Peak Demand Shift and Demand Response Programs Study

(MAE- Energy Conservation and Savings, Alternate Power Sources)

Problem Background

The idea for this analysis comes from discussions in a graduate level class and a prior internship experience. Again, with energy costs on the rise in the United States, it is becoming typical for well educated owners to ask for out of the box solutions, especially when dealing with energy. The use of a peak demand shift or demand response program allows contractors and consultants to market a system that takes advantage of other facilities high peak demand by shifting their own to a time less costly. The ability to shift demand at a residential facility may prove difficult with the individual units, however, shifts in communal energy sources and HVAC systems, as well as the opportunity to utilize emergency power systems for energy generation may prove beneficial to the owner. The critical industry issue involves the non-typical use of a building system to create a project during a potential recession. The current market is fading away from new construction into renovation and this provides a possible project that benefits both the contractor and the owner.

Problem Statement

This analysis problem statement is twofold. After determination of demand response accessibility in the Washington D.C. area, it is necessary to develop a feasible system or process to shift the peak demand at Crystal Plaza II to another part of the day outside of the typical demand peak. This must still allow for the operation of critical systems and be able to continue occupant comfort. The second area is the use of the installed diesel generator to produce energy during the demand peak to lower or offset the buildings own demand or to sell to the utility at a commodity rate. Another option to consider is the replacement of the diesel generator with a combined heat and power source that is capable of handling emergency power generation, but can also provide energy to the grid.

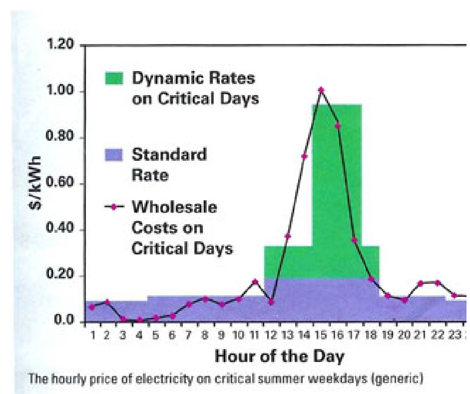

Figure 57 Energy demand spike courtesy of http://www.energy.ca.gov

Goals

The goal of this research is to determine the feasibility of a demand response program at Crystal Plaza II and the use of the emergency power generation system to help offset demand or provide revenue. The analysis is not entirely an energy saving idea, but more of an energy cost savings for the owner. Interviews with specialty contractors that may have experience in this field will be crucial in determination of feasibility. The focus is to create a cost analysis and constructability review of the system.

Research Procedure

1. Research local demand response programs
2. Determine potential building energy use and energy use patterns
3. Conduct industry interviews about demand response and energy generation systems
4. Develop energy management program to shift demand for standard demand response program
5. Investigate use of generator to produce energy daily
6. Estimate life cycle costs of generator use
7. Develop cost/benefit analysis of energy production
8. Provide conclusion on demand response and suggested course of action

Tools and Resources

1. Washington area Energy Utility Company
2. CLT Efficient Technologies Carnegie PA (Energy Service Company)
3. Energy10 or similar energy modeling software
4. Industry member interviews or surveys
5. Various manufacturer and supplier data

Expected Outcome

The expected outcome for this analysis is the ability for Crystal Plaza II to successfully be able to shift peak demand and produce energy that can be sold to the local utility during the demand peak time. The implementation of the demand response program should be feasible, as well as the use of the diesel generator. However, even a shift in the peak demand could provide potential savings for the owner and occupants.

Research Background

This analysis focuses briefly on two different types of programs that can be implemented on projects to help in energy costs. The basic idea is to curtail loads during peak times for the utility grid and take advantage of the real time peak price of electricity. In demand response, the local utility or a third party company notifies the building owner/operator sometime prior to a peak demand, and as part of the contract the owner/operator is required to offset their load by the amount agreed upon. While some versions of this program are more flexible in the ability to choose when or if curtailment will incur, the more rigid and guaranteed frameworks often produce the largest profit. Peak demand shift works in much the same way, however, it allows for the owner to regulate when they would like to cap their usage demand by using onsite generation or by turning off equipment. This limits the billed demand which comes at much higher cost to the owner/operator. The energy saved is often during peak times, as that is when demand is highest, and can be sold back to the utility through a net meeting program, if one exists. Each of these programs will be broken down in more detail below as they apply to Crystal Plaza II.

Demand Response

Demand response is a highly complex system for individual users to monitor their energy use during peak times, thus allowing for the overall grid to operate at lower demand. As put by the International Energy Agency "At its most general level, demand response is the ability of demand to respond to various in market prices in real time"(Harrington, 2003). This is achieved in many ways ranging from overall reduction, shifting loads to off peak times, or using another energy source such as a generator or solar/wind power. Use of demand response has shown to reduce overall demand on a utility by at least 6%, meaning fewer power stations and fewer emissions(Harrington, 2003). The financial benefits from demand response have also gone vastly untapped over the past few years. In fact in a report to the US Congress in 2006, it was recommended to foster price based demand response using time varying pricing plans and improve incentive based programs to bring in more users to improve the grid(Benefits of Demand Response, 2006).

As for the opportunity at Crystal Plaza II, a local program entitled EnergyConnect is a primary provider of demand response programs. EnergyConnect provides solutions for its users to reduce their demand during periods of high demand, low supply, or times with high wholesale energy prices effectively selling the unused energy demand at a premium. EnergyConnect uses an automation system that allows predetermined processes and equipment with non critical loads to shift to times of lower demand. This is sometimes accomplished using standby generators. According to EnergyConnect's website, Crystal Plaza II is able to enroll in two offered programs, EventConnect and FlexConnect, both part of the PJM program(Solutions) . PJM is a regional transmission organization that services 14 different states on the mid-Atlantic coast. Currently PJM is the world's largest competitive wholesale electric market(PJM Interconnection, 2008).

The first program available to Crystal Plaza is the EventConnect. This program pays a reservation fee to the participant to be ready for a notification. If the participant is not contacted during the billing cycle, the participant receives only the reservation fee. However, if called, the participant is compensated for the amount of energy curtailed plus the reservation fee.(Solutions)

FlexConnect is a program base more on the real time price of electricity. In this program the participant is paid the applicable wholesale price determined using PJM's day ahead or real time energy price depending on the participant's selection. For this service there is a fee removed from any sales for EnergyConnect.(Solutions)

To estimate the potential revenue for joining an EnergyConnect program, the website provides a potential revenue calculator. Options for calculation include state (Virginia), utility (Dominion Virginia Power), energy rate (state average of $0.06/kWh), peak demand (1098 = 0.6 * 1830.5, demand for main switchboard on 277/408V system, and the curtailment capability (estimated to be somewhat flexible given the building use).

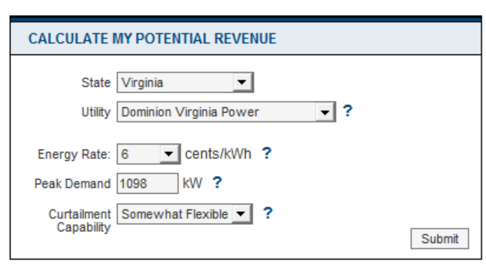

Figure 58 Revenue Calculator from EnergyConnect

The calculator then provides the amount that would have been paid to the participant based on the previous year's performance given the parameters. In the case above, Crystal Plaza II would have been eligible to receive $8,138 for participation. This value does not include the savings associated with lowering demand or energy use during program involvement. Also, not included is the revenue potential to supply power to the grid via net meeting using on-site generation during peak demand times. The basis for the payment is typically calculated using the prior ten days energy use and the amount able to curtail during an event when compared to that ten day average. Events are determined by the utility or demand response provider and notification can be anywhere from week to day ahead up to a 15 minute notice dependent upon the program.

Unfortunately, there is little negotiation power of the participant in the price received for the curtailment and no way of estimating the amount of that price. This is due to the varying operation of the demand response program selected for the participant and its proprietary means for calculated such payment. Also, use of demand response is not common in residential applications as tenants would be required to agree to the curtailment procedure as part of their lease, knowing that their temperature set points, lighting, and demand load would be monitored and potentially shut off during program participation. However, given the system used to determine the possible savings is that which provides power to communal areas and equipment, the opportunity is apparent for the property manager to curtail energy use during program participation.

The suggestion for the owner would be to utilize the 277/408V system in one of the EnergyConnect programs beginning with an inflexible curtailment to see how the program fits into the overall operation of the building. Careful attention should be paid to determine if when notified a response is mandatory or voluntary. Once established, the program can be evaluated for feasibility and alternative programs can be determined.

Peak Demand Shift

Peak demand shift is a different program that requires more owner interaction with the local utility and onsite management. The basis behind demand shift is to monitor the building's time of high demand and then shave the demand by implementing reduction sequences such as limiting temperature controls, lighting, or mechanical equipment. This works much the same way as demand response, but requires the owner to manage the selling of demand back to the utility. The reason for separating this into a different category is the analysis performed deals more with the owner control in managing the use of the generator for on-site energy generation, rather than curtailing loads to meet requirements.

The analysis shown below focuses on using equipment already installed at the building to produce power, in a sense adding value to the component. Attempts to avoid changing the equipment were key as much of the system has either been procured or installed. This also avoids the necessary re-engineering that would be required if a new system were to be implemented.

In this analysis, the emergency generator will be used to provide power during peak times in the daily cycle at Crystal Plaza II. The ability for the generator to run and provide power allows for the owner to determine a reasonable limit for demand and use the generator's capability to provide the necessary demand above the limit. Peak times are estimated to be for 2-3 hours in the morning when elevator use is high, along with the sudden surge by people preparing for work/school. Another peak is estimated to be for 2-3 hours in the afternoon when those individuals return and again begin using the elevators and other systems in the building. During the off hours, the mechanical systems will be in set back as all units have programmable thermostats and the elevator use will be drastically less. By using the generator to power the major energy consumers during these peak times, the building demand can be reduced. Also, the ability to use the generator in connection with a demand response program also becomes applicable. Slight control changes would be required to utilize the generator, but since it is already designed to power the systems in the event of an emergency, it is mostly the programming and not the hardware that will need configuration. For instance, to avoid power spikes outside the operable range of the generator and possible damage to it, elevators cannot start at the same time. This is an easy fix as the elevator contractor can program a partial second delay that would be unnoticeable to the everyday occupant. Also, to keep demand low, a program for the mechanical system should be implemented that keeps both cooling towers from operating during the peak times unless absolutely necessary. Given the capacity it is unlikely that the occupants will notice.

There are areas of concern for the generator in that it may be regulated as to the amount of time it can run continuously. There are no listings as to this restriction in the specifications, however, it is listed as an EPA certified motor. Generator specifications can be found in the Appendix B. Also of concern is the wear and tear on the generator by running daily. If the savings are such that they can compensate for depreciation of the equipment and fuel use, then the owner should find a means to overcome the restrictions for continuous running. In other words if the limit for continuous running is due to emissions, new equipment could be added to the generator to mitigate the emissions.

ENGINE

- Air Cleaners
- Oil Pump
- Full Flow Oil Filter
- Jacket Water Pump
- Thermostat
- Exhaust Manifold – dry
- Blower Fan & Fan Drive
- Radiator - Unit Mounted
- Electric Starting Motor - 24V
- Governor – Electric Isochronous
- Base - Structural Steel
- SAE Flywheel & Bell Housing
- Charging Alternator - 24V
- Battery Box & Cables
- Flexible Fuel Connectors
- Flexible Exhaust Connection
- EPA Certified Engine

Figure 59 Excerpt from generator specifications

Net Metering

While Dominion of Virginia does offer net metering, it is in limited capacity and has restrictions as to what source is generating the power. According to the Terms and Conditions for net metering, it is available to “customer-generator” using a “renewable energy facility” for the first 0.2% of Company’s North Carolina jurisdictional peak load during the previous year. After that level has been met, there will be no more accepted meters. The definition provided by the document for “renewable energy facility” is

1. Alternating current capacity of no more than 100 kW for nonresidential customers
2. Its total fuel source is solar PV, wind power, micro-hydro, or biomass
3. Is for the customer-generator’s use and not for sale to a third party
4. Is interconnected and operated in parallel with the electric distribution system provided by the company (Virginia Electric and Power Company, 2006)

As for the metering process, a standard metering practice would be adhered to with a meter capable of reading on and off peak power in both directions. However, if Crystal Plaza would request the meter equipment to be installed at the facility, the utility would charge for the equipment, as it is intended to read off site. (Virginia Electric and Power Company, 2006)

As for the billing setup, it seems rather simple. The customer-generator would be billed for the basic usage charge and the demand charges. As for kWh's the difference in the production from that generated and that delivered to the customer would be what is billed or if the customer generates more than they used there would be no bill. If there is variance in the on and off peak values, such as the customer produces ample on peak to exceed demand but not enough off peak, credits will be applied in a scheme that benefits the utility. The credits expire at the beginning of the summer billing season. The document clearly states that "In no case will any credit balance have any cash value of be convertible to cash." (Virginia Electric and Power Company, 2006)

As forfeited by the customer is any renewable energy credits or green tags. These are granted to the utility when the kWh credits balance zeroes out. (Virginia Electric and Power Company, 2006)

This scheme for net metering provides little value to the owner at Crystal Plaza. Participation into other programs seems to be a better choice as there is little incentive to use net metering. The BIPV system would provide the only applicable power source, and while it does generate power, it is extremely costly. The energy offset by using a BIPV could be sent back to the grid for kWh credits, but a better use would be for the energy to be used within the building to lower demand. However, if the BIPV were to be implemented and produced above the needed capacity for Crystal Plaza II, the excess could be sent back to the grid earning some kWh credits.

Application at Crystal Plaza II

The program to be analyzed at Crystal Plaza is peak demand shift. As mentioned above, utilization of the emergency generator will provide approximately 400 kW of power during the 2-5 peak hours of the daily cycle at the building. These peak times will be measured monthly and determined as to when they occur to ensure proper shaving of the demand.

The generator details can be seen at right. The generator will not be run at its full capacity to allow for instance overloads to the system to be incorporated into the performance without potentially harming the system. The following chart lists the breakdown for the operation of the generator.

DDC/MTU POWER GENERATION MODEL: (Qty - 1) - 450RXC6DT3
GENERATOR: 450 kW, 562.5 kVA
VOLTAGE: 277/480 ACV 3-Phase (R)
ENGINE: Detroit Diesel 6063HV35-685HP, 60 Hz Diesel, 1800 RPM

Standard Features Included:
Steel Sub Base, Battery Cables, Battery Box, Flex Fuel Connector, Oil Drain Extension, Lube Oil and Anti-freeze
Selected Model Features Included:
Isochronous Governor + / - .25%
Permanent Magnetic Generator
2 (Two) Year / 3000 Hour Basic Standby Limited Warranty

Figure 60 Excerpt from generator specifications

		Fuel Use (gal/hr)			Cost/hr		Runtime till empty (hr)	
Power	**kW**	**Standby**	**Prime**	**Fuel Cost/gal***	**Standby**	**Prime**	**Standby**	**Prime**
100%	450	35	32	3.76	$130.10	$121.45	16.24	17.40
75%	337.5	26	24	3.76	$99.26	$91.37	21.29	23.13
50%	225	18	16	3.76	$68.43	$61.66	30.88	34.27
25%	112.5	9	8	3.76	$34.22	$30.83	61.76	68.54
***average from Jan 08-Jan 09**								

As noted the fuel cost is a national average from the past year. As fuel prices are falling, the benefit of utilizing this system can drastically increase. The fuel tank for the generator is located in the parking garage area and is routinely serviced by a local fuel supplier. The tank size is 500 gallon with a 62 gallon tank located underneath the generator.

The power output used in this analysis is 88% of the capacity for the generator. The value for cost/hr is therefore $115.30 under standby and allows the system to run for 18.66 hours until empty.

The estimated run time per day for the system is 5 hours in this analysis to show the benefits of shaving demand. The table that follows on the next page lists the major equipment that can be powered using the emergency generator with results listed as per day.

Equipment Name	Type	Service	HP	kW	% used/hr	hours used	kW/hr	kWh
P-5	vertical inline pump	HP Loop	125	103.09	100%	5	103.09	515.46
RTU-1	RTU			47.49	60%	5	28.49	142.47
RTU-2	RTU			47.49	60%	5	28.49	142.47
RTU-3	RTU			47.49	60%	5	28.49	142.47
RTU-4	RTU			47.49	60%	5	28.49	142.47
CT-1	cooling tower fan	cooling tower	50	37.29	50%	5	18.65	93.23
CT-2	cooling tower fan	cooling tower	50	37.29	50%	5	18.65	93.23
P-3	Double Suction	cooling tower	40	34.59	50%	5	17.29	86.46
P-1	vertical inline pump	cooling tower	30	26.60	50%	5	13.30	66.51
Elevator 1			26	19.29	90%	5	17.36	86.80
Elevator 2			26	19.29	90%	5	17.36	86.80
Elevator 3			26	19.29	90%	5	17.36	86.80
RTU-5	RTU			11.71	60%	5	7.02	35.12
HP-11	water source hp	lobby		9.71	40%	5	3.88	19.42
HP-15	water source hp	lobby floor		9.71	40%	5	3.88	19.42
HP-17	water source hp	party room		9.64	40%	5	3.86	19.29
HP-18	water source hp	party room		9.64	40%	5	3.86	19.29
HP-10	water source hp	office		7.05	40%	5	2.82	14.10
RF-31	fan	SP-1	7.5	5.59	100%	5	5.59	27.95
RF-32	fan	SP-2	7.5	5.59	100%	5	5.59	27.95
HP-12	water source hp	vestibule/storage		4.92	25%	5	1.23	6.15
HP-16	water source hp	mail room		3.72	25%	5	0.93	4.66

The percent used per hour is an estimate as to the amount of time the given equipment will run in an hour. The hours run is the estimated run time of the generator to power that equipment, and the total kW/hour and kWh are listed at right.

Using this information, a direct comparison to the original energy use and cost can be done. The original energy use and cost was determined using a demand of 1830.5 kW and a load factor of 0.6. The charges associated with use are from Dominion of Virginia's schedule for Large General Service Primary Voltage, which can be found in an abbreviated version in the Appendix B.

As a comparison, the shaved demand bill was also calculated. The demand was lowered by 400 kW since that is the amount to be shaved by the generator, and the load factor remained at 0.6. As for the kWh calculation, the kWh saved from the table above were summed over 30 days of use and then subtracted from the original value.

Distribution Service Charge				**Distribution Service Charge**			**Difference**
cost per kw	*kw*	*cost*		*cost per kw*	*kw*	*cost*	
1	1830	$1,830.00		1	1430	$1,430.00	*$400.00*
Basic Customer Charge		$127.60		*Basic Customer Charge*		$127.60	
Supply Service Charges				**Supply Service Charges**			
On Peak Supply Demand Charge				*On Peak Supply Demand Charge*			
cost per kw	*kw*	*cost*		*cost per kw*	*kw*	*cost*	
12.003	1098	$13,179.29		12.003	698	$8,378.09	*$4,801.20*
11.715	1098	$12,863.07		11.715	698	$8,177.07	*$4,686.00*
Off Peak Supply Demand Charges				*Off Peak Supply Demand Charges*			
0.632	1098	$693.94		0.632	858	$542.26	*$151.68*
Supply Adjustment Demand Charge				**Supply Adjustment Demand Charge**			
0.421	1830	$770.43		0.421	1430	$602.03	*$168.40*
On peak kWh				**On peak kWh**			
0.404	428220	$173,000.88		0.404	371865.56	$150,233.69	*$22,767.19*
Off peak kWh				**Off peak kWh**			
0.272	362340	$98,556.48		0.272	362340.00	$98,556.48	
Total		$301,021.69		**Total**		$268,047.22	*$32,974.47*
					Fuel Cost	$17,295.00	
					Savings	***$15,679.47***	

The comparison shows a substantial savings, nearly two times the cost of fuel for the generator. The largest area of savings was in the on peak kWh, as there is a large savings by running the generator. By saving approximately 1,800 kWh a day through the use of the generator, the savings begin to add up.

Summary

Based on the results of the analysis, it is suggested for the owner to consider a demand response program or a demand shift operation as the savings/revenue available from each is substantial enough to warrant investigation. With the state of Virginia allowing net meeting, the owner can take advantage of selling the energy produced/curtailed back to the grid for large savings. However, given the circumstances in the Dominion of Virginia's net metering agreement, demand response may be the way to go, as the agreement limits the potential for the owner to "sell" energy back but rather to receive energy credit for future months. In either case it is highly recommend pursuing one of the above mentioned options.