Boeing Comments
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Block #1 - Definitions

Uninterruptible Power Supply - the basic definition is fine as written. But there are some terms for subsets worth noting, which do not readily fall into the other definition groups.
• Static UPS - uses power electronics to convert between AC and DC for interacting with chemical batteries or flywheels.
• Rotary UPS - uses a flywheel with a motor-generator on a common shaft.
• Multiple Module UPS - for very large systems the static or rotary components are separate assemblies paralleled through one system control, usually in separate switchgear.

System Topology - for line interactive systems the last sentence refers to the battery charging current. The industry term is "float current". But any UPS that leaves the rectifier energized regardless of operating state will float the batteries. Shelf life for UPS lead acid batteries without float current is around six months. Other battery technologies (e.g. NiCd) may have different shelf life, but lead acid is by far the most common battery type in the UPS marketplace. Also it is certainly possible to mate a larger UPS to a flywheel and eliminate the chemical battery. Flywheel systems have their own version of float current to keep the flywheel at nominal spin.

System Topology – the definition for double conversion is not specific enough. IEC 62040-3 states "Any UPS operation, where continuity of load power is maintained by a UPS inverter, with energy from the d.c. link in normal mode of operation or from the energy storage system in stored energy mode of operation (see annex B.I). The output voltage and frequency are independent of input voltage and frequency conditions." I would change the first part of the framework definition to "A double conversion UPS device routes input power through a rectifier, then separately derives output power through an inverter. The DC link between the rectifier and inverter also supplies float current for the UPS batteries or flywheel." The use of the term "separately derived" has significance and ties this particular topology to section 250.30 of the National Electrical Code (NEC, a.k.a. NFPA 70). I am not suggesting any direct link between this specification and the NEC, but "separately derived" is a useful term in this context. *Note: Passive standby and line interactive UPS systems may not be separately derived sources depending on their construction.*

System Topology - one manufacturer (Schneider Electric/APC) has developed a variation of double conversion with elements of line interactive which they call delta conversion. The target market is identical to standard double conversion systems. In their own white paper on UPS types, they liken delta conversion to double conversion. For ease of general classification, I recommend adding to the double conversion paragraph, "Delta conversion is considered a form of double conversion with regard to this specification."

Energy Storage Mechanisms - Flywheel storage is implemented in two ways, of which only one is described. The definition as written is applicable to a diesel rotary UPS (DRUPS) such as manufactured by Hitec. The ride-through time is extremely short, on the order of ten to twenty seconds. The other application for flywheels is as a battery replacer in a static UPS, such as manufactured by Active Power. The ride-through time can be extended beyond twenty seconds through individual flywheel design and by paralleling flywheels.

The operational states described in the Framework are more specific to topology than the generic descriptions provided in the March 24 conference call presentation. I prefer the specificity, although I know that goes against the technology-agnostic objective of this process.

There is one missing operational state: charging state. If a UPS has been in the stored energy state for several minutes, the batteries or flywheels will be significantly depleted and need to be recharged. Meanwhile the UPS must also carry the critical load. Additional power is drawn through the UPS input connection to supply the charging energy. The charging energy may be supplied as a current-limited load over time. Whether this is significant enough to include as part of this specification needs to be determined.

Block #1 Questions

2) UPS Operational States - a minor nit for this section where all options state utility power without mentioning site generated power. Operationally the two are the same as seen by the UPS. Somewhere in this framework there might be a mention that site generated power is used interchangeably with utility power.

3) Systems with alternate modes that have significant distinction might need to prove efficiency in each mode, perhaps noted with slash ratings. So a UPS that is 97% efficient at 30% loading in eco mode but only 85% efficient in emergency mode could be denoted 97/85 (or 85/97) for that efficiency rating. An Energy Star rating might be based on the non-eco mode only as that maintains an apples-to-apples comparison. There are other market forces which may encourage the use of eco mode but the building design has to allow for non eco mode, which impacts overall building construction and operational metrics.

4) Redundancy topology of a mission critical facility will determine the standard load condition. A rule of thumb for data center operators is to keep the worst case continuous load at or below 80% of the nominal rating for a single UPS system. For system plus system redundancy the standard load limit is only 40% of nominal; if one side fails the other side doubles its load. Most operators are loading individual UPS systems well below 40%, especially early in a facility's life cycle. Multiple data points in the 0 to 40% range are very useful, but manufacturers commonly test at 0, 25%, 50%, 75% and 100% of nominal. Because the low end is so prevalent, I would recommend quite a few data points below 50%, ideally: 0,5,10,15,20,30,40,60,80,100. (You'll note I threw away the 25%, 50% and 75% data points, they are not really significant for normal operations. But they can certainly be included as additional points to the ones I recommend.) The manufacturer practice of 0,25,50,75,100 would be sufficient for the commodity UPS (home and small office) market. Redundant modules in a multiple module UPS system add to this complexity, as the module loading will be less than the system loading at any point while all modules are sharing load. In an N+1 system, when system loading is at X percent then module loading will be around X/(N+1) percent. But the power conversion is occurring in each module, and that is where almost all the losses will be.

5) Power conditioning is usually specified in THD (total harmonic distortion). Power conditioning may be present at the UPS output separate from conditioning at the input. Conditioning at the inverter output is designed to meet a specification for downstream equipment and applications. Conditioning at the input is intended to minimize impact on other site loads, site generation (where present) and distortion propagation into the utility grid. IEEE 519 is the standard defining and setting targets for harmonic pollution. (A mild treatment is provided here: http://www.ieee.org/organizations/pes/meetings/gm2008/slides/pesgm2008p-001497.pdf) A small UPS in a large facility will be far less "abusive" than a large UPS which dominates the facility load, which is the data center case. Input filters may be provided to mitigate input THD and should be specified, especially if input filtering is a discrete option. Note that transient voltage surge suppression (TVSS) should be separately specified, especially in large systems where a TVSS assembly is a discrete option.

Block #2 – Eligible Product Categories

The Framework is clearly oriented toward data center users, being two thirds of the UPS market by your referenced EPRI study. But the nature of data center installations makes a standard framework a difficult proposition. Most medium and large data centers have multiple module UPS systems. The individual modules are standardized but the systems are specifically engineered for the application. The modules contain the power conversion and connections to batteries or flywheels, so they could be individually rated. But system design will have a big impact on energy efficiency. A 2.5MVA specification might be met with three 1MVA modules, four 750kVA modules or five 600kVA modules, and that doesn't include module level redundancy.

Block #3 – Efficiency Criteria

Right now CSA C813.1.01 is the more appropriate standard, other than the omission of power factor testing. Until I can see the draft updates to IEC 62040-3, I cannot tell if the deficiencies of the IEC standard are sufficiently mitigated. The draft is available as a password protected pdf, but I do not have the password. The IEC standard released in 1999 also includes many performance tests that do not relate to energy efficiency.

IEC 62040-3 is only good to 1000V rating, this would exclude medium voltage models of diesel rotary systems and the S&C PureWave line-interactive UPS. Medium voltage is not common in data center critical distribution—but if there were appropriate UPS technology it should be. The PureWave is even less common, but I know of one new facility that has this make. Note: the CSA standard doesn't mention voltage at all, so it is presumably valid for medium voltage systems.

In order to compare apples to apples, a multi-module UPS, or modular UPS with redundancy built into a single frame, should be tested in a non-redundant configuration. This means the basic tests should be applied to a system with only as many modules as required to support the nominal system rating. It would be valuable to know how a level of redundancy affects the efficiency in addition to the non-redundant result for each load step.

Value Added Resellers (VAR) – in large multi-module systems, the VAR plays a key role in ensuring the integration of the UPS modules and control system, and the switchgear which is supplied by another manufacturer, possibly incorporating major equipment by yet a third manufacturer (e.g. Liebert UPS with Russelectric switchgear using Cutler Hammer or Square-D drawout circuit breakers). The VAR will have a role in coordinating equipment testing according to customer specifications. None of this should affect product efficiency, except that proper systems integration is required to ensure a specific system meets the expectation of the make and model.

Block #3 Questions

1) The normal state is the only significant state with regard to energy efficiency. The bypass state should have an efficiency of 100% or it is not a true bypass path. The stored energy state efficiency is not meaningful as the input will be zero. Only the charging state has a significant input/output ratio, but the duration is relatively short and the extra energy for charging might not be worth quantifying. Charging state limits can be adjustable, adding to the complexity.

3) Business cases for redundancy and partial loading will be based on facility reliability, with energy efficiency a distant secondary factor. The Energy Star label will be of little value if partial loading is treated as a negative factor. Far better to encourage UPS manufacturers to improve low-end efficiency so there is not much difference between 10% loading and 80% loading.

4) Modularity and scalability, either in the form of plug-in units to a fixed backplane or modules connected to a multi-module system controller, may be desirable for rightsizing a UPS system. However, I would suggest type certification based on a built-to-rating system without redundancy. So if a modular or scalable system was designed for 500kVA then test it with 500kVA worth of non-redundant modules. If you try to capture all the variations, the amount of testing will be prohibitive and hard to compare across products.

7) As stated for Block #1 Question 4, even the CSA test standard load steps are insufficient to cover real-world application where redundancy is installed. The load steps I suggest for that question cover these systems in the critical load loading area of 10% to 40% found in most redundant facilities.

Block #4 Questions

2 & 4) Data center systems are highly customized. Power monitoring equipment supplied by the manufacturer may or may not be augmented by customer-requested devices compatible with preferred building management products, although a trend towards open platforms might reduce that requirement. If parameters beyond the manufacturer's standard monitoring packages are desired then third-party hardware becomes more likely. At the least for an Energy Star product, input power and output power must be monitored and unit efficiency should be reported. Utilization as a percentage of capacity would be worthwhile, even more so if the system auto-adjusted for measured power factor to the load—thus incorporating any necessary derating. I am not aware of any product that offers such an auto-adjusted utilization reporting.

Low end devices for the home and small business market will not have more than basic metering, if any at all.