

**White Paper**

**Basic Load Management Sequences Using ATs**

# Basic Load Management Sequences Using ATs

## *Reactive and Proactive Load Management Strategies Compared*

Load management strategies are used to add and subtract loads from backup power systems to ensure that the most important equipment is served, and to maximize utilization without overloading gensets. This paper describes strategies for reactive load management and proactive load management, two elementary approaches for adding and removing loads according to their assigned priorities.

### **Background Information**

In backup power systems, controls match the amount of power produced to the real-time equipment load. The most elementary example is when controls increase power output by simply increasing engine throttle to meet demand. However, if demand exceeds the maximum capacity of the genset, then the backup power system will become unable to provide sufficient power at an acceptable quality. The engine could slow or stall, leading to outages and failures.

For reasons that include cost, backup power systems often are not sized to supply all of the loads in a facility. Because facilities typically do not operate at maximum load, gensets may be sized to supply specific loads required by electrical codes, plus a portion of the remaining potential load. As total load approaches a genset's maximum output, controls must keep the most important loads online while managing the remainder to avoid overloading and failure. The following sections describe load management applications, and then explain two strategies for adding and removing loads. While load management equipment could add and shed loads by controlling circuit breakers or specific loads directly, this paper describes how to manage loads using automatic transfer switches (ATs).

### **Load Management Applications**

Load management strategies can be used to limit the size of planned backup power systems, and to better utilize the capacity of existing backup power sources. To do so, loads must first be prioritized and appropriate load management equipment must be supplied.

For governed facilities, the National Electrical Code® (NEC®) requires backup power for life-safety loads, then prioritizes critical and optional loads in that order. By using effective strategies to add and remove loads according to demand, the most important loads can be cost effectively supplied when total load exceeds capacity. Similarly, load management strategies can maximize the usefulness of existing backup power equipment as facilities expand or new loads are added, avoiding costs for adding generator capacity.

### **Load Management Strategies**

Basic load management approaches include reactive and proactive strategies. Reactive load management is the simplest and easiest strategy to implement. Proactive load management offers more efficient utilization of generator capacity and avoids placing certain stresses on gensets. Before selecting one of these approaches, it is important to understand how load management systems monitor generator performance.



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### Load Monitoring Parameters

In order to manage loads, a method for identifying overload must be implemented. The simplest way is to monitor generator output frequency. As demand begins to increase, more engine throttle is applied to maintain frequency. When demand exceeds genset capacity, frequency decreases until the engine stalls. Interestingly, controls on some gensets maintain frequency so closely that the frequency does not sag significantly before the engine stops. In such cases, frequency-based monitoring could be a poor indicator of overload conditions.

Alternatively, system output can be effectively monitored by measuring current or power (kW). Because output kW reflects other important real-time power characteristics, kW provides better predictability for changes in load. This paper describes load management strategies that primarily rely on monitoring generator output kW.

Before a load management strategy can be implemented, the loads must be prioritized. For the examples in this report, the most essential loads are unaffected by load management equipment, and the non-essential loads are managed in order of decreasing priority. For instance, ATS 3 has a lower priority than ATS 2. Using a self-contained load management unit, a typical application could be configured as shown in Figure 1.

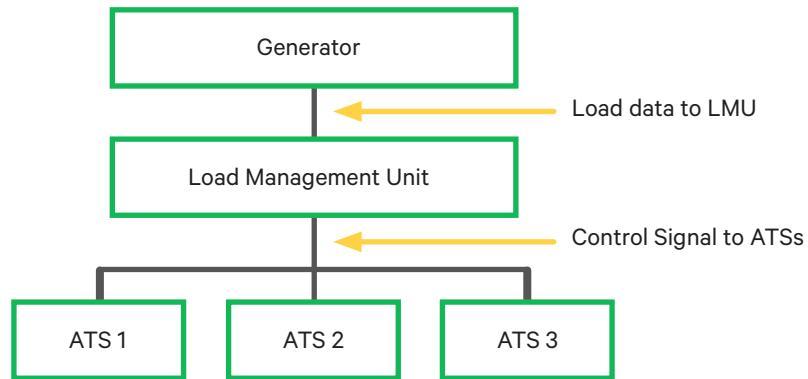


Figure 1: Simple Load Management Configuration

### Reactive Load Management

Reactive load management is a simple approach for adding and subtracting loads. Under this strategy, the controller measures generator kW output and adds loads by sequentially signaling ATSs to transfer to the emergency source. The ATSs are added sequentially to avoid instantaneous block loading that could stress generation equipment.

When using a reactive load management approach, the user sets an Overload Threshold relative to the actual generator rating. When the connected load momentarily exceeds this threshold, the lowest priority ATS is removed. Thereafter, the controller may periodically attempt to reload that ATS to check if sufficient capacity is available for the remaining loads. To minimizing cycling, the controller invokes an extended, user-defined retry interval.

Additional means can be available to reduce or eliminate load cycling. After the controller has shed a specific load, the controller could lock out that load until reset by some manual or automatic means. Alternatively, the controller could establish an interim set point below the Overload Threshold, which must be met before attempting to re-add load. This measure ensures that additional capacity will become available than was free during the prior attempt. These approaches increase complexity and cost and could further decrease utilization of generator capacity. Consequently, an application warranting these features may be better served by a more advanced load management strategy.

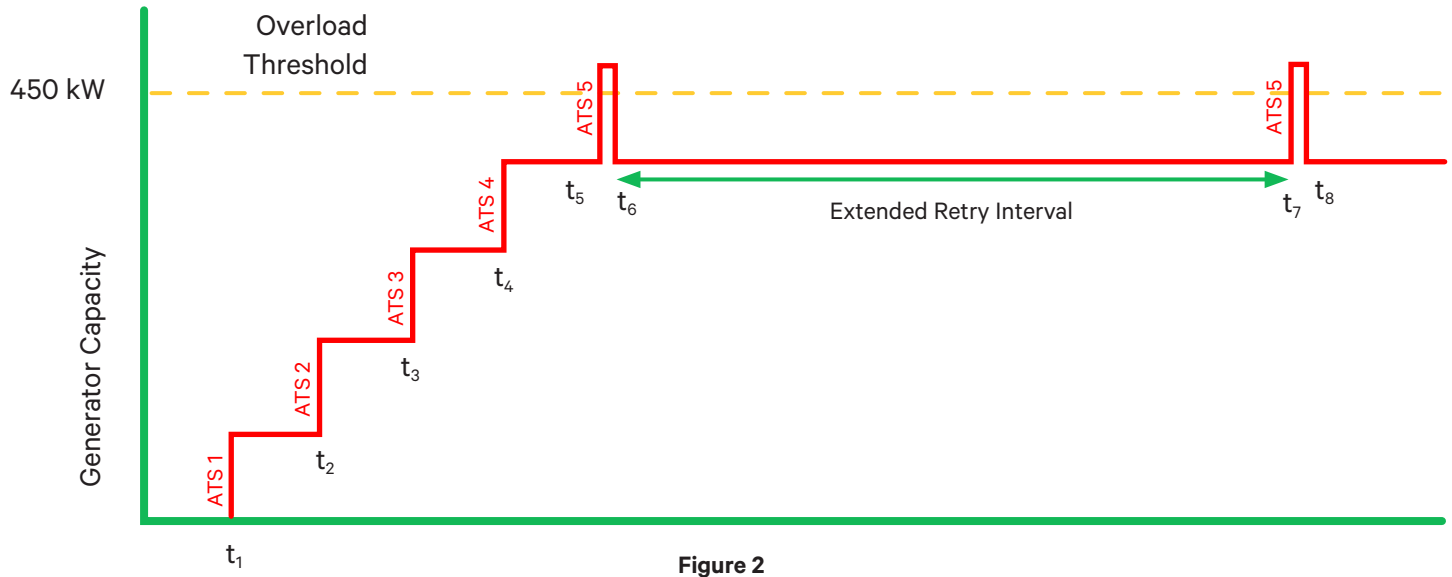
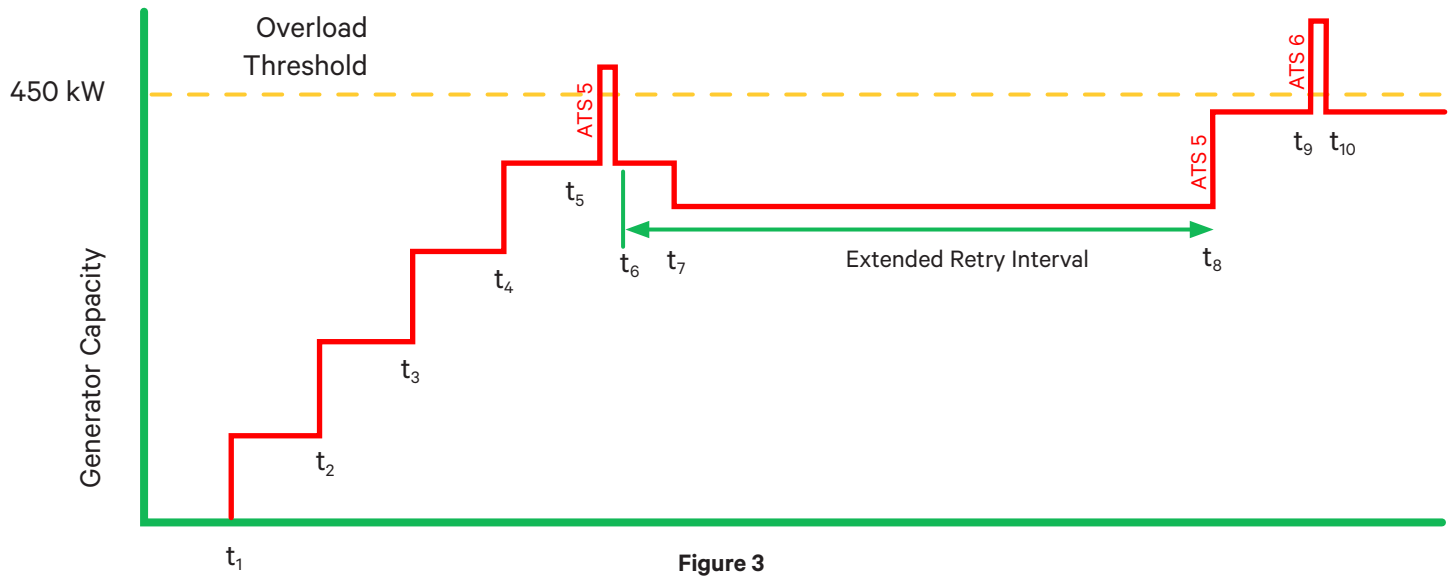
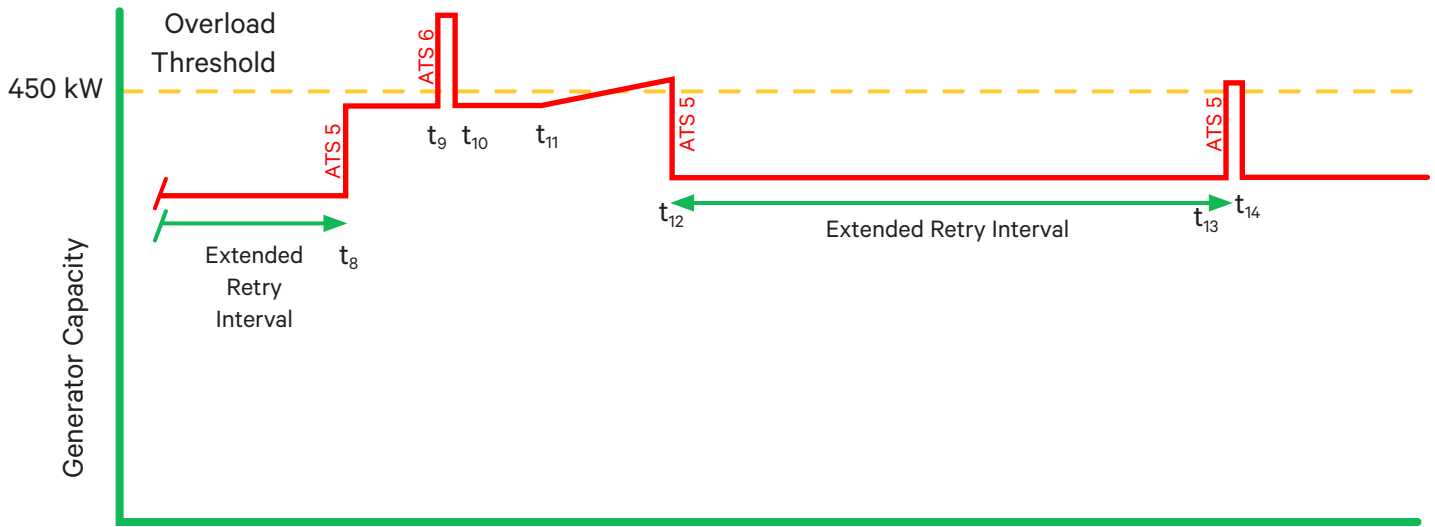


Figure 2 above illustrates a sequence for a reactively managed backup power system that feeds seven ATSs, each serving 100 kW loads. From  $t_1$  through  $t_4$ , 100 kW loads are successively added to the system, which has a 450 kW Overload Threshold. With 400 kW online, the controller signals ATS 5 to add the fifth 100 kW load at  $t_5$ . The resulting total load exceeds the 450 kW limit by 50 kW, so the controller quickly removes ATS 5 at  $t_6$ . Over time, the amount of connected load could decrease, leaving unused capacity. After a user-defined interval, perhaps one hour, the controller tries to add ATS 5 again to check whether the generator can support the additional load. After momentarily exceeding the Overload Threshold, the controller removes ATS 5 at  $t_7$ .



In Figure 3, one of the loads decreases at  $t_7$ . After the retry interval expires at  $t_8$ , the controller adds ATS 5. This 100 kW load remains online because the total load is less than the Overload Threshold. Thereafter, the controller adds ATS 6 at  $t_9$ , which is quickly removed at  $t_{10}$  when the Overload Threshold is exceeded.



**Figure 4**

Figure 4 above illustrates events following those shown in Figure 3. The load management system continues to react as loads change. At  $t_{11}$ , after the aforementioned removal of ATS 6, the load on one of the online ATSs increases, causing the total load to exceed the Overload Threshold. In response, the controller removes ATS 5 at  $t_{12}$ . After another extended retry interval, the controller checks for capacity by quickly adding and removing ATS 5 at  $t_{13}$  and  $t_{14}$ , respectively.

Reactive load management is simple to implement because very little set-up is required to program the associated equipment. In addition, the necessary hardware can be less expensive than that required to implement a proactive load management strategy. However, the reactive approach can potentially subject the backup power system to stresses from repeated cycling and momentary overloads. Reactive load management can also result in lower overall utilization of backup capacity because the extended retry intervals, designed to limit unnecessary cycling, can arbitrarily keep loads off-line.

### ***Proactive Load Management***

Proactive load management, sometimes referred to as standard bus optimization, is a more sophisticated approach that compares the expected kW of an ATS to a user-configured Overload Threshold before connecting the load to a backup power system. Using this approach, a controller is programmed with information about both the priority and maximum expected kW for each ATS. Before adding an ATS, the controller first checks the real-time load on the backup system and compares it to the sum of the existing and next expected loads. If the sum is below the threshold, the load is added. If the sum exceeds the threshold, the load is not added.



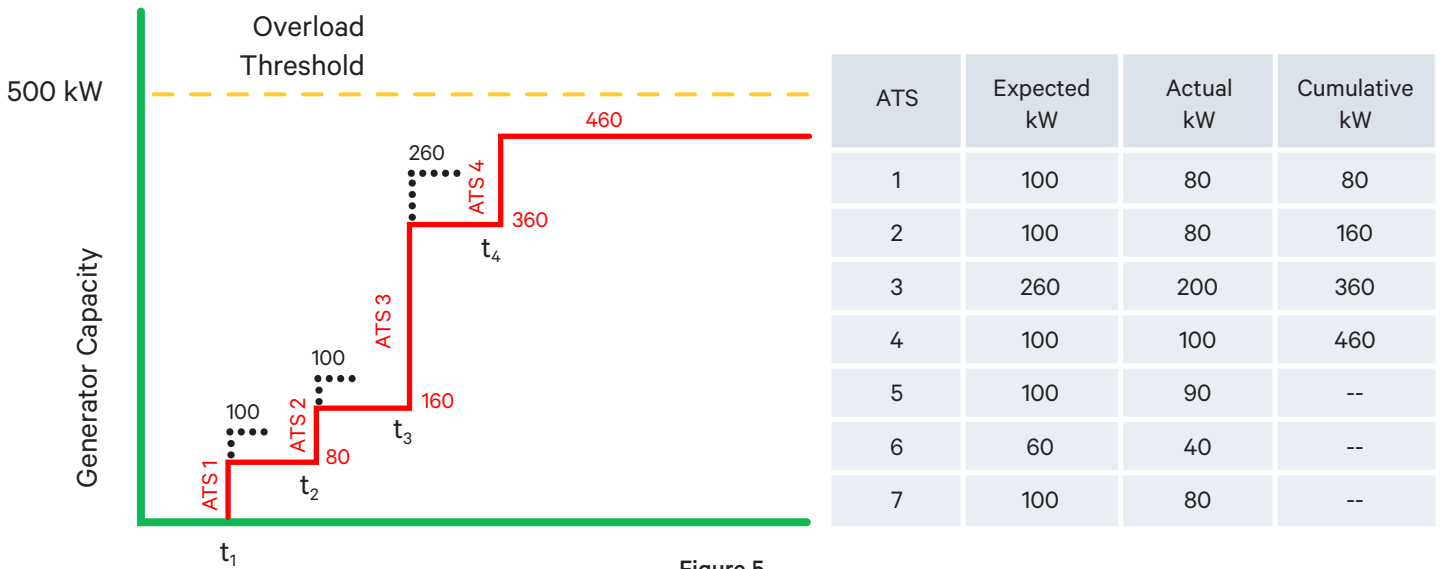


Figure 5

Figure 5 above illustrates the sequence of events for a proactively managed backup power system feeding seven ATSs with varying expected loads. For instance, at  $t_2$ , the controller (1) detects that there is 80 kW on the backup system, (2) recalls the expected 100 kW value for ATS 2, (3) adds the respective kW values and computes an anticipated total load of 180 kW, (4) compares the 180 kW value to the 500 kW threshold, and (5) adds ATS 2 because the total expected load is below the threshold. This is repeated at  $t_3$  and  $t_4$  because there is sufficient capacity at each moment to accept the expected kW of the next ATS. Because the controller continually compares the sum of the existing load and the expected kW of the next ATS to the Overload Threshold, it does not add load after  $t_4$ .

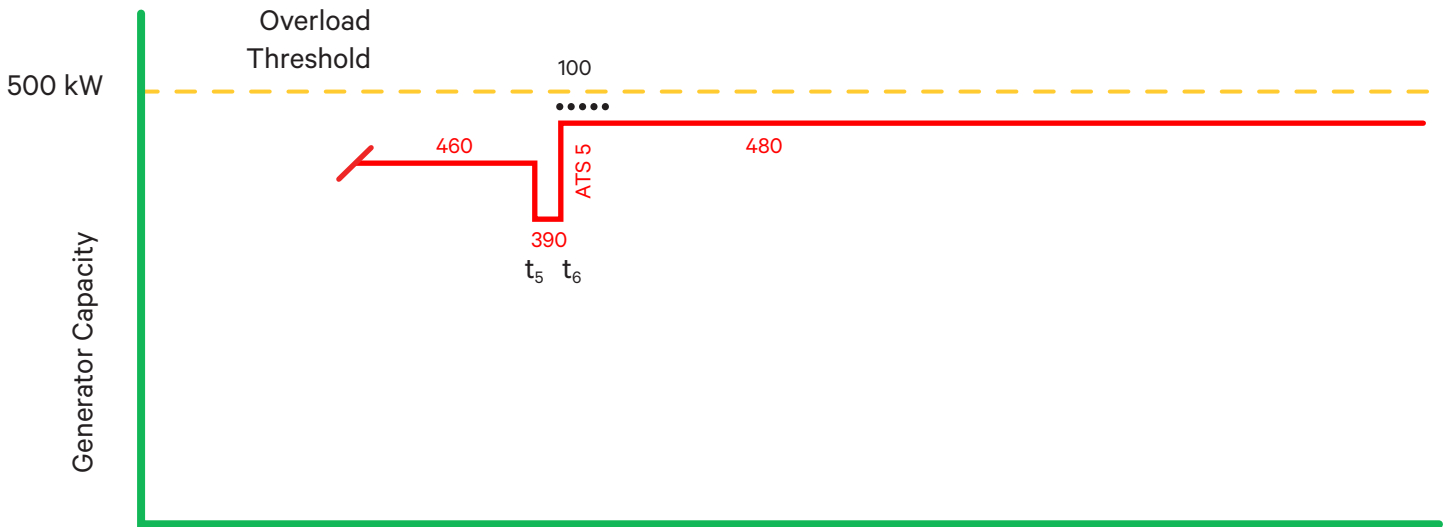


Figure 6

After a period of time, the load on one of the online ATSs decreases by 70 kW at  $t_5$  as shown in Figure 6. The controller quickly verifies that adding the expected 100 kW load for ATS 5 will not exceed the threshold value, and then adds this load at  $t_6$ . If the total load subsequently increases above the Overload Threshold, ATS 6 would be removed to return the total load to a level below the threshold.

Proactive load management can achieve greater utilization of generator capacity than a reactive strategy because it continually compares the expected size of the next load to the remaining generation capacity and adds load when sufficient capacity becomes available. Proactive load management avoids unnecessarily overloading the backup power system, producing fewer stresses on the genset, and minimizes load cycling associated with the reactive approach.

Proactive systems require additional effort to engineer, program, and deploy because the expected kW values must be evaluated and programmed into the controller. In addition, they require upgraded hardware to support their advanced logic. Because of their benefits, the increased cost of proactive systems can be justified for many applications.



The ASCO Model 5850 Load Management Unit uses a proactive strategy to optimize utilization of backup system capacity.

## Value-Added Features

The above-described strategies can be augmented to provide additional value in specific applications. The following sections describe a few of the supplementary features that could provide benefits.

### *Time Sequencing*

In some facilities, non-critical loads may all share equal priority. For example, an assisted living facility may usually supply power to separate air conditioning systems that service different portions of a building. Although each air conditioning system has equal priority, the facility may not have sufficient backup capacity to power all of the air conditioning loads simultaneously. However, the system may have sufficient capacity to power one of the air conditioning systems. Consequently, an appropriate load management strategy could sequentially power each system for a specific period of time to intermittently cool each space. Likewise, time sequencing could be used to power equal-priority loads such as separate refrigeration systems in a food store. In each case, sequentially powering loads for prescribed periods could avoid a need to increase generation capacity. This solution can provide an acceptable level of performance while keeping backup power generation costs low.

### *Dynamic Bus Optimization*

The performance of a proactive load management system can be improved by using dynamic bus optimization. When programming proactive systems, the expected kW value for each ATS is set at a fixed worst-case value. However, using dynamic bus optimization, the controller periodically updates expected kW value based on real-time measurements of each load. This typically results in lower expected kW values that drive more accurate and efficient utilization of capacity. Because site-specific metering, communications, and programming are all required, dynamic bus optimization may be added to a load management system following an assessment of the cost and benefit for a particular facility.

### *Overrides*

Loads are normally prioritized when load management systems are programmed during commissioning. However, in some situations, circumstances could warrant forcing some loads offline or online, despite their assigned priority. For instance, a building complex for a municipal government houses offices for both administrative and emergency services. When commissioned, the load management system is provisioned to prioritize certain loads in occupied spaces for every organization in the complex. However, when an outage occurs because of a natural disaster, the municipality decides to suspend all non-emergency business, leaving open only offices for emergency services. As a result, some of the associated administrative loads can be taken offline to conserve fuel during the emergency. Alternatively, the additional capacity could be reallocated by forcing lower priority loads online.

Properly implemented load management strategies prevent backup power system overloading. Although override features provide flexibility, they should include appropriate protective measures to prevent inexperienced users from adding excessive loads that could result in failure of the backup system. Manual override features should be operated only by qualified and authorized personnel.



## **Additional Considerations**

When implementing load management capabilities, designers should consider how features of other elements of the electrical system can add value. Two of these elements are described in the following sections.

### ***ATS Transition Modes***

Load shed signals issued by load management equipment to ATS controllers take precedence over most other signals. Open Transition Transfer Switches offer only two possible states: connected to Normal, and connected to Emergency. As a result, when shedding load from the Emergency source, the only alternative is for the switch to reconnect it to the Normal source. Consequently, loads could be transferred to a Normal source that has unacceptable characteristics, such as aberrations in voltage, frequency, or other parameters. If the load were transferred to a Normal source experiencing brown-out conditions, motors served by the ATS could be susceptible to damage that may be worse than the direct impacts of an outage.

Delayed Transition Transfer Switches can be used to mitigate risks associated with shedding loads to unacceptable sources. These switches offer a disconnected position where neither source is feeding the load. The ATS can hold this disconnected position while the normal source remains unacceptable, avoiding exposure of load equipment to adverse conditions that could cause damage.

### ***Load Metering***

Installing power meters on distribution and load equipment provides additional benefit for proactive load management systems. Data from the meters can enable designers to more accurately set expected kW values for individual transfer switches. In addition, real-time power data from the meters could support dynamic bus optimization to increase the effective use of available generator capacity.

## **Summary**

Reactive and proactive management strategies offer differing approaches for managing loads on backup systems that cannot supply electricity for all of the loads in a facility. Reactive systems add loads according to pre-established priorities until system capacity is momentarily exceeded. These systems offer relatively simple set-up and low cost.

Proactive systems continually compare the available generation capacity to the amount of power expected to be required by the next ATS, then adds that ATS when sufficient capacity exists. While proactive systems initially require additional engineering, set-up, and programming, they efficiently use capacity while avoiding the stresses associated with unnecessary load cycling.



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