DATA CENTRE CO_2 SYSTEM PROFILE

PROJEC AT A GLANCE

Bell Canada, Ottawa

Location: Ottawa, Ontario, Canada
Principal Use: Data Centre
Temperature Requirement: 28 C
Completion: Summer 2014
Times of Operation: 24/7/365

Bell Canada, like other data and communication companies faces the challenge of exponential growth while minimizing energy consumption. For operators the Power Utilization Effectiveness, or PUE, is the standard upon which to measure overall cooling effectiveness.

For most operators the above must be balanced against their Corporate Social Responsibility (CSR) and sustainability objectives which adds another difficult variable given that the mainstream manufacturers of data room cooling uses a refrigerant of moderately high global warming potential (GWP).

In fact, this current primary refrigerant has a high enough GWP that many suspect it will face restrictions in North America in the coming 5 years as it does in Europe. Lastly, what consequence may the current primary refrigerant present as more and more jurisdictions roll out various carbon cap and trade programs?

With any new capital replacement of a data cooling system, the operator will plan for a minimum of 10-15 years of efficient operations and management. Is the procurement of the current industry standard cooling system the best 10-15 year solution or does another alternative exist?

In 2012 Carnot Refrigeration, with application guidance from Bell Canada, set about designing the Acquilon data room system using the natural refrigerant Carbon Dioxide (CO2). It was thought that CO2 may provide an ideal solution for this environment.

Refrigeration System Configuration

The Acquilon CO2 data room system is generally configured as expected with options for either up flow or down flow air supply. Its footprint and refrigeration cooling capacity is also typical at 15TR, 30TR and 45TR offered. The system at Bell Canada in Ottawa is 30TR. The onboard control package is Corel tying back to Bell Canada's central data operations department in Montreal, Quebec.

The system is located in the lower level of the facility and is an up flow system. For CO2 the rooftop condenser is an all stainless steel coil gas cooler. The piping on the high side between the Acquilon and the gas cooler is stainless steel with tube and orbital welding process used where possible. The gas cooler is located approximately 25' above the indoor Acquilon unit.

Installation Differences of CO_2

From the perspective delivery and placement onto the roof (gas cooler) and within the facility (Acquilon unit), the CO2 system is essentially the same as an HFC system. However, the first difference that emerges that can reduce inconvenience in a retrofit application is that the piping of a CO2 system is smaller than HFC. As a result, the refrigerant volume is less – and possibly considerably less when longer pipe runs are required.

Electrical configuration, controls and footprint are the same as the typical HFC solutions.

A condenser option is to use the Adiabatic Gas Cooler. This was not used in this particular application but it should be noted that Neelands Refrigeration has recognized up to a 15% increase in efficiency and subsequent energy savings during higher ambient rooftop conditions.

One of the greatest benefits of CO2 is its free cooling capabilities. However, to accommodate the free cooling, the piping between the gas cooler and the Acquilon unit must be a constant negative slope.

Heat Recovery Advantages of CO_2

In this particular installation, there is no design requirement for heat recovery. It should be noted however that CO2 possesses tremendous heat reclaim capabilities that may have an application in certain data facilities.

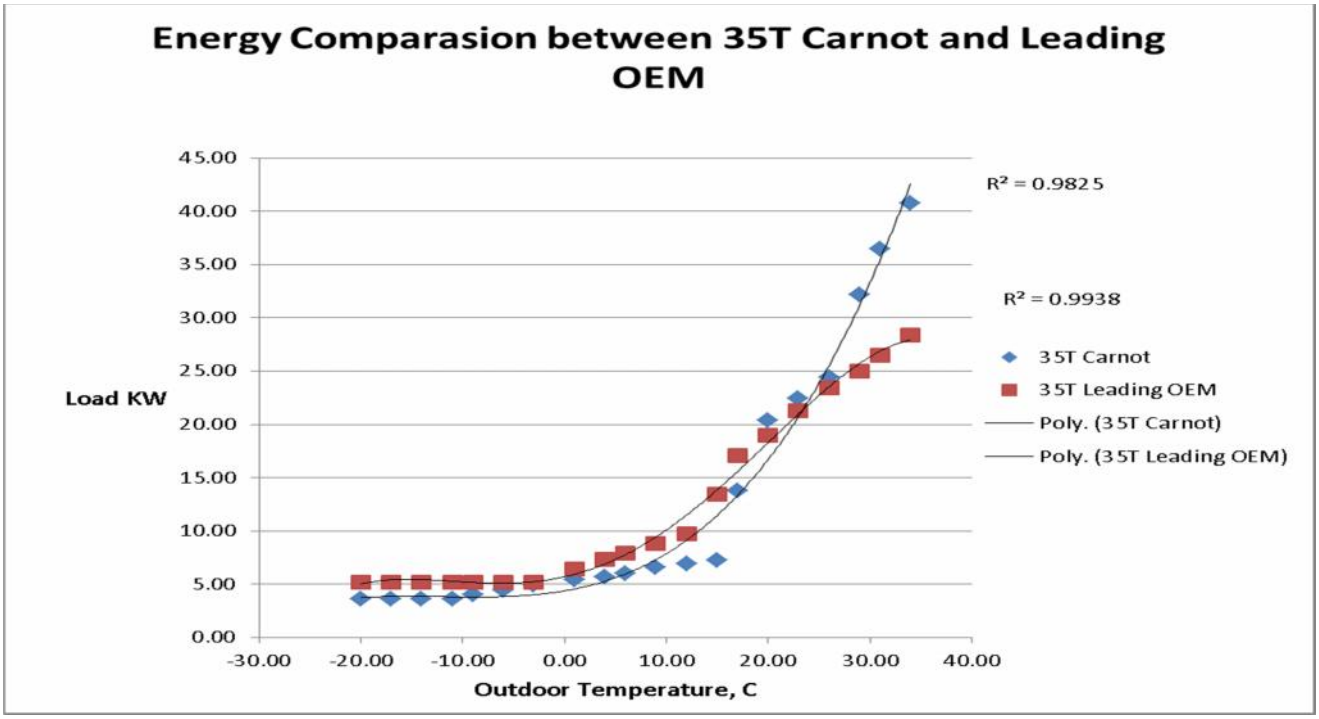
Free Cooling Advantages of CO_2

Carnot Refrigeration uses their patented thermosyphon free cooling (TFC) design called "***Rain Cycle***". Due to the natural characteristics of CO2, the potential for free cooling can be realized whenever the difference between return air temperature and outside rooftop temperature is greater than 5-6 C. As a consequence, if an operator has a higher return temperature as a result of a higher set point or improved room air management, they will realize increased hours of free cooling.

In a TFC condition the Carnot Acquilon requires no mechanical cooling other than the operation of the evaporator and gas cooler fans. This differs from a typical HFC free cooling system where one or more refrigerant pumps are required. The use of pumps increases energy consumption and the number of points of failure (POF) that the data room facilities manager must account for.

In a survey completed in February 2016 of twelve (12) Mechanical Service Contractors of America (MSCA) the purchase price of the refrigerant pump, excluding installation and contractor profit, ranged between $8,400.00 and $11,200.00 US.

Energy Analysis

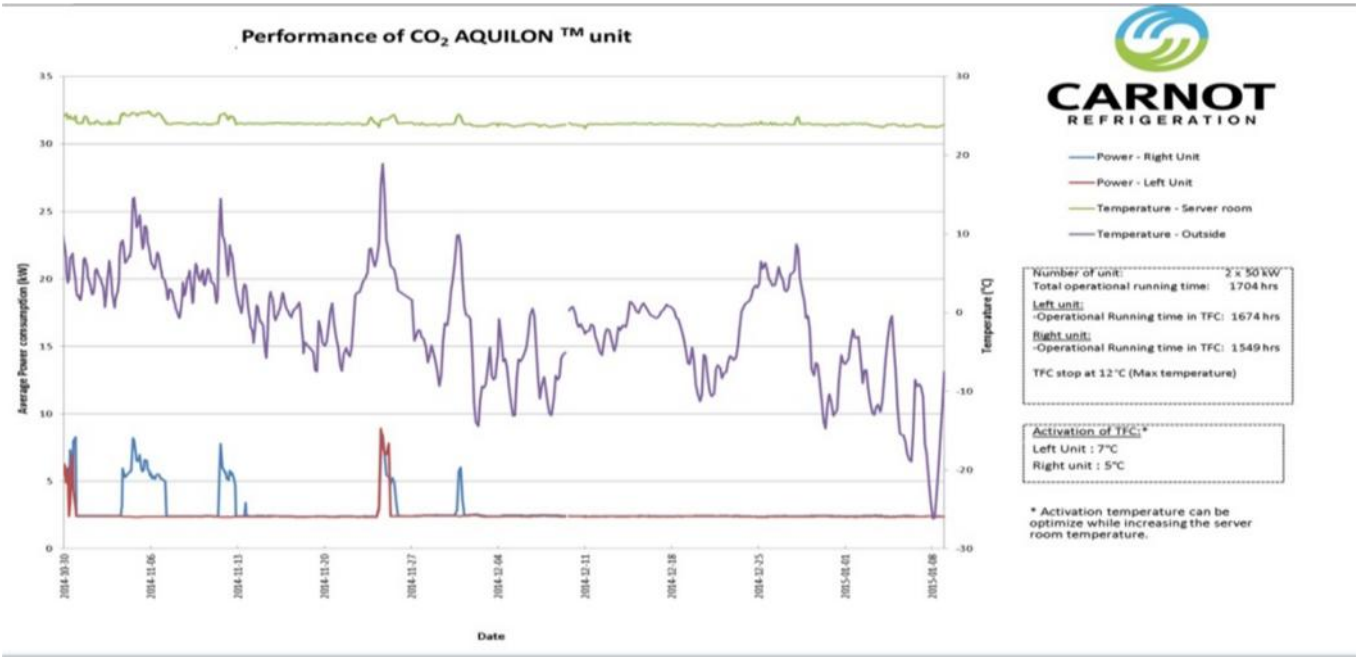


Graph above is showing BIN Energy Analysis between 35T Carnot unit and same capacity leading OEM Data Center unit. As it can be seen for temperatures below 7 °C both units are in a total free cooling mode with Carnot unit slightly more efficient. From 7 °C leading OEM unit is in the hybrid mode, while Carnot unit stays in the free cooling mode up to 18 °C. This represents 6360 hours or 72% of free cooling hours throughout whole year for Ottawa.

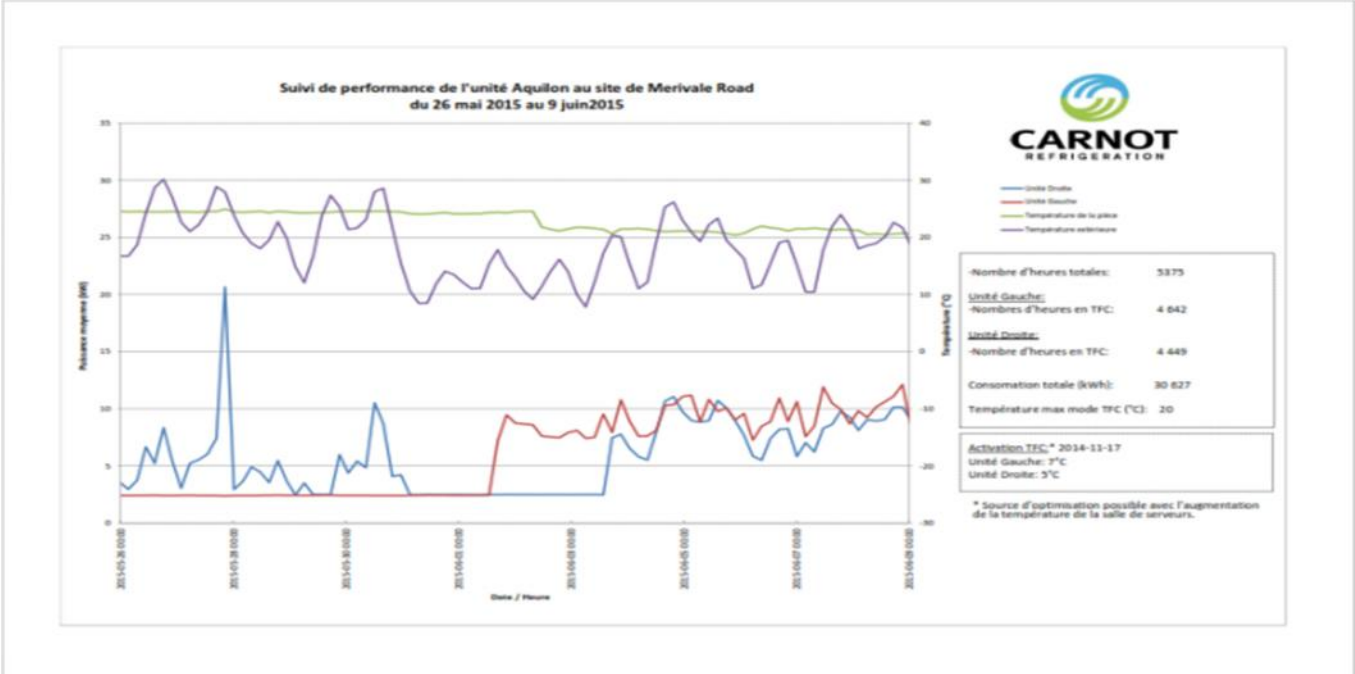
Model	Nominal Cooling capacity at 35°C (kW)		Room (or return) temperature		Outside air temperature [°C]										
	Refrig.	Sensible	°C	%RH]		-10	-5	0	5	10	15	20	25	30	35
Aquilon-15	63.7	62	28	36	kW(1)	1.8	2.2	2.7	3	3.3	3.6	10.2	12.2	16.1	20.4
					pPUE(2)	1.029	1.035	1.044	1.048	1.05	1.06	1.16	1.20	1.26	1.33
	60.5	58.8	26	39	kW(1)	2	2.4	2.8	3.1	3.4	9.3	10.1	12.5	16.3	20.5
					pPUE(2)	1.034	1.041	1.048	1.053	1.06	1.16	1.17	1.21	1.28	1.35
	54.7	46.8	24	45	kW(1)	2.1	2.6	3	3.2	8.5	9.1	10.3	12.9	16.7	20.8
					pPUE(2)	1.045	1.056	1.064	1.068	1.18	1.19	1.22	1.28	1.36	1.44
	51.1	38.7	22	50	kW(1)	2.3	2.8	3.1	8.4	8.5	9.2	10.5	13.2	16.9	20.9
					pPUE(2)	1.059	1.072	1.080	1.217	1.22	1.24	1.27	1.34	1.44	1.54

(1) Total power consumption for 80% load (kW)
(2) Power utilization effectiveness (pPUE)

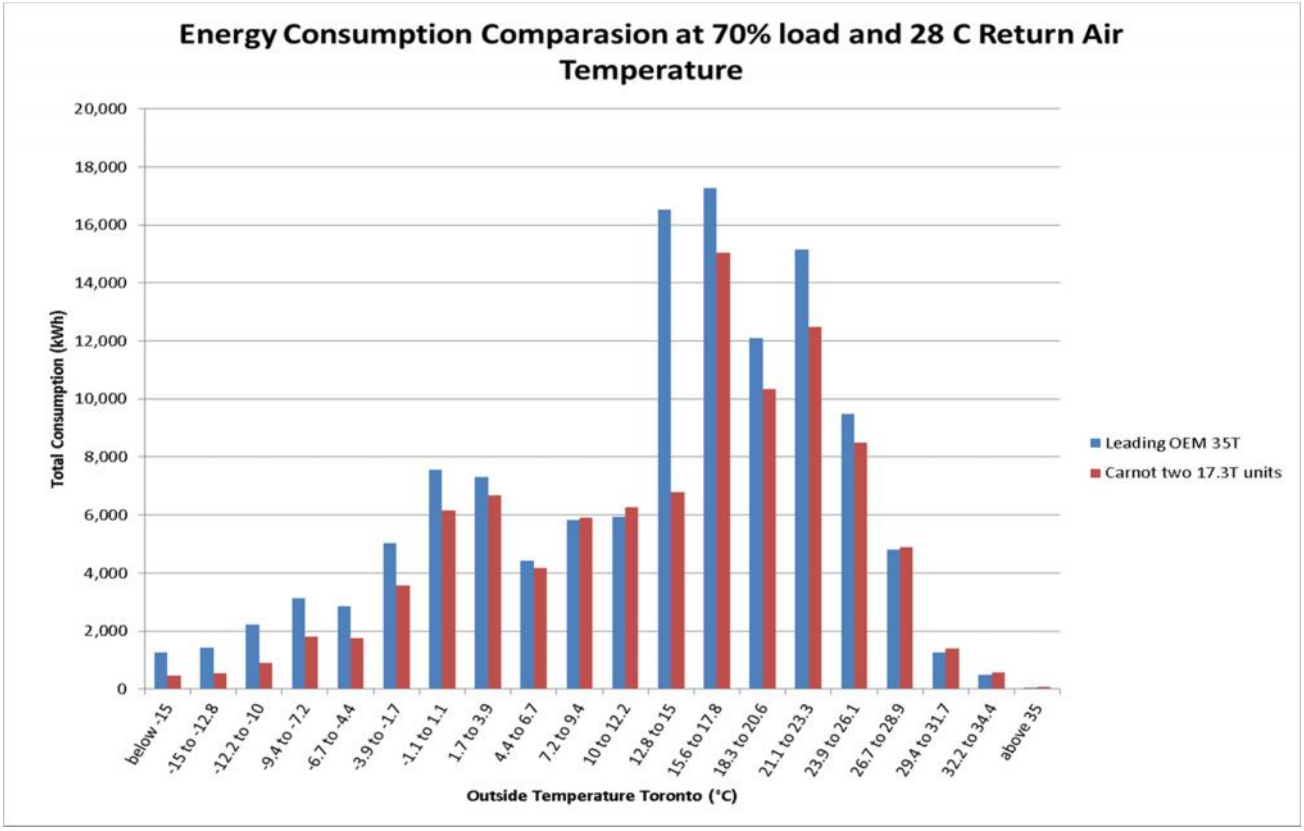
Free Cooling
Hybrid Mode
Mechanical Cooling
Mechanical Cooling Transcritical



Graph above is showing period from November 2014 to January 2015. As it can be seen average running hours between two Carnot units in free cooling mode was 1,611 hours or 94.5% of total running hours



Graph above is showing period from May 26th to June 9th of 2015 As it can be seen average running hours between two Carnot units in free cooling mode was 4545 hours or 84.5% of total running hours



Graph above is showing Energy BIN comparison between 35TR Carnot and same capacity leading OEM unit. Note in particular BIN between 13 to 15 °C where Carnot is in total free cooling mode versus full mechanical or hybrid mode of leading OEM Data Center unit

Conclusion

CO2 represents not only a commercially feasible alternative to traditional HFC based systems, but has proven to provide significant environmental and performance benefits as well. With pPUE's of 1.03 during the frequently used thermosyphon free cooling operating mode; a GWP of 1; an ODP of 0; a virtual elimination of carbon footprint; and a competitive price point – the CO2 Acquilon system provides the manager of a critical room environment the most complete technical, environmental and business long term solution.

Customer Reaction

One additional site was equipped with the Acquilon in 2015 and 4 additional sites are being installed in spring of 2016