Monroe Community College
STATE UNIVERSITY OF NEW YORK

Cogeneration: What and Why?

Cogeneration (also referred to as Combined Heat and Power or CHP) as a concept is a relatively simple one. Traditionally, electricity is generated by large plants located quite a long distance away from where the electricity will ultimately be used. That means that the massive amounts of heat created during the process are lost because heat cannot be transported over the same distances as the electricity can. There are also electric losses that occur as a result of sending the energy such long distances. As much as 2/3 of the energy that a plant uses to make electricity can be wasted due to thermal and transmission losses.

Cogeneration tries to solve these problems by placing the generation plant in close proximity to where the electricity and especially the heat can be utilized either for space heating, industrial processes, or to be converted into other forms of useful energy. Ultimately, this relationship between the amount of electricity generated and the amount of heat produced by the process is very critical, which is one of the reasons that cogeneration does not make sense for every situation and why the design of the system is so crucial to being able to successfully operate a cogeneration plant.

In addition to being able to utilize both the heat and electricity created by the generation process, there is one other very significant benefit to operating a Cogeneration plant that has not yet been mentioned which is system redundancy and resiliency. Resiliency and redundancy are not exactly the same thing but let's save that discussion for another time and simply understand that because a cogeneration plant has the ability to provide a large percentage of the electric load (sometimes 100% or more) it is essentially a very large backup generator. This capacity means that many facilities with cogeneration plants are able to operate at or close to their normal conditions even during extended power outages. If those systems remain tied to the grid (some don't and operate completely independently) it also means that if there are problems with the cogeneration equipment, the facility can simply switch to grid power and operate as a traditional facility would. Now, in certain cases this switchover from grid power to cogeneration power (or vice versa) will go completely unnoticed by building occupants but, this transition is not always as seamless as one would hope. Due to the varying nature of the causes of grid outages and the realities of some of the safety equipment involved (more on this later) outages do still occur and should be expected, but the duration of outages should be drastically less than they would otherwise be.

Cogeneration at MCC

A Brief History

The cogeneration plant at Monroe Community College was installed in 2003. Prior to this, MCC obtained heat in the form of steam generated at the Iola plant, and electricity directly from the local utility grid. The steam was transported through tunnels to the MCC campus where it was distributed to each of the buildings. Due to the age, condition, and inability of the Iola plant meet more stringent regulations, as well as the deteriorating condition of the steam distribution systems, it became obvious that drastic changes would have to be made to the heating systems in order to maintain service to the MCC campus. The decision was made that the best long-term solution would be to install a cogeneration system which could supply hot water to the MCC campus as well as provide for the full electrical load of the campus at any given time.

In parallel, the decision to use cogeneration at MCC was accompanied by the decision to retrofit the Iola plant with a cogeneration system of its own which would serve the other county owned facilities previously served by the plant. To facilitate this project, Monroe County formed an LDC (Local Development Corporation) known as Monroe Newpower. Monroe Newpower owns and is responsible for the operation of all of the equipment including the generators, chillers, boilers, and even the basement which houses them on the MCC campus. They are also responsible for purchasing of the fuel and electricity that serves the campus from the utility grid. As part of the project, MCC entered into a power purchase agreement with Monroe Newpower, agreeing to purchase all of the electricity and heat produced by the new plant. This arrangement has a number of interesting implications, not the least of which is the limited influence that MCC has over the operation of the cogeneration plant and decisions made relative to service and support of the equipment.

The costs of this project were obviously a huge consideration during its inception. Monroe Newpower incurred a debt of $20.5 million in order to fund the project, and as part of the power purchase agreement MCC agreed to fund that debt on a monthly basis. This results in a monthly payment of approximately $73,000 (it decreases slightly every year) that MCC pays to Monroe Newpower as a fixed cost, regardless of the production output of the cogeneration plant. MCC is contractually obligated to fund this debt payment through the end of 2035.

In addition to the debt payment, Monroe Newpower charges MCC for a portion of the service contract which is in place (currently) with Siemens to operate and maintain the cogeneration plant. This contract includes all of the preventative maintenance, service, and operations for both the MCC and Iola cogeneration plants. Currently the proportion of the service contract paid by MCC vs Iola is determined by the ratio of the annual gas consumption of each plant. For example, if each plant used the same amount of natural gas for the previous year the service contract would be paid half by MCC and half by Monroe County, if MCC used three times as much gas as the Iola plant, we would pay 75% of the service contract fee. This contract has been in place since the start of operations and expires at the end of calendar year 2015. Prior to the expiration of the contract, Monroe Newpower will issue a request for proposals for a new service contract to continue operations of both cogeneration plants and select a new vendor (or possibly the same vendor) for this service.

The final piece of the puzzle governing the cogeneration plant and its operations is the service agreement that we have in place with the local utility provider (Rochester Gas and Electric). Obviously generating most of our electricity on site but simultaneously maintaining our connection with the utility grid has significant implications with RG&E, and a service agreement with RG&E was signed at the time the plant was put into service. This service agreement governs the different scenarios that could arise with regard to how we interact with the electrical grid. For the most part these scenarios are simple rate structures and are not worth fully understanding within the scope of this document. There is, however, one scenario that is important to understand especially with regards to its impact on how the plant is operated. In the case where the cogeneration plant is producing more electricity than the campus can utilize, that electricity flows back into the grid. The catch, is that MCC does not receive any revenue or billing reduction for that electricity. This means that it is financially disadvantageous for the cogeneration plant to produce more electricity than it can use, even if the campus calls for more heating than the plant can produce at that level of electric output.

The electrical switchgear is located in a vault adjacent to the gensets.

Technical Details

The cogeneration plant at MCC is a complex and interesting system, one that most occupants and users of the campus probably seldom think about. At the heart of the system are four Caterpillar engines powered by natural gas. Each of these engines has:

- 16 cylinders
- Twin turbochargers
- 4,210 cubic inches of displacement (almost 70 liters)
- Over 27,000 lbs. dry weight

- 1971 horsepower
- Theoretical electric output of 1.35 megawatts

These engines coupled to their electrical generation components are commonly referred to as gensets. three of the gensets in the MCC cogeneration plant are designated as the campus' primary electric source and are configured with heat recovery to capture the thermal output as well. The fourth genset does not include heat recovery, and is intended as a backup for electricity production.

In total, the plant has a theoretical maximum output of 5.4 mW of electricity. That means we could theoretically produce enough electricity in a day to power 4,336 average American households. In reality though, limitations caused by the sizing of our transformers and electrical switchgear equipment mean we can't really produce more than about 4.5 mW at any given time. The gensets produce electricity at 480 volts, which then gets fed through a transformer to convert it to 34,500v in order to match our primary electric service from the grid. This electricity then gets converted to 11,500v for distribution around the campus and is reduced in voltage further at each of our substations located throughout the buildings.

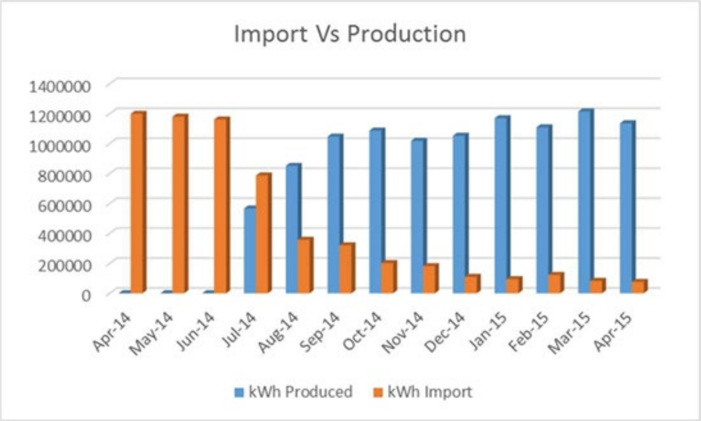
A plate & frame style heat exchanger capturing the heat from one of the gensets.

In addition to electricity, the cogeneration plant also produces heat of course. This heat is captured from the cooling water as well as the exhaust air from the engines and is transferred through heat exchangers to hot water circulation loops that distribute it throughout the campus for various uses including heating the air in the buildings, heating hot water for domestic use, heating the pool, and to provide cooling through a piece of equipment known as an absorption chiller. The campus also has three boilers, which have enough capacity to provide all of the heat the campus would need on their own in the event of a problem with the cogeneration plant. This provides 100% redundancy with our heating system.

Operations

One of the pumps that circulates hot or chilled water through the buildings.

There are two primary schools of thought when choosing an operational strategy for a cogeneration plant known as electrical following and thermal following. Electrical following is practiced when the desire is to minimize the amount of electricity imported to the plant from the local utility grid. Thermal following is a strategy designed to make only enough electricity to allow the heat recovered to be completely utilized. One variation the electrical following variation would be a plant that operates as an island. Such a plant would not be connected to the local utility grid at all and would be responsible to produce 100% of the electricity used on campus. MCC's plant has the ability to operate in this mode during local utility grid outages. MCC's cogeneration plant essentially operates in an offset electrical following mode. The plant typically attempts to generate the majority of the electric energy required by the campus, while allowing a small amount of electricity to be imported from the local utility grid (typically between 100 and 400 kW). This methodology has a couple of advantages, most notably it allows the generators to be operated at a stable output level, and lets the utility grid adjust to the small changes in the amount of electricity the campus needs. Also, as mentioned previously, MCC would not receive any benefit from overproduction of electricity. This operating strategy allows for a slight cushion to ensure that we do not produce more than we can use at any given time. The graph at the right shows the breakdown of our imported vs produced (export) electricity.



One aspect of our operations that is critical to understand is what happens during an outage and how that affects the campus. It would be very reasonable to assume that since we have the capacity to generate enough electricity to serve the needs of the entire campus that any local utility grid outages should not have any effect on us and should go unnoticed. Indeed, there are times when this is in fact the case. Unfortunately, while outages are relatively rare and short lived, it is not always possible to maintain service through an outage. There are a number of reasons why the local utility grid may go down and a number of these reasons cause our equipment to shut down in order to protect it from damage. When this happens, there is a specific set of steps that need to be taken in order to bring the equipment back online. Details of the procedures that MCC staff go through during such an outage can be found in Appendix 1. This process requires an operator from Siemens to be on-site. Therein lies one of the challenges that we face with regards to the relationship between the MCC and Iola plants and how the plants are operated. The Iola plant is legally obligated to have an operator on site 24/7, whereas the MCC plant is not. That means that if an outage occurs during a time where only one operator is on site at the Iola plant, that operator is legally prevented from leaving Iola to come to the MCC plant and restart our equipment and a second operator has to be called in to perform that task. It can take an extended amount of time for this to happen and the service contract has no requirement for response time in these types of scenarios.

With all that said, it is important to recognize that outages are very rare. When they do occur, the time that we are without power is much shorter than it would be without the cogen plant operating. The following table attempts to quantify this. It is important to note that not every utility grid disturbance would result in an outage as they frequently last only microseconds, but often our system protects us from equipment damage that might occur during such instances and in most cases, we would not even notice them without the monitoring system alerting us to their occurrence.

Every month, a report showing all of the disturbances and the resulting impacts that occurred at each facility is distributed by the plant operator. If a disturbance results in any outages or equipment damage, the report includes corrective actions and/or potential action items for discussion. These reports are available on request from MCC Engineering Services staff or from the plant operator.

Month	Disturbances	MCC Outages	Duration
Apr-15	2	0	
Mar-15	2	0	
Feb-15	1	0	
Jan-15	1	1	25
Dec-14	1	0	
Nov-14	1	0	
Oct-14	1	0	

Month	Disturbances	MCC Outages	Duration
Sep-14	1	0	
Aug-14	1	0	
Jul-14	4	0	
Jun-14	3	0	
May-14	2	0	
Apr-14	3	1	90
Totals	**23**	**2**	**115**

- Annual Hours: 8760
- Annual Minutes: 525600
- Minutes of Down Time: 115
- Up Time Minutes: 525485
- Up Time Percentage: 99.98%

Future Challenges

Daily operations of MCC's cogeneration plant are a fairly significant challenge by themselves, but there are a number of other challenges we face moving forward as well that should be discussed and understood. Each of these specific challenges are intimately linked with one another and each must be understood in order to have an accurate picture of the outlook for MCC's cogeneration plant.

The first major challenge that we face is the rebid of the operations and service contract for the plant. The current contract is held by Siemens and it is our understanding that they intend to submit a bid for ongoing operations of the plant. The RFP bids are due October 2, 2015 and it remains to be seen how many qualified bidders will submit. Current indications are that at least one additional bidder will prepare a proposal. If Siemens were to be selected to continue the service and operations of the cogeneration plants, there would be some potential negative as well as some definite positive implications. On the positive side, we would avoid the problems that would otherwise occur during the transition between an incumbent and a new operator. Siemens would maintain all of the operational history and experience that they have gained in the previous years of operating the plant. We also would have a single point of responsibility for any problems or issues that arise down the road. It is certainly feasible that a new contractor down the road could have problems with certain aspects of the plant operations and place the blame for those problems on the previous contractor. On the negative side of things, it will likely be difficult to make significant changes to how the plant is operated given Siemens' long history of operating it a certain way. The execution of new terms, conditions, and reporting requirements that were not previously required is likely to meet with some resistance until they become standard operating procedure. Another significant component of this rebid process is simply the evaluation of potential bidders especially when it comes to pricing. It may be tempting to select a contractor whose proposed budget shows lower costs, only to find out later on that they are unable to provide the necessary level of service given those budgeted figures.

The second major challenge that we face in the near future is of course very linked to the first. That is that the engines in our gensets are rapidly approaching their recommended service interval for a full overhaul. The cost to complete that work is very significant and will need to be factored into the upcoming service contract award or awarded as a separate contract. We may also want to evaluate the continued cost of operating the generators at that time. Given the cost of the overhaul procedures, we may want to consider alternatives (selling the engines as is and purchasing new ones, discontinuing their use altogether, running them till failure, etc.). But whatever our decision with regard to the gensets, we will still be required to pay the debt payment through 2035.

The final challenge is, of course, also linked to the previous. Current financial analysis (PIT Energy) is suggesting that we maximize our electric production as much as possible to offset fixed costs of the plant. This presents a unique challenge within the confines of the design of our plant. With each generator producing 1.35mW at full load, there are numerous instances where our load requirements don't justify bringing an additional genset on line, but where not doing so would require a significant amount of imported electricity from the utility grid. Bringing the additional genset on would require all of the gensets to operate at a partial load which is less efficient from an energy standpoint and potential increases maintenance costs. Thus, this scenario has a significant impact on how we may choose to operate the plant going forward, as well as what we ultimately decide to do with the gensets needing major overhaul.

Conclusion

The cogen plant at MCC is a complex and often misunderstood asset. Hopefully this document will help to alleviate some of the confusion and lay out most of the basic operating challenges and benefits inherent to the plant. The intent is for this document to be a living one, and be updated as changes in operating conditions or procedures occur. Please refer any questions or comments to the Facilities Engineering Department.