Essential Standby Generator System Requirements for Next Generation Data Centers

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Executive Summary

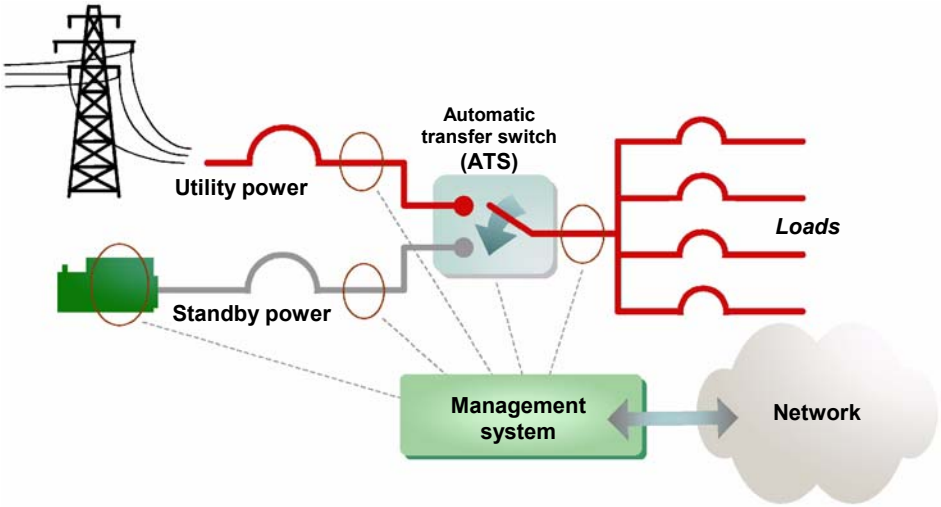
Effective standby generator system installations must address the known problems and challenges relating to current and past designs. This paper presents a categorized and prioritized overview of generator system challenges and the requirements needed to overcome them.

Introduction

Standby power generation is a key component of a high availability power system for data centers and network rooms. Information technology systems may operate for minutes or even a few hours on battery, but local power generation capability is key to achieving high availability. In locations with poor utility power, local power generation may be needed to achieve even a minimal requirement of 99.9% availability.

Generator systems with diesel or natural gas engines are, in most cases, the solution for standby power generation. A generator system includes not only the standby generator, but also the automatic transfer switch (ATS), the output distribution, and the communication or management system as shown in **Figure 1**. The ATS is fed by two sources, the utility and the generator, with the utility the preferred source. When the preferred source is unacceptable, the ATS automatically switches to the generator. APC White Paper #93, "Fundamental Principles of Generators for Information Technology", provides a detailed explanation of the operational principles of generator systems.

Figure 1 *– Standby generator system*



Standby generator systems are typically used in conjunction with UPS systems. There are several issues that need to be considered when choosing, installing and operating a generator system that operates seamlessly with a UPS. This paper outlines the key problems and requirements for effective selection and operation of a generator system to support today's mission critical data centers.

Inadequacy of Current Generator Systems for IT Managers

In the past, network-critical physical infrastructure (NCPI) such as UPS and generator systems were solely the responsibility of facilities managers. However, two trends have led to a convergence of facilities and IT.

1. Data centers have become more critical to the profitability of businesses (i.e. downtime is very expensive), which has led IT managers to take more responsibility for the UPS and generator systems. IT managers are bringing these systems closer to the equipment racks in order to decrease the single points of failure between them and the critical loads.

2. Data center power densities are increasing, which has placed a greater importance on cooling critical loads during power outages. When a power outage occurs, the UPS system maintains the critical load; however the cooling system will not resume operation until after utility power returns. Data centers with high density racks cannot sustain a long cooling outage and will shut down before cooling has resumed.

Since IT managers are ultimately responsible for the critical data processing that takes place in their data centers, they are becoming more involved in the specification and operation of generator systems. The challenges presented in this paper are largely based on traditional generator systems tend to offer too many options and design choices. The many available alternatives often leads to delays in installation, unnecessary engineering costs, and less reliable systems. IT managers require a pre-engineered generator system with pre-selected and tested options / features that allow for reliable operation. A clean and concise documentation package that explains and guides all aspects of installing, configuring, operating, troubleshooting, and servicing the system is also an important necessity. In essence, IT managers require turnkey solutions that will allow them to specify standby generator systems on their own.

Generator System Challenges in Mission Critical Installations

A comprehensive analysis of data center and facility managers with mission critical installations was conducted to identify key challenges associated with choosing, installing and operating standby generator systems. The results of the analysis were grouped according to common concepts. For each group, a solution requirement was derived and categorized into core challenges. These core challenges were then further grouped into five key theme areas:

- Manageability
- Availability / Reliability
- Maintenance / Serviceability
- Lifecycle cost
- Adaptability

For each theme area, the challenges, underlying problems, and generator system requirements are presented in tabular form. The highest priority challenges are listed first under each theme.

Manageability Challenges		
Challenge	**Underlying problems**	**Generator System Requirements**
Monitor and display generator system status	It is important that the operator can easily see that the system is working. In many cases there are generator system parameters which can not be easily monitored and understood by the operator (i.e. fuel level, oil level, battery status, etc.)	A generator system that measures the most important parameters and displays them to the operator in a meaningful way. For example, instead of showing how much fuel is left, it would be more meaningful for the IT manager to know the run time remaining at current load whether or not the generator is running.
Provide predictive failure analysis	Users need to know beforehand if some aspect of the generator system is going to fail so proper preventative measures can be taken.	A management system that monitors all generator subsystems and provides early warning through preventative maintenance reminders. Real time remote and local monitoring system that provides critical information and alarms at every interface: ▪ Battery monitoring and weak battery detection ▪ An automatic alarm that is sent whenever the controller is not set to automatic, the emergency stop is engaged, or the generator output breaker is not closed ▪ Block temperature and coolant level monitoring and alarms ▪ Fuel level and load power measurements, available even when the generator is in standby ▪ Oil level monitoring so that oil can be added or leaks repaired, rather than waiting for the generator to start and shutdown due to low pressure
Manage system with an intuitive interface	It may be difficult for various systems within an organization to interface and may not be "user friendly".	A management, control and communication system that is simple, functional, and familiar to IT operators. Embedded help within the user interfaces and factory defaults set to ensure proper system functionality.
Know when service is required and how to plan for it.	Sometimes it may be difficult to find and / or interpret the service log. This may cause unnecessary confusion.	A diagnostic system that reminds the user when maintenance is required both in operating hours as well as in calendar time. This information should be available in various ways such as on the local ATS interface, and via SNMP or other web-based protocol.
Have visibility to standby generator system	ATS and power distribution panels are typically hidden in a back room far away from the IT equipment. This makes it difficult to find them and quickly diagnose status and problems.	ATS and power distribution that have a look-and-feel that is suitable for data center environments. A system that can be installed in close proximity to the load to improve visibility and control.

It is important that the management system be designed in such a way that it fits the need of the daily operation. The needs of server room operators are sometimes different from the needs in other applications. The parameters shown must relate purely to the operation and status of the system and should be presented in such a way that makes it very easy to understand. For example, it is more intuitive for the system to display the remaining runtime instead of remaining fuel. These challenges clearly suggest the need for pre-engineered, pre-tested, and standardized management tools that support not only the generator but all of the generator system components including the ATS.

Availability / Reliability Challenges		
Challenge	**Underlying problems**	**Generator System Requirements**
Minimize starting failures (demand failures) of the generator	A generator may fail to start or fail to deliver power due to problems with various subsystems.	A monitoring system that oversees the following critical system and clearly communicates status in a proactive fashion: ▪ Battery status ▪ Fuel level / runtime ▪ Temperatures ▪ Fluid levels ▪ Automatic switch position ▪ Output breaker position ▪ Sensor / generator faults A system that has a built in test scheduler to exercise the system periodically, to verify that it operates correctly.
Deliver expected runtime	Runtime may be shorter than expected due to low fuel level in the tank or higher loading than originally planned.	A monitoring system that measures fuel in the tank and power consumption and translates that to runtime. A system that displays the runtime available not only when the generator is operating, but also when in standby.
Minimize single points of failure	Legacy ATS and generators that are designed as one large centralized system can be single points of failure, leading to reduced reliability and availability.	A generator system that can be scaled without interrupting existing loads, as new zones are added. Failure of any one generator system that affects only a portion of the data center rather than the entire data center.
Maintain the specified generator output	The generator may deliver lower power than specified due to lack of maintenance. Radiators can become restricted with dirt, fuel quality can degrade with time and conditions, filters become less efficient with use.	A system that provides scheduled self tests to routinely operate the entire system and validate proper functionality. Also, a maintenance counter and reminder based on time or hours run that indicates when service or inspection is required.

Human error is a major cause of generator demand failures since humans tend to take actions based on their own understanding of how the system behaves, while very often such understanding may be incorrect. These errors may not only occur during operation, but also during the design and installation of the generator system, including the ATS. Standardization, automation, and simplification are required to overcome these problems.

Maintenance / Serviceability Challenges		
Challenge	**Underlying problems**	**Generator System Requirements**
Minimize down time due to service requirements	The generator and ATS may have a need for certain maintenance that may cause the system to be out of service for short periods of time	An ATS that is designed with modular, standardized, high volume components that require minimal maintenance (i.e. major components that have a 20 – 30 year life) and provides a low mean time to recover in the event of a component failure. A generator system that provides preventative maintenance reminders for the generator and proactive monitoring of all generator subsystems to provide early warning of impending problems, before they cause downtime.
Simplify the complexity of system and service procedures	Complex systems require highly experienced staff to service and maintain. It is difficult for the operators of the system to know what the cause of a problem may be. Typical generator system repairs require a minimum of two trips by a technician – one to diagnosis the problem and one repair / replace parts.	Pre-engineered and pre-tested control systems that require minimal setup time. A system with minimal number of settings and adjustable parameters. A clean and concise documentation package that explains and guides all aspects of installing, configuring, operating, troubleshooting, and servicing the system. A system that provides proactive notification to vendor of fault codes, so that problems can be addressed quickly (i.e. technician arrives with required parts). Integrated and standardized generator systems that have standardized labeling.
Minimize vendor interfaces	Generator systems often involve multiple contractors and vendors making it difficult for personnel to determine responsibility for problems leading to wasted time and money.	A system that is designed, sized, supplied, and serviced by a single trusted leader in business continuity with reputable customer support.

Pre-engineered and integrated generator systems facilitate the service and maintenance required. Systems that are easy to operate and service will reduce the likelihood of downtime caused by human error and ultimately reduce costs.

Lifecycle Cost Challenges		
Challenge	**Underlying problems**	**Generator System Requirements**
Optimize cost of electrical and mechanical design and installation	Typical generator systems are custom designed for a specific site that can result in: ▪ high labor cost (as a percentage of total cost) ▪ hidden costs due to unclear definitions or interpretation of how the installation should be completed Custom generator designs require individual sub-system installations including the fuel system, oil system, cooling system, and exhaust which can lead to high installation costs.	Systems that reduce the design and installation cost by providing: ▪ fuel storage and delivery systems that are integrated into the generator ▪ a pre-engineered AC power source for the battery charger and block heater ▪ clear, standardized site prep and installation instructions ▪ one pad design ▪ plug and play communication ▪ built-in automatic commissioning test to increase start-up accuracy and speed ▪ factory assembled and tested ATS, panel board, and breakers ▪ factory default settings that don't need to be modified for proper operation Generator subsystems that are delivered as a single skid-mounted unit, including fuel system, cooling system, and sound attenuated enclosure.
Minimize delivery lead time of generator system	Typical generators have lead times of 12 – 24 weeks, which means either planning far in advance of the need or not meeting the delivery requirements.	A generator system that allows for fast delivery of off-the-shelf SKUs.
Properly size the generator system	In many cases the generator is oversized due to lack of knowledge regarding the power requirements and power factor of UPS and cooling products in the data center. This leads to unnecessary capital and operating costs. Occasionally, generator systems are undersized when UPS interactions are overlooked leading to downtime.	A pre-engineered and tested solution that provides seamless integration and operation with all subsystems including generator, automatic transfer switches (ATS), power distribution, UPS and computer room air conditioners. A standardized power solution in which the generator is sized to match the UPS and cooling loads, increasing the predictability of operation.

It is important to use solutions that minimize custom engineering and onsite work to avoid delays and unforeseen costs. Standardized and pre-engineered systems lower TCO considerably because they can be delivered quickly and installed relatively easily, reducing field-based work. In addition, by designing the generator system and UPS system as an integrated solution, oversizing costs are eliminated as rightsizing is made possible.

Adaptability Challenges		
Challenge	**Underlying problems**	**Generator System Requirements**
Match generator capacity to power zones of data center	Traditional generator systems are typically sized to support the entire facility, which usually results in one of two outcomes: ▪ The generator is too large, resulting in overcapacity which is expensive to install and maintain as well as reducing the overall life of the generator. ▪ The generator is too small, so additional loads require the installation of a larger generator system, resulting in further costs.	A generator system that can be rightsized to each power zone of the data center.
Minimize noise level to make system "neighbor friendly"	Noise level from generators may disturb neighbors even when within local noise limitations.	A generator system that offers standardized sound attenuated enclosures.
Fulfill emission requirements	Emissions regulations are becoming more stringent leading to approval delays.	A standardized generator system that meets or exceeds emission requirements using emission compliant engine technology.

A common problem related to adaptability is obtaining the required permissions to install a generator system. Important issues that must be addressed include environmental factors like noise and emissions. Since these requirements can be quite stringent and often vary between different sites it is important to choose a generator system that can provide the characteristics needed to fulfill them.

Standby Generator Systems for Mission Critical Installations

To satisfy the mission critical challenges identified in this paper, there are a number of changes required from current design practice. Most of these changes will require a paradigm shift in how generator equipment is specified and integrated in the total system. Integration of the components of the generator subsystem must move away from the current practice of unique component-level designs, and toward pre-engineered and even pre-manufactured solutions. Such solutions would ideally be standardized and would ship complete for rapid on-site installation. Standardization will also facilitate the learning process. By spreading the cost of developing high performance management systems across large numbers of standardized installations, advanced generator management would be affordable to a wider range of customers.

Conclusions

A systematic analysis of customer problems relating to generator systems provides a clear statement of direction for next generation systems. The most pressing problems related to generator systems today stem from the custom approach to their design, installation and maintenance. Legacy systems require site specific engineering and installation expertise that not only increases capital costs but also increases operational costs due to their unique management and service requirements.

In many industries, a maturity level is reached when new advances in reliability, cycle time, and cost lead to standardization and pre-engineered solutions. Designers of mission critical installations, designers of the power equipment used in them, and owners should consider whether this point has been reached.

The findings of this paper suggest the time has arrived for a new generation of integrated standby generator systems for mission critical installations.

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