Toronto East Health Network

Energy Conservation and Demand Management Plan

2019 Update

June 2019

Contents

Energy Conservation and Demand Management Plan

1.0 Executive Summary

Ontario Regulation 397/11 under the Green Energy Act 2009 requires public agencies, including municipalities, municipal service boards, school boards, universities, colleges and hospitals, to report on their energy consumption and greenhouse gas (GHG) emissions annually beginning in 2013, and to develop and implement energy Conservation and Demand Management (CDM) Plans starting in 2014, to be updated every five years.

Our 2014 CDM plan set a conservation target that would see TEHN reduce its 2011 energy consumption by 3% by the end of 2018. In 2018, our Michael Garron Hospital's energy consumption was 9.7% below baseline 2011. As a result, GHG emissions were down 11.8%.

During the period from 2012 through 2018, MGH reduced its total energy consumption by 29,307 MWh (7.1%), and its total GHG emissions by 4,634 t (8.4%), relative baseline 2011.

Between 2012 and the year-ended May 2019, energy intensity declined from of 68.2 kWh/ft² to 59.7 kWh/ft² – a decrease of 12.5%. During the same period, GHG intensity declined from 8.6 kg/ft² to 7.1 kg/ft² – a decrease of 17.4%.

Most of these improvements occurred subsequent to publication of the 2014 CDM plan. By far, the largest contributor was a one-third reduction in natural gas for space-heating, achieved by our facilities staff through optimized control of temperature and ventilation, while maintaining patient and staff comfort. Reducing natural gas consumption was essential to achieving the large reduction in GHG emissions, because in Ontario gas combustion emits 8.9 times the GHGs of grid electricity per unit energy.

Greening Health Care (Toronto and Region Conservation Authority) awarded Michael Garron Hospital the Energy Efficiency Leadership Award as one of five hospitals recognized at the silver level for total energy efficiency, and the 5 Percent Club Award for saving 5.6 per cent in energy since 2014 (including electricity, gas and GHG Emissions).

Green Hospital Scorecard gave Michael Garron Hospital a gold seal of recognition with high scores in the "Overall" and "Highest Energy Scorers" categories, compared to participating hospitals across Ontario.

In 2018, MGH began a site redevelopment that will see the construction of a new 8-floor patient care tower, designed to achieve a LEED silver designation, with annual energy intensity less than 1.6 GJ/m² (41.3 kWh/ft²). Existing Wings A, B, C, E and F will be demolished. TEHN has committed to reducing the 2018 energy consumption of the surviving Wings D, G, H, J and K by

3% by the end of 2023. The energy and GHG intensity of the redeveloped site is expected to be significantly less than that of the existing configuration.

2.0 TEHN 2017 Energy and GHG Report

The following table summarizes TEHN's 2017 energy and GHG report to the MOE.

Table 1
Toronto East Health Network
2017 Energy and GHG Report

	Area	Electricity	Gas	GHG Emissions		Energy Intensity
Facility Name	**ft²**	**kWh**	**m³**	**kg**	**%**	**ekWh/ft²**
Michael Garron Hospital	864,923	18,322,358	3,276,732	6,512,019	97.6	61.45
Medical Arts Building	59,998	894,237	0	15,469	0.2	14.90
Doctors' Offices	59,514	0	51,648	97,647	1.5	9.22
Withdrawal Management	16,523	169,258	16,558	34,232	0.5	20.89
Community Outreach	4,327	49,270	5,272	10,819	0.2	24.33
Aboriginal Day Program	904	3,788	0	66	0.0	4.19
TEHN Total	1,006,189	19,438,911	3,350,210	6,670,251	100.0	54.71

Michael Garron Hospital (MGH) accounted for 97 percent of TEHN's energy consumption and 98 percent of GHG emissions. The following section reports MGH's progress in reducing energy consumption and GHG emissions.

3.0 MGH Energy and GHG reductions to-date

Table 2 summarizes Michael Garron Hospital's (MGH) annual and total energy and GHG reduction relative baseline 2011, for the years 2012 through 2018. Over this period, MGH reduced total energy consumption by 29,307 MWh (7.1%), and total GHG emissions by 4,634 t (8.4%).

Table 2
Michael Garron Hospital
Annual Energy and GHG Reduction Relative Baseline 2011

	Electricity				Natural Gas				Total Energy			
	Energy		GHG		Energy		GHG		Energy		GHG	
Year	MWh	%	t	%	MWh	%	t	%	MWh	%	t	%
2012	-46	-0.2	-4	-0.2	411	1.1	73	1.1	365	0.6	69	0.8
2013	187	1.0	14	1.0	2,447	6.1	435	6.1	2,634	4.5	450	5.3
2014	232	1.2	9	1.2	3,100	7.4	551	7.4	3,332	5.5	561	6.8
2015	462	2.4	19	2.4	5,259	12.9	935	12.9	5,720	9.6	954	11.9
2016	1,097	5.6	39	5.6	5,471	14.4	973	14.4	6,568	11.4	1,012	13.6
2017	1,064	5.5	18	5.5	3,746	9.7	666	9.7	4,809	8.3	685	9.5
2018	891	4.6	18	4.6	4,987	12.2	886	12.2	5,878	9.7	904	11.8
Total	3,887	2.9	113	1.8	25,420	9.2	4,521	9.2	29,307	7.1	4,634	8.4

The baseline against which annual energy and GHG's are measured is calendar year 2011 - the inaugural year of energy reporting by Ontario's broader public sector (BPS). The effects of weather differences between 2011 and each reporting year have been accounted for by normalizing the 2011 consumption to the weather of the reporting year. The methodology has been described in Appendix A.1.

The GHG reduction is based on the electricity and natural gas carbon emission factors used by the MOE for BPS reporting in each year. Since 2018 data is not yet available, we have used the 2017 values for 2018.

Since 2015, the annual electricity and associated GHG reduction relative baseline 2011 has been statistically significant at the 95% confidence level, i.e. there was less than a 5% probability that the reduction could be explained by the statistical variance of the baseline. Natural gas and its associated GHG reduction have had the same level of statistical significance since 2013.

3.1 Energy intensity benchmark plots

Figure 1 plots annual energy, natural gas and total energy intensity since 2011, on a weather-normalized basis. Weather-normalization facilitates reliable comparison, by adjusting for annual variations in weather. The methodology is described in Appendix A.2. The total energy intensity peaked in 2012 at 68.2 kWh/ft², then declined steadily to 59.9 kWh/ft² in 2016, mainly due to a reduction in natural gas use. Gas use and total intensity rose in 2017, but have declined thereafter, reaching an historic low of 59.7 kWh/ft² during the year-ended May 2019.

By far, the largest contributor to our reduced energy intensity was a large reduction in natural gas for space-heating, achieved mainly by our facilities staff through optimized control of temperature and ventilation, while maintaining patient and staff comfort. Figure 2 plots annual weather-normalized natural gas energy intensity since 2011, broken down into baseload and space-heating components. In 2011, natural gas for space heating accounted for 23.1 kWh/ft². By 2015, this had been reduced by 20% to 18.4 kWh/ft². The year-ended May 2019 saw a record low space-heating energy intensity of 14.7 kWh/ft² - 36% below the 2011 baseline.

Reducing natural gas consumption was essential to achieving the large reduction in GHG emissions, because in Ontario gas combustion emits 8.9 times the GHGs of grid electricity per unit energy.

3.2 GHG intensity benchmark plot

Figure 3 plots annual weather-normalized GHG intensity since 2011. The GHG emission factor of electricity declined significantly during this period, due to the permanent closure of Ontario's coal-fired generators, and the increased use of lower or zero carbon alternatives. This had the effect of lowering the carbon footprint of all consumers of electricity. To make clear the results of MGH's efforts, the 2017 electricity emission factor has been applied to all years. On this basis, the total GHG intensity has been reduced from 8.6 kg/ft² in 2011 and 2012, to 7.1 kg/ft² during the year-ended May 2019 – a decline of 17.4%.

Figure 1
Michael Garron Hospital
Weather-normalized Annual Energy Intensity

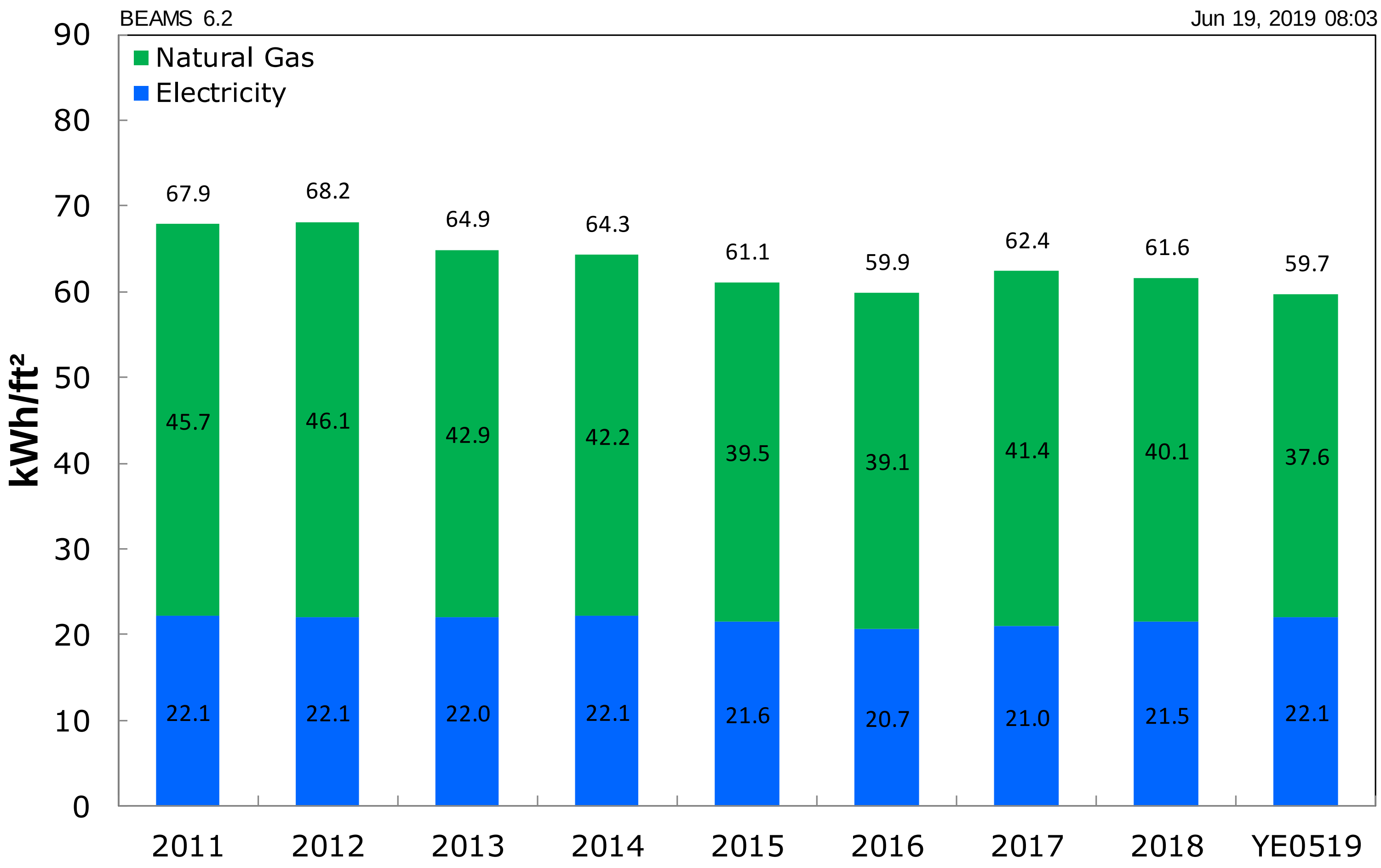


Figure 2
Michael Garron Hospital
Weather-normalized Annual Natural Gas Energy Intensity

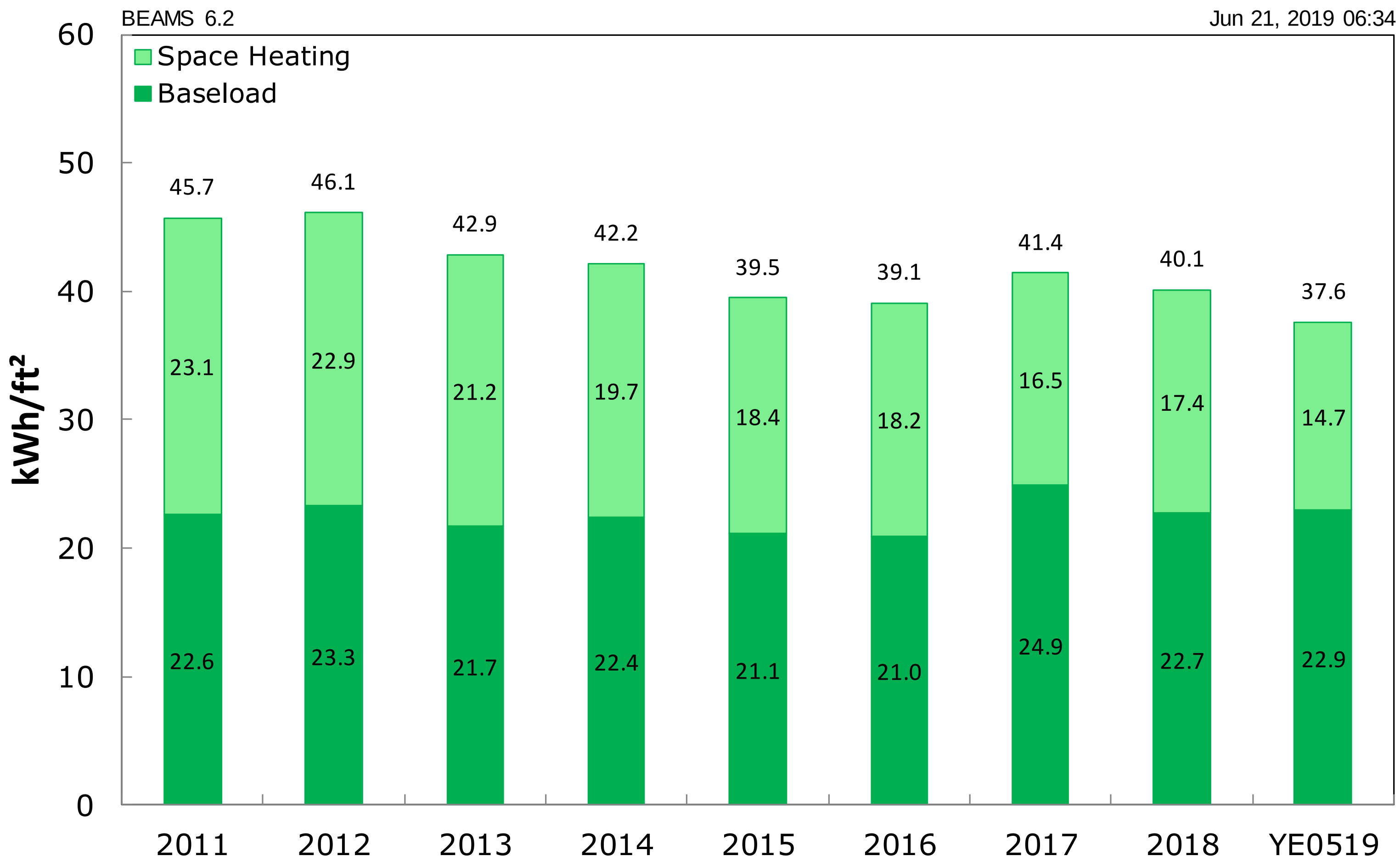
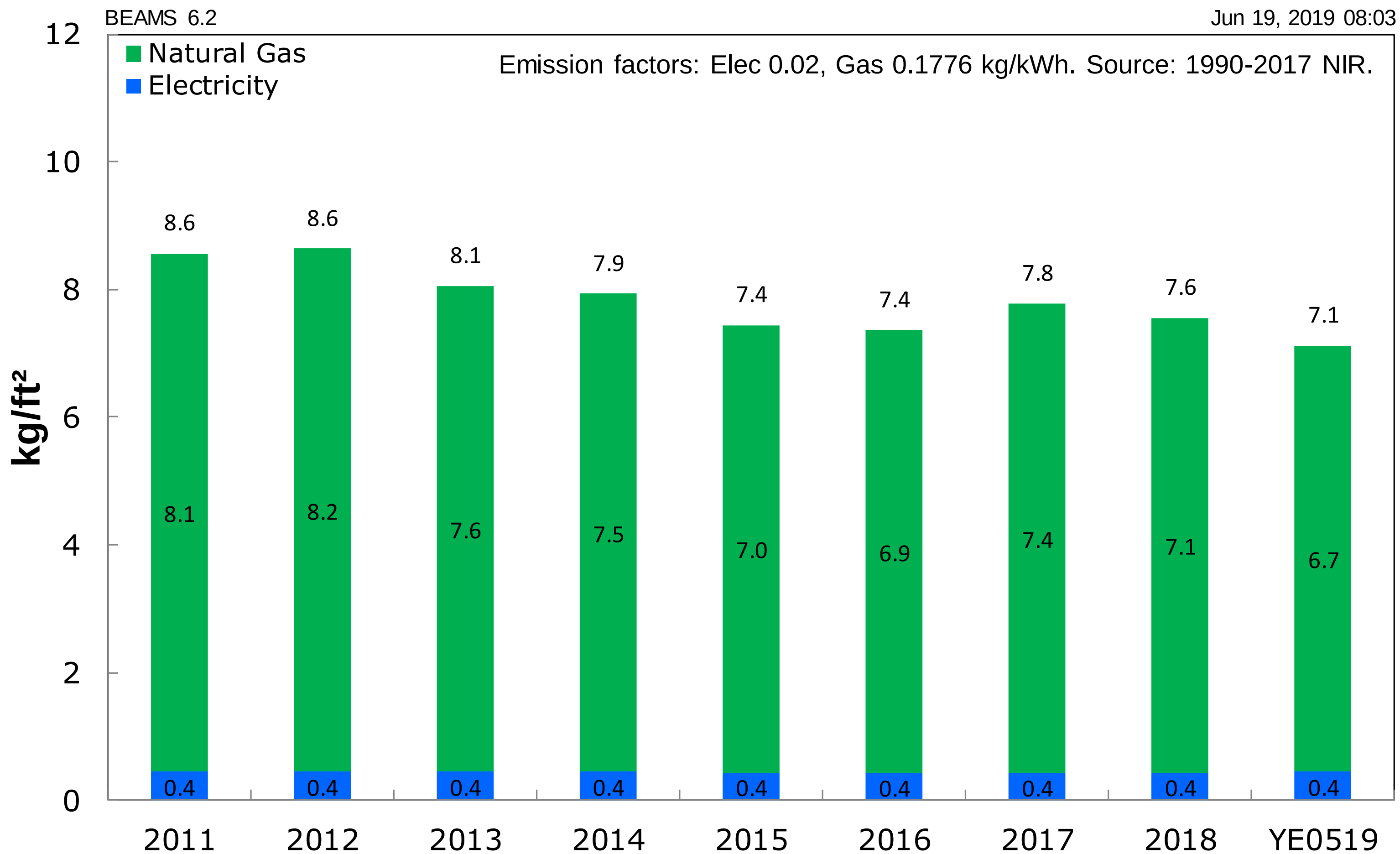


Figure 3
Michael Garron Hospital
Weather-normalized Annual GHG Intensity



4.0 Goals and objectives for conserving energy and managing demand

It is of critical importance to improve energy efficiency and reduce our operating costs. Equally important is displaying our commitment to the environment through the reduction of greenhouse gases, while improving our air quality. It is also important that these actions be carried out without adversely impacting operations. TEHN Staff will have an essential role in the success of this energy management plan. It will be the responsibility of the Energy Management Team to ensure that energy management measures are properly communicated and effectively implemented. An Energy Mandate for TEHN has been developed and is an integral component of this CDM Plan.

The primary objective of this plan is to improve the management of TEHN's energy consumption. Part of this objective is setting a conservation target that will see TEHN reduce the 2018 energy consumption of the portion of MGH that will survive the site redevelopment now underway (Wings D, G, H, J and K) by 3% by the end of 2023.

4.1 Energy management team

Historically, TEHN addressed Energy Conservation and Demand Management on a project by project basis through the activities of Facility Services. Strategic directives have been provided by the Hospital Chief Executive Officer and the Senior Executive Team. A Sustainability Team and a Green Team have been active partners in the management of energy conservation at the Hospital.

4.2 Energy monitoring

TEHN closely monitors energy consumption and GHG emissions. Since 2015, TEHN has contracted with independent energy analyst Ted Molczan, to provide regular progress reports on energy performance, and to support its reporting and CDM obligations. Ted Molczan produced the energy analyses in this report.

5.0 Energy and GHG reduction measures

5.1 Past measures

Michael Garron Hospital completed the following energy and GHG reduction measures since the publication of the 2014 CDM plan.

2013 - present	Optimize control of space-heating
2015 - 2017	LED lighting upgrade project began – approx. 20% of building converted
2016	Replaced cooling tower with high-efficiency model
2016 - 2017	Complete roof replacement: Powerplant, G & H Wings
2017	Two boilers replaced with high-efficiency model. One boiler eliminated
2018	Decommissioning of E-Wing and F-Wing Podium (approximately 33,300 ft^2 eliminated). Part of site redevelopment.

5.2 Current and proposed measures

The following measures have been approved or are under consideration for the existing MGH.

2019 - Installation of variable speed drives on three 800-ton chillers
2019 - BAS system review of all AHU occupancy scheduling adjustments
LED lighting project continuation – goal of +80% of Facility to be LED, with controls.
Complete roof replacement – J-Wing & K-Wing
Updated purchasing policies to include additional standards of sustainability, or high efficiency, or Energy Star equipment components.

5.3 Site redevelopment

Michael Garron Hospital (MGH) is undergoing a major site redevelopment that is expected to significantly reduce energy and GHG emissions.

Construction of a new 8-floor patient care tower began in 2018, that is designed to achieve a LEED silver designation, with annual energy intensity less than 1.6 GJ/m^2 (41.3 kWh/ft^2). That is far below the existing intensity of 2.3 GJ/m^2 (59.7 kWh/ft^2) during the year-ended May 2019. The energy saving features of the new patient care tower have been summarized in Section 5.3.1.

Natural gas will account for a much lower fraction of the total energy consumption of the new patient care tower, which will result in a GHG intensity approximately half that of the existing MGH configuration.

Existing Wings A, B, C, E and F will be demolished. TEHN has committed to reducing the 2018 energy consumption of the surviving Wings D, G, H, J and K by 3% by the end of 2023. The energy and GHG intensity of the fully redeveloped site is expected to be significantly less than that of the existing configuration.

5.3.1 Summary of design energy saving features of NPCT

A high-performance envelope, numerous high efficiency HVAC measures, and an efficient lighting system have been incorporated in the design in order to reduce the heating/cooling loads of the building and achieve the mandatory energy requirements in the RFP. The energy saving features incorporated in the design are described below:

High Performance Envelope

- Windows and curtain wall vision panels have a centre of glass U-value of 0.24 Btu/h-ft^{2}˚F and an overall SHGC of 0.27
- The roofs are high performance have an overall R-value of 30 h-ft^{2}˚F/Btu

High Efficiency HVAC System

- A heat recovery chiller act as the first stage of cooling (when a coincident heating load exists). The heat recovery chiller cools the process loads and recovers condenser waste heat to the hot water loop; thereby significantly reducing boiler energy use.
- High efficiency centrifugal chillers (non-heat recovery) operate as the second stage of cooling, after the heat recovery chiller. The centrifugal chillers have VSDs and operate very efficiently under part-load.
- Heat recovery chillers also act as the first stage of heating (when a coincident cooling load exists).
- High efficiency condensing boilers act as the second stage of heating after heat recovery chiller. The condensing boilers have high thermal efficiencies (93.0% with a EWT of 100˚F).
- DHW is served by instantaneous high efficiency gas-fired heaters.
- Low flow plumbing fixtures are incorporated throughout the building to reduce DHW heating requirements.
- All chilled water and hot water pumping is equipped with variable speed drives.
- All AHUs with 100% outdoor air are equipped with enthalpy recovery wheels to preheat the outdoor air and recover humidity from the exhaust air.

Efficient Lighting System

- The interior lighting design has an installed average lighting power density of 0.65W/ft^{2}. The LED design significantly reduces the electricity consumption, which is one of the largest energy end-uses in the building.
- Occupancy sensors are incorporated throughout the building to automatically shut down lighting when spaces are unoccupied.
- Daylight sensors are incorporated in the design, including corridor areas with exterior glazing, which automatically shut down lighting when sufficient daylighting is available.
- The exterior lighting design is LED and controlled via photo sensors.

Appendix A: Energy Analysis Methodology

Energy and GHG reductions and benchmark plots have been prepared using Ted Molczan's proprietary software, BEAMS (Building Energy Analysis and Monitoring System. BEAMS has been in development and use continuously since 1991, and has been used to analyze hundreds of facilities in the commercial, institutional, residential and industrial sectors.

BEAMS is suitable for the determination of actual changes in energy use and cost relative a baseline period, following current best practice, as defined in International Performance Measurement and Verification Protocol (IPMVP) 2012 Volume 1, specifically for Option C (Whole Facility) applications; and in ASHRAE Guideline 14-2014 - Measurement of Energy, Demand, and Water Savings.

Section A.1 describes how energy savings and GHG reductions were estimated.
Section A.2 describes how the data for the energy and GHG intensity plots was estimated.

A.1 Energy and GHG reduction

A.1.1 Electricity

TEHN measures reductions in energy and GHG emissions in comparison with baseline 2011, the inaugural year of Ontario broader public sector reporting.

Differences in weather between baseline 2011 and the reporting period are accounted for by means of weather-normalization. This is accomplished by creating a statistical model that relates the monthly energy use of the baseline year to heating degree-days and/or cooling degree-days.

Table A-1 displays the result of the BEAMS statistical analysis of MGH's 2011 electrical energy consumption. The Billing Period section reports the dates on which the meter was read, the number of days between readings, and the number of heating and cooling degree-days during this period. The Actual Use section lists the kWh of energy consumed.

To account for billing periods of different duration, actual use and degree-days have been normalized by dividing by the duration of the billing period for input into the linear regression calculation, as shown in the Regression Data section of Table A-1. A weighted least squares regression analysis is performed to find the linear equation relating consumption and degree-days that best fits the data. The energy and degree-day inputs are weighted by the duration of the billing period, to minimize bias.

Energy consumption was found to correlate strongly with heating and cooling degree-days relative a balance temperature of 12.2 C. The co-efficient of determination (r^2) was .991, which means that 99.1 percent of a change in consumption can be explained by a change in heating and/or cooling degree-days. Both degree-day co-efficients are statistically significant at the 95% confidence level. The model predicts total annual baseline energy consumption with an uncertainty of about 1.5%.

The linear regression equation is displayed beneath the regression data table, and reproduced here in a simpler form:

Baseline Use = 44446.525 X Days + 222.716 X hdd + 2071.135 X cdd

The Accounted section of Table A-1 displays the energy use computed by the above equation. The residuals section is the difference between the actual and accounted energy use. The total annual residual equals zero, which confirms the lack of bias – the model neither over-estimates nor under-estimates the annual baseline use.

Table A-1
Toronto East Health Network
Michael Garron Hospital
Electricity: Energy
Baseline Correlation With Degree-Days
Jan 2011 - Dec 2011

BEAMS 6.2 Jun 20, 2019 12:25

Billing Period					Actual Use	Regression Data				Accounted	Residuals	
Mon	**Rdg Date**	**Days**	**hdd<12.2**	**cdd>12.2**	**kWh**	**kWh/d**	**hdd/d**	**cdd/d**	**Out**	**kWh**	**kWh**	**%**
	2010 12 23											
Jan	2011 01 23	31	510.55	0.00	1,478,154	47,682	16.47	0.00		1,491,551	13,397	0.9
Feb	2011 02 23	31	512.49	0.00	1,503,257	48,492	16.53	0.00		1,491,982	(11,275)	(0.8)
Mar	2011 03 23	28	310.40	0.00	1,324,876	47,317	11.09	0.00		1,313,634	(11,242)	(0.8)
Apr	2011 04 23	31	243.67	2.50	1,431,817	46,188	7.86	0.08		1,437,280	5,463	0.4
May	2011 05 23	30	32.80	51.22	1,427,626	47,588	1.09	1.71		1,446,778	19,153	1.3
Jun	2011 06 23	31	0.00	206.71	1,773,894	57,222	0.00	6.67		1,805,972	32,078	1.8
Jul	2011 07 23	30	0.00	353.25	2,036,758	67,892	0.00	11.77		2,065,015	28,258	1.4
Aug	2011 08 23	31	0.00	340.47	2,103,500	67,855	0.00	10.98		2,082,995	(20,506)	(1.0)
Sep	2011 09 23	31	0.27	212.97	1,872,064	60,389	0.01	6.87		1,818,995	(53,069)	(2.8)
Oct	2011 10 23	30	25.04	86.98	1,515,371	50,512	0.83	2.90		1,519,110	3,739	0.2
Nov	2011 11 23	31	141.22	1.30	1,431,286	46,171	4.56	0.04		1,411,995	(19,291)	(1.3)
Dec	2011 12 23	30	252.10	0.00	1,376,246	45,875	8.40	0.00		1,389,543	13,296	1.0
Total		365	2028.55	1255.39	19,274,848					19,274,848	0	0.0

Weather Data: Environment Canada, Toronto City, Baseline Actual

Baseline Use = 44446.525 X Days + 222.716 X (hdd<12.2) ($p < .05$) + 2071.135 X (cdd>12.2) ($p < .05$); $r^2 = .991$

NDBE = 0.000%, CV(RMSE) = 1.67%, PI = ±1.54% ($p < .05$)

The baseline equation provides the basis to estimate the change in energy use relative baseline in any past or future period. Table A-2 documents the energy reduction estimate for 2016. Applying the baseline equation to the duration and heating and cooling degree-days of the billing period yields the baseline-equivalent use. Subtracting the actual use yields the reduction. The total for 2016 was 1,096,746 kWh (5.6%) for the year, which is the source of the 1,097 MWh reduction for 2016 reported in Table 2. The energy reduction of all other years was computed in the same manner.

The right-most columns report the prediction interval, which is an estimate of the uncertainty of the baseline-equivalent use at the 95% confidence level. The total energy reduction of 5.6% far exceeded the annual prediction interval of 1.5%, which means that there was less than a 5% probability that it was due to the statistical variance of the baseline. Six monthly reductions also exceeded the monthly prediction interval.

Table A-2
Michael Garron Hospital
2016 Electrical Energy Reduction Relative Baseline 2011

BEAMS 6.2 Jun 20, 2019 13:05

Billing Period					B.L. Equiv.	Actual Use	Reduction		+/- P.I.	
Mon	Rdg Date	Days	hdd<12.2	cdd>12.2	kWh	kWh	kWh	%	kWh	%
	2015 12 23									
Jan	2016 01 23	31	417.3	0.0	1,470,786	1,413,793	56,994	3.9	67,436	4.6
Feb	2016 02 23	31	409.6	0.0	1,469,067	1,388,357	80,710	5.5	67,170	4.6
Mar	2016 03 23	29	278.8	0.5	1,352,109	1,292,649	59,460	4.4	62,613	4.6
Apr	2016 04 23	31	226.4	8.2	1,445,286	1,344,964	100,322	6.9	65,006	4.5
May	2016 05 23	30	68.1	43.0	1,437,644	1,336,610	101,033	7.0	66,208	4.6
Jun	2016 06 23	31	0.2	253.1	1,902,006	1,719,957	182,048	9.6	66,398	3.5
Jul	2016 07 23	30	0.0	329.7	2,016,344	1,833,364	182,980	9.1	69,665	3.5
Aug	2016 08 23	31	0.0	371.6	2,147,446	2,099,103	48,342	2.3	73,596	3.4
Sep	2016 09 23	31	0.0	293.9	1,986,488	1,935,656	50,832	2.6	68,145	3.4
Oct	2016 10 23	30	18.8	97.4	1,539,304	1,400,846	138,457	9.0	65,497	4.3
Nov	2016 11 23	31	145.4	5.9	1,422,536	1,375,067	47,469	3.3	66,964	4.7
Dec	2016 12 23	30	340.0	0.0	1,409,116	1,361,017	48,098	3.4	64,428	4.6
Total		366	1904.6	1403.3	19,598,130	18,501,384	1,096,746	5.6	301,815	1.5

Baseline Period: Jan 2011 - Dec 2011

Weather Data: Environment Canada, Toronto City

Baseline Use = 44446.525 X Days + 222.716 X (hdd<12.2) ($p < .05$) + 2071.135 X (cdd>12.2) ($p < .05$); $r^2 = .991$

NDBE = 0.000%, CV(RMSE) = 1.67%, PI = ±1.54% ($p < .05$)

A.1.2 Natural gas

The reduction in natural gas was estimated using the methodology for electrical energy, described in the previous section. Table A-3 displays the statistical correlation between natural gas and heating degree-days.

Gas consumption was found to correlate strongly with heating degree-days below a balance temperature of 18.4 C. The co-efficient of determination (r^2) was .990, which means that 99.0 percent of a change in consumption can be explained by a change in heating degree-days. The degree-day co-efficient is statistically significant at the 95% confidence level. The model predicts total baseline annual energy consumption with an uncertainty of about 4.4%.

The linear regression equation is displayed beneath the regression data table, and reproduced here in a simpler form:

Baseline Use = 5058.773 X Days + 534.707 X hdd

The Accounted section of Table A-3 displays the natural gas use computed by the above equation. The residuals section is the difference between the actual and accounted energy use. The total annual residual equals zero, which confirms the lack of bias – the model neither over-estimates nor under-estimates the annual baseline use.

The baseline equation provides the basis to estimate the change in energy use relative baseline in any past or future period. Table A-4 documents the natural gas reduction estimate for 2016. Applying the baseline equation to the duration and heating degree-days of the billing period yields the baseline-equivalent use. Subtracting the actual use yields the reduction. The total reduction for 2016 was 514,815 m^3 (14.4%) for the year. Multiplying by the conversion factor 0.010627777 MWh/m^3 yields the 5,471 MWh reduction for 2016 reported in Table 2. The energy reduction of all other years was computed in the same manner.

The right-most columns of Table A-4 report the prediction interval, which is an estimate of the uncertainty of the baseline-equivalent use at the 95% confidence level. The total energy reduction of 14.4% far exceeded the annual prediction interval of 4.4%, which means that there was less than a 5% probability that it was due to the statistical variance of the baseline. Most of the reduction in use occurred during the heating season, Oct-May. The reduction in each of those months was statistically significant.

Table A-3
Toronto East Health Network
Michael Garron Hospital
Natural Gas
Baseline Correlation With Degree-Days
Jan 2011 - Dec 2011

BEAMS 6.2 Jun 20, 2019 21:05

Billing Period				Actual Use	Regression Data			Accounted	Residuals	
Mon	**Rdg Date**	**Days**	**hdd<18.4**	**m³**	**m³/d**	**hdd/d**	**Out**	**m³**	**m³**	**%**
	2010 12 20									
Jan	2011 01 21	32	704.88	562,782	17,587	22.03		538,784	(23,998)	(4.3)
Feb	2011 02 21	31	718.91	526,184	16,974	23.19		541,229	15,045	2.9
Mar	2011 03 21	28	503.13	391,492	13,982	17.97		410,671	19,179	4.9
Apr	2011 04 19	29	421.41	373,092	12,865	14.53		372,036	(1,056)	(0.3)
May	2011 05 23	34	224.21	269,802	7,935	6.59		291,883	22,081	8.2
Jun	2011 06 21	29	36.55	164,166	5,661	1.26		166,250	2,084	1.3
Jul	2011 07 21	30	0.00	156,588	5,220	0.00		151,763	(4,825)	(3.1)
Aug	2011 08 22	32	0.00	156,367	4,886	0.00		161,881	5,514	3.5
Sep	2011 09 21	30	33.54	169,288	5,643	1.12		169,695	407	0.2
Oct	2011 10 20	29	99.68	217,000	7,483	3.44		200,006	(16,994)	(7.8)
Nov	2011 11 20	31	310.23	325,239	10,492	10.01		322,705	(2,534)	(0.8)
Dec	2011 12 19	29	417.38	384,781	13,268	14.39		369,879	(14,902)	(3.9)
Total		364	3469.91	3,696,781				3,696,781	0	0.0

Weather Data: Environment Canada, Toronto City, Baseline Actual

Baseline Use = 5058.773 X Days + 534.707 X (hdd<18.4) ($p < .05$); $r^2 = .990$

NDBE = 0.000%, CV(RMSE) = 4.85%, PI = ±4.41% ($p < .05$)

Table A-4
Michael Garron Hospital
2016 Natural Gas Reduction Relative Baseline 2011

BEAMS 6.2 Jun 20, 2019 21:05

Billing Period				B.L. Equiv.	Actual Use	Reduction		+/- P.I.	
Mon	**Rdg Date**	**Days**	**hdd<18.4**	**m³**	**m³**	**m³**	**%**	**m³**	**%**
	2015 12 20								
Jan	2016 01 21	32	588.8	476,743	432,157	44,586	9.4	36,987	7.8
Feb	2016 02 21	31	613.9	485,065	416,915	68,150	14.0	36,816	7.6
Mar	2016 03 21	29	464.6	395,124	334,510	60,614	15.3	34,317	8.7
Apr	2016 04 15	25	394.6	337,480	284,784	52,696	15.6	31,570	9.4
May	2016 05 19	34	264.2	313,277	256,737	56,540	18.0	36,655	11.7
Jun	2016 06 20	32	25.8	175,695	162,146	13,549	7.7	36,937	21.0
Jul	2016 07 20	30	0.0	151,763	145,406	6,357	4.2	35,854	23.6
Aug	2016 08 21	32	0.0	161,881	141,483	20,398	12.6	37,226	23.0
Sep	2016 09 20	30	2.9	153,305	142,249	11,056	7.2	35,821	23.4
Oct	2016 10 23	33	107.3	224,297	173,618	50,679	22.6	36,837	16.4
Nov	2016 11 21	29	289.6	301,565	224,739	76,826	25.5	33,579	11.1
Dec	2016 12 19	28	484.6	400,778	347,414	53,364	13.3	33,957	8.5
Total		365	3236.4	3,576,973	3,062,158	514,815	14.4	157,874	4.4

Baseline Period: Jan 2011 - Dec 2011

Weather Data: Environment Canada, Toronto City

Baseline Use = 5058.773 X Days + 534.707 X (hdd<18.4) ($p < .05$); $r^2 = .990$

NDBE = 0.000%, CV(RMSE) = 4.85%, PI = ±4.41% ($p < .05$)

A.2 Weather-normalized energy and GHG benchmarks

Benchmarking is a popular method of tracking energy and GHG performance over time. The standard approach for commercial and institutional buildings is to plot intensity graphs - total energy consumption or GHG emissions, divided by gross floor area. However, annual variations in weather complicate interpretation. For example, a mild winter can make one year's fuel results appear better than those of another year. A cold winter can have the opposite effect. Weather-normalization addresses this concern.

The previous section described the use of weather-normalization to compare the energy use of two different years. In that case, the energy use of the baseline year was normalized to the weather of the reporting year. Since benchmarking typically compares more than two years, all years must be normalized to a common year. In principle, the weather of any year could be selected, but the best method is to employ a typical meteorological year (TMY). A TMY is a year that best represents the average weather of each month and its variation. The TMY for TEHN has been derived from a statistical analysis of Environment Canada Toronto City weather station data for the years 1996-2015.

MGH's monthly electricity and natural gas consumption of each year has been statistically correlated with weather (heating and/or cooling degree-days), and the linear regression co-efficients have been applied to the weather of the TMY. Below is a description of this process for 2011.

Appendix A.1.1 presented the statistically derived equation relating electrical energy use in 2011 with degree-days. Table A-5 displays MGH's weather-normalized 2011 energy consumption, based on applying this equation to the TMY. MGH would have consumed 19,132,675 kWh. Dividing by the GFA of 864,923 ft² yields weather-normalized 2011 intensity of 22.12 kWh/ft².

Appendix A.1.2 presented the statistically derived equation relating natural gas use in 2011 with degree-days. Table A-6 displays MGH's weather-normalized 2011 gas consumption. MGH would have consumed 3,722,365 m³. Multiplying by the conversion factor 10.627777 kWh/m³ yields 39,560,465 kWh. Dividing by the GFA of 864,923 ft² yields intensity of 45.74 kWh/ft².

The above intensities and their sum, 67.86 kWh/ft², are displayed in Figure 1. The same method was used to derive the values of each year in Figure 1.

Figure 2 was derived in the same way, but for natural gas only, broken down into baseload and space-heating components.

The GHG intensity displayed in Figure 3 was obtained by multiplying the electrical energy and natural gas intensities of Figure 1 by their GHG emission factors.

The GHG emission factor of electricity declined significantly during this period, due to the permanent closure of Ontario's coal-fired generators, and the increased use of lower or zero carbon alternatives. This had the effect of lowering the carbon footprint of all consumers of electricity. To make clear the results of MGH's efforts, the 2017 electricity emission factor has been applied to all years of the benchmark plot. On this basis, the total GHG intensity has been reduced from 8.6 kg/ft^2 in 2011 and 2012, to 7.1 kg/ft^2 during the year-ended May 2019 – a decline of 17.4%.

Table A-5
Michael Garron Hospital
Weather-Normalized Electrical Energy Consumption
Baseline 2011 Applied to a TMY

Mon	Dur	hdd<12.2	cdd>12.2	kWh	+/- P.I.	%P.I.
Jan	31	501.2	0.0	1,489,468	71196	4.8
Feb	28	421.2	0.0	1,338,310	65254	4.9
Mar	31	330.7	2.4	1,456,465	65273	4.5
Apr	30	130.6	14.7	1,392,834	65505	4.7
May	31	17.2	97.7	1,584,067	66984	4.2
Jun	30	0.5	226.6	1,802,826	64647	3.6
Jul	31	0.0	321.1	2,042,892	69757	3.4
Aug	31	0.0	291.4	1,981,336	68015	3.4
Sep	30	0.3	182.1	1,710,507	64192	3.8
Oct	31	70.1	47.3	1,491,419	67351	4.5
Nov	30	194.1	0.0	1,376,624	64575	4.7
Dec	31	395.5	0.0	1,465,927	66723	4.6
Total	365	2061.3	1183.2	19,132,675	294647	1.5

Weather Data: Environment Canada, Toronto City, TMY

kWh = 44446.525 X Days + 222.716 X hdd + 2071.135 X cdd

Table A-6
Michael Garron Hospital
Weather-Normalized Natural Gas Consumption
Baseline 2011 Applied to a TMY

Mon	Dur	hdd<18.4	cdd>18.4	m³	+/- P.I.	%P.I.
Jan	31	693.4	0.0	527,588	37900	7.2
Feb	28	594.8	0.0	459,687	35194	7.7
Mar	31	520.5	0.0	435,137	35822	8.2
Apr	30	301.9	0.0	313,194	34198	10.9
May	31	134.1	22.4	228,502	35331	15.5
Jun	30	33.2	73.3	169,515	35497	20.9
Jul	31	1.5	130.4	157,622	36526	23.2
Aug	31	2.3	101.5	158,045	36517	23.1
Sep	30	42.2	37.9	174,310	35408	20.3
Oct	31	216.7	1.7	272,693	34928	12.8
Nov	30	380.1	0.0	355,003	34376	9.7
Dec	31	587.7	0.0	471,069	36505	7.7
Total	365	3508.3	367.2	3,722,365	164291	4.4

Weather Data: Environment Canada, Toronto City, TMY

$m^3 = 5058.773 \times Days + 534.707 \times hdd$