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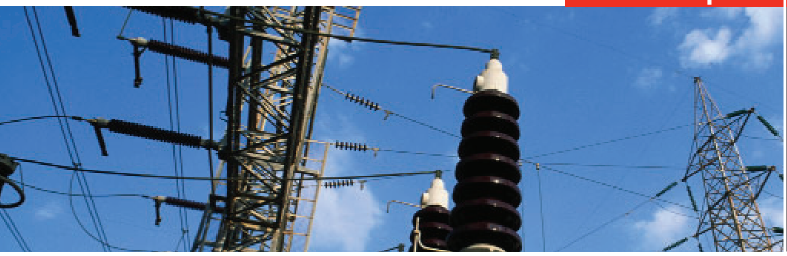

The applications and the economic impact of interconnecting a backup generator with a utility owned power system from the energy manager’s perspective.

white paper

Full Interconnection of Customer Owned Standby Generators: Cost/Benefit Analysis

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Synchronous interconnection of small generators with utility power distribution systems offers energy managers the potential to increase electric power reliability and to reduce overall energy costs. In selecting synchronous interconnection technologies, energy managers are faced with investment risk as they are challenged to define and then deliver the additional benefits associated with closed transition transfer systems. Traditionally small generators have been installed with an open transition transfer system creating a physical barrier between the generator and the utility distribution network. In contrast a closed transition transfer system maintains a fluid link connecting the utility network with the generator. This white paper explores the applications and illustrates the economic impact of interconnecting a backup generator with a utility-owned power system from the energy manager's perspective.

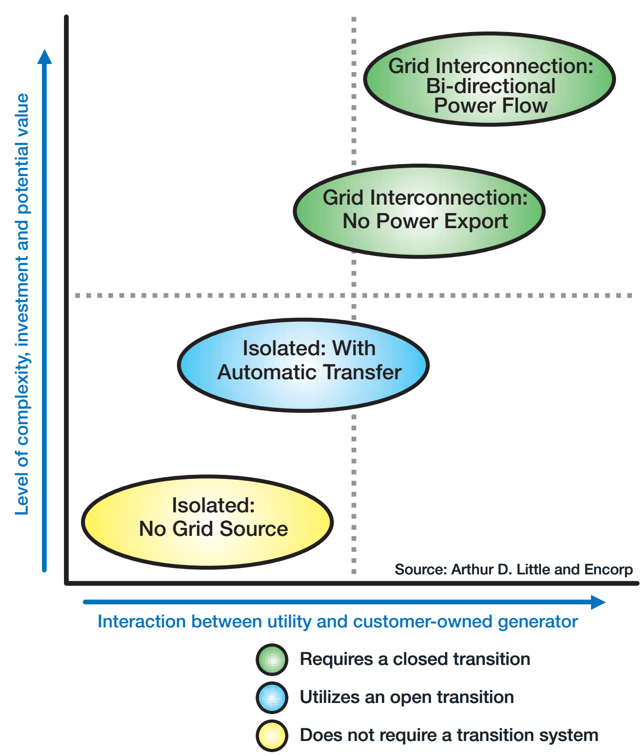
Value Proposition: Closed Transition Transfer Systems

Interconnection of a small generator with the utility grid provides benefits unavailable through isolated installations including those with automatic transfer systems. A closed transition transfer system linking the customer owned generator and the utility owned power distribution network is the most cost effective means available to create full interconnection. Closed transition transfer systems enable synchronous or parallel operations with the utility grid in over-lap type transfers, soft loading type transfers or continuous parallel operations. Synchronous operations enable seamless transfers of load between the utility and the generator. Interconnection benefits include: improved power reliability and power quality, enhanced peak shaving capabilities, performance testing under normal operating conditions, and the ability to dispatch the generator seamlessly for economic purposes.

The ability to shift or share power sources enables energy managers to leverage a variety of applications with a level of freedom and flexibility unavailable when generators are isolated from the grid with an open transition transfer system. These advanced applications carry a higher cost than traditional open transition transfer systems. However, in certain applications demanding a high degree of operator control, the additional costs of interconnection are far less than the economic and operational benefits of isolating a generator from the utility grid. Throughout this paper, each interconnection application and its costs assume the use of a single generator interconnected with a single utility provider.

Figure 1

Interfaces between the utility energy distribution system and the backup generator span a range of technical complexities, costs and potential benefits. Isolating a generator from the utility grid often does not require utility approval. In contrast, grid interconnection requires meeting requirements specific to the local utility and a potentially lengthy utility approval process. These elements often increase total project costs as additional capital equipment and man-hours are required. However through grid interconnection energy managers are able to capture a variety of potential benefits unavailable through isolated installations of their backup generators.



Interconnection Applications

Improved Power Reliability: The paramount function of a backup generator is to provide a reliable power source when utility supplied energy is disrupted. Relative to an open transition transfer system, a closed transition transfer system improves power reliability. Generators with both an open or closed system provide power during an outage. However, only in a closed transition transfer system can power be seamlessly transferred without any interruption of supply when both sources are present.

An open transition transfer system requires that utility supplied power must be completely disconnected prior to the backup generator serving the load. If an unexpected disruption of utility service occurs, the consumer experiences two "bumps" or two interruptions of service with an open transition transfer system. The first disruption occurs when the utility supplied power halts (or when a supplemental power source such as a UPS device is taken off line). The second interruption occurs when power is transferred from the backup generator to the utility source.

With a closed transition transfer system, the second interruption is avoided. When utility service is restored, the backup generator with closed transition transfer system control operates in parallel with the utility and the load can be seamlessly transferred. In scenarios with a backup generator operating prior to the utility service disruption, the consumer does not experience any disruptions in power supply.

The economics of power disruption vary with individual consumer scenarios. Typically industries with continuous manufacturing processes or with intensive data processing functions cannot tolerate even a transient service outage. In these industries, a closed transition transfer system is crucial. In advanced applications, energy managers monitor weather forecasts for extreme conditions. When weather conditions are likely to cause an outage, the backup generator is placed in test mode and load is transferred seamlessly from the utility. When the storm passes, the load is seamlessly transferred back to the utility then the generator is shut down. In the future, third-party services such as commercial weather forecasters, utilities, generator retailers and technology firms may provide automatic dispatch services alleviating energy managers the responsibility of monitoring meteorological conditions.

Improved Power Quality: For consumers with power factor issues, a generator with a closed transition transfer system can improve power quality. Power quality problems can be defined as the difference between the quality of power delivered and the quality of power required for a specific load. Power quality issues are resolved in three ways: reducing the variations in the power supply, improving the load equipment tolerances or conditioning the power before it reaches the load. This paper addresses the ability of a closed transition transfer system to reduce the variations of the power supply.

Utilizing a backup generator to address power quality issues can provide a long-term solution. Local conditions should be analyzed to confirm this approach. Installing power-metering equipment that continuously monitors the power system over time can supply the data necessary to objectively assess the cost-effectiveness of a closed transition transfer system. The connected load can affect power quality at a customer's site. Customer owned loads such as motors could cause the power factor to vary below many utilities' prescribed standards. This in turn creates an additional charge on the customer's monthly energy bill since the utility must correct this problem at the utility owned distribution site. To avoid these charges, the customer's connected load power factor can be stabilized when a customer owned generator synchronously operates with the grid.[1] With a closed transition transfer system, the generator set can help correct or offset excessive inductive loads that cause lagging power factors. An isolated open transition transfer system cannot assist in correcting power factor issues unless a dedicated generator serves the problem-causing load.

Flexibility for Testing under Operating Loads: In many critical applications, backup generators are tested under load to simulate performance in an actual emergency. An open transition transfer system requires that facility operations be suspended while power is transferred from the utility to the backup generator or that the generator is tested without load—a practice harmful to the generator and that only provides partial reliability assurances. With an open transition transfer system, tests under load conditions are often disruptive to production schedules or occur during non-manufacturing periods. Additional costs include loss of production and/or additional labor overtime expenses to conduct testing during non-production periods.

With a closed transition transfer system however, tests can be conducted without interruption to operations. When power from the generator becomes available, a seamless transfer is made between the utility and the standby generator. Facilities managers benefit from avoiding plant shutdowns and eliminating increased labor costs to schedule tests during non-production periods.

[1] Power factor control is accomplished by controlling the inductive component of the synchronous machine. When the utility and generator are paralleled together, they share the inductive component, Vars. By varying the amount of excitation the generator receives through the voltage regulator, the power factor of the load can be increased or decreased. Reactive power is nonproductive. Vars do not register on customers' kWh meters. Generation of Vars expends fuel and other generation resources. The generation burden is commonly passed from energy supplier to distributor in the form of power factor requirements and associated penalties. Excessive reactive load is unprofitable, unnecessary, and highly visible in today's marketplace.

Enhanced Peak Shaving and Load Following: With a closed transition transfer system, intelligent peak shaving can occur. In this mode, the generator is paralleled with the utility for an indefinite amount of time. The generator output can then be set to meet customer demands in excess of a pre-defined limit. As customer demand fluctuates, the output of the generator continually adjusts to meet the load. Simultaneously the utility load remains constant as the generator meets demand beyond a predetermined threshold. In contrast, peak shaving in an open transition transfer system scenario often requires a generator to power equipment isolated from the utility load. The generator follows the load on a dedicated circuit, as opposed to following the total customer load. Often this does not match optimal scenarios to achieve the lowest possible energy costs.

Peak shaving is a contentious issue with many utilities as it reduces their revenue stream. A reduction in peak demand may alter a favorable rate structure and result in penalties from the utility in the form of standby service charges. And as peak demand is lowered, the consumer may be reassigned to a different and more expensive tariff. To understand the total financial impact of peak shaving, adverse changes in utility tariffs should be recognized prior to engaging this application.

Seamless Demand-Side Management, Economic Dispatch and Power Export: Similar to peak shaving, a utility may offer incentive programs to consumers who are able to reduce consumption during periods when the utility is short of capacity. Through demand-side management or economic dispatch programs utilities, energy marketers and transmission organizations are able to reduce their total loads through voluntary customer energy curtailment. From a consumer's point of view, these offers provide the potential for total energy savings if the utility incentive exceeds the cost of curtailing grid-supplied power.

Power is curtailed when high demands placed on the utility system create potential constraints or when the spot prices on the wholesale market exceed certain thresholds.[2] During curtailment periods, standby generators can be dispatched to meet the reduction in utility supplied energy. As noted previously, to achieve a seamless transition of power between the utility and a standby generator, a closed transition transfer system is required.

Exporting power to the utility grid requires synchronous operations and is not possible with an open transition transfer system. It has been the objective of many standby generator owners to export power during periods when wholesale spot market prices exceed marginal operating costs. Unfortunately, of all the barriers, technical challenges are the easiest to meet. High barriers to exporting power include regulatory hurdles, the lack of interest among power marketers to trade small blocks of energy and the overwhelming financial risk of liquidated damages for failing to deliver previously committed energy. In regions with net or bi-directional metering, these hurdles are lowered. However, utilities generally offer to pay exporters the avoided cost or the retail price of energy exported to the grid which generally amounts to less than the marginal operating costs of a small standby generator.[3]

[2] The occurrence of high spot market prices and utility constraints are often correlated.

Capital Costs

In most applications, the largest cost associated with a seamless utility interconnection is the non-reoccurring capital expense of purchasing and installing a closed transition transfer system. The typical cost for grid interconnection ranges from $50/kW to $200/kW depending on the size of the generator, application and utility requirements. Higher costs are not uncommon for smaller units (under 500 kW) or where complex technical requirements are encountered.[4] However, once installed, a closed transition transfer system provides the benefits previously detailed which are difficult to achieve with a less costly open transition transfer system.

Operational Costs

Small generators are generally designed for backup power applications and can be de-rated when their productivity exceeds a finite number of hours without additional maintenance routines. Many service schedules call for two maintenance checks a year for a backup generator in good condition. Base load power or peak shaving operations require a greater frequency of maintenance visits that will increase operational costs. All operations consume fuel, which is the largest variable cost. Depending on price and efficiency, the fuel cost to operate a backup generator often ranges from 5.5¢ to 11¢ per kWh.

Indirect operational costs include potential new permitting and emissions requirements as well as unfavorable utility tariff changes. While there is an acute shortage of peak generation and transmission capacity in many regions, regulators, legislators and utilities have not created a simple and consistent program for adding customer owned capacity to meet peak reserve requirements. Utilities may offer generous demand-side management programs while simultaneously threatening to levy high penalties to reduce customer peak shaving. Lawmakers often rely on separate entities with dissimilar missions to regulate environmental and energy policies.

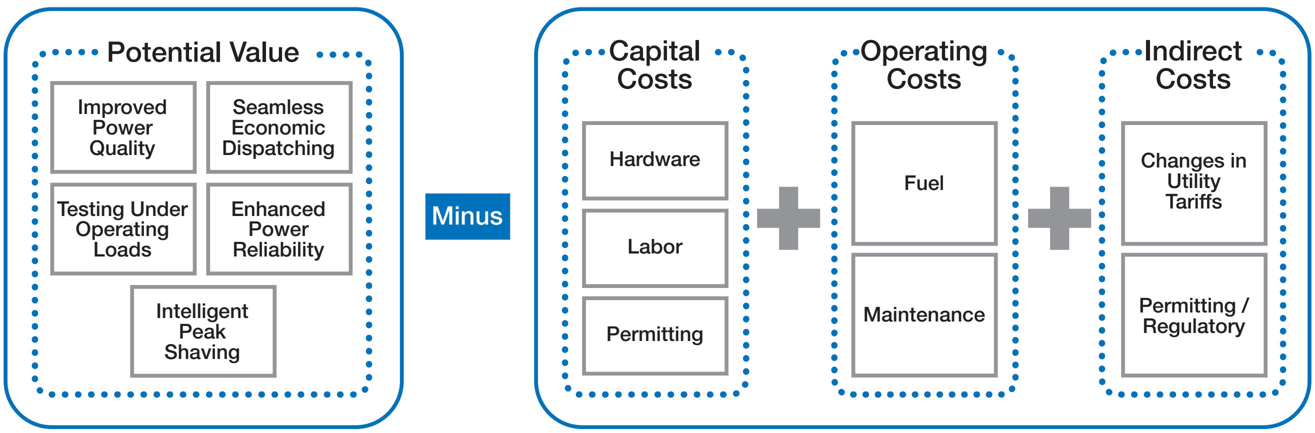
[3] Avoided costs are often defined as the utility's cost of power generation and delivery infrastructure and *not* the spot market price.

[4] Source: Arthur D. Little: Distributed Generation Systems Interfaces and ENCORP.

Recommendations

Prior to committing to capital projects, energy managers should understand the local economic dynamics and the regulatory impact of operating a small generator in standby, peak shaving and base load power modes. In doing so, they should consider the potential costs and benefits of grid interconnection.

The potential value[5] of a full interconnection can be calculated once energy managers are able to quantify the benefits that can be achieved through applications such as increased power reliability, improved power quality, the ability to test under normal operating loads, peak shaving and economic dispatch. These benefits over a reasonable period of time may be greater than initial capital costs, however it is unlikely that an energy manager can expect full payback within a year. The equation below summarizes the potential costs and benefits:



Assuming the potential value of full interconnection exceeds the estimated costs, the project warrants initial approval. After engaging the local utility to define technical requirements and project implementation processes a second project review should occur. Protracted utility procedures can increase total project costs.

The distributed generation marketplace will remain complex until national standards for interconnection are adopted. Utilities have not adopted national interconnection standards and often have complex and lengthy procedures for interconnection with their distribution networks.[5] However, due to enhanced power reliability and potential for energy savings, managers should carefully review the economics of parallel interconnection on an individual project basis. As energy prices, regulatory requirements and system interface standards vary greatly by region, attention to local market conditions is necessary for sound business decisions.

5 The Institute of Electrical and Electronics Engineers is in the process of drafting distributed generation interface standards. However, once completed, individual utilities may elect to adopt the standards in whole or in part.

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Authors' Note: Certain figures and illustrations for this white paper were obtained from the consulting firm of Arthur D. Little. ENCORP has sponsored Arthur D. Little's research and has noted the portions of this paper that are derived from Arthur D. Little's work.

Appendix

Illustrative Scenarios

The following three scenarios are intended to provide illustrative examples of decision-making criteria energy managers may face. For simplicity, each scenario will assume identical cost structures as it is assumed energy managers have a high degree of certainty in identifying expenses. Often there is greater ambiguity in capturing the benefits of full interconnection and these examples serve to broaden the energy manager's understanding of the potential economic impact of these applications:

Scenario 1

When full interconnection benefits are easily identified

Facilities that have high costs of momentary power disruptions, often those engaged in continuous manufacturing processes or that have mission critical information technology operations, generally require greater power reliability that only a synchronous interconnection can provide. To enhance power reliability and to decrease costs, testing under normal operating loads is both technically and economically advisable. Combined with high peak demand charges and few (or no) utility disincentives, peak shaving provides substantial energy savings. Assuming power quality issues are prevalent, the generator can be incorporated as a cost savings solution. In addition, the facility can participate in economic dispatch programs sponsored by local energy marketers.

Scenario 2

When full interconnection benefits are difficult to define

A facility that can be adequately served with an open transition transfer system for power reliability may be hesitant to increase its investment. This is particularly difficult if savings from peak shaving are minimal and power quality issues are non-existent. Testing under operating loads and the availability of economic dispatch programs may provide additional economic benefits. The sum of these benefits may exceed the costs over time. However, facilities in regions where the local utility erects high interconnection barriers, the total costs of interconnection may exceed expected benefits.

Scenario 3

When full interconnection is not advised

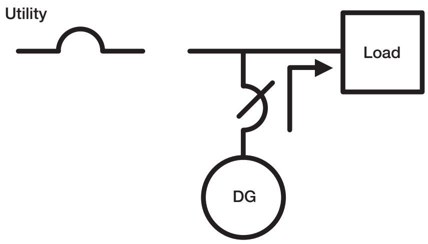
The facility has a low cost of outages and does not have power quality problems. As such, the backup generator is rarely utilized and testing infrequently occurs. The local utility tariff structure penalizes peak shaving or the facility has a flat load profile and there is not a meaningful peak to shave. The utility or energy service firms in the local region do not offer economic dispatch programs. Last, the local utility has complex and lengthy interconnection procedures.

Figure 2

Configuration A

Isolated – No Grid Source / Prime Power System

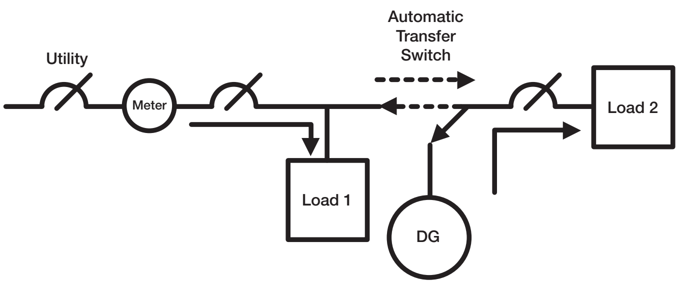
- *Generator provides power for all loads completely isolated from the grid*
- *Utility provides no backup or supplemental power*



Configuration B

Isolated with Automatic Transfer System

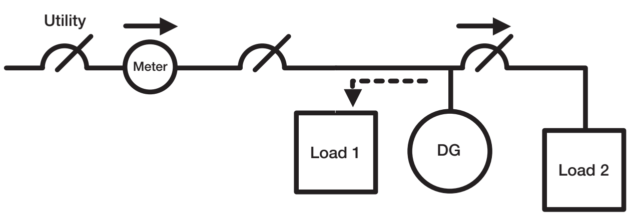
- *Generator provides power to an isolated customer load (load 2) for peaking, base load or backup power*
- *Utility provides power to customer load 1 and occasionally load 2*
- *Generator does not operate in parallel*



Configuration C

Grid Interconnected with No Power Export

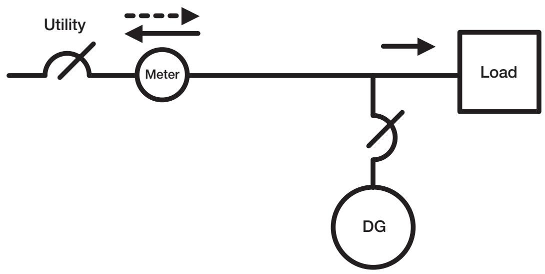
- *Generator parallel with the grid*
- *Generator provides peaking or base load power to all or some loads*
- *Generator does not export power to the grid*
- *Utility provides supplemental / backup*



Configuration D

Grid Interconnection with Power Export – Customer Side

- *Generator parallel with the grid*
- *Generator provides peaking or base load power to load and exports power to grid*
- *Utility may provide supplemental or backup power*



Configuration E

Grid Interconnection with Power Export – Utility Side

- *Generator provides peaking, base load or backup power for utility to provide to customer*
- *Generator operates in parallel with grid*