Successful DG Projects: Design and Build Considerations

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Abstract – These four projects are in service in three different utility jurisdictions. They are connected to the distribution lines and a 69kV customer-owned substation. The need for these facilities varied with each location, and the economic studies showed a good payback for this DG investment.

Two of the projects are in southern California and are installed on the process industries distribution delivery point. The goal was reliability and continuity of service when the industrial customers are curtailed during a shortage of energy from the supplying utility. In one case, the use of natural gas for the 2 -700kW diesel generator sets meets the California Emission Standards for cleaner air. The use of numeric protective relays for generator, feeder, and intertie protection reduced the cost for the multifunction protective systems in the customer-owned medium voltage switchgear lineup.

An automobile glass manufacturing plant project in Tennessee balanced the electric cost with the cost to generate for the glass process. This interconnection for parallel operation is at the low side of the customer-owned 69/12kV substation. The supplying utility is a gas and electric utility that buys power wholesale for resale.

The fourth project is a combined heat and power installation in the NY City area. It saves the condominium association significant HVAC system costs. The generator is an induction machine driven by a steam turbine and interconnected on the customer's side of the utility revenue meter. The turbine generator and parallel interconnection are protected by numerical protective systems.

I. INTRODUCTION

This presentation will set forth the design and build challenges for four DG projects known as On-Site Generation Resources. The projects are 3 existing Industrial Customers with critical processes and 1 Residential condominium facility receiving energy from the local provider. Three local providers are Investor Owned Utilities and one is a Municipal Distributor of Wholesale for Resale power and energy utility.

The categories of challenges for the design and build teams include the following issues:

1. On-Site generation operating in parallel continuously with local electrical utility power and the energy provider. Both synchronous and induction generators are protected and controlled using existing standards and guidelines.
2. Paralleled Interconnection system following the technical requirements of the local provider and interconnection standards like IEEE Std. 1547-2003.
3. Engineering, Operation and Maintenance procedures for the completed projects for the life of the assets.

The reason for the development of these 4 projects over the last 3 years was to provide operational flexibility for the mutual benefit of the local provider and their customers' needs. The projects were justified based on economics, reliability considerations, and flexibility for daily operational situations such as ISO requests for load curtailment due to generation, transmission and distribution system constraints.

II. PROJECT CAPABILITY DESCRIPTIONS

a. Project #1 includes a 1.7 MW Gas Fueled Internal Combustion Engine driving a synchronous generator. The project provides electrical backup for critical process loads and also delivers hot water for in-plant use. The generation has load- following capability using PLCs. The project is interconnected with the local utility's radial distribution feeder delivery system. It is not capable of export since the customer's normal load exceeds the generation capability. The generation, plant feeder load and interconnection systems use multifunction numeric integrated systems for protection and control. Figure 1 is a one-line diagram.

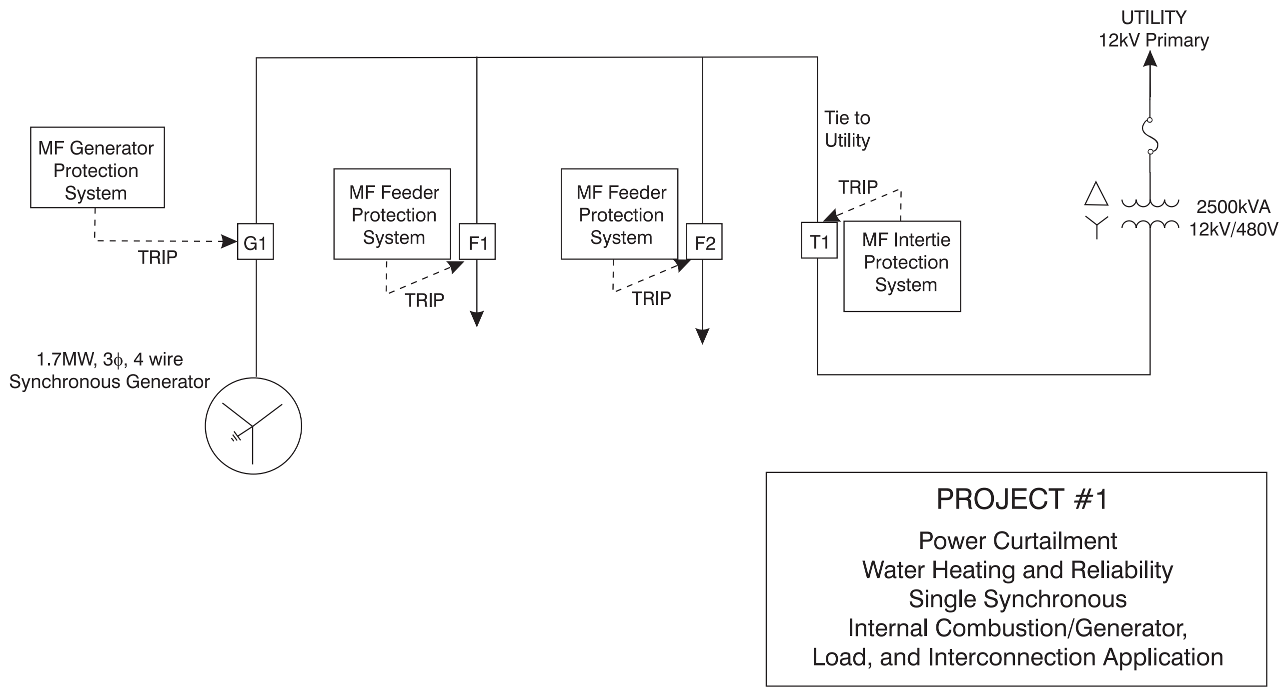

Figure 1: Project #1 One-Line Diagram

b. Project #2 includes a 150 kW steam turbine driven induction generator. The steam turbine recovers energy through control valves in series with the residential condominium complex chillers. The induction generator operates in parallel with the local distribution delivery system. The generator and the interconnection systems are protected and controlled by multifunction numeric integrated devices. Figure 2 is a project one-line diagram.

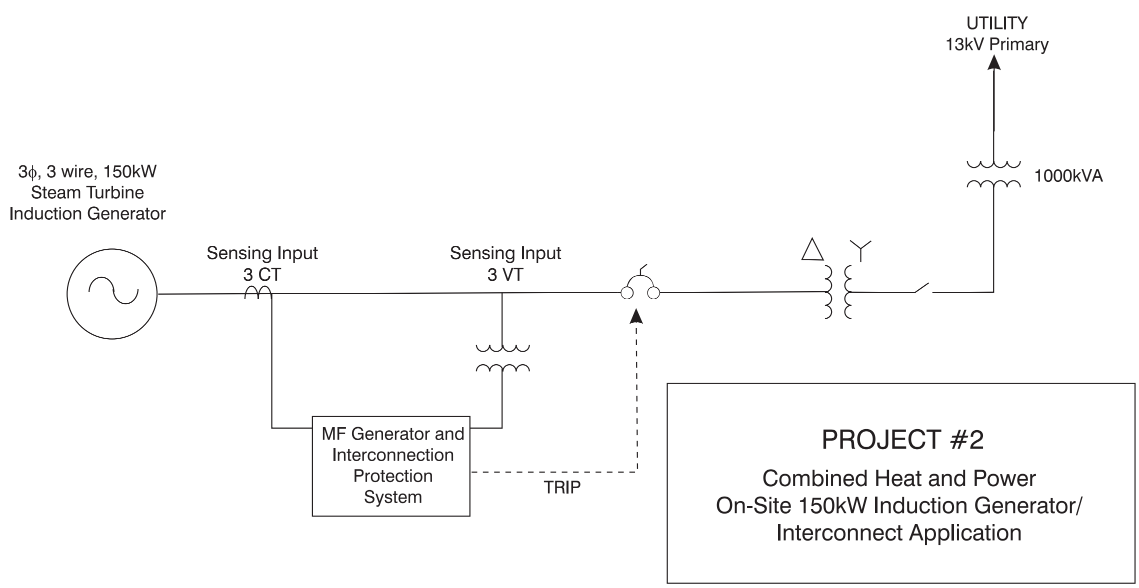

Figure 2: Project #2 One-Line Diagram

c. Project #3 includes two 0.8 MW gas turbine generator sets in combined cycle configuration using HRSG (Heat Recovery Steam Generator) with scrubber control for NOX emission control. The generators are equipped with OEM load-following control devices. The 2 synchronous generators are interconnected with the radial local distribution delivery system. This project has a complement of generator, interconnection, and plant load multifunction numeric protection and control systems. Figure 3 is a project one-line diagram.

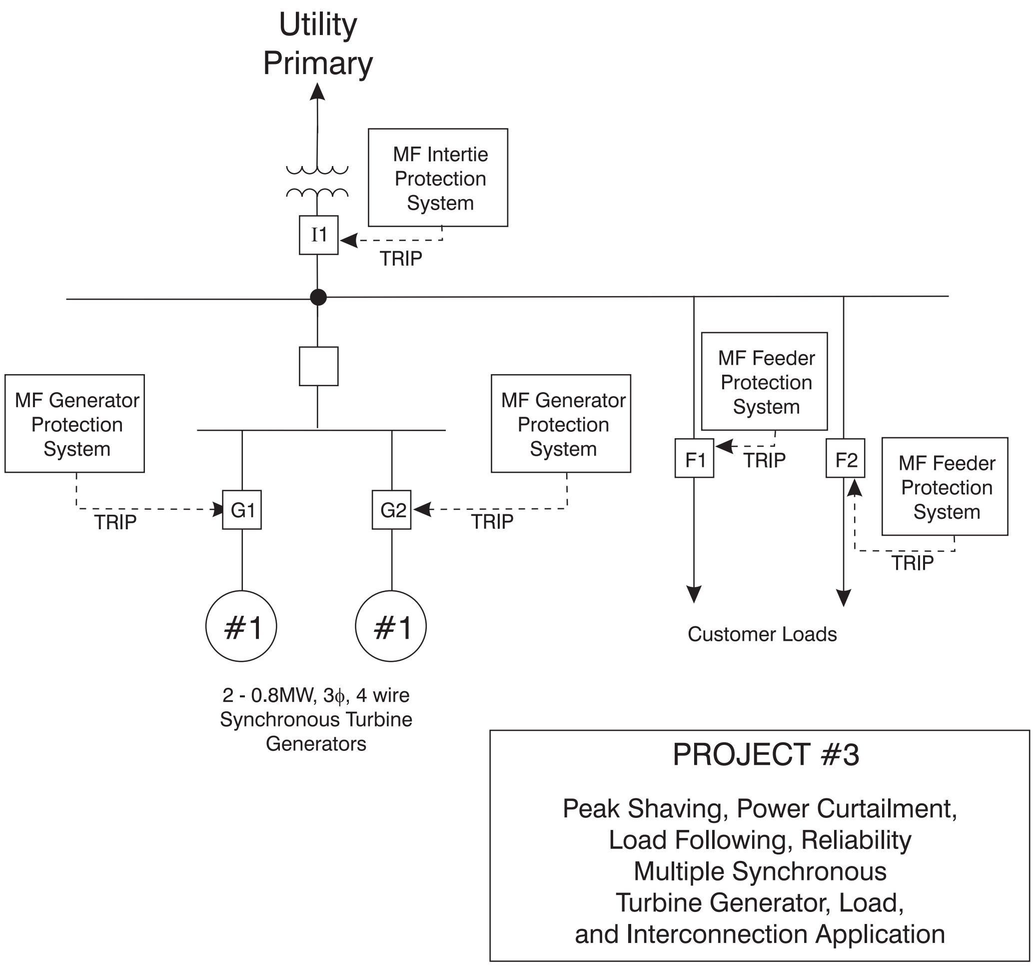

Figure 3: Project #3 One-Line Diagram

d. Project # 4 includes a dual fed 69/12 kV customer owned substation feeding separate sets of customer switchgear lineups. An additional gas fired 2.5 MW internal combustion engine driven synchronous generator was added for continuous delivery to critical plant loads. The local power and energy provider is a combined gas and electric provider. This local energy provider is a "wholesale for resale" municipal system. Operational flexibility for this industrial was needed to remain an economic provider for automobile glass products. The project has multifunction numeric protection and control systems that are integrated with a plant SCADA system. The mutual economic benefits justify the parallel interconnection system for both parties. This project gives the plant owner complete monitoring, remote control, and information exchange for the most beneficial parallel operation of his assets. Figure 4 is a project one-line diagram.

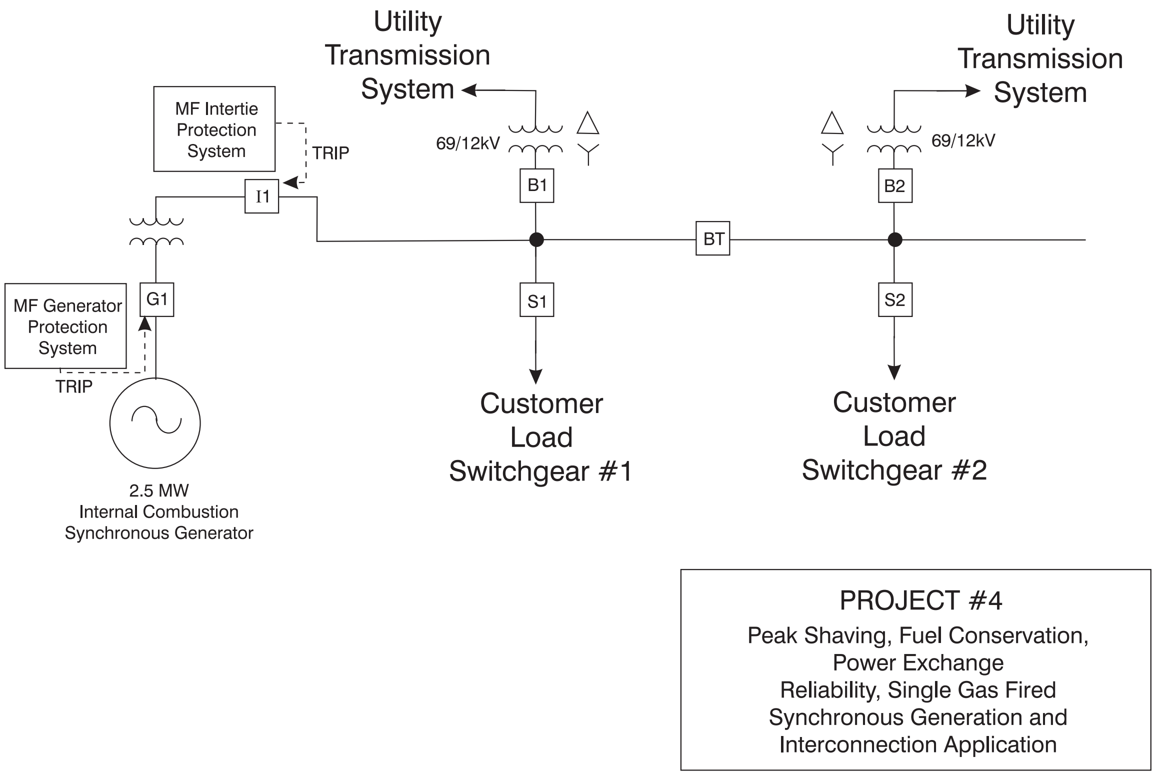

Figure 4: Project #4 One-Line Diagram

III. DESIGN AND BUILD CHALLENGES

a. The protection and control systems used in these projects vary with the overall project scope. Protection design is based on multifunction numeric integrated systems for economic and performance technical requirements for parallel operation. Removal of faulted parts of the interconnected system is paramount. Voltage and frequency must be held to minor deviations. The solution to abnormal operation requires the interconnection to be opened, so that the electrical system in trouble can correct the problem with the appropriate protective elements without placing a burden on both parties. The sensing and time delays are measured in cycles.

The control aspects are done with a PLC platform or an integrated OEM control system. This is required for load following by measurement of voltage, frequency, current, and power parameters. Response time to deviation of parameters is usually on the order of seconds. The governor and voltage regulation devices usually are furnished as an integral part of the generator control package.

b. The protection of the generator is designed to meet the IEEE AC Generator Protection Standard Guide. The protective elements include 27/59, 81O/U, 50/51, 24, 87G, and others as required by the project design specifications.

c. The minimum technical requirements for the protection and control of the DG/Utility Interconnection for units of 10Mva or less are covered in IEEE Std.

1547-2003 Interconnection System Standard. Local requirements supplement these minimum mandatory technical requirements as a part of the project design scope.

d. The protection and control requirements for the customer's load may include load shedding when the interconnection is broken due to abnormal electric system conditions.

e. Emission regulations may require additional control systems to meet local requirements or continuous and intermittent operation.

IV. SUCCESSFUL OPERATION OF COMPLETED DG PROJECTS

The projects were completed over a period of time, requiring a learning curve of the technical aspects of the interconnected operation between the customer and the utility. The induction generator in project #2 had a possible ferroresonance issue. Approval of the project protection and control devices had to meet the utilities' approval for the interconnection system.

Prudent review and preparation of the project documentation as construction progressed to final inspection stage was required for a successful start-up and performance testing of the project. If the project is built to the correct prints, then the project performs as designed.

All 4 projects had different requirements that the design team had to meet to satisfy the interconnection standards in the 4 different locations. Approval was not an easy task to complete.

The technical aspects of Distributed Generation facilities have many benefits. These benefits include improvements in the economics and efficiency of energy delivery for utilities as well as industrial and residential customers.

The security issue after 9/11 has received some indication that Distributed Generation would become a part of prudent facilities planning and operation. When the bulk power grid shuts down as it did recently many utilities and their customers could find a DG useful as long as the safety issues had been designed according to interconnection system standards like IEEE 1547-2003.

The operational experience gained since PURPA for interconnected systems operating in parallel continuously with both import and export of power and energy also has agreements that have worked in a regulated environment.

Issues that can impede or enhance the ability to specify, install, and operate the necessary equipment include legal, technical, economic, and environmental issues.

V. PROJECT #4 INDUSTRIAL GLASS FACILITY STORY

The Industrial Glass facility is in Vonore, TN. They were approached in the fall of 2002 by an advanced Generating Company to consider installation of natural gas fired engine generator equipment. The purpose was to gather operating data as a peak shaving unit interconnected and ran in parallel with the local electric distribution delivery system. The project was completed and placed in service in May 2003.

Since being placed in service, the operating experience has produced data to implement a power supply contract change that will result in significant power demand cost savings for the industrial glass facility. It also has had positive effects on the wholesale for re-sale energy delivery system operated by a municipal utility system. The glass generator unit ran continuously for a 30-day period in May 2003. The Area EPS Power Factor, System Load Factor, and Peak Demand were impacted by this 2,000kW drop and insert customer power plant. The customer generation exported power and energy to the municipal electric delivery system.

There was a significant design and build effort to place the generating unit interconnected with the municipal electric system. IEEE 1547-2003 standard for interconnecting a distributed resource with an Electric Power System was useful in overcoming the past interconnection barriers. The Industrial Glass Facility

Electric System Design and Build Consultant was already involved with the existing design of this plant.

The consultant contacted a protection and control manufacturer of solid state and numerical protection and control devices for application technical support. Figure 4 is the one line diagram of the installation. A recent addition added a sync check relay and a differential relay to provide the ability to parallel back to the utility when operating in an emergency standby mode when a dead bus is present in the substation due to a power delivery system failure.

The following actual photographs are for information and illustration of the project.

Figure 5: 69/12 kV Dual Power Transformer Substation and Generator Building

Figure 6: Interconnection Power Transformer

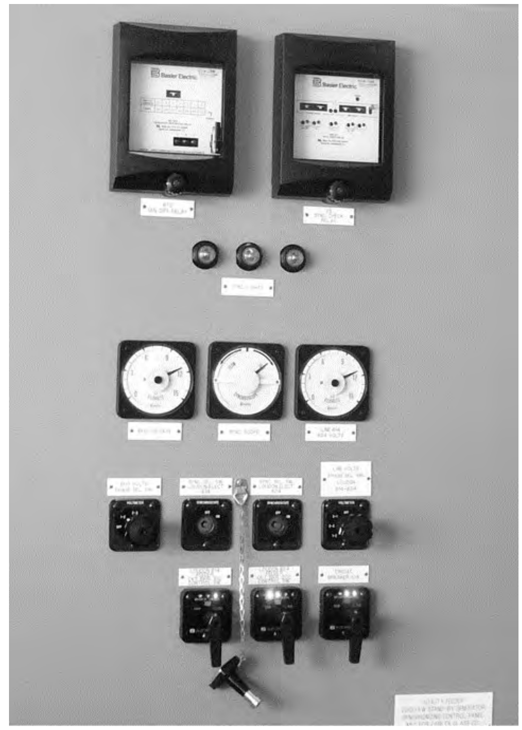

Figure 7: Interconnection Protection and Control Panel

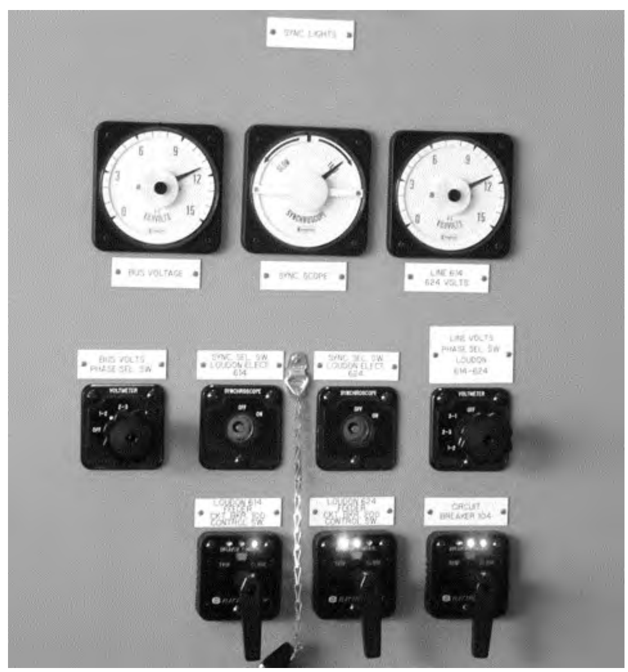

Figure 8: Interconnection Breaker Controls for Synchronizing the Generator to the Utility Grid

Figure 9: Generator and Interconnection Breaker Protection and Control Multifunction Protection Systems

Figure 10: Generator Building

Figure 11: Multifunction Integrated Numerical Protection Systems – Generator and Interconnection Systems

Figure 12: Differential and Sync check Relay addition

The multifunction protection equipment for generator protection is labeled GMR. (Generator Multifunction Relay). The multifunction protection equipment for the interconnection protection is labeled UMR (Utility Multifunction Relay). A multifunction numerical metering system is for monitoring power delivery to the industrial plant switchgear. The Switchgear Power Module incorporated the protective devices along with the respective circuit breakers, monitoring and control systems when operating in parallel with the distribution grid. This switchgear module has capability for operating in an islanded mode by supplying the generated output to the industrial glass plant.

VI. DESIGN AND BUILD TEAM EFFORT

There was a significant technical effort required to meet the minimum mandatory technical requirements for a continuously interconnected operation between the Industrial Glass Co., the Municipal Utility, and the Generator Vendor. The start-up and commissioning effort went well because the design team worked closely together. Good engineering practices were followed during the planning, design, build, start-up and commissioning phases of this project. The Industrial and Utility worked together to make sure the operating and maintenance procedures were well thought out.

The engineering efforts by the project owner's consultant helped keep the team effort on track. Successful operation was achieved for this project.

VII. SUMMARY AND CONCLUSIONS

Data gathered to date indicates that the economics for these projects have shown the production of the on site generation is dependant primarily on fuel cost and local utility energy costs. Operational data indicates that the economics of operating the on site generation for Power Demand cost reduction and for the release of the distribution capacity and reduced delivery losses have been achieved.

In the Industrial Glass Facility, the benefits of energy cost reduction, improved cash flow, and emergency power from the DG were achieved. The Municipal Utility retains a financially stronger and more viable industrial customer. Both parties to the parallel operation receive the benefit of released system capacity of in the range of 10%. Improved voltage regulation and power quality also have been achieved. The bottom line seems to be this DG project achieved a cost effective effort for the capital outlay to design and build onsite generation.

The balancing of electric demand and energy has improved the overall Load Factor of both parties to these interconnection projects. The economics for these projects is a win-win situation for all parties involved in these projects.

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