Introduction

This mechanical study will compare the existing mechanical system of The Virginia Commonwealth Life Sciences Building and a modified system in which the roof top units will be powered by an on-site low-emissions generator that would in turn also produce hot water for use as domestic hot water. With this cogeneration system, it is necessary to analyze the various aspects in order to discern whether it is economical or not in The VCU Life Sciences Building.

Existing System

The existing mechanical system consists of eight roof top units. One is dedicated to the animal facility and is 100% outdoor air, another one is dedicated to the aquatics facility and is also 100% outdoor air, two more are for the classroom building, and of the final four that are dedicated to the laboratory building, two re-circulate air and the other two are 100% outdoor air. Currently, all of these roof top units are connected to three motor control centers. The animal and aquatics facility rooftop units are also connected to the emergency generator as they must continue to run in the case of a utility power outage. The current emergency generator is a 900kW 480V diesel generator for emergency use.

Modified System

The modified system consists of a low-emissions generator that is fueled by natural gas. This generator powers the roof-top units while also producing what will become domestic hot water in the long run.

The generator that was used to study this system is a 480/277V, 60 Hz, 1250kW generator. This generator runs off of natural gas in order to avoid maintaining a fuel tank for normal operating conditions. Refer to Appendix A for the generator's specifications.

Motor Control Centers

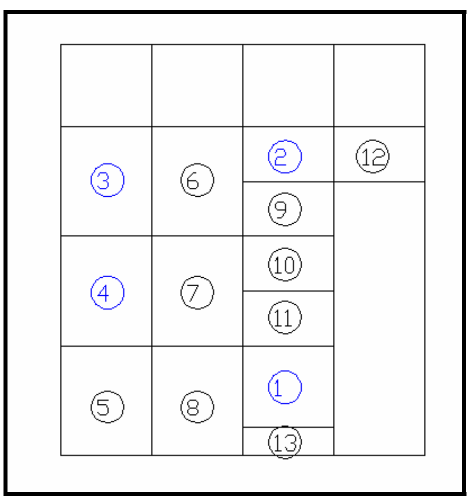
The roof top unit equipment was then placed on its own motor control center, MCC-G1 and the remaining equipment combined into two motor control centers. Therefore, there would be no change in cost for the motor control center equipment. Below are the existing and modified motor control center schedules and elevations. On the schedules, the modified positions are highlighted in yellow on the schedules and blue on the elevations.

EXISTING

MCC- S3M

BUS 800A
AIC 42,00A
VOLTAGE: 480Y/277V

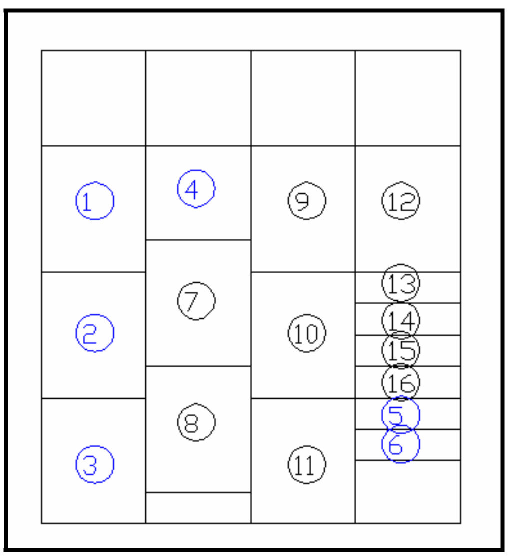
EQUIP. SEC. NO.	EQUIP. TAG	DESCRIPTION	HP	KW	F.L.A.	POLE	OVERCURRENT PROTECTIVE DEVICE				STARTER									CIRCUITRY			
							CKT. BKR.		FUSE		TYPE	SIZE	CONT. VOLT.	CONTROL DEVICES						WIRE QTY. & SIZE		GRND. SIZE	CONDUIT SIZE (IN)
														PILOT LIGHTS		CONTROL	TYPE	CONTACT					
							CONT.	TRIP	TYPE	AMPS				TYPE	COLOR			N/O	N/C	QTY	SIZE		
1	SF-7	RTU-7SUPPLY FAN	15	-	21	3	50	150	-	-	FV/NR	2	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#10	#6	3/4"
2	SF-8	RTU-8 SUPPLY FAN	10	-	14	3	30	105	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#6	3/4"
3	CU-7	RTU-7 CONDENSING UNIT ROOF	-	49.6	59.7	3	-	125	-	-	-	-	-	-	-	-	-	-	-	3	#4	#6	1 1/4"
4	CU-8	RTU-8 CONDENSING UNIT ROOF	-	36.1	43.4	3	-	100	-	-	-	-	-	-	-	-	-	-	-	3	#6	#8	1"
5	EF-2	EXHAUST FAN #2 ROOF	50	-	65	3	150	490	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#4	#2	1 1/4"
6	EF-4	EXHAUST FAN #4 ROOF	50	-	65	3	150	490	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#4	#2	1 1/4"
7	EF-6	EXHAUST FAN #6 ROOF	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
8	EF-8	EXHAUST FAN #8 ROOF	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
9	EF-13	EXHAUST FAN #13 ROOF	12-Jul	-	11	3	15	75	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#8	3/4"
10	EF-15	EXHAUST FAN #15 ROOF	2	-	3.4	3	7	27	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
11	EF-17	EXHAUST FAN #17 ROOF	3	-	4.8	3	7	35	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
12	EF-19	EXHAUST FAN #19 ROOF	3	-	4.8	3	7	35	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
13	DAC-1	DESICANT UNIT ROOF	-	-	44.1	3	-	60	-	-	-	-	-	-	-	-	-	-	-	3	#6	#10	1"
14	HC-7	RTU-7 HEATING COIL	-	80	96.2	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#1	#6	1 1/2"
15	HC-8	RTU-8 HEATING COIL	-	50	60.1	3	-	80	-	-	-	-	-	-	-	-	-	-	-	3	#4	#6	1 1/4"



Elevation View of MCC-S3M

Lindsay Rekuc
Virginia Commonwealth University Life Sciences Building
Richmond, VA

MCC- N3M																							
																				BUS 800A			
																				AIC 42,00A			
																				VOLTAGE: 480Y/277V			
EQUIP. SEC. NO.	EQUIP. TAG	DESCRIPTION	HP	KW	F.L.A.	POLE	OVERCURRENT PROTECTIVE DEVICE				STARTER									CIRCUITRY			
							CKT. BKR.		FUSE		TYPE	SIZE	CONT. VOLT.	CONTROL DEVICES						WIRE QTY. & SIZE		GRND. SIZE	CONDUIT SIZE (IN)
														PILOT LIGHTS		CONTROL	TYPE	CONTACT					
							CONT.	TRIP	TYPE	AMPS				TYPE	COLOR			N/O	N/C	QTY	SIZE		
1	SF-1	RTU-1 SUPPLY FAN	75	-	96	3	-	225	-	-	-	-	-	-	-	-	-	-	-	3	#1	#4	1 1/2"
2	SF-2	RTU-2 SUPPLY FAN	60	-	77	3	-	175	-	-	-	-	-	-	-	-	-	-	-	3	#2	#6	1 1/4"
3	SF-3	RTU-3 SUPPLY FAN	100	-	124	3	-	300	-	-	-	-	-	-	-	-	-	-	-	3	#2/0	#4	2"
4	SF-4	RTU-4 SUPPLY FAN	50	-	65	3	-	150	-	-	-	-	-	-	-	-	-	-	-	3	#4	#6	1 1/4"
5	RF-2	RTU-2 RETURN FAN	15	-	21	3	-	50	-	-	-	-	-	-	-	-	-	-	-	3	#10	#10	3/4"
6	RF-4	RTU-4 RETURN FAN	7 1/2	-	11	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#12	#10	3/4"
7	CT-1	COOLING TOWER ROOF	50	-	65	3	-	150	-	-	-	-	-	-	-	-	-	-	-	3	#4	#6	1 1/4"
8	CT-2	COOLING TOWER ROOF	50	-	65	3	-	150	-	-	-	-	-	-	-	-	-	-	-	3	#4	#6	1 1/4"
9	EF-1	EXHAUST FAN #1 ROOF	50	-	65	3	150	490	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#4	#2	1 1/4"
10	EF-3	EXHAUST FAN #3 ROOF	50	-	65	3	150	490	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#4	#2	1 1/4"
11	EF-5	EXHAUST FAN #5 ROOF	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
12	EF-7	EXHAUST FAN #7 ROOF	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
13	EF-9	EXHAUST FAN #9 ROOF	1 1/2	-	3	3	7	24	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
14	EF-12	EXHAUST FAN #12 ROOF	7 1/2	-	11	3	15	75	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#8	3/4"
15	EF-14	EXHAUST FAN #14 ROOF	2	-	3.4	3	7	27	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
16	EF-16	EXHAUST FAN #16 ROOF	3	-	4.8	3	7	35	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"



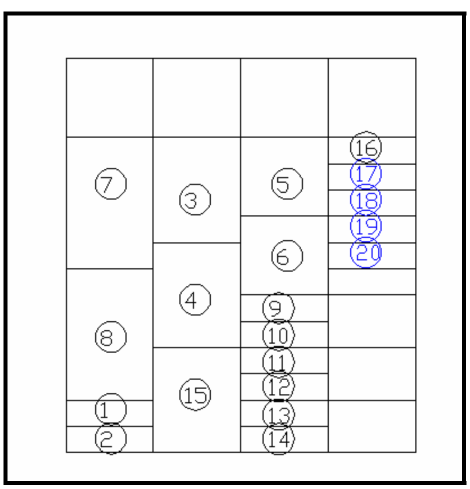
Elevation View of MCC-N3M

Lindsay Rekuc
Virginia Commonwealth University Life Sciences Building
Richmond, VA

MCC- NGM

BUS	800A
AIC	42,00A
VOLTAGE:	480Y/277V

EQUIP. SEC. NO.	EQUIP. TAG	DESCRIPTION	HP	KW	F.L.A.	POLE	OVERCURRENT PROTECTIVE DEVICE				STARTER									CIRCUITRY			
							CKT. BKR.		FUSE		TYPE	SIZE	CONT. VOLT.	CONTROL DEVICES						WIRE QTY. & SIZE		GRND. SIZE	CONDUIT SIZE (IN)
														PILOT LIGHTS		CONTROL	TYPE	CONTACT					
							CONT.	TRIP	TYPE	AMPS				TYPE	COLOR			N/O	N/C	QTY	SIZE		
1	B-1	BOILER #1 RM 019	7 1/2	-	11	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#12	#10	3/4"
2	B-2	BOILER #2 RM 019	7 1/2	-	11	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#12	#10	3/4"
3	CHP-1	CHILLED WATER PUMP #1 RM 019	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
4	CHP-2	CHILLED WATER PUMP #2 RM 019	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
5	CHP-3	CHILLED WATER PUMP #3 RM 019	75	-	96	3	-	225	-	-	-	-	-	-	-	-	-	-	-	3	#1	#4	1 1/2"
6	CHP-4	CHILLED WATER PUMP #4 RM 019	75	-	96	3	-	225	-	-	-	-	-	-	-	-	-	-	-	3	#1	#4	1 1/2"
7	CWP-1	CONDENSED WATER PUMP #1 RM 019	75	-	96	3	150	700	-	-	FV/NR	4	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#1	#1/0	1 1/2"
8	CWP-2	CONDENSED WATER PUMP #2 RM 019	75	-	96	3	150	700	-	-	FV/NR	4	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#1	#1/0	1 1/2"
9	HWP-1	HOT WATER PUMP #1 RM 019	5	-	7.6	3	15	56	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
10	HWP-2	HOT WATER PUMP #2 RM 019	5	-	7.6	3	15	56	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
11	HWP-3	HOT WATER PUMP #3 RM 019	25	-	34	3	-	80	-	-	-	-	-	-	-	-	-	-	-	-	#8	#8	3/4"
12	HWP-4	HOT WATER PUMP #4 RM 019	25	-	34	3	-	80	-	-	-	-	-	-	-	-	-	-	-	-	#8	#8	3/4"
13	RP-1	WATER PURIFIER RM 019	3	-	4.8	3	7	35	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
14	LCV-1	CENTRAL VACUUM RM 019	10	-	14	3	30	105	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#6	3/4"
15	AC-1	AIR COMPRESSOR RM 019	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
16	EF-18	EXHAUST FAN #18 RM 019	5	-	7.6	3	15	56	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
17	SF-5	RTU-5 SUPPLY FAN ROOF	15	-	21	3	-	50	-	-	-	-	-	-	-	-	-	-	-	3	#10	#10	3/4"
18	SF-6	RTU-6 SUPPLY FAN ROOF	15	-	21	3	-	50	-	-	-	-	-	-	-	-	-	-	-	3	#10	#10	3/4"
19	RF-5	RTU-5 RETURN FAN ROOF	7 1/2	-	11	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#12	#10	3/4"
20	RF-6	RTU-6 RETURN FAN ROOF	7 1/2	-	11	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#12	#10	3/4"



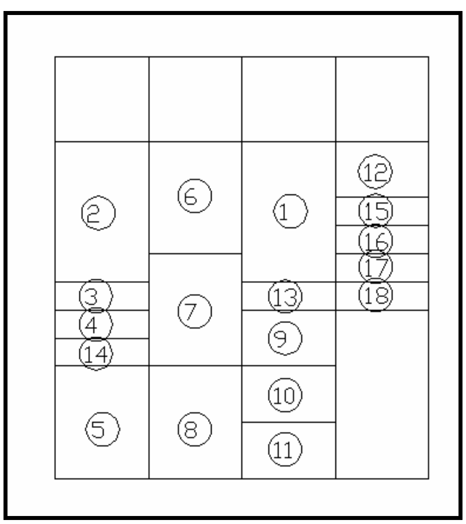
Elevation View of MCC-NGM

MODIFIED

MCC- S3M

BUS: 800A
AIC: 42,00A
VOLTAGE: 480Y/277V

EQUIP. SEC. NO.	EQUIP. TAG	DESCRIPTION	HP	KW	F.L.A.	POLE	OVERCURRENT PROTECTIVE DEVICE: CKT. BKR. CONT.	CKT. BKR. TRIP	FUSE TYPE	FUSE AMPS	STARTER: TYPE	SIZE	CONT. VOLT.	CONTROL DEVICES: PILOT LIGHTS TYPE	PILOT LIGHTS COLOR	CONTROL	TYPE	CONTACT N/O	CONTACT N/C	CIRCUITRY: WIRE QTY. & SIZE QTY	WIRE SIZE	GRND. SIZE	CONDUIT SIZE (IN)
1	CWP-1	CONDENSED WATER PUMP #1 RM 019	75	-	96	3	150	700	-	-	FV/NR	4	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#1	#1/0	1 1/2"
2	CWP-2	CONDENSED WATER PUMP #2 RM 019	75	-	96	3	150	700	-	-	FV/NR	4	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#1	#1/0	1 1/2"
3	HWP-1	HOT WATER PUMP #1 RM 019	5	-	7.6	3	15	56	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
4	HWP-2	HOT WATER PUMP #2 RM 019	5	-	7.6	3	15	56	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
5	EF-2	EXHAUST FAN #2 ROOF	50	-	65	3	150	490	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#4	#2	1 1/4"
6	EF-4	EXHAUST FAN #4 ROOF	50	-	65	3	150	490	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#4	#2	1 1/4"
7	EF-6	EXHAUST FAN #6 ROOF	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
8	EF-8	EXHAUST FAN #8 ROOF	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
9	EF-13	EXHAUST FAN #13 ROOF	12-Jul	-	11	3	15	75	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#8	3/4"
10	EF-15	EXHAUST FAN #15 ROOF	2	-	3.4	3	7	27	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
11	EF-17	EXHAUST FAN #17 ROOF	3	-	4.8	3	7	35	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
12	EF-19	EXHAUST FAN #19 ROOF	3	-	4.8	3	7	35	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
13	DAC-1	DESICANT UNIT ROOF	-	-	44.1	3	-	60	-	-	-	-	-	-	-	-	-	-	-	3	#6	#10	1"
14	HWP-3	HOT WATER PUMP #3 RM 019	25	-	34	3	-	80	-	-	-	-	-	-	-	-	-	-	-	-	#8	#8	3/4"
15	HWP-4	HOT WATER PUMP #4 RM 019	25	-	34	3	-	80	-	-	-	-	-	-	-	-	-	-	-	-	#8	#8	3/4"
16	RP-1	WATER PURIFIER RM 019	3	-	4.8	3	7	35	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
17	LCV-1	CENTRAL VACUUM RM 019	10	-	14	3	30	105	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#6	3/4"
18	EF-18	EXHUAST FAN #18 RM 019	5	-	7.6	3	15	56	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"

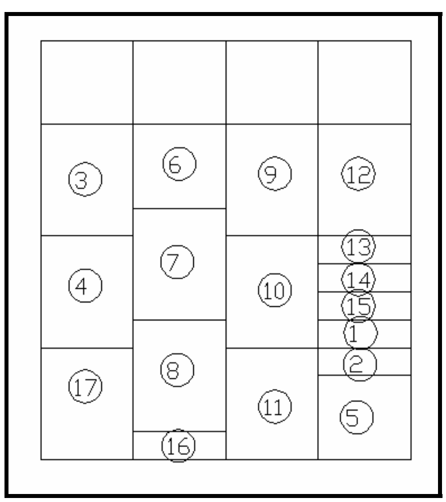


Elevation View of MCC-S3M Modified

MCC- N3M

BUS 800A
AIC 42,00A
VOLTAGE: 480Y/277V

EQUIP. SEC. NO.	EQUIP. TAG	DESCRIPTION	HP	KW	F.L.A.	POLE	OVERCURRENT PROTECTIVE DEVICE: CKT. BKR. CONT.	OVERCURRENT PROTECTIVE DEVICE: CKT. BKR. TRIP	OVERCURRENT PROTECTIVE DEVICE: FUSE TYPE	OVERCURRENT PROTECTIVE DEVICE: FUSE AMPS	STARTER: TYPE	STARTER: SIZE	STARTER: CONT. VOLT.	STARTER: CONTROL DEVICES: PILOT LIGHTS TYPE	STARTER: CONTROL DEVICES: PILOT LIGHTS COLOR	STARTER: CONTROL DEVICES: CONTROL	STARTER: CONTROL DEVICES: TYPE	STARTER: CONTROL DEVICES: CONTACT N/O	STARTER: CONTROL DEVICES: CONTACT N/C	CIRCUITRY: WIRE QTY. & SIZE: QTY	CIRCUITRY: WIRE QTY. & SIZE: SIZE	CIRCUITRY: GRND. SIZE	CIRCUITRY: CONDUIT SIZE (IN)
1	B-1	BOILER #1 RM 019	7 1/2	-	11	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#12	#10	3/4"
2	B-2	BOILER #2 RM 019	7 1/2	-	11	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#12	#10	3/4"
3	CHP-1	CHILLED WATER PUMP #1 RM 019	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
4	CHP-2	CHILLED WATER PUMP #2 RM 019	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
5	CHP-3	CHILLED WATER PUMP #3 RM 019	75	-	96	3	-	225	-	-	-	-	-	-	-	-	-	-	-	3	#1	#4	1 1/2"
6	CHP-4	CHILLED WATER PUMP #4 RM 019	75	-	96	3	-	225	-	-	-	-	-	-	-	-	-	-	-	3	#1	#4	1 1/2"
7	CT-1	COOLING TOWER ROOF	50	-	65	3	-	150	-	-	-	-	-	-	-	-	-	-	-	3	#4	#6	1 1/4"
8	CT-2	COOLING TOWER ROOF	50	-	65	3	-	150	-	-	-	-	-	-	-	-	-	-	-	3	#4	#6	1 1/4"
9	EF-1	EXHAUST FAN #1 ROOF	50	-	65	3	150	490	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#4	#2	1 1/4"
10	EF-3	EXHAUST FAN #3 ROOF	50	-	65	3	150	490	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#4	#2	1 1/4"
11	EF-5	EXHAUST FAN #5 ROOF	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
12	EF-7	EXHAUST FAN #7 ROOF	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"
13	EF-9	EXHAUST FAN #9 ROOF	1 1/2	-	3	3	7	24	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
14	EF-12	EXHAUST FAN #12 ROOF	7 1/2	-	11	3	15	75	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#8	3/4"
15	EF-14	EXHAUST FAN #14 ROOF	2	-	3.4	3	7	27	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
16	EF-16	EXHAUST FAN #16 ROOF	3	-	4.8	3	7	35	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#10	3/4"
17	AC-1	AIR COMPRESSOR RM 019	30	-	40	3	100	300	-	-	FV/NR	3	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#8	#4	3/4"



Elevation View of MCC-N3M Modified

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Virginia Commonwealth University Life Sciences Building
Richmond, VA

GENERATOR MOTOR CONTROL CENTER

MCC-G1

EQUIP. SEC. NO.	EQUIP. TAG	DESCRIPTION	HP	KW	F.L.A.	POLE	OVERCURRENT PROTECTIVE DEVICE				STARTER									CIRCUITRY			
							CKT. BKR.		FUSE		TYPE	SIZE	CONT. VOLT.	CONTROL DEVICES						WIRE QTY. & SIZE		GRND. SIZE	CONDUIT SIZE (IN)
														PILOT LIGHTS		CONTROL	TYPE	CONTACT					
							CONT.	TRIP	TYPE	AMPS				TYPE	COLOR			N/O	N/C	QTY	SIZE		
1	SF-1	RTU-1 SUPPLY FAN	75	-	96	3	-	225	-	-	-	-	-	-	-	-	-	-	-	3	#1	#4	1 1/2"
2	SF-2	RTU-2 SUPPLY FAN	60	-	77	3	-	175	-	-	-	-	-	-	-	-	-	-	-	3	#2	#6	1 1/4"
3	SF-3	RTU-3 SUPPLY FAN	100	-	124	3	-	300	-	-	-	-	-	-	-	-	-	-	-	3	#2/0	#4	2"
4	SF-4	RTU-4 SUPPLY FAN	50	-	65	3	-	150	-	-	-	-	-	-	-	-	-	-	-	3	#4	#6	1 1/4"
5	RF-2	RTU-2 RETURN FAN	15	-	21	3	-	50	-	-	-	-	-	-	-	-	-	-	-	3	#10	#10	3/4"
6	RF-4	RTU-4 RETURN FAN	7 1/2	-	11	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#12	#10	3/4"
7	SF-7	RTU-7SUPPLY FAN	15	-	21	3	50	150	-	-	FV/NR	2	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#10	#6	3/4"
8	SF-8	RTU-8 SUPPLY FAN	10	-	14	3	30	105	-	-	FV/NR	1	120	STD.	R-RUN G-STOP	START/ STOP	H.O.A. SWITCH	2	2	3	#12	#6	3/4"
9	CU-7	RTU-7 CONDENSING UNIT ROOF	-	49.6	59.7	3	-	125	-	-	-	-	-	-	-	-	-	-	-	3	#4	#6	1 1/4"
10	CU-8	RTU-8 CONDENSING UNIT ROOF	-	36.1	43.4	3	-	100	-	-	-	-	-	-	-	-	-	-	-	3	#6	#8	1"
11	HC-7	RTU-7 HEATING COIL	-	80	96.2	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#1	#6	1 1/2"
12	HC-8	RTU-8 HEATING COIL	-	50	60.1	3	-	80	-	-	-	-	-	-	-	-	-	-	-	3	#4	#6	1 1/4"
13	SF-5	RTU-5 SUPPLY FAN ROOF	15	-	21	3	-	50	-	-	-	-	-	-	-	-	-	-	-	3	#10	#10	3/4"
14	SF-6	RTU-6 SUPPLY FAN ROOF	15	-	21	3	-	50	-	-	-	-	-	-	-	-	-	-	-	3	#10	#10	3/4"
15	RF-5	RTU-5 RETURN FAN ROOF	7 1/2	-	11	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#12	#10	3/4"
16	RF-6	RTU-6 RETURN FAN ROOF	7 1/2	-	11	3	-	25	-	-	-	-	-	-	-	-	-	-	-	3	#12	#10	3/4"

Feasibility

Typically, cogeneration is used when there is a process exhaust stream that contains waste heat that can be harnessed and used to drive absorption chiller machines or create domestic hot water. However, The VCU Life Sciences Building does not have a "process" exclusive to the generator set. Instead, the process has been created and then the waste heat has been attempted to be recouped. The feasibility of this system depends on the relative cost of producing the electricity on site from the generators versus purchasing it from the utility company.

Basically, in this case, a fossil fuel is being burned to create energy. There is inefficiency in this process from both the moving parts/ friction and from the waste heat leaving through the exhaust. By attempting to harness this waste heat to create domestic hot water, another inefficiency is introduced that is inherent with the heat exchangers in the flue system and at the hot water heater.

Initial Cost

With the modified system, no equipment from the existing system is significantly modified or taken away. The power source is simply changed. Because of the addition of the generator though, some initial costs are incurred with the modified system. The initial cost information was found on the CostWorks program.

INITIAL COSTS			
MODIFIED			
Equip.	Amt.	Bare Mat. Cost (U.S. $)	Total Equip. Cost
GEN SET	1	$142,500.00	$142,500.00
6" PIPE	500	$32.50	$16,250.00
T's	30	$106.00	$3,180.00
90's	30	$70.00	$2,100.00
		TOTAL	$164,030.00

Because the equipment is added to the existing system, the modified system will cost $164,030.00 more than what is currently in place at The VCU Life Sciences Building.

Energy

In order to decide whether or not the modified cogeneration system is economical in The VCU Life Sciences Building, the cost of energy must be compared. Currently, the roof top units are powered by the utility. Below is a calculation of what the yearly costs are to power these roof top units through the utility. It was assumed that all systems were running 24 hours a day all year. Rate data was obtained from the Potomac Electric and Power Company. It was assumed that for a week, 40 hours were on-peak, 40 hours were intermediate, and 88 hours were off-peak.

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CURRENT SYSTEM- MONTHLY ELECTRIC COSTS

Enter the kw for the desired system		Billing Months of June-October	kw	Billing Months of November- May	kw
			662,892		122,399
GENERATION					
kW-hr Charge	On Peak	$0.08682 per kW-h	$2,302,091.34	$0.06889 per kW-h	$337,282.68
	Intermediate	$0.06632 per kW-h	$1,758,519.90	$0.07239 per kW-h	$354,418.54
	Off Peak	$0.05645 per kW-h	$3,292,982.30	$0.05757 per kW-h	$620,092.92
kW Charge	On Peak	$0.84507 per kW	$560,190.14		
	Maximum	$0.30248 per kW	$200,511.57	$0.30248 per kW	$37,023.25
TRANSMISSION					
All kW-h		$0.00111 per kW-h	$123,616.10	$0.00111 per kW-h	$22,824.97
kW Charge	On Peak	$0.71000 per kW	$470,653.32		
	Maximum	$0.59000 per kW	$391,106.28	$0.59000 per kW	$72,215.41
DISTRIBUTION					
Customer Charge		$20.93000 per month	$20.93	$20.90000 per month	$20.90
All kW-h		$0.01029 per kW-h	$1,145,954.66	$0.01029 per kW-h	$211,593.60
kW Charge	Maximum	$4.80000 per kW	$3,181,881.60	$4.80000 per kW	$587,515.20
Delivery Tax		$0.00770 per kW-h	$857,517.09	$0.00770 per kW-h	$158,335.35
Public Space Occupancy Surcharge		$0.00154 per kW-h	$171,503.42	$0.00159 per kW-h	$32,695.22
Reliability Energy Trust Fund		$0.00065 per kW-h	$72,387.81	$0.00065 per kW-h	$13,365.97
Gneration Procurement Credit		$0.00002 per kW-h	$2,227.32	$0.00002 per kW-h	$411.26
SUB-TOTAL			$14,531,163.77		$2,447,795.27
Subtracting once monthly charges			$560,190.14 $200,511.57 $470,653.32 $391,106.28 $20.93 $3,181,881.60		$0.00 $37,023.25 $0.00 $72,215.41 $20.90 $587,515.20
Billing for average 7 day week less demand and peak charges			$9,726,799.93		$1,751,020.51
Billing for 1 month less demand and peak charges			$38,907,199.70		$7,004,082.04
Billing for 1 month of electrical service			**$43,711,563.55**		**$7,700,856.80**
Yearly Cost of Electrical Service				**$272,463,815.34**	

The generator will run off of natural gas. Below is a summary of the yearly costs for the natural gas. Again, it was assumed that the system was running 24 hours a day all year. The natural gas rate information was obtained from Washington Gas.

MODIFIED SYSTEM- MONTHLY NATURAL GAS COSTS			
Enter the therms for the desired system	Billing Months of January-Decebmer		Therms
			140.2310
SYSTEM			
Heating and/or Cooling	$17.00000	per month	$17.00
Non-heating and Non-cooling	$11.75000	per month	$11.75
MONTHLY			
January	$1.0957	per therm	$153.65
February	$1.0957	per therm	$153.65
March	$0.9833	per therm	$137.89
April	$0.9833	per therm	$137.89
May	$0.9390	per therm	$131.68
June	$0.7543	per therm	$105.78
July	$0.7543	per therm	$105.78
August	$0.7331	per therm	$102.80
September	$0.8568	per therm	$120.15
October	$0.8603	per therm	$120.64
November	$0.9512	per therm	$133.39
December	$1.0957	per therm	$153.65
DISTRIBUTION			
First 125 therms	$0.30930	per therm	$43.37
Next 875 therms	$0.25030	per therm	$0.00
Over 1,000 therms	$0.19030	per therm	$0.00
SUBTOTAL MONTHLY COSTS			$72.12
Monthly Costs Incurred Over a Year			$865.48
Yearly Cost of Natural Gas			**$2,422.42**

According to this information, the natural gas is significantly less than buying power from the utility. There is a $272461392.90 cost difference between these systems.

Conclusions

The modified cogeneration system has a much higher initial cost than the existing system for The VCU Life Sciences Building. However, this cost is offset by the low cost of natural gas as compared to electricity from the utility company. When looking at cost alone, the cogeneration system would be very economical in this situation. However, when considering the other factors of this system, it is not quite so economical. Due to the creation of a process exhaust stream that contains waste heat that can be harnessed, a great inefficiency was introduced to this system. A fossil fuel was being burned to create energy. Inefficiency was found in the moving parts/ friction and the waste heat that leaves through the exhaust. In attempting to harness this waste heat to create domestic hot water, another inefficiency was introduced with the heat exchangers in the flue system and at the hot water heater. In this situation, it would be better to just burn the fossil fuel directly at the hot water heater and by pass the inefficiencies.