History of Cogeneration

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The practical use of cogeneration is as old as the generation of electricity itself. When electrification of broad areas was devised to replace gas and kerosene lighting in residences and commercial facilities the concept of central station power generation plants was born. District heating systems were popular during the late 1800's and why not. District heating dates back to Roman times when warm water was circulated in open trenches to heat buildings and communal baths. District electrification dates back to Thomas Edison's plants in New York and it didn't take long to combine the two. The prime movers that drove electric generators throw off waste heat that is normally blown to atmosphere. By capturing that heat and making low pressure steam that steam could be piped throughout the district for heating homes and businesses. Thus, cogeneration on a fairly large scale was born.

As electrification marched across the country most of the generated electricity was on site in large industrial plants. With that generation there is no doubt that much waste heat was captured and utilized in industrial processes as a natural offshoot. Probably the word cogeneration was not even used in conjunction with those efforts, but cogeneration it was. As large, central generating stations were built it became cheaper for those industries that had been self generating electricity to now buy from the central utility. With that change came the end to 'cogeneration' in those industrial plants. Central station utility plants were now located off the beaten path so even district heating suffered as the lines to connect to districts became too long and costly. Cheap oil and natural gas were the cause of our return to wastefulness

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and little thought was given to energy efficiency when oil was selling for under a dollar a barrel.

But nothing is steady. Change is everything. With the first OPEC energy crisis in 1973 came a realization that America was no longer self sufficient in supplying its total energy needs and that foreign countries now controlled what the price of energy would be. The oil produced in America may still only cost $4.00 per barrel, but if OPEC was going to sell its oil at $20.00 per barrel and we had to import over half our needs, then all oil was going to sell at the going rate. With expensive energy came plans to conserve energy and to seek energy supplies that were heretofore costly to get at and to seek alternative sources of energy. The famous tar sands of the Athabasca region in west central Canada were exploited when the cost of oil was predicted to go to $40 a barrel. Drilling rigs were punching holes all over the traditional oil bearing areas of the United States opening small 'stripper' wells and re-opening wells that had been abandoned due to the higher costs of production. America was in an oil boom only to see it burst when OPEC, knowing they controlled these matters, let the cost of oil slide to $10 a barrel and watched those efforts at exploiting domestic sources go a-wanting.

Conservation was now a household word. With the cost of electricity tied to the price of oil consumers felt the pinch of rising electricity prices. An enterprising group of neighbors in the Bronx section of New York decided to put up a windmill to generate enough electricity to help cut their costs from Consolidated Edison, the major supplier of electricity in New York. They would still be tied into Con Ed's system, but when the wind blew they could count on their costs being lowered by their wind-powered production of electricity. The system was so successful that at its peak it generated slightly more electricity than was needed at any given time so they decided to sell this excess back to Con Ed who, of course, was getting it free whenever an excess was generated. Con Ed balked at having to buy power from this upstart neighborhood and abjectly refused. The neighbors sued, won, and from this meager beginning came the Public Utility Regulated Policy Act that we fondly call PURPA today.

The PURPA law paved the way for larger scale cogeneration and independent power generation. Very few businesses could afford to generate their own electricity exclusively. Variations in their power needs on an hour by hour basis; reliability and maintenance of the on site generators; additions to their operations; all required the back up of the central station utility to make these independent power generators and cogenerators feasible. In effect, PURPA says that a central station utility must allow interconnection of these facilities with their grid to act as standby and makeup power sources. It further defined that the cost of the fuel to power these cogenerators would be similar to that which the central station utilities paid for their fuel.

Furthermore, it reinforced the law requiring the central station to purchase any excess power generated by these independent facilities at the 'avoided cost' of the utility. The term 'avoided cost' led to very creative accounting by the utilities to determine exactly what was their 'avoided cost'. Too low and their guaranteed return on investment would be jeopardized; too high and their payment for purchased kilowatts would be too expensive. It is doubtful that any two utilities in the country had identical policies when it came to determining their 'avoided cost'. Those utilities that were selling kilowatts at 5 cents each were virtually immune to independent power producers and cogenerators, while those whose prices were 16 cents a kilowatt were now inundated with alternative sources of electricity. Abuses were rampant on both sides. Facilities were built in these high priced regions presumably as cogeneration facilities, but they were mostly power generators that wanted to capitalize on the cheap fuel costs for cogeneration systems and the other PURPA law advantages. When the utility was forced to pay 8 and 10 cents a kilowatt for 'excess' power it became advantageous to produce 'excess' power.

With these abuses came regulations. The Federal Energy Regulatory Commission, FERC, was set up by the government to put some ethics into the business of generating, buying and selling independent power. An efficiency standard was set up requiring a cogeneration system to meet a minimum standard of thermal energy utilization in order to derive the full benefits of PURPA. The formula used is: (All inputs are in Btu's)

$$\text{Efficiency} = \frac{\text{(Thermal Energy Produced/2 + Electrical Energy Product}}{\text{Fuel Input}}$$

The minimum efficiency required to meet this formula is 42.5%.

Squabbles between utility and cogenerators still ensued, however, as the responsibility to prove FERC efficiency was argued. The cogenerators said that if the utilities wanted to know FERC efficiency they could instrument and monitor the units. The utilities said it was up to the cogenerators to prove they were meeting the minimum efficiency levels. Cogenerators still wanted to generate as much electricity as possible as this was the motive force that paid for their investment. If the heat could be used, fine. But if it could not be used it was then discarded via blow off radiators while the electrical generation went on. These blow off radiators, also called dump radiators, were integral to the system and were actuated thermally when the cogeneration heat transfer fluid, usually the engine coolant, reached a maximum temperature. To continue to operate the cogenerator with reduced heat transfer caused excess coolant temperatures and the engine would shut down on high temperature.

Obviously, this would interrupt the on site generation of electricity and the engine could not be restarted until the temperature of the coolant came down. Not being practical, nor economical, the dump radiator was incorporated into the system to take care of these periods of little useful heat transfer. The utilities could not prove that the FERC efficiency was being violated so if the cogenerators did not supply the information the utility enforced the PURPA rule and all gas that was purchased at the cogeneration rate would now be priced at the commercial rate and was retroactive to the previous three years. This was a hefty penalty. Even a small cogeneration plant, say 120 kW, could face penalties of up to $90,000 for three years worth of cogen gas.

So, cooperation was instituted with the cogenerators instrumenting their plants to provide the annual report to the utility on the efficacy of their systems. Newly designed cogeneration packages incorporated instrumentation built in to the package to record kilowatt output, fuel input and thermal output, including dump radiator output, so that the FERC efficiency could be calculated instantaneously and reporting to the utility made easy.

A typical example of this method of control and optimization is when a cogeneration plant is placed into service at a municipal swimming pool or a health and fitness club that heats their pool and spa year round. During the winter months and most of the spring and fall, the cogenerator heat is used efficiently to heat the pool water with little or no heat being "dumped." But, when summer comes and the pool water escalates to 90 degrees from Mother Nature, the heat from the cogenerator must be redirected to the dump radiator.

It is at this very time of year that the utilities value their product most dearly by imposing higher energy charges per kilowatt as well as exorbitant demand charges. Energy charges may go from 4 cents a kilowatt in the winter to over 7 cents a kilowatt in the summer. Demand charges will go from $4.80 per kilowatt to over $25 per kilowatt of demand. The period of this high demand usually runs from May 1 through September 30 and be bracketed from 11:00 AM to 6:00 PM daily except weekends. The utility monitors the demand meter so that if any demand increase occurs for 15 minutes during this period the full demand charge is made for the entire month. For example, if a cogenerator is producing 120 kW of electricity and the remainder of the facilities needs are 80 kW then the facility only gets billed for the 80 kW. At $25 per kW his monthly bill for demand would be $2000. However, if the cogenerator should go down for any 15 minute period during this high demand window, then the facility gets billed not only for the 80 kW he had been getting from the utility, but also the 120 kW the utility must now send him due to his cogenerator being down, even if were only down for 20 minutes! His demand bill for that month would leap from $2,000 to $5,000, an increase of $3,000 in one month alone!

Now you see the value of the dump radiator. Should a system be getting near a default situation with regards to FERC efficiency, it would be far better to shut the system down at night or during the late fall or winter months than to have it down during peak demand periods. The same would be for routine maintenance such as oil and filter changes. This service should be done only at night or early morning during those high summer demand charge months.

ABOUT THE AUTHOR

Mr. Bernard F. Kolanowski is the president of Kolanowski & Associates in Carlsbad, CA. His company specializes in applying small-scale cogeneration packages to commercial and industrial users.

Mr. Kolanowski has more than 35 years experience in the sales and marketing of capital equipment including various forms of alternative energy and cogeneration. He was national sales manager for Ingersoll-Rand's compressor line, setting up a network of more than 100 dealers across the U.S. He was V.P. of sales and marketing for Environmental Control Products, Inc., a manufacturer of incinerators and waste heat recovery equipment.

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