Distributed Power Opportunities For Investor-Owned Utilities

Cogeneration Can Play A Major Role

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The Investor Owned Utility (IOU) industry is on the verge of going through massive change. Deregulation of electricity may change the face of electric supplies in the same way that deregulation of transportation changed the face of the rail industry.

In 1979 the rail industry was made up of several hundred small railroads serving specific markets with regulated rates. Since deregulation the industry has consolidated to six major railroads, three in the east and three in the west. This consolidation may continue until there are three railroads which serve from east to west.

Today's utility industry consists of approximately 300 locally regulated companies who provide electricity into franchised areas at regulated rates. The rate structure is based on a bottom up pricing format which allows profit to be based on costs. This is similar to purchasing an automobile by going to your local NAPA dealer and starting with the purchase of a battery, four tires with rims, an exhaust pipe, etc. To all of this a profit margin is added and the price is established.

Deregulation means supply and demand pricing where the lowest cost suppliers will command the most customers. As the IOUs wake up to this process, they will need to re-think their generation and distribution decisions to create a far more efficient system.

In the past, the philosophy has been to create large central plants with a network of transmission from these central facilities to ultimately reach the customers. The entire process has been based on the lower cost of construction for larger coal and nuclear power facilities.

Unfortunately this approach is counterproductive for the transmission and distribution system. When 100 percent of the generation is located in central plants and the system load factor is only 60%, then the transmission system must be nearly 50% larger than required for use as a baseload supply network.

When electricity is deregulated the value of available transmission space will be increased significantly. Therefore, the need for improved efficiency of transmission and distribution can be documented.

IMPROVING T&D

It has been suggested that for the first time the cost of transmission and distribution exceeds the cost of generation. If the current load factor for the T&D system is 60% and it could be improved to over 90% through changes in generation, then the cost of T&D could be reduced by as much as 50%.

At the same time the available space on the T&D system for base load transmission could be increased by as much as 50%. This change in baseload capacity could further improve the operation of the larger, more efficient equipment and increase the revenue from these facilities.

How is it possible to accomplish this efficiency improvement? Distributed generation is the answer for IOUs in a number of different ways. The first piece of the puzzle relates to the generation of peaking capacity at the lowest practical and most efficient level. To accomplish this the general system configuration (Figure 1) is assumed.

When power is produced at the top 500 kV level and transmitted downward, it is necessary to produce to meet the peak requirements. When base load power is produced at the 500 kV level with peaking and intermediate are produced at the 69 kV level, the utilization factor for the T&D system can be increased to over 90%.

A typical load duration curve (Figure 2) demonstrates the concept.

This annual loading curve shows clearly that optimum utilization of the T&D system could be achieved by moving the peaking and

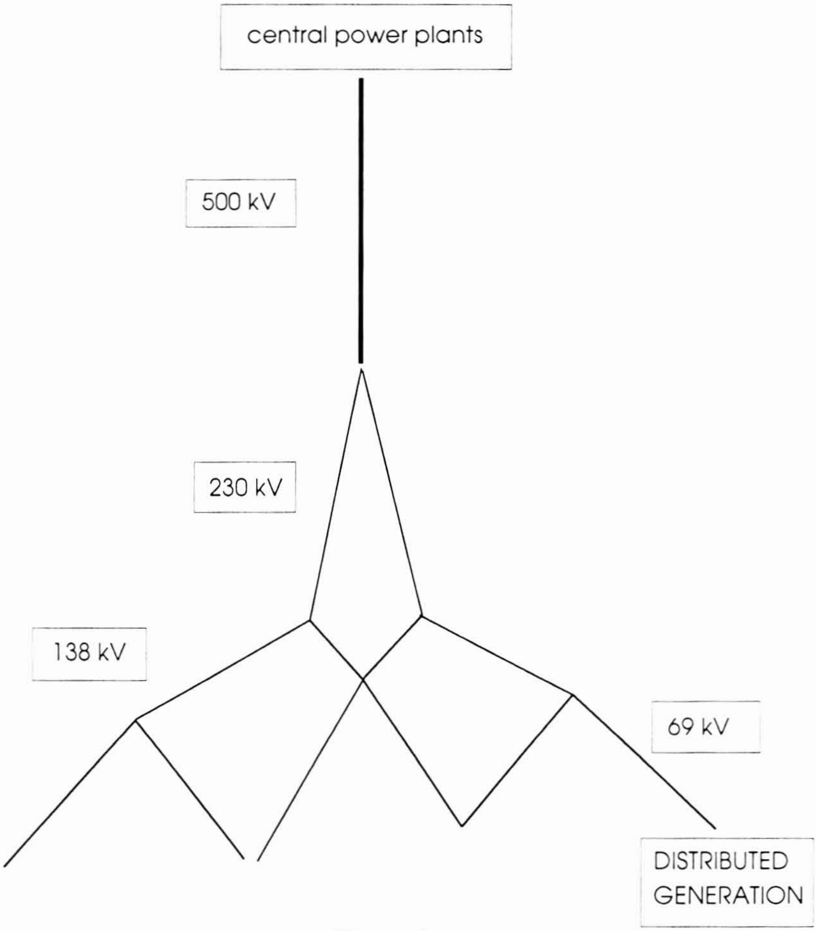

Figure 1

intermediate generation to the lower transmission voltage levels. In other words: Move the generation closer to the load centers and away from the base stations.

Peaking units must be made to provide quick response to load changes at low capital costs. Fuel cost is always a factor, but, in this case it plays a smaller role. By the same token, fuel type is less important in this role. Diesel engine-generating systems are one advantageous way to meet the needs of low capital cost, high reliability, high efficiency when compared to combustion turbines in simple cycle and appropriate size for integration into the system at the 69 kV

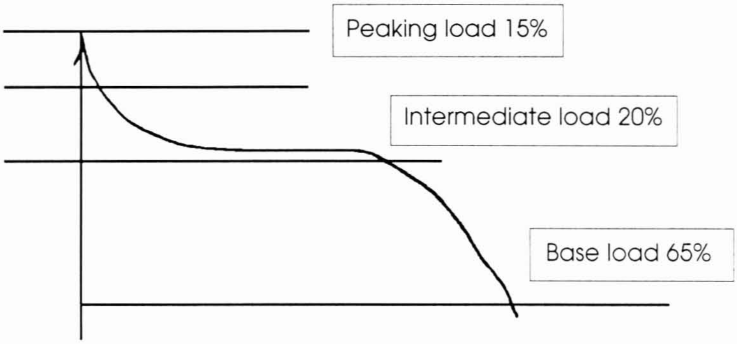

Figure 2

substation level.

It is true that combustion turbines can be installed less expensively at the central station level. This fact does not take into account the opportunity cost for the transmission system which is being utilized. Or for that matter, it does not fully account for the T&D losses which would be avoided by using distributed generation at the lower transmission level.

Peaking units are normally planned for operation from 0 to 500 hours per year, based on a daily load curve which normally looks as follows:

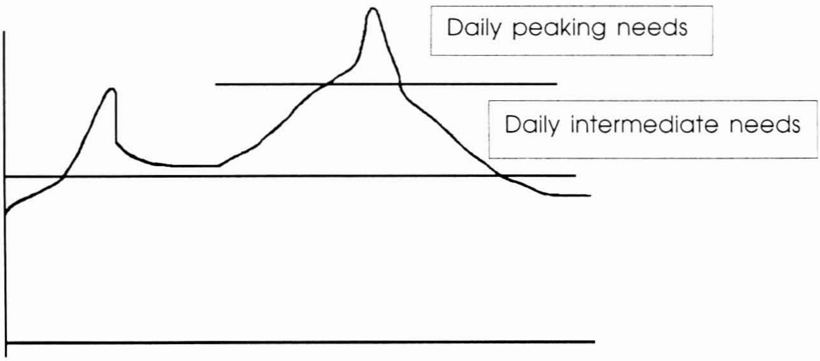

Figure 3

The intermediate needs will normally require operation between early morning and mid-evening and will vary with time of year. The normal intermediate operations will total between 500 and 5000 hours per year and will have varying loads within those hours of operation.

Diesel Engine Combined Technology equipment is ideal for this type of operation. These systems are designed to operate at very high thermal efficiency while maintaining separate control of both steam and electrical generation. The plant efficiencies for these facilities will always be more than 65%. As a result these facilities will provide low cost electricity and process steam for utility users. The typical plant may look as follows:

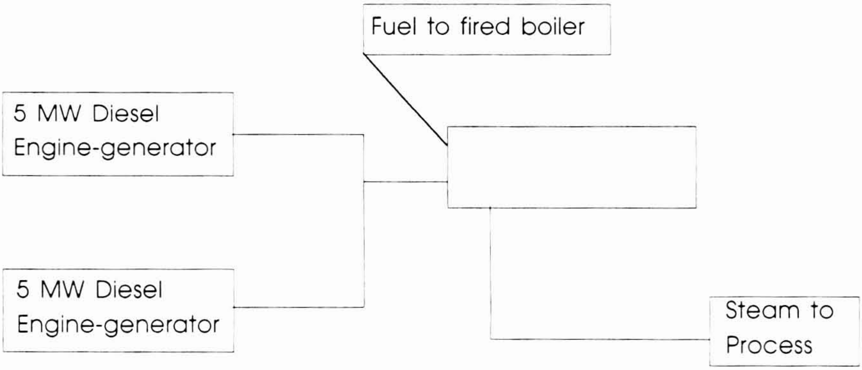

Figure 4

In this case the two 5 MW engines would provide heat to a conventional steam boiler. The boiler would take advantage of the heat from the engines, but, the boiler could operate in a stand alone mode when the engines are not in operation. On the other hand, the engines can operate completely independently from the boiler and do not require the boiler in normal duty. The high efficiency of the engines and ability to use natural gas, make this an ideal opportunity.

This industrial cogeneration system would be owned and operated by the IOU in such a way that it maximized the efficiency of the system and optimized the operation of the T&D system.

Typically, the intermediate duty engines would only operate during the day for five days per week. This 60 to 70 hour per week operation would allow for maintenance during periods when engine operation was not required.

The high efficiency enjoyed by the system and the ability to use low cost base load generation when the engines are off, provide a means for IOUs to maintain Return On Investment to stockholders, while providing lower rates to industrial and, potentially, other customers.

In addition to these situations, it is possible that distributed generation may also provide an opportunity for making cost effective repowering improvements to older power stations. Most of the older and smaller stations are located near to or inside of the load centers. Under the current thinking, these units are considered as stranded assets. When engines are added to existing plants in the form of feedwater heating or hot windbox repowering, the efficiency of the base plant may be improved by as much as 10% and the output increased by as much as 25%.

The engines are configured in the same way as the industrial cogeneration systems, so that the engines can be operated when the boiler is not. The extremely high simple cycle efficiency of the engines may make them excellent peaking duty equipment. And, when the boiler is operated in conjunction with them, they become good intermediate or even base load units.

REGULATED VS OPEN MARKET PRICING

All regulated industries have certain common characteristics. Most important is the fact that regulated profit margins are set and based on an agreed upon cost structure. This theory allows regulators to insure that rate payers are not being over charged for the services they receive. This theory functions reasonably well, in that it places constraints on pricing in a monopoly environment.

Unfortunately, the practice of basing profit on cost creates an environment where it is profitable to justify the highest possible cost in order to get the highest possible profit for stockholders. To put this in real terms, it is necessary to view the stockholders and ratepayers as having completely opposing interests with the regulators acting as judge and mediator.

If a regulated utility experiences an increase in peak load which is of short duration, it is possible to satisfy that load by adding peaking capacity. To satisfy the need, the IOU looks to the regulators to determine what is viewed as "Prudent Utility Practice." If it is determined that installation of peaking simple cycle combustion turbines at the central station level is viewed as "Prudent," then the planner will proceed accordingly. By doing this, the IOU is assured that they will be able to recapture costs and receive their rate of return on the investment.

If this installation requires all or part of the T&D system to be improved, the cost is factored into the program and all of these costs are allowed into the customer rate base with an agreed-upon margin for stockholders of the IOU stock.

In an unregulated environment the same situation could trigger a completely different reaction. The IOU will look at the market price for the electricity in determining the best direction for satisfying the need. The market price is determined by the lowest cost supplier willing to serve the identified need. Since this price is determined by the forces of supply and demand, and the profit is dependent on the IOUs ability to find a way to satisfy the need in the most efficient manner, the rate payer enjoys the lowest rates and the stockholder depends on efficiency of operation to be profitable.

If the total capital cost, operating and maintenance cost, and opportunity cost for both the generation and distribution system is lowest by installing the same peaking unit at a central location, then that would be the choice. If it was more economic to purchase the peaking from a third party then that would be done. If it is more economical to install the peaking at the lowest transmission level, then that alternative would be selected.

The decision would be based on market factors, rather than cost factors. This approach overall will lead to a more efficient generation and T&D system.

Clearly, competition of this type can only exist where a comprehensive grid structure which is accessible to all parties is available. Therefore, decisions which tie up transmission systems for very low load factor uses will be much less viable.

THE OFFENSIVE STRATEGY:

IOUs who have significant low cost highly efficient base load capacity which can be made available to customers outside of their own system will be seeking opportunities for the use of these plants. To do this, it will be necessary to satisfy a number of conditions. Clearly, the first criteria will be the availability of excess low cost generation capacity which is not committed to the local grid. Second, the T&D system must be available to carry the capacity to the area which needs to be served. Third, there must be a customer for the electricity who is willing to purchase capacity and energy from a remote supplier. And fourth, peaking and intermediate generation must be local to the user.

The reasoning for these conditions is obvious in some cases but is less obvious in others. The first condition must be satisfied or there is no reason for either the seller or buyer to be interested. The second condition is necessary to make the connection between the seller and buyer. In fact, the second condition must include considerations about line losses, transformation losses, and the cost for connecting the buyer and seller. The third condition may be the largest hurdle because it requires more faith in change by the buyer.

The fourth condition is not as obvious as the other three and requires some discussion. In this case it is necessary to minimize the cost of service to the buyer. To accomplish this at the lowest cost it is necessary that only base load service be transmitted from the serving utility to the customer. The balance of the electricity, that is, the intermediate and peaking required by the customer should be generated at the local level. Ideally, the intermediate portion of this load should be generated in a cogeneration system where the cost of service will be minimized. The peaking portion of the load is not as sensitive to fuel use and can be done by smaller peaking generators.

THE DEFENSIVE STRATEGY FOR UTILITIES

The defensive strategy for higher cost utilities will be similar to the offensive strategy with the following alterations. IOUs who feel that they are likely to lose customers in the new environment may find that they can follow a very similar strategy by creating smaller cogeneration facilities which serve their key customers. To make this strategy work even better, they could purchase wholesale base load capacity from other utilities which they provide to the same customers. By taking these actions, the IOUs will preserve their customer base, protect themselves from other sellers, and provide lower cost electricity to their customers.

THE POTENTIAL ROLE OF MUNICIPAL ELECTRICS AND OTHER NON-IOU ENTITIES

The municipal electric utilities may play an important role in electric utility reorganizations. They represent small islands of customers including potential cogeneration opportunities which are located within other utility areas. As such, in an unregulated environment, it may be possible for an outside seller of electricity, including power brokers, to establish a location for peaking and intermediate generation within a municipal electric service territory while bringing base load into the territory from outside.

The benefits to the local rate-payers and the individuals within the territory can be significant. Further, the supplier then has a base of generation for spreading to other customers outside of the territory.

SUMMARY

The installation of peaking and intermediate capacity at the 69 kV and 138 kV level may provide an opportunity to improve the utilization of the T&D system. At the same time, it may provide a new opportunity to lower rates to key customers.

EXAMPLES OF POTENTIAL SITUATIONS:

Case 1:

A utility is experiencing rapid load growth along a specific corridor of operations. The area is served by three 69 kV substations which are serviced by three independent single 69 kV feeders. The 69 kV feeders originate at from two 138 kV substations which are cross connected to provide high reliability. All three of the 69 kV feeders are at near capacity, and, as a result, the two 138 kV systems are also at near capacity.

The load is largely residential with a growing commercial and industrial base. The industries in the area are largely one shift operations, with a few of them operating on three shifts and requiring process steam.

The load profile is not very good with 15% peaking on a daily basis, 25% intermediate and 60% base load.

The peak load is growing rapidly and the intermediate load is also increasing. This will further reduce the load factor for the transmission system and create a greater bottleneck.

The Old Method

Under the old thinking the utility would install one or two peaking combustion turbines at some central point and then reinforce the transmission grid by increasing conductor sizes or running new lines.

The New Method

Under the new distributed thinking process the IOU might install 60 MW of peaking located in 20 MW blocks at the three 69 kV substations. The units would be operated remotely and would eliminate the line and switchgear losses from the old system as well as eliminate the need for changes to the transmission system.

In addition, as the load continued to grow, the IOU would install an additional 60 MW of intermediate load in the form of industrial cogeneration or diesel combined technology plants at the same 69 kV level. This would relieve the need for new transmission for a much longer period and would transfer 120 MW of total transmission capacity over to base load duty.

This would be accomplished because the 120 MW of peaking and intermediate capacity installed at the 69 kV level would back up the system to the 500 kV level where it would free up 120 MW of high voltage which could be used to transport coal and nuclear capacity to other places inside or outside of the service territory served by the IOU.

Case 2:

An industry inside of the service territory of a large IOU is having trouble as a result of high electrical and steam cost. They have resisted the idea of using an IPP, but, now feel that they will either have to relocate to a lower cost area, talk to an IPP about cogeneration, wait for de-regulation and shop for cheap power, or bargain with the IOU to cut a special deal which reduces their rates.

The industry has a modest 20 MW electrical load with a 250,000 pph steam load. The steam load is fairly constant, but the electrical load is much higher during the day than at night. The industry employs 2,500 people who would be displaced if they should fail. This added loss would be significant for the economy in the area and the revenues for the IOU.

In addition to these problems, the industry is using old boilers which burn No. 6 oil, are not very efficient, and they no longer meet environmental standards. The industry will have to improve these units if they switch fuels to make them more efficient to operate.

They have approached the IOU to see if there is some way to solve their problem.

The New Approach

The IOU puts them in touch with their group which specializes in these types of problems. The team manager instructs the team that they must find a solution which helps the IOU by improving load factor in the transmission system and maintains the current ROI for the IOU. The team arrives at the following solution:

The plant will consist of four 18V34 gas engines connected to two 125,000 pph steam boilers which will serve the steam needs for the industry. The four engines will be connected in a way which allows them to be dispatched by the IOU while not altering the steam operations. The engines will operate on a daily basis in a load following mode.

The exhaust and other waste heat from the engines will be recovered and utilized in the steam boilers. This may be done by simply connecting the engine heat into the feedwater and condensate return system. In this way the engine efficiency will be maintained at between 70% and 90%.

The boiler fuel will be directly reduced by the amount of recovered heat from the engines. Otherwise, the boilers will behave in the same was as conventional units. In the process the primary fuel for the industry will be switched from oil to natural gas with back-up light fuel oil.

The IOU offers to purchase the old boilers for use as back-up for the new boilers. The industry will no longer be in either the electrical or steam business and the IOU will pick up the additional revenue. The rate for the steam is set to reflect the true cost of steam with a reasonable rate of return to the IOU.

In the end, the industry signs a long term purchase contract for steam and electricity. The utility improves its T&D load factor and maintains ROI. And, the industry saves money.

Case 3:

A large mid-western IOU has a very efficient coal based generation system which under a deregulated environment could be marketed to other areas of the US. They have transmission lines to many areas, but, most of them are operating at full load during parts of the year. They have attempted to construct new 765 kV lines to move power to other areas, but, have run into very heavy public resistance. In fact, they have been stopped completely in some areas. The public appears to be convinced that EMF problems are real.

The problem for the IOU is, therefore, to better utilize their existing transmission system in order to enable the transportation of the previously constructed base load capacity.

In this case the IOU has systematically purchased combustion turbines for peaking needs and placed them adjacent to existing coal fired facilities. The logic is that the low cost of the turbines and close proximity to other facilities was a distinct advantage. This logic is correct in instances where the transmission system can be expanded at will and at low cost, but has problems where constraints to transmission expansion occur.

The New Solution:

Again, the solution to this problem lies in the proper use of distributed peaking capacity and intermediate cogeneration. Each 69 kV sub-station can be provided with up to 15 MW of peaking and each 69 kV network can be provided with 20 MW of cogeneration. By doing this, the high voltage system is cleared for transmission of base load capacity to other areas where the electricity can be marketed.

Case 4:

A northern US utility recognizes that they have very high cost aging generation, much of which is using low sulfur oil as a fuel. These expensive-to-operate units place them at a distinct disadvantage under a deregulated environment. They have formed separate companies for generation and T&D and feel that they are going to decrease their stock value when de-regulation takes place.

WHAT CAN THEY DO?

It is probably true that, under the conditions above, their large generation facilities will be uneconomic to operate under these new conditions. It will be much more cost effective to bring in lower cost power from outside of the local area. If power is brought in, it will only be cost effective to bring in base load, therefore, the peaking and intermediate formula used above will be appropriate.

The utility will need to shift its generation focus from large baseload units to cogeneration and peaking orientation. This will insure the economic viability for the generation company and maximize profits for the T&D company.

At the same time this will reduce personnel need in the utility and insure that customers are provided with the lowest cost electricity.

ABOUT THE AUTHOR

Mr. Shelor has 23 years of experience in various engineering fields. This experience includes early design of commercial building automation systems, industrial power project management and development of waste-to-energy and small-scale power systems.

Mr. Shelor has provided innovative concepts in many different applications. He received a first-place design award for an early building automation system from Region III of ASHRAE and has written papers on fluid bed applications. He is the creator and patent holder for the Diesel Coal Combined Cycle concept.

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