Arthur Erikson Place – DHW CO_2 Heat Pump Case Study

PREPARED BY: SES CONSULTING

Building Name/Address	AEP, 1075 W. Georgia St. Vancouver, BC
Building's Asset Class	Office
Building Size	~39,000 sq.m (~420,000 sq.ft.)
Year Built	1968
Building Owner & Manager	Owners: Kingsett Capital, Crestpoint Realestate Investments and Reliance Properties Manager: Colliers
Engineering Consultant	SES Consulting
Mechanical Consultant	Kern BSG (formerly Pacific Mechanical)

BOMA BRITISH COLUMBIA SES CONSULTING A/E ArthurEricksonPlace

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PROJECT SUMMARY

In 2021, SES consulting, along with Kern BSG (formerly Pacific Mechanical), installed a CO_2 domestic hot water (DHW) heat pump system at Arthur Erickson Place (AEP), located at 1075 West Georgia Street in Vancouver, BC. This project was the first phase of a plan to decarbonize the building. AEP is a 39,000 m^2, 26-storey office tower built in 1968. The CO_2 heat pump system replaces the existing natural gas-fired DHW boilers serving the tenant spaces. It was estimated that the upgrade would save approximately 700 GJ of natural gas per year.

Energy Savings			Cost Savings		GHG
Natural Gas (GJ/yr)	Electricity (kWh/yr)	Demand (kW/yr)	Natural Gas* ($)	Electricity ($)	Savings (tons/yr)
675	-63,000	-84	$7,375	-$5,700	40

*including avoided carbon taxes

Table 1: Energy Study Calculated Savings

PROJECT BACKGROUND

In 2020 SES Consulting Inc. was engaged to provide a BC Hydro CleanBC Custom-Lite Energy Study to analyse the feasibility and business case of replacing the existing natural gas DHW system at AEP in downtown Vancouver with a CO_2 heat pump upgrade.

AEP was a good candidate for this upgrade as one of the building owners, Kinsett Capital, has won an annual *Innovation in Sustainability* competition for their managed properties. Winners of the competition received a $50,000 contribution towards implementation of the project. In 2020 Kinsett focused on projects with new technologies that had not yet been fully adopted by the industry. The DHW heat pump project aligned with the focus of the competition and ultimately was chosen as the winner.

Following a BC Hydro review and incentive approval, SES Consulting was engaged to design and implement the DHW CO_2 upgrade at AEP.

Existing Building Systems

AEP is a 39,000 m^2 (420,000 ft^2) office tower that was originally constructed in 1968. The building is 26-stories with five levels of underground parking. The ground floor of the building is occupied by retail stores.

The existing DHW system was separated into two independent loops: the upper loop served Floors 11 through 26 while the lower loop served floors 10 through to the basement. In the winter season DHW was provided using the primary space heating boilers. However, in the summer season when the primary boilers were turned off, the two loops were served by smaller gas-fired boilers (a 300 Mbtu/hr boiler served the upper loop while two 500 Mbtu/hr boilers served the lower loop as well as the fitness room). Each loop also included a 350 gallon storage tank and recirculation pump. The fitness room DHW load was not incorporated into the design as the equipment was less than 10 years old.

A review of the building electrical load was also conducted to ensure that the existing building capacity could support electrifying the DHW system. It was found that the average peak demand of 1,500 kW only accounted for approximately 40% of the existing capacity, indicating that there was ample room in the existing system to upgrade the DHW to ASHPs.

DHW Load Analysis

Using monthly natural gas billing data, it was estimated that DHW accounted for approximately 700 GJ of natural gas consumption per year (approximately 55-60 GJ per month). Natural gas usage for DHW was estimated using summer month billing data as at this time the primary heating boilers have been disabled and remaining gas consumption is only being used by the DHW boilers.

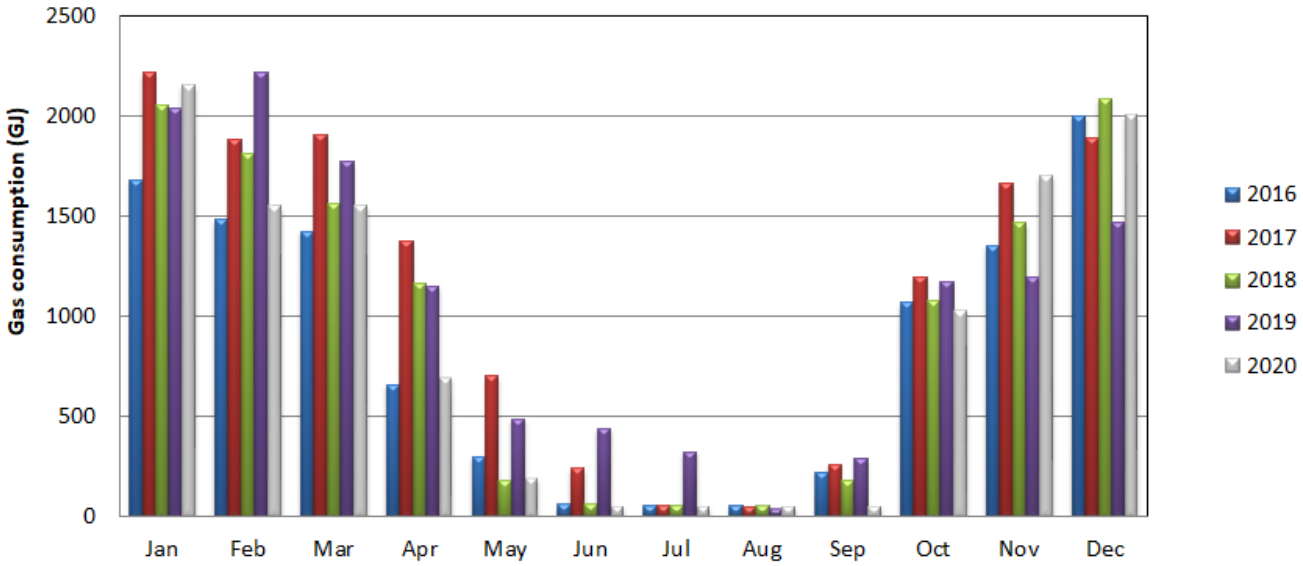

Figure 1: Monthly Natural Gas Consumption

To ensure right sizing of the new equipment, SES conducted an audit of all the plumbing fixtures to determine the DHW load of the building. The methodology outlined in the American Society of Plumbing Engineers (ASPE) handbook was used as starting point, which was then refined based on on-site conditions (low flow fixture upgrades, monthly billing data), as well as consultation with the heat pump manufacturer and distributor.

PROJECT DESCRIPTION

Based on the DHW load analysis, two separate DHW systems were selected. The upper system consisted of:

- Six Sanden CO_2 Heat pumps
- Four 119 Gallon (450 L) storage tanks
- One 30 kW electric swing tank
- One 1/8 HP recirculation pump

The lower system consisted of:

- Four Sanden CO_2 Heat pumps
- Three 119 Gallon (450 L) storage tanks
- One 30 kW electric swing tank
- One 1/8 HP recirculation pump

The schematic for the upper DHW system is shown in Figure 1 below.

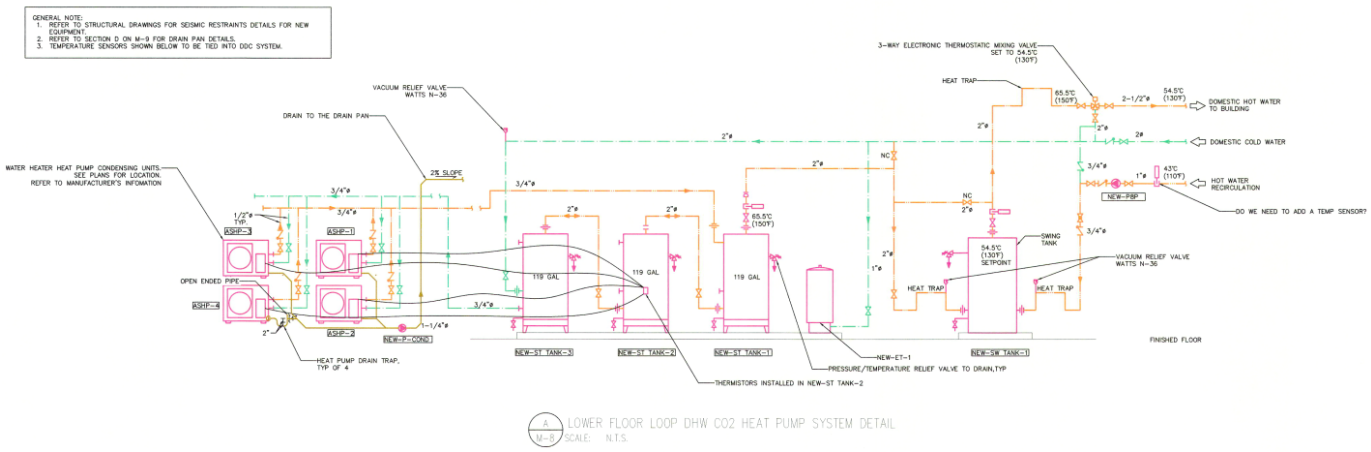

Figure 1: Upper Loop Schematic

As the existing DHW system primarily used the main building heating water boilers that would still be used for space heating, new locations for the two DHW plants needed to be located. The upper loop system was installed in the top floor mechanical room while the lower heat pumps were installed in the parkade and the storage tanks and pumps were installed in a nearby storage room. Installation began in September 2020 and was substantially completed by June 2021.

Figure 2: Upper loop HPs (left) and swing tank (right)

Figure 3: Lower loop HPs (left) and swing tank/storage tanks (right)

Installation Challenges

Sizing the new recirculation pumps was challenging as this was a retrofit of an existing system, and determining the size and length piping to the tenant spaces was also difficult. The initial recirculation pump selection was undersized and recirculation temperatures and flows were too low to properly maintain adequate water temperatures at the farthest fixtures. Larger pumps were selected and installed to maintain loop temperatures.

Post Upgrade Consumption and Savings

A review of the monthly natural gas billing indicates that summer gas usage (used to indicate DHW consumption) has decreased from approximately 56 GJ per month to approximately 14 GJ to month, representing an annual savings of 500 GJ. The remaining gas usage is attributed to the fitness centre water usage which is still provided by natural gas boilers. Based on an incremental cost and with the BC Hydro and Innovation in Sustainability award, the payback for the project is approximately 15 years (incremental cost was based on a like-for-like replacement of the existing natural gas boilers).

Gas Consumption GJ

Month	2016	2017	2018	2019	2020	2021	2022	Energy Study Baseline	Post Construction Baseline
Jan	1683	2219	2053	2042	2151	1610	2350	**2,029**	**1,980**
Feb	1484	1883	1816	2219	1552	1819	1630	**1,728**	**1,725**
Mar	1425	1904	1566	1772	1552	1920	1454	**1,644**	**1,687**
Apr	658	1373	1161	1153	690	1163	1210	**1,007**	**1,186**
May	302	704	178	488	191	735	960	**372**	**848**
Jun	62	240	64	440	54	26	19	**122**	**22**
Jul	54	56	57	323	54	23	10	**56**	**17**
Aug	56	52	53	39	52	11	11	**53**	**11**
Sep	221	263	183	289	54	204	25	**202**	**115**
Oct	1071	1195	1083	1175	1025	952	530	**1,110**	**741**
Nov	1354	1667	1468	1197	1697	1464	1888	**1,477**	**1,676**
Dec	2004	1889	2089	1469	2007	2541	2509	**1,891**	**2,525**
Total	**10,375**	**13,444**	**11,770**	**12,607**	**11,079**	**12,467**	**12,596**	**11,692**	**12,532**

Baseline Implementation Post Construction

Table 3: Monthly Gas Consumption

Since installation, there have been no complaints with lack of hot water to the tenant spaces and there have been no major issues with the system.

FUTURE RECOMMENDATIONS

The fitness centre is still served by natural gas boilers. As there have been no issues with lack of hot water, the fitness centre DHW heating may be piped into the lower heat pump system. If it is determined that additional capacity is required to incorporate the fitness centre, more heat pumps may be added to the lower loop.

CONCLUSION

Since the completion of the DHW upgrade, DHW for the tenant spaces has been fully electrified and is being provided by the new heat pump system. To date there have been no issues with lack of hot water or mechanical issues with the new system. SES and AEP are now in the process of implementing the remaining phases to decarbonize the building including adding a heat recovery chiller and replacing the boilers with air source heat pumps.