White Paper

Telecom Engine Generators for Backup Powering Solutions

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TELECOM ENGINE GENERATORS FOR BACKUP POWERING SOLUTIONS

Thomas H. Sloane
Vice President
Corporate Technology
(tsloane@alpha.com)

David Olps
Strategic Accounts Manager
Telecom Sales
(dolps@alpha.com)

Alpha Technologies, Inc
3767 Alpha Way
Bellingham, WA 98225
www.alpha.com

1. Introduction.

The number of remote terminal (RT) locations has increased dramatically over the last ten years as population centers expand and migrate further and further away from existing central offices (COs). In addition to geographic expansion, the continuing growth of internet traffic is creating an explosion in demand for pair gain and also driving commensurate growth in RT deployments. Data centers, points of presence (POP), banking centers, and other “dot-com” businesses all require reliability and availability of services which are significantly greater than exhibited by the electric utility grids which power these facilities. Furthermore, as deregulation of the electric utility industry continues, the quality and reliability of the electric utility grid is expected to worsen [1].

Accompanying the dramatic growth of RT installations, most of which support digital loop carrier (DLC) architectures, are requirements for powering the equipment within the RT site, whether at a POP site, controlled environmental vault (CEV), cabinet, or hut. Historically, with fewer RTs, the operations, administration, maintenance and provisioning (OAM&P) demands were tolerable, consisting primarily of battery maintenance and replacement. Life expectancies of the batteries powering these outside plant (OSP) RTs are shortened by heat, as discussed in many animated and heated sessions at the IEEE Intelec conference each year. These life expectancies typically range from as short as eighteen months to a battery best-case of perhaps seven years, making for substantial battery maintenance and replacement costs.

The RT growth rate is dramatic and, when combined with increasing competitive pressure within the communications market, is causing operators to eliminate or reduce periodic battery plant maintenance at RT sites. Reduced battery plant maintenance causes shortened battery life, necessitates more frequent battery replacements, and diminishes system reliability. Prior to the increase in RT sites, maintenance at the RT was consistently performed; thus during unanticipated or emergency power outages, operation of the RT was assured. Any potentially prolonged outages arising from natural disasters, such as a snow storm, ice storm, hurricane, or flood, could be effectively serviced with relatively orderly dispatches of repair vehicles, each equipped with a mobile backup generator. This strategy served the small quantities of deployed RTs effectively, ensuring network availability during extended power outage situations.

Presently, however, today's network has far more RT sites making the dispatch and coordination of personnel, trucks, and mobile generators a logistical nightmare. Expenses associated with such disaster recovery and support can quickly create costs of hundreds of thousands of dollars for the owner and operator.

2. Telecom and Datacom Powering Trends

Increased revenues are being created from the addition of new services, such as data and video, and also from plain ordinary telephone services (POTS) over derived lines and through conventional twisted pairs. Although end consumers perceive these services to arrive at their office or residence with little or no additional cost to the provider, reality demands significant additions and/or changes to the plant architecture. Electrical power for the equipment providing these additional services is a subtle but critical component of the changes and additions to the plant. For many years, all powering was collocated with the transmission equipment inside the walls of the CO. Today's deregulated telephony landscape, with unbundled network elements, collocations, mixes of fiber and copper, digital loop carriers, digital subscriber loops, and competitive market pressures, is pushing and forcing transmission equipment out of the CO. Power processing equipment is accompanying the relocation of transmission equipment from the CO out into the OSP. Battery plants, which are quite cost effective in large, controlled-environment CO-based applications, are significantly more expensive to operate and maintain in the OSP, because of high thermal stress. Any OSP site which contains a battery plant is a candidate for a collocated, curbside engine generator (genset) which has some significant performance and cost advantages over a battery-only plant. These curbside gensets have evolved over the last decade to a highly refined, reliable, proven powering alternative. Such gensets are designed and tested to comply with telecom standards and requirements using the experience gained from a decade of deployments, over several generations of product designs, and a significant installed base of more than 10,000 units.

In many applications, the need for OSP power outside of the CO is in support of a fiber in the loop (FITL) architecture. Such architectures often use network powering to deliver power from a power node or other OSP enclosure to a multiplicity of optical network units (ONUs) where the optical-to-electric (O/E) conversions occur. Powering architectures for these deployments vary, but typically the size of the power node providing the network power is nominally about 5kW. A power node with larger powering capacity is underutilized with more power available than can be delivered from the power node to the ONUs. The reach or distance between power node and the ONU receiving network power from this power node is limited by the voltage drop along the twisted copper pair running between the power node and ONU. Thus, the gensets presented here have power ratings in the 2kW to 5kW range, considerably smaller than the ac gensets providing extended support for long-term power outages at the CO.

This paper explores characteristics of these curbside gensets and presents financial data for cost-of-ownership (life cycle costs) analyses for these curbside gensets. Before the life cycle costs are undertaken, the statistics of power outages are examined so that the reliability improvements accompanying the 100-hour unattended operating period of a telecom genset can be compared to the traditional eight-hours provided by a battery plant. Further discussion of the characteristics of a telecom genset provides insight into the genset control system and functional operating issues.

3. Power Outages and Reliability

Power outages create the need for a standby power source, but these power outages vary considerably. Although outage statistics can be acquired at several different levels in the power transmission and distribution network, power quality at the power distribution level is critical for datacom and telecom services [2-4]. Aside from the various hierarchical levels in the power transmission and distribution network, data can be acquired for different population densities, such as urban and rural [5]. Data from [5] are reproduced here in Fig. 1. Although these data are acquired for the United Kingdom, the statistics are similar to those obtained in the U.S. [2]. Of particular interest is the variation in the quality of power between urban and rural settings. As telecom and datacom services propagate out beyond urban areas, the quality of utility power is poorer.

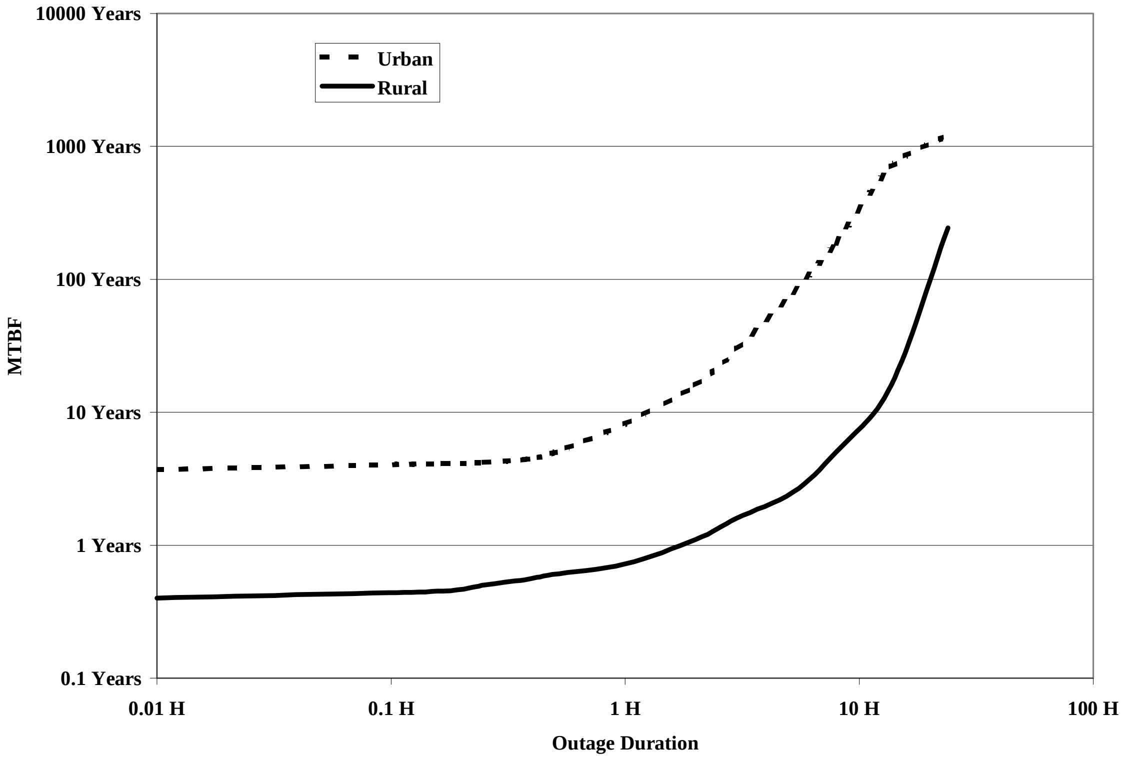

Figure 1. From [5], reliability of 240-Vac mains in urban and rural areas of the UK.

Data from [2] indicate that a 24-hour outage occurs with a mean time between failure (MTBF) of 1,000 years in an urban area, compared to a 120-year MTBF in rural areas. Based *only* on this 24-hour outage statistic, the reliability of power in a rural area is 99.998 percent, while in an urban area the reliability is better, at 99.9997 percent. To reach five nines (99.999 percent) power reliability, based only on a 24-hour outage, a 274-year MTBF for this single 24-hour outage is necessary.

More relevant is the data illustrating the power reliability as a percentage for different standby powering intervals. These power reliability data in Figs. 2 and 3 are derived from the utility reliability and mean time between failure (MTBF) data from Fig. 1. As seen from these figures, a traditional 8-hour battery plant provides approximately five nines of power reliability in a "rural"-quality area, and six nines in an area with "urban"-quality power. Typically, for telecom applications, the reliability requirement assigned or budgeted to the power system is 99.99995 percent [2], or six and one-half nines. From data in Figs. 2 and 3, a standby interval of between fifteen to twenty hours is needed to provide a power reliability of 99.99995 percent.

With a telecom genset providing unattended, 100-hour, –48Vdc standby power, the goal of providing reliable telecom power to achieve the six and one-half nines reliability is exceeded. Such telecom gensets provide very high power reliability even in the case of power outages of 100 hours. The data contained in Table 1 also illustrate the effect of increasing the standby interval on the powering reliability.

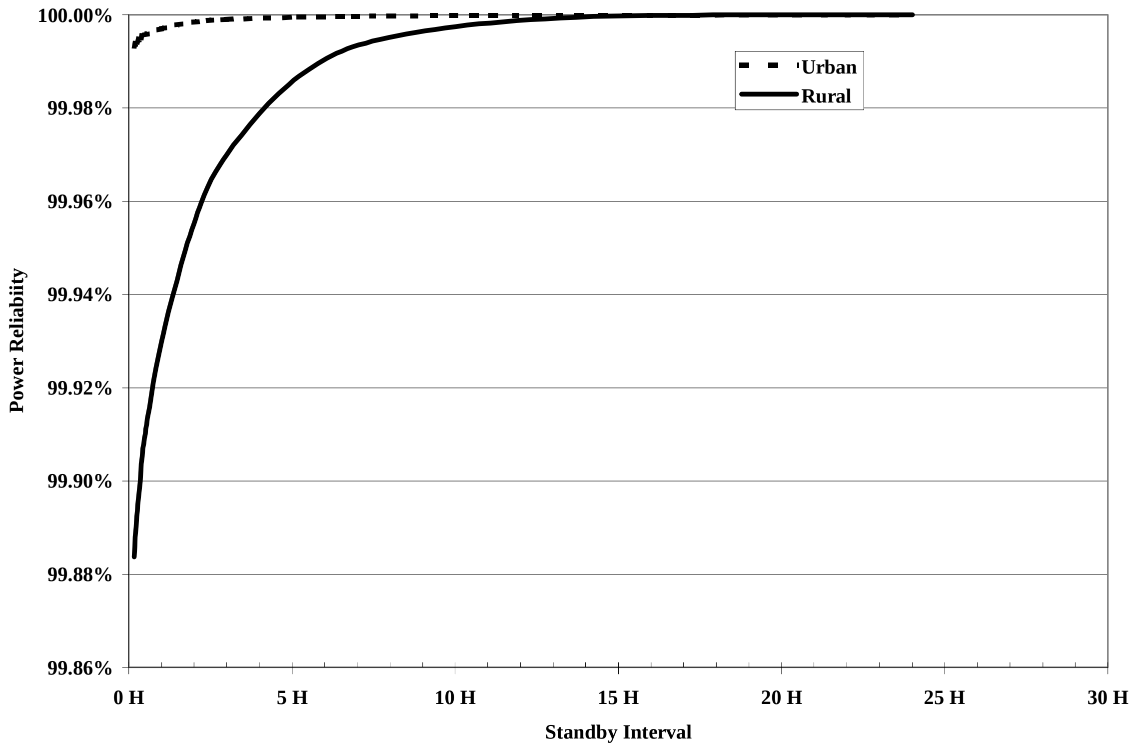

Figure 2. Powering reliability as a function of the powering standby interval. Statistical data does not include data for outages in excess of 24 hours, so reliability with a 24-hour genset is 100 percent.

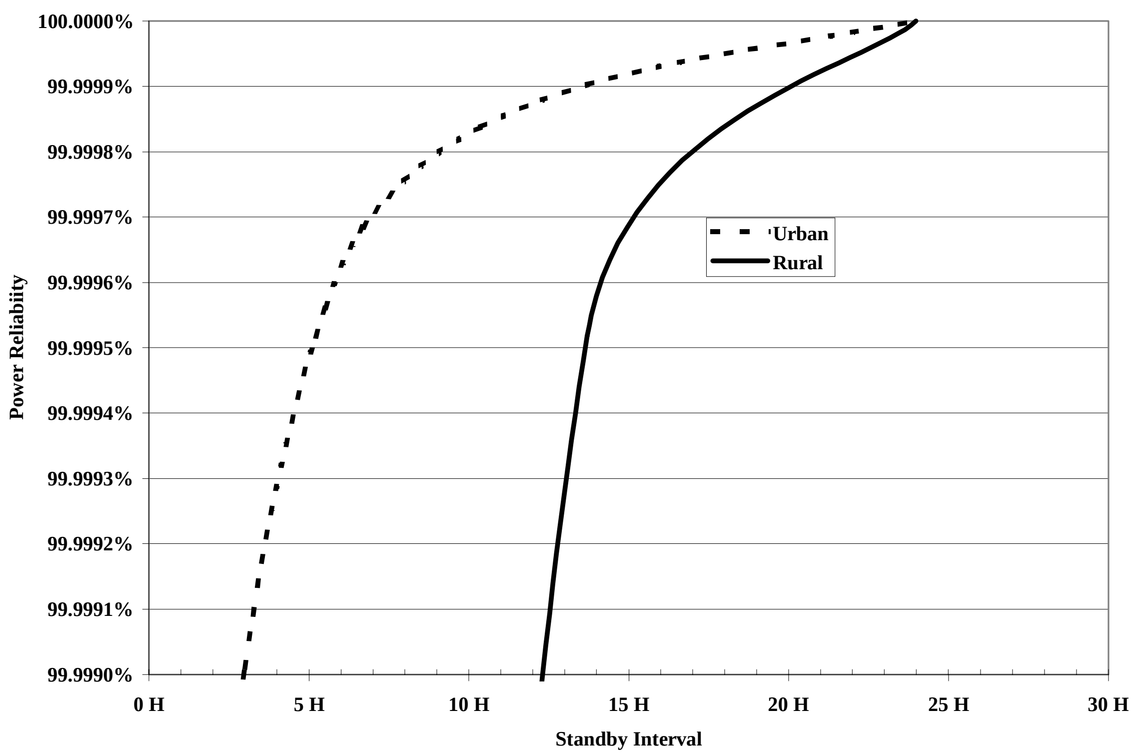

Figure 3. Same data as Fig. 2, with a change in scale for the power reliability to illustrate power reliability between five and six nines.

	Required Standby Interval	
Nines of Reliability	Rural	Urban
3	0.3 h	<0.1 h
4	6.3 h	<0.1 h
5	13.0 h	3.0 h
6	21.9 h	13.7 h
7	23.8 h	22.9 h

Table 1. Nines of powering reliability as a function of differing standby intervals for urban and rural mains reliability from Fig. 1.

4. Telecom Genset Characteristics

The telecom gensets under discussion are connected to either the natural gas grid for extended, unattended operation, or to an on-site propane storage system and enclosure where the natural gas grid is not available, such as in remote locations [6]. These gensets are designed for unattended operation and have a 100-hour maintenance interval. As a standby source, when connected to the natural gas grid, the gensets operate unattended for the 100-hour maintenance period; gensets connected to a propane supply are limited in their run time by the quantity of propane available. A propane enclosure is available which mates with the genset enclosure to create an integrated propane and genset system. This propane enclosure, designed and tested to comply with the necessary agency and regulatory bodies, typically offers a 24-hour supply of propane. The nominal propane consumption rate is 1 gallon per hour, but this is dependent on load and power rating of the genset. A picture of such an installed genset is seen in Fig. 4.

As a component of the genset system, the controller is responsible for autonomous control of the starting and stopping of the genset, either as required by system conditions, or as part of the automatic test sequence. The genset produces –48Vdc voltage compatible with traditional telecom requirements. With connection to the dc bus, the genset provides a redundant source of dc power for the bus, in addition to traditional rectifiers. As an added benefit, the dc bus redundancy provided by a dc genset can be used in place of a redundant rectifier. Use of a dc genset also eliminates automatic ac transfer switches which are costly and sometimes difficult to certify.

A decrease in the –48Vdc bus voltage, such as can occur with a failure of a primary rectifier, is detected by the genset controller, which initiates an immediate startup of the genset. Use of status monitoring, with either traditional major and minor alarms, or more inclusive monitoring, such as with an intranet, all can provide the network monitoring locations and operations centers the information necessary to take appropriate action.

Figure. 4. Installed telecom genset collocated with RT. Genset is the smaller enclosure on the right of the figure.

In a typical utility power outage scenario, the battery plant is relatively fully charged, such that the –48Vdc bus is capable of supporting the load. Within the genset controller, the algorithm responsible for the genset startup uses two inputs: ac utility voltage, and -48Vdc bus voltage. In the case of a utility power failure, and with the –48Vdc bus voltage at an acceptable level, the genset controller starts the genset after a user-programmable delay, typically ten minutes. Such delay is present since the duration of most utility outages is relatively short, and most of these short outages can be supported by the battery plant. If, however, the –48Vdc bus is at an unacceptable level, the genset controller commands an immediate startup of the genset.

In addition to demand-based control of the genset, the genset controller is also responsible for autonomous execution of the self-test algorithm. This self-test algorithm initiates an automatic run sequence at user-programmable intervals, typically every fourteen days. Any anomalies or inconsistencies in the results of this self-test algorithm are reported via the monitoring system, either with traditional minor and major alarms, or with more advanced interfaces.

Perhaps the largest obstacle to wider genset use is one of public perception. The widespread, and mostly unfounded, concerns regarding the Y2K issue created a market for consumer engine-generators that sold at a very inexpensive price and offered very little in the way of acoustic performance. These generators purchased through retail sales channels bear no resemblance to the telecom gensets being discussed here. One immediate and easily apparent operational difference is the acoustic performance. Generators available to the retail consumer typically have an audible noise level of 77dBA, while the telecom genset produces 67dBA. With sound power pressures measured in dBA, a 3dBA change in sound levels is equal to a halving of power. Thus, the 10dBA decrease in noise with a telecom genset is more than eight times quieter than the sound power of a retail-grade generator. The 67dBA noise level from a telecom genset is quiet enough that ordinary conversations can be conducted in the immediate vicinity of the genset.

And finally, local agencies and municipalities almost universally look for agency approvals for these gensets. In addition to agency approvals, compliance with the appropriate National Fire Protection Agency (NFPA) codes is also critical. However, the greatest safety and operation credibility arises from experiences of an installed base, and also from approvals from other townships and municipalities throughout North America.

5. Cost Comparisons

Cost comparisons for net-present-value (NPV) costs between a telecom genset and traditional battery backup systems are made here for various battery life expectancies ranging from 18 months to five years. These NPV comparisons are based on maintenance and installation costs acquired from significant quantities of installed and operating gensets, some of which have been in operation since 1993. The results from these analyses are seen in Fig. 5.

As Fig. 5 illustrates, the battery plant lifetime has a great influence on the overall fifteen-year NPV costs. As brought up earlier, battery plant life expectancies in the OSP are significantly shorter than in a CO. The data in Fig. 5 include the installation costs for a genset as well as the maintenance costs. For the battery strings, whether in a system with a genset, or in a battery-only backup system, the burdened labor costs of changing the batteries at the end of battery life are incorporated too. Omitted from Fig. 5 are the savings which result from eliminating a redundant rectifier when a genset is used. Savings from elimination of a rectifier occur at the start of the fifteen-year analysis and thus the NPV is equal to the cost savings from the elimination of the rectifier. For a 50-A rectifier, these costs are approximately $1,300.

6. Conclusions

Batteries represent a technology which over recent decades has not had any truly fundamental improvements in lowering maintenance costs, or in improving reliability or longevity. Use of a telecom genset offers a cost-effective, convenient complement to traditional battery strings. With further degradation of the quality of the utility power grid, longer standby times will become essential to ensuring the reliability and quality of service telecom customers expect. Finally, these improvements are accompanied by lower operating costs, as measured over the lifetime of operation.

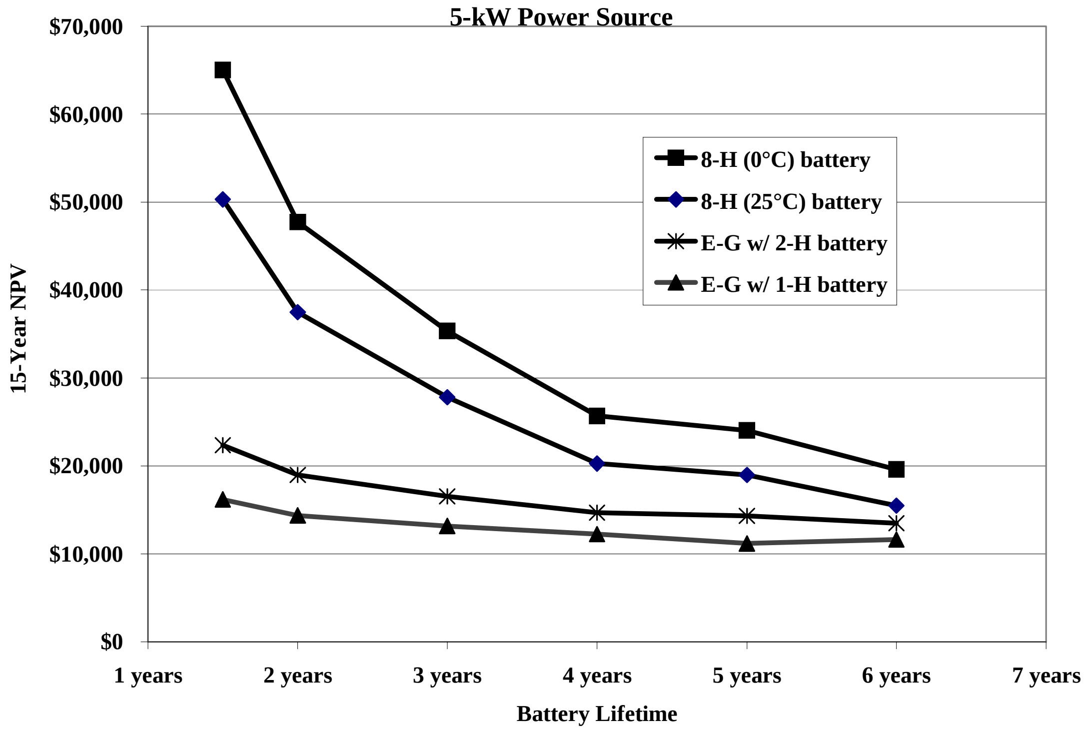

Figure 5. Fifteen-year net present value analysis which compares eight-hour battery plants, sized for eight-hour backup at both 25°C and 0°C. Telecom genset examples assume a one-hour and two-hour battery plant together with the genset.

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