HSBC Building – Heat Recovery Chiller Case Study

PREPARED BY: SES CONSULTING

Building Name/Address	HSBC, 885 W. Georgia St. Vancouver, BC
Building's Asset Class	Office
Building Size	~66,136 sq.m (~711,882 sq.ft.)
Year Built	1985
Building Owner & Manager	The Cadillac Fairview Corporation Limited
Engineering Consultant	SES Consulting
Mechanical Consultant	Leverage Mechanical

BOMA SES CONSULTING Cadillac Fairview

Project Summary

In February 2019, SES consulting, along with Leverage Mechanical, installed a cascading heat recovery chiller (HRC) at Cadillac Fairview's HSBC building, located at 885 West Georgia Street in Vancouver, BC. The HSBC building is a 66,136 m^2, 24 storey office tower built in 1985. The HRC captures waste heat from the existing cooling tower's condensing loop, raises the temperature and injects the heat into the existing heating water loop, offsetting steam consumption.

Steam	Electricity	Demand	Greenhouse Gases
20%	20%	25%	27%

Table 1: M&V Metered Data Energy

The M&V period was interrupted by the COVID-19 pandemic, which skewed the meter data and prevented energy savings from being properly calculated. Table 1 shows the actual metered data percent reductions, while Table 2 shows the original estimated savings prior to implementation.

Energy Savings			Cost Savings			GHG Savings
Steam (GJ/yr)	Electricity (kWh/yr)	Demand (kW/yr)	Steam ($)	Electricity ($)	Net ($)	(tons/yr)
4,100	(210,000)	(850)	$58,000	($25,000)	$33,000	360

Table 2: Energy Study Calculated Savings

Project Background

In 2018 SES Consulting Inc. was engaged to provide a BC Hydro Provincial Retrofit Incentive Program (PRIP) Energy Study (now called the CleanBC Custom Incentive Program) to analyse the feasibility and business case of a heat recovery chiller retrofit at the HSBC building in downtown Vancouver. The project was originally identified in the Long-Term Sustainable Heating Strategy Study that SES produced for Cadillac Fairview in 2017.

The HSBC building was a good candidate for heat recovery due to the fact that it had a consistent winter cooling load when outside air temperature was above 0°C, a low heating supply water temperature that varied between 40 - 50°C, and its P1 Level mechanical room contained both steam heat exchanges/hot water piping and cooling tower piping. This allowed tie-in points for the heat recovery chillers' evaporator and condenser lines to be located in the same mechanical room, requiring minimal new piping to connect.

Following the BC Hydro review and incentive approval, in 2019 SES Consulting was engaged to design and implement the heat recovery upgrade at the HSBC office tower.

Existing Building Systems

The HSBC Building is a 66,136 m^2 (711,624 ft^2) office tower that was originally constructed in 1985. The building has 24-stories with four levels of parking. The lower floors of the building are occupied by retail stores.

Heating for HSBC is provided by three secondary heating loops serving floor-level fan coil units, retail spaces, and the large atrium lobby. Heating for the loops is provided first by a condensate to water heat exchanger, then two steam to water heat exchangers. The building utilizes low temperature heating water that is programmed to reset from 32°C to 64°C based on outdoor air temperature, with temperatures typically operating between 40°C – 50°C throughout the heating season.

Cooling is provided by two 480-ton Trane water cooled centrifugal chillers with speed drives and provide space cooling for the building. Each chiller has a dedicated cooling tower with two fans – one with a VFD and one without. The chiller plant runs year-round.

The building has two main ventilation systems:
Retail spaces on the lower floors have dedicated air handing units (AHUs) that are each equipped with a supply fan, access to outdoor and return air, and a heating and cooling changeover coil. Each floor of the office tower has its own AHU, equipped with a supply fan with VSD and chilled water coil. These units receive outdoor air from building make-up air.

Floor fans are equipped with CO_2 sensors with outdoor air dampers that modulate to provide adequate fresh air based on CO_2 concentrations. The floors are divided into six zones, each served by a fan coil unit. The units are equipped with heating/cooling changeover coils. Although thermostats for these units are electronic, the FCUs themselves are not connected to DDC. Floor VAVs are also controlled pneumatically.

Heating and Cooling Load Analysis

To determine the energy demanded by the three heating loops and the energy rejected by the chiller plant's condenser loop, SES analyzed 15-minute interval year-long trends. The analysis was used to determine whether there was a suitable load match between the heating needs of the building and the heat rejected by the cooling towers. Figure 1 illustrates the hourly heating delivered to or removed from the building plotted against the outside air temperature. It can be seen that the heating energy rejected from the building for OAT less than 15°C is generally greater than the heat demanded by the building. This information was used to size the heat recovery chiller.

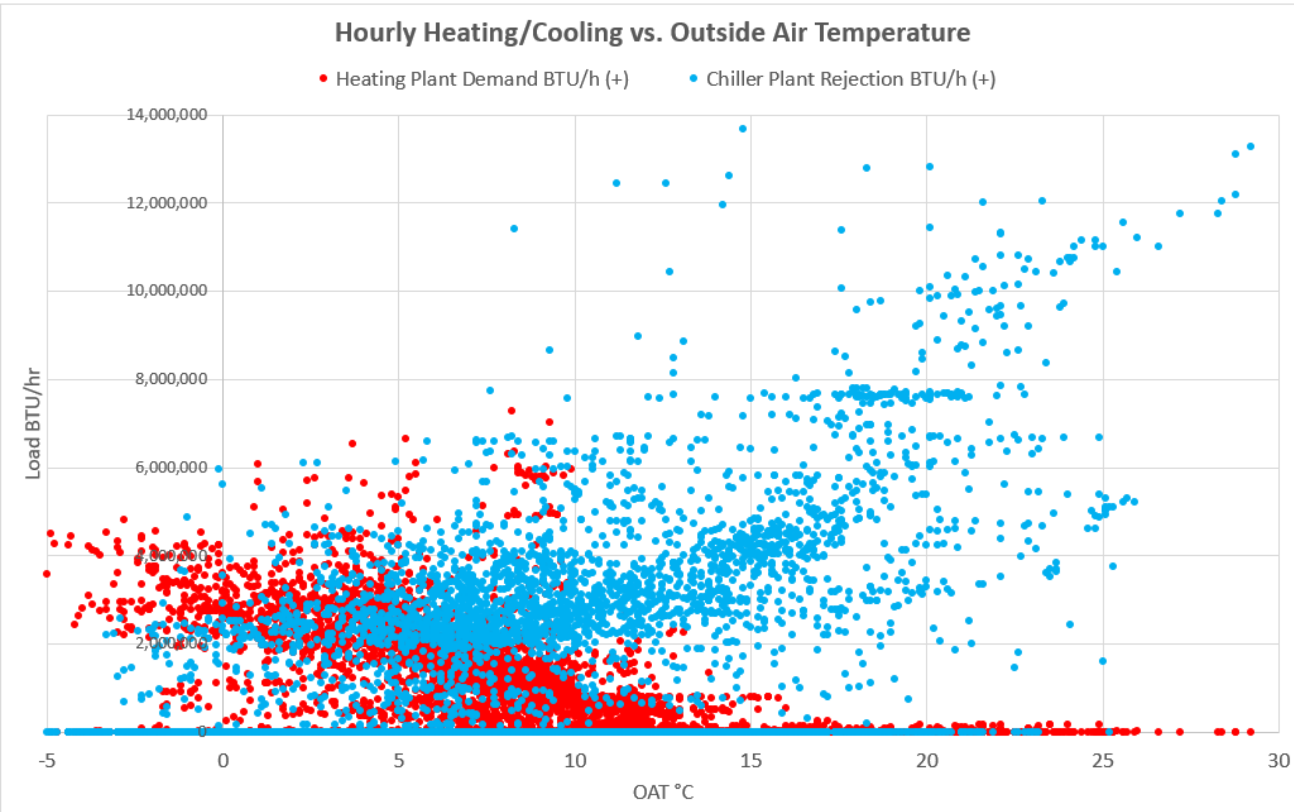
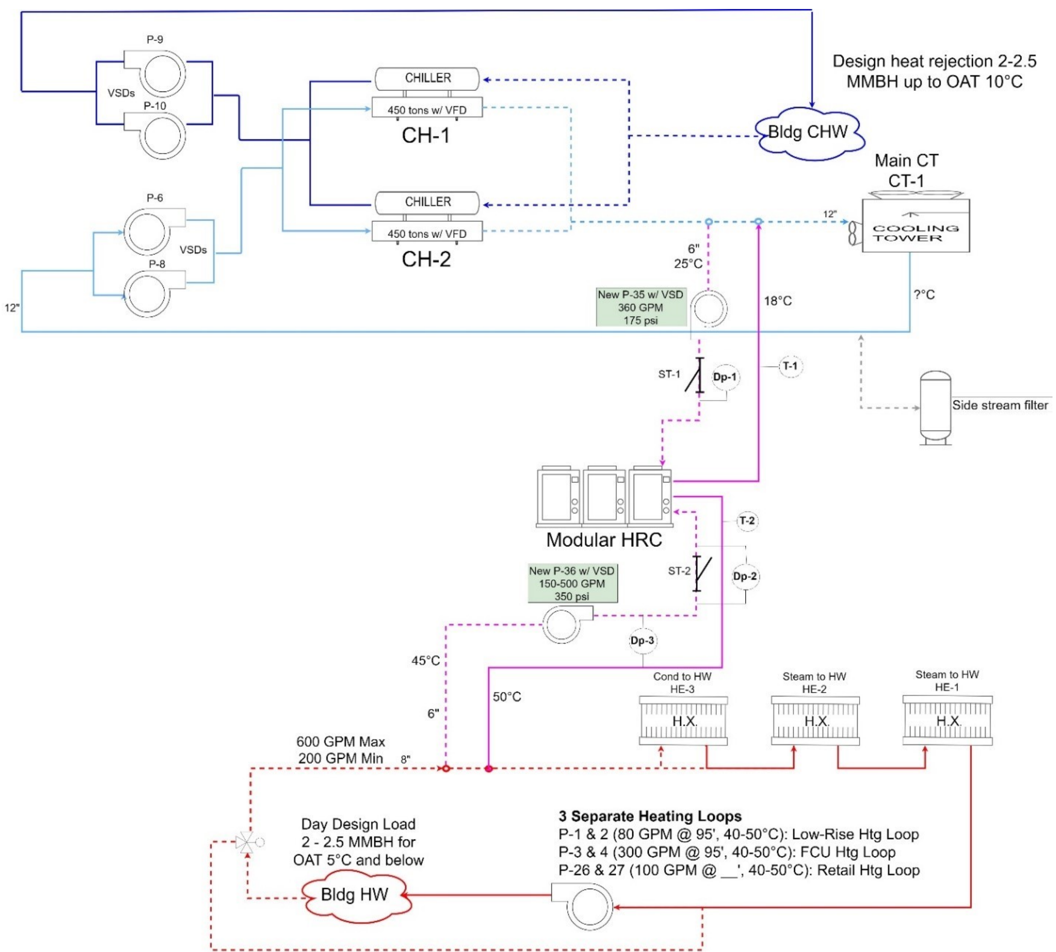


Figure 1: OAT Heating and Cooling Loads

Project Description

Based on the trend analysis, it was found that there is a load match between heat rejected by the chiller plant and heat demanded for space heating after 9 am. A new 120-ton nominal modular heat recovery chiller was selected to reclaim waste heat from the chiller plant's condenser loop in a "cascaded" or "dedicated" configuration. The HRC transfers the heat into the return of the hot water loop. The heat recovery chiller is able to offset steam use during the heating season whenever the chiller plant is running. This is the case for outside air temperatures of -3°C to 15°C.

As well, two new pumps were required for the new heat recovery chiller, one for the condenser loop and one for the evaporator loop. These pumps along with the heat recovery chiller will add electrical load to the building, but this will be offset by steam savings and cooling tower electricity savings. Both pumps will have speed drives to optimize flow and minimize electricity use. Installation of the HRC was completed in early 2022. A schematic of the HRC system is shown in Figure 2.



Installation Challenges

The cooling tower for the chilled water loop is located close to the ground floor. It is an open loop system and dirt/debris from nearby trees and from the street is able to get into the loop causing water quality issues. There was concern that the dirty water would clog the HRC and potentially damage the machine. To prevent damage and flow issues to the HRC, a side stream filter was added to the HRC evaporator loop.

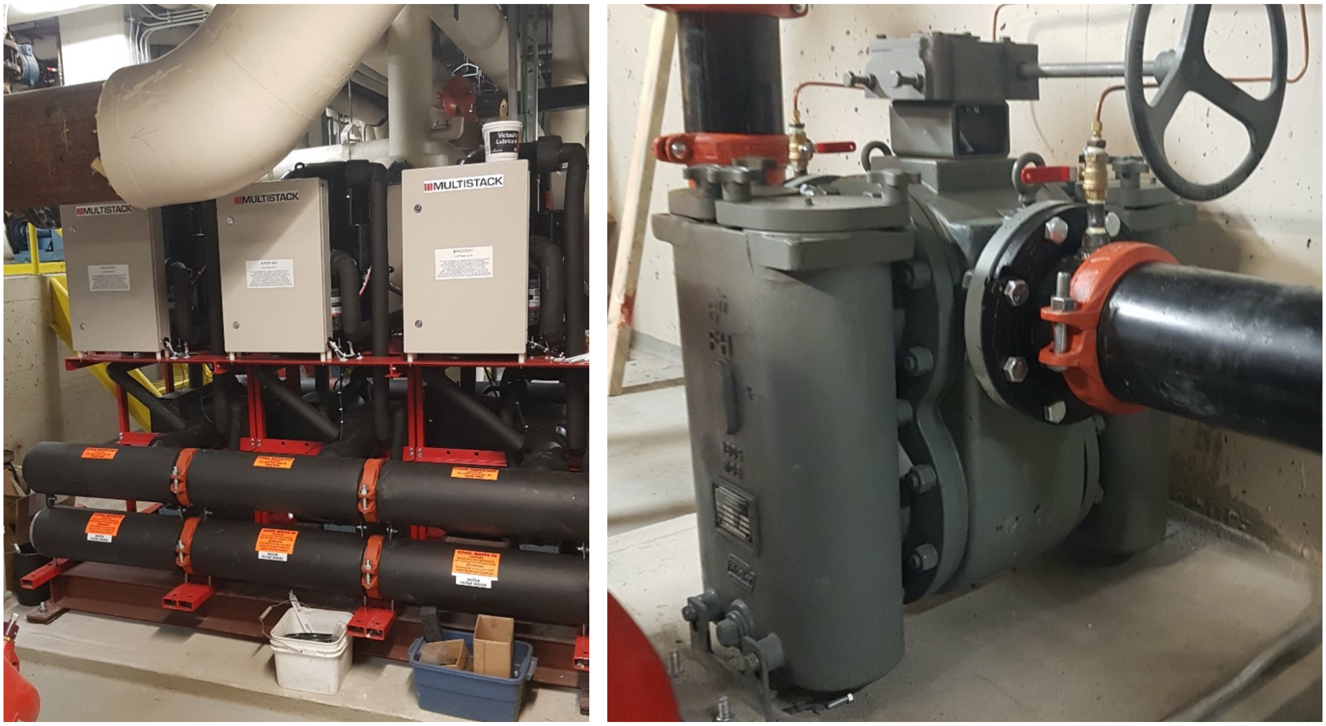


Figure 3: HRC (left), HRC Evaporator Strainer (right)

M&V Period Consumption and Savings

Monitoring and Verification (M&V) of the new HRC system was conducted during the year following installation. Unfortunately, the COVID-19 pandemic hit less than 2 months into M&V period. Building HVAC operation and occupancy changed significantly during this time, preventing proper savings analysis. During the M&V period (starting in April 2020) only 20-30% of the building was occupied and ventilation rates were increased based on ASHRAE recommendations:

- Washroom exhaust fan schedule was extended until midnight.
- A MUA fresh air purge was scheduled between 6:00 am and 8:00am.

In general, the HRC has been performing as intended and has been able to recovery heat from the cooling plant when it is enabled, typically running between 25% and 50% of total capacity. Original design intentions were to have the HRC running closer to 100% of capacity. However, programming changes to optimize the MUA and cooling plant and increase the amount of heat available to be recovered were not able to be completed as the MUA schedules were updated to increase ventilation in accordance with ASHRAE COVID-19 guidelines.

Figure 4 shows the HRC capacity in the fall of 2020 through the spring of 2021. The chiller plant has lower run hours during the winter, which are being further reduced with the increased make up air schedule as part of the COVID-19 mitigation strategy (increased cool outdoor air provides free cooling that normally the chiller would provide). This will reduce the amount of heat that the HRC can recover.

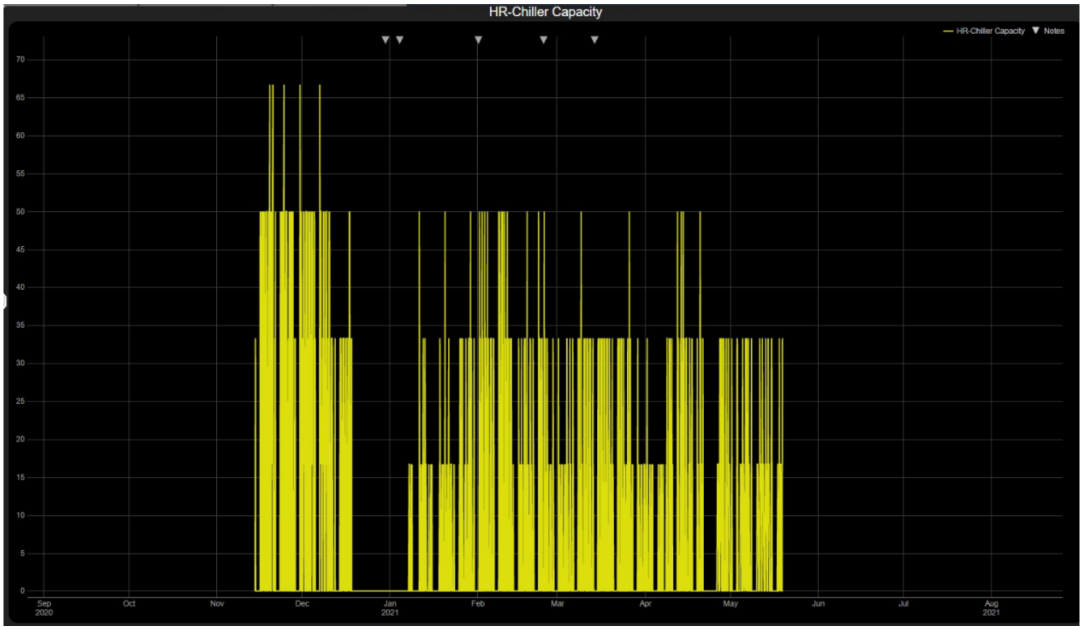


Figure 4: System Schematic

Updated building steam (represented as GJ of energy), electrical consumption and demand and cooling tower water consumption are presented in Table 3, Table 4, Table 5 and Table 6 below. The tables calculate the difference in consumption between January 2020 to March 2021 and the baseline (as determined for the BC Hydro Energy Study).

These savings represent overall, building-level reductions in steam, electrical and water usage during the M&V period and cannot solely be attributed to the installation of the HRC. Operational and occupancy changes due to COVID-19 would also have had a significant impact on the energy consumption of the building, with some changes increasing energy consumption (increased ventilation schedules) and some assumed to decrease energy consumption (low occupancy).

Original energy calculations estimated steam savings of over 4,000 GJs per year, an increase in electrical consumption of 200,000 kWh per year and an increase in annual demand of 850 kW. In 2020, steam consumption was approximately 1,200 GJ (~20%) less than the baseline, electrical consumption was approximately 1,300,000 kWh (~20%) less than the baseline and demand was down on average 28%. Cooling tower water consumption has been down approximately 50%. This reduction can be attributed to the HRC utilizing waste heat, reducing the amount of heat required to be rejected by the cooling tower as well as a reduced cooling load due to lower-than-normal occupancy.

COVID-19 has impacted occupancy and operations patterns so drastically that it is difficult to determine what portion of the savings is associated with the HRC. We can say that the equipment is working well, and that savings will increase when occupancy patterns return to pre-COVID levels.

	GJ								Energy Study	Savings	Savings
Month	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Baseline**	**2020**	**2021**
Jan	1,488	1,092	917	1,512	1,189	928	1,113	874	**1,240**	126	366
Feb	1,463	548	789	1,136	1,005	1,202	819	1,007	**988**	169	-19
Mar	1,044	498	731	1,009	841	791	339	704	**820**	481	117
Apr	371	381	217	426	463	546	331		**349**	18	
May	119	139	72	224	16	173	110		**138**	28	
Jun	14	3	3	0	0	0	0		**7**	7	
Jul	0	0	2	0		0	0		**2**	2	
Aug	0	5	3	0		0	5		**4**	-1	
Sep	0	156	5	28	88	37	0		**63**	63	
Oct	340	374	241	595	354	507	372		**388**	15	
Nov	729	940	572	857	574	769	715		**774**	60	
Dec	847	990	1,334	1,115	816	1,011	832		**1,072**	240	
Total	**6,416**	**5,125**	**4,886**	**6,902**	**5,345**	**5,964**	**4,637**	**2,584**	**5,845**	**1,208**	**464**
	Baseline		Implementation			M&V				21%	18%

Table 3: Steam Consumption

	kWh								Energy Study	Savings	Savings
Month	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Baseline**	**2020**	**2021**
Jan	613,074	536,361	536,850	494,400	523,200	537,720	489,600	412,800	**540,777**	51,177	127,977
Feb	532,754	484,335	513,600	552,000	576,000	509,528	518,400	446,400	**531,738**	13,338	85,338
Mar	591,377	551,519	548,514	499,200	508,800	527,097	484,800	446,400	**539,882**	55,082	93,482
Apr	605,661	534,848	530,824	523,200	537,600	497,455	446,400	427,200	**546,427**	100,027	
May	620,448	576,086	564,160	523,200	590,400	480,000	403,200		**574,859**	171,659	
Jun	630,869	611,972	566,400	576,000	576,000	499,200	427,200		**592,248**	165,048	
Jul	678,825	658,292	542,400	624,000	590,400	552,000	480,000		**618,783**	138,783	
Aug	639,620	625,422	643,200	667,200	643,200	532,800	470,400		**643,729**	173,329	
Sep	611,486	586,748	556,800	633,600	563,170	537,600	460,800		**597,158**	136,358	
Oct	586,529	563,680	571,200	609,600	545,969	523,200	460,800		**582,752**	121,952	
Nov	540,312	521,486	537,600	662,400	512,100	489,600	451,200		**565,450**	114,250	
Dec	557,494	562,326	552,000	556,800	522,600	513,600	470,400		**557,155**	86,755	
Total	**7,208,450**	**6,813,076**	**6,663,548**	**6,921,600**	**6,689,439**	**6,199,800**	**5,563,200**	**1,732,800**	**6,890,958**	**1,327,758**	**306,797**
	Baseline		Implementation			M&V				19%	23%

Table 4: Electrical Consumption

	kW						Energy Study	Savings	Savings
Month	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Baseline**	**2020**	**2021**
Jan	0	1,248	1,224	0	1,272	1,022	**1,236**	-36	214
Feb	0	1,248	1,238	0	1,238	969	**1,243**	5	274
Mar	0	1,248	1,228	0	1,243	940	**1,238**	-5	298
Apr	0	1,267	1,344	0	1,099	1,032	**1,306**	207	274
May	0	1,737	1,660	0	988	1,075	**1,699**	711	623
Jun	1,713	1,771	1,656	0	1,118		**1,713**	595	
Jul	1,497	1,708	1,780	0	1,248		**1,662**	414	
Aug	1,795	1,761	1,737	0	1,262		**1,764**	502	
Sep	1,732	1,857	0	0	1,080		**1,795**	715	
Oct	1,310	1,761	0	0	960		**1,536**	576	
Nov	1,324	1,440	0	1,233	1,008		**1,382**	374	
Dec	1,257	1,344	0	1,248	969		**1,301**	332	
	Baseline		Implementation			M&V		25%	25%

Table 5: Electrical Demand

Month	m^3					Baseline	Savings	Savings
	2017	2018	2019	2020	2021		2020	2021
Jan	0	1,654	2,568	985	1,236	**2,111**	1,126	875
Feb	0	1,938	2,923	2,458	2,088	**2,431**	-28	343
Mar	0	1,522	2,742	959	723	**2,132**	1,174	1,410
Apr	0	2,183	2,398	793	1,126	**2,183**	1,390	1,057
May	0	2,888	2,923	1,138	1,888	**2,888**	1,749	999
Jun	0	5,963	4,352	2,319	2,173	**5,963**	3,644	3,790
Jul	6,006	5,856	4,827	2,741		**5,931**	3,189	
Aug	8,374	9,406	6,237	4,448		**8,890**	4,441	
Sep	9,882	12,265	8,437	4,459		**11,073**	6,614	
Oct	7,181	7,566	3,686	3,445		**7,374**	3,928	
Nov	4,385	3,889	1,915	1,390		**4,137**	2,747	
Dec	2,984	3,004	1,429	746		**2,994**	2,248	
Total	**38,812**	**58,132**	**44,437**	**25,882**	**9,233**	**58,105**	**32,223**	**8,474**
		Baseline		Imp.		M&V	55%	48%

Table 6: Water Consumption

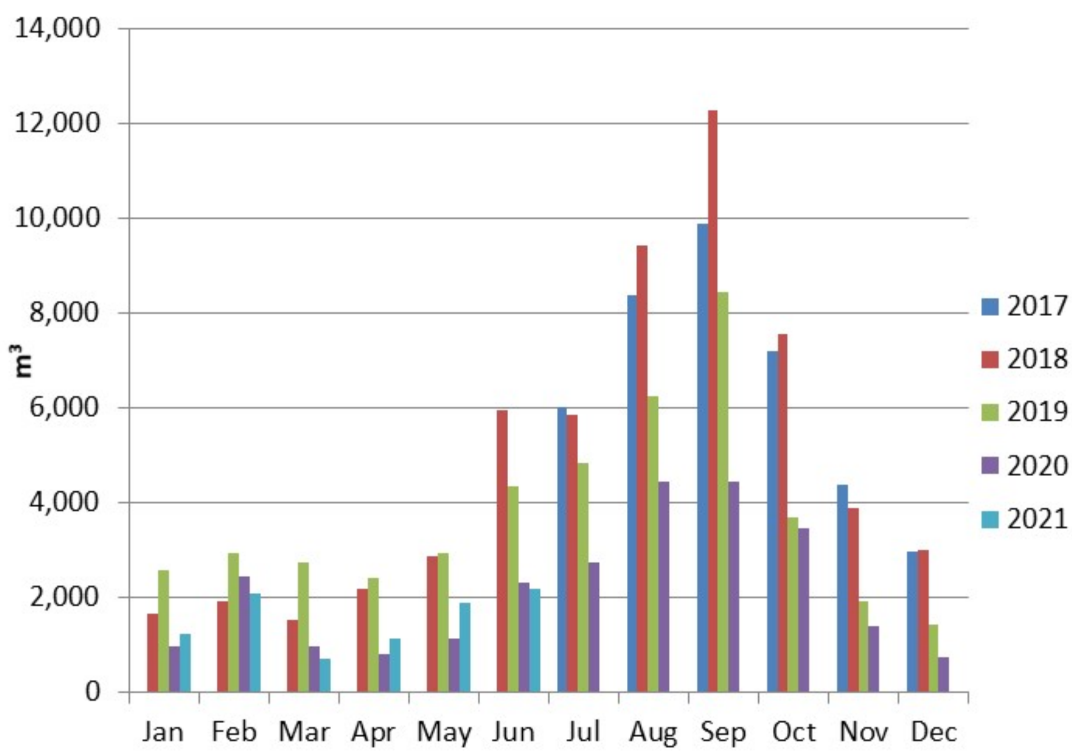


Figure 5: Water Consumption Profile

Future Recommendations

During the trend analysis we found the demand for heat typically starts at 6:00 am during the winter (when the MUA is enabled), while the chiller plant does not start until 9 am. In order to address the early-morning mismatch in load (MUA enabled at 6:00 am while chiller plant is not enabled until 9:00

am) it is recommended that the schedule and controls of the MUA and chiller plant be optimized. An early morning cooling load can be created by minimizing free cooling provided by the make-up air unit in the penthouse. The building currently has CO_2 sensors on every floor connected to the DDC. The feedback from these sensors can be used to delay the start of the MUA in the morning. If the start of the MUA is delayed until 8:00 am when occupants begin to arrive at the building, it will reduce the heating load in the cold spaces and increase the cooling load in the warm spaces. The VFD-equipped chiller can operate at a lower load and can be used earlier in the morning in place of free cooling. This would generate source heat for the heat recovery chiller to offset early morning steam.

Conclusion

Since the completion of the heat recovery system installation in December 2019, steam consumption and electrical consumption has decreased by approximately 20%, monthly demand is on average 28% less and cooling tower water consumption is down approximately 50% when compared to the Energy Study baseline. Due to the COVID-19 pandemic, occupancy levels and operational changes have impacted building energy and water consumption to a point that we cannot quantify the impacts of the HRC based solely on metered data comparisons.

Once COVID-19 mitigation strategies (increased ventilation rates) are no longer required and building occupancy returns to normal levels, we recommend optimizing MUA and chiller plant schedules to fully take advantage of the HRC.