-free UPS technology has raised the efficiency bar considerably – with over 96% in double-conversion, even at 50% load
- Modular UPS architecture has introduced the huge opportunity to keep the load per module high and thereby minimize the UPS power losses
- Eco-mode technology options in UPS have enabled efficiency of >98% even at 10% load – especially useful in one of the two power-buses even when the end-user may have reservations about eco-mode operation for all the load

With modern technology the load can be provided with dual-bus power from high-efficiency double-conversion without any of the traditional penalties of low efficiency.

The upside of dual-bus (Tier IV) power systems

In addition to the clear advantage of several magnitudes of increased statistical Availability, Tier IV power has the potential to raise the actual system performance if implemented correctly: With most reports agreeing that 60-70% of all failures in the data-centre attributable to human error any feature that protects against human intervention has the capacity to remove instantaneous failures and including inadvertent EPO activation.

Conclusions

Whatever Tier Classification is chosen, 24x7 remote diagnostics, tele-maintenance, spare-parts access and sub-4 hour emergency repair performance achievement are essential to meet the Tier III and IV Availability targets. The first-time fix rate will dictate the site Availability.

Tier IV, for dual-corded loads is, by more than 1000x, the most resilient power architecture possible. The traditional drawbacks have been the high CapEx (typically a 35-40% premium over Tier III), higher OpEx with partial load inefficiencies and under-utilized plant that can be regarded as wasteful of resources, However if the client needed a specific classification (e.g. Tier IV for a given business case) then there was little choice but to follow TUI. For the future in Europe the new standard, EN50600, will offer a locally applicable Availability Class.

With modern UPS technology, modular architecture and, optionally, eco-mode operation, all the efficiency disadvantages of Tier IV are removed.

About Uninterruptible Power Supplies Limited

UPSL is a leading provider of power protection product and service solutions including UPS, standby diesel generators, battery banks, software and ancillaries. Part of the Kohler Corporation's Global Power Group, UPSL has a proven and enviable track record with customers across all market sectors around the world ensuring 24/7 power protection of mission-critical business systems.

Uninterruptible Power Supplies Ltd, a Kohler company,
Woodgate,
Bartley Wood Business Park,
Hook, Hampshire RG27 9XA

Tel: 01256 386700

Fax: 01256 386701

Email: sales@upspower.co.uk

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UPS713-01-00 A review of data-centre Tier Classifications – White Paper