

Getting It Right the First Time: Actual Energy Performance of Ontario's New Hospitals

A GREENING HEALTH CARE WHITE PAPER



This white paper is the result of a Greening Health Care research project directed by Enerlife Consulting. We acknowledge and appreciate the participation and support of the hospitals, Infrastructure Ontario and all those who played their parts in the May 31st workshop. Particular thanks to Markham Stouffville Hospital for hosting that event and their tireless leadership by example.

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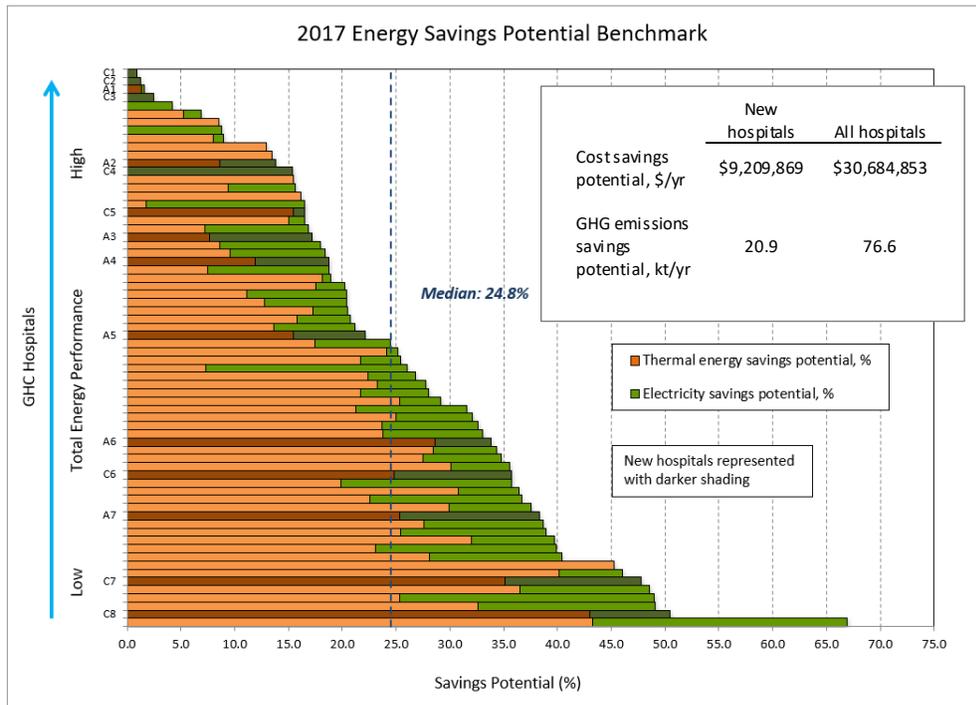


1 Executive Summary

This white paper quantifies and characterizes the relative energy efficiency of new hospitals and presents evidence-based recommendations for achieving and sustaining high performance. Applying the lessons learned to new hospital facilities still in the pipeline is expected to raise the bar further still, enabling consistently high performance from the day they open their doors – in effect, “getting it right the first time.” Higher energy performance standards are attainable in these and future hospitals, without a significantly capital cost premium¹, by further integrating design, commissioning and operations focused on the energy target.

Over the past decade, almost twenty new hospitals have opened across the province under Ontario’s Alternative Financing and Procurement (AFP) delivery model². The 2017 energy use of fifteen of these hospitals has been evaluated relative to Greening Health Care’s good practice efficiency standards derived from its large database of existing hospitals. Results are presented in Figure 1 as the energy savings potential for each hospital through meeting these good practice targets. The most efficient are at the top with savings potential below 5%. The least efficient at the bottom are consuming as much as double their good practice energy targets. The 15 new AFP hospitals are indicated with darker shading. Four of these are at the top of the chart with the rest distributed across the range of relative energy performance.

Figure 1 Energy savings potential for new hospitals and Greening Health Care member hospitals



¹ The [Toronto Green Standard](#) references cost premiums in the order of 3.6% - 4.9% to reach near-zero emissions in new commercial buildings.

² Under AFP, provincial ministries and/or project owners establish the scope and purpose of a project, while design and construction work is financed and carried out by the private sector. Typically, only after a project is completed will the province complete payment to the private-sector company. In some cases, the private sector will also be responsible for the maintenance of a physical building or roadway. Source: <http://www.infrastructureontario.ca/AFP-FAQs/>

In comparison with existing, older hospitals, all these facilities have the advantages of new equipment and the latest technology. They feature advanced designs in heating and cooling plants and fully digital building automation systems. Although the top few are attaining the performance levels of the best of the existing hospital stock, they are all technically capable of so much more. The difference lies in performance engineering, operational excellence and smart programming, getting every building system performing individually and together to achieve and sustain exceptional performance.

Several of these new hospitals have utility cost savings potential worth more than a million dollars per year. The changes needed to deliver the targeted savings will be mostly low-cost operational improvements and systems' optimization with a high ROI. Contractual gain/pain share provisions create incentives for all parties to achieve and maintain savings. A systematic, performance-based approach to comprehensive assessment and improvement will be the key to achieving and sustaining high performance in all of these hospitals and in those to follow under the AFP model.

Evidence-based recommendations are presented to achieve this. New hospitals should:

- Adopt consistent, evidence-based total energy use intensity (TEUI), thermal energy demand intensity (TEDI) and greenhouse gas emissions intensity (GHGI) targets which will further improve over time as best practices emerge.
- Engage the "Integrated Building Performance Team" at every stage of the development process in the design metrics, operational practices and occupant engagement necessary to meet the energy and emissions standards.
- Require LEED certification with mandatory energy efficiency and water credits.
- Adopt new, more rigorous continuous commissioning processes so that whole-system and whole-building performance are achieved from the outset.

For hospitals already in operation, the following actions are recommended:

- Support hospital teams working towards meeting and exceeding targets with training, best practices and case studies from top-performers.
- Work in collaboration with other hospitals and organizations (such as Greening Health Care) to support shared learning, monitoring and reporting of results and systematic, evidence-based progress towards the consistent high performance of which these hospitals are capable.

Greening Health Care will continue to support its member hospitals in meeting their targets. We will also continue to report on performance trends for all AFP hospitals as the hospitals, industry and government work to deliver the best possible performance outcomes.

2 Background

Over the past decade the Government of Ontario has made an unprecedented investment in new hospitals using an Alternative Financing and Procurement (AFP) delivery model. Many of these have been delivered using either the Build-Finance-Maintain (BFM) or the Design-Build-Finance-Maintain (DBFM) models, under which operational responsibility for the facilities is transferred to the private sector. Seventeen of these new hospitals, of different sizes and types, have now been operational for more than a year. Nine of the seventeen which participated in the study are members of the Greening Health Care program.

Greening Health Care has been tracking and reporting for several years on the actual energy and water performance of these new hospitals. In 2018, an open invitation was made to all seventeen hospitals to submit their utility data and facility information to enable a large-scale performance evaluation. Fifteen of the hospitals chose to participate in the research project, with all nine Greening Health Care members taking part.

On May 31st, 2018 a workshop was held at Markham Stouffville Hospital with hospitals, industry, utility companies and government to review and discuss the results of the evaluation, consider lessons learned and propose actions which can help every new hospital achieve exceptional performance from the outset. The workshop participants are listed at the end of this report.



Markham Stouffville Hospital

Founded in 2004, Greening Health Care is the largest collaborative program of its kind in North America, helping hospitals work together to lower their energy costs, raise their environmental performance and contribute to the health and well-being of their communities. Members manage data, assess their performance and track savings using a powerful online information system. They share knowledge and best practices to help plan, implement and verify improvements. This is a program of The Living City managed by Toronto and Region Conservation with technical direction by Enerlife Consulting.

The program provides its members with:

- Energy and water targets and monthly online reporting of actual savings compared against baselines and targets;
- Workshops and webinars presenting case studies and best practices associated with top-performing and top-saving hospitals;
- Networking with a large group of hospitals facing similar challenges and opportunities;
- Participation in applied research projects going deeper into best practices; and
- Recognition for success.

This white paper presents the individual energy efficiency of each hospital, quantifies and characterizes its potential for efficiency improvements and makes recommendations to help bring all these hospitals, as well as those to follow using the same delivery process, up to their best practical level of energy efficiency.

3 Participating Hospitals

Figure 2 shows the type, number of years since opening, and LEED Rating of the fifteen AFP hospitals alongside their targeted energy and water savings. Not all hospitals reported on water use.

Figure 2 Participating hospitals

Hospital	Years Since Opening	Target Savings %				GHG Emissions (kt)	Rating	LEED Energy & Atmosphere Credits
		Total Energy	Electricity	Thermal	Water			
C1	0-4	1.0%	1.5%	0.0%	-	0.0	LEED Gold	9/17
C2	0-4	1.3%	2.8%	0.0%	-	0.0	LEED Gold	6/17
A1	0-4	1.6%	0.5%	2.8%	0.0%	0.2	LEED Gold	24/35
C3	0-4	2.5%	4.8%	0.0%	-	0.0	LEED Gold	9/17
A2	>4	13.8%	12.8%	14.5%	0.0%	1.1	LEED Silver	8/17
C4	0-4	15.4%	25.0%	0.0%	3.1%	0.1	Not yet certified	N/A
C5	0-4	16.5%	2.0%	32.3%	68.6%	0.4	LEED Gold	8/17
A3	>4	17.2%	22.2%	13.4%	37.6%	0.4	LEED Silver	6/17
A4	>4	18.7%	17.1%	19.8%	17.2%	2.2	N/A	N/A
A5	0-4	22.1%	17.4%	25.0%	-	0.7	N/A	N/A
A6	0-4	29.7%	13.8%	37.5%	0.0%	5.4	LEED Gold	9/17
C6	>4	35.7%	26.7%	41.9%	-	1.0	LEED Gold	6/17
A7	>4	43.2%	39.0%	45.8%	42.9%	3.2	LEED Gold	9/17
C7	>4	47.8%	33.3%	56.6%	-	3.3	LEED Silver	3/17
C8	0-4	47.8%	22.4%	59.5%	0.0%	2.8	LEED Gold	8/17

Since the focus of LEED New Construction certification is on sustainable design, the awarded LEED Ratings and Energy and Atmosphere Credits do not indicate any strong correlation with the targeted performance metrics (Figure 2) which are strongly influenced by operations. Discussions at the May 31st Greening Health Care workshop suggested that not all of the hospitals had emphasized energy in attaining the required LEED certification, but at least two that had done so were among the top-performers. LEED provides a useful framework for energy efficiency best practices, and mandatory certification and required energy and water credits are recommended.

4 Getting It Right the First Time

The May 31st Greening Health Care workshop discussed a wide range of issues which support or get in the way of high performance in new healthcare facilities, summarized as follows:

1. Energy targets

The bid documents provided to project developers include minimum energy efficiency standards. Proponents are invited to propose higher standards, with the NPV of energy costs over the term of the agreement factored into the total cost of their submissions. With the large volume of empirical data available for high-performing hospitals, consistent, evidence-based EUI standards can be developed for all hospital types, avoiding use of whole-building modeling which produces inconsistent results. Greenhouse gas intensity standards aligned with provincial climate change goals are also needed.



Top of the benchmark chart: St Joseph's Health Care London - Parkwood Institute exemplifies current best practice

2. Sharing best practices

As actual energy performance of these hospitals (and those to follow) continues to unfold, design and operational attributes of top-performers can be documented, helping to advance the general level of knowledge and improve results by sharing evidence-based best practices.

3. Continuous commissioning

The transition from design intent to high-performance facility requires considerable attention to detail which takes time and costs money. By

combining the design, construction and operations of hospitals under one project company the AFP Model should provide opportunities for an integrated, holistic approach to energy management. The data show that several hospitals have met good practice energy targets from the time they opened their doors. The additional energy use, utility costs and greenhouse gas emissions incurred by those that started out inefficiently are often very large.

Continuous commissioning with appropriate role definitions, responsibilities and budgets is required, beginning at the design stage and continuing through construction and the first 1-2 years of operation. The design engineer is an essential member of the commissioning team, along with controls and testing and balancing contractors and the FM provider. The process should focus on whole-building and whole-system performance, ensuring that component energy use is achieved, metrics such as power density are met, operating schedules are confirmed and implemented, and smart operating sequences are put in place and working as intended.

4. Planning, monitoring and reporting

All hospitals should know their utility cost savings potential and have a strategy, plan, budget and timelines for meeting their energy and water targets. Tracking and reporting monthly, weather-normalized performance against baselines and targets provides the accountability framework needed to deliver and maintain the high performance and savings of which all these hospitals are capable.

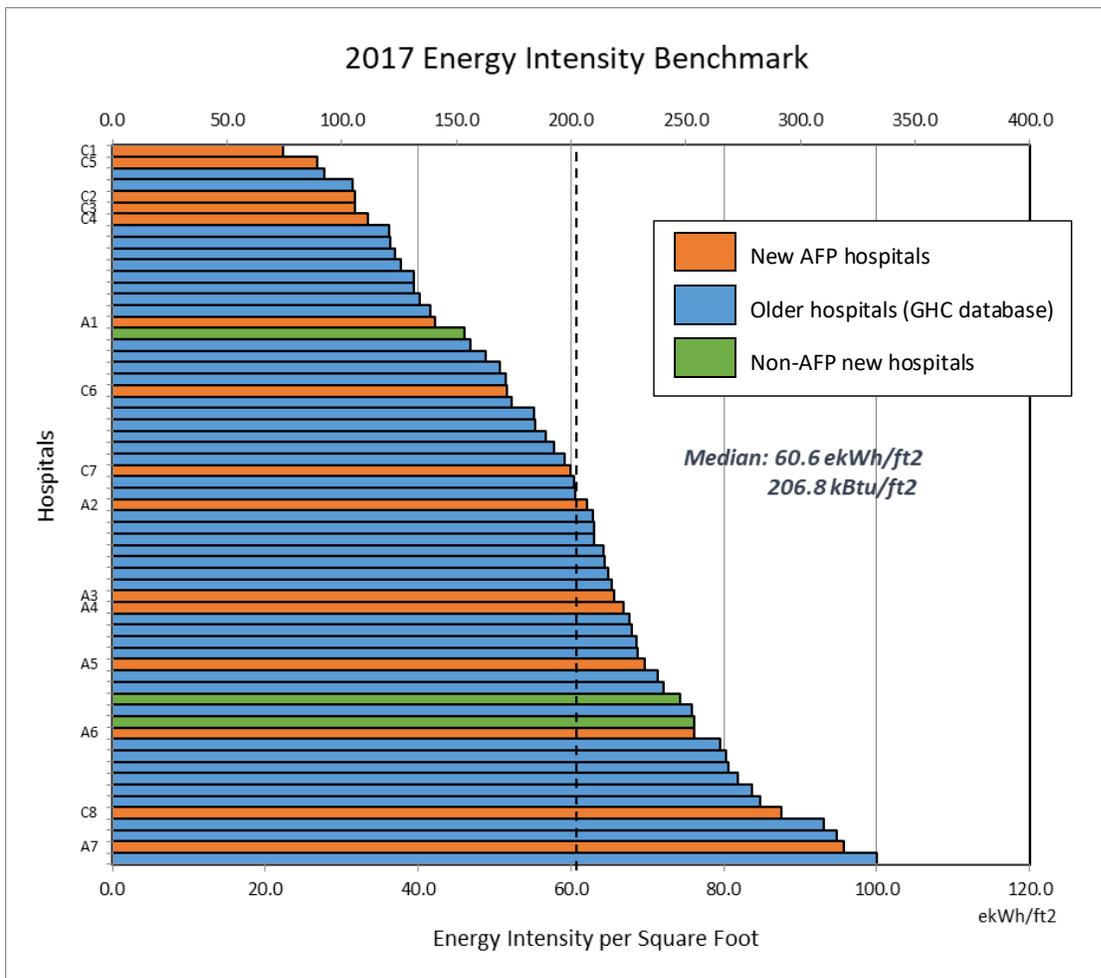
5 Energy Use Benchmark Analysis

The 2017 electricity, natural gas, and steam consumption was processed through the online Greening Health Care analysis system to produce the benchmark chart presented in Figure 3. Weather-dependent energy components (heating and cooling) are separated from base (year-round) components and normalized to Toronto, Ontario 2017 heating and cooling degree-days. The energy components are as follows:

- Base Electricity – year-round equipment including fans, lighting, medical equipment and IT, as well as heat pumps and auxiliaries where applicable.
- Cooling Electricity – additional electricity use in summer months due to cooling plants.
- Base Thermal (gas or steam) – year-round loads such as sterilizers, domestic hot water and reheat in air handling systems.
- Heating Thermal – additional use in winter months due to space and ventilation heating and humidification.

Figure 3 shows the 2017 total energy use intensity of new AFP hospitals (orange) benchmarked against the Greening Health Care database of older hospitals (blue) and three other non-AFP new hospitals (green).

Figure 3 Energy intensity benchmark



The top 15 hospitals in the chart are all continuing care facilities which are inherently less energy-intensive than acute care hospitals. Humber River Hospital is in the sixteenth position, which is the most energy efficient of all acute care hospitals in the database. Many of the hospitals are consuming significantly more energy than expected or required.

6 Energy Targets

Over the years, Greening Health Care has established empirical good practice energy targets for different healthcare facility space types based on top-quartile performance metrics from its large database. Site-specific targets are weather normalized and further adjusted for non-standard variables such heating energy source (purchased steam or heat pumps) and use of combined heat and power (CHP) plants or laundries. The target for each hospital can be considered as the most energy a well-performing facility of its type should need, knowing that 25% of existing hospitals are already operating at or better than this standard.

The resulting energy savings potential for the 17 hospitals is presented in Figure 4, ranging from 1.0% (best) to 47.8%. Target adjustments are incorporated where information is known and will be confirmed with the individual hospitals as ongoing energy tracking and reporting progresses.

Figure 4 Hospital energy savings potential

Hospitals	Electricity (kWh/ft2)				Thermal (ekWh/ft2)				Total Energy (ekWh/ft2)		Savings Potential	
	Base		Cooling		Base		Heating		Actual	Target	%	Cost
	Actual	Target	Actual	Target	Actual	Target	Actual	Target				
C1	13.0	13.0	1.1	0.9	1.2	1.2	6.5	6.5	21.8	21.6	0.9%	\$14,421
C2	13.0	13.0	1.3	0.9	10.1	7.8	6.6	8.9	31.0	30.6	1.3%	\$50,630
A1	19.5	19.4	1.8	1.8	6.8	6.8	13.1	12.6	41.3	40.6	1.6%	\$58,910
C3	14.7	14.1	1.2	0.9	8.2	7.8	7.0	7.3	31.0	30.2	2.5%	\$28,270
A2	22.4	19.4	2.3	2.1	18.1	18.1	17.8	12.6	60.6	52.2	13.8%	\$611,757
C4	17.7	14.1	2.4	0.9	3.7	3.7	8.9	8.9	32.7	27.6	15.4%	\$468,403
C5	13.1	12.8	0.5	0.5	3.2	1.0	9.3	7.5	26.2	21.9	16.5%	\$93,205
A3	25.6	19.4	2.0	2.0	26.5	19.0	9.9	12.6	64.1	53.0	17.2%	\$380,861
A4	23.6	19.4	2.3	2.1	21.7	19.0	17.7	12.6	65.3	53.1	18.7%	\$1,219,922
A5	23.9	19.4	2.0	2.0	25.9	19.0	16.2	12.6	68.1	53.0	22.1%	\$325,130
A6	22.2	19.2	2.5	2.1	32.7	18.6	17.1	12.5	74.4	52.3	29.7%	\$1,608,019
C6	18.2	14.1	2.3	0.9	20.3	7.8	9.5	9.5	50.4	32.4	35.7%	\$154,012
A7	28.7	19.4	6.5	2.1	42.0	19.0	16.3	12.6	93.5	53.1	43.2%	\$1,652,987
C7	21.0	13.9	1.2	0.9	24.1	6.6	12.3	9.2	58.6	30.6	47.8%	\$1,256,645
C8	25.5	19.4	1.5	1.5	36.9	14.3	21.6	9.4	85.4	44.6	47.8%	\$836,178

Green cells indicate energy components which are at or close to the Greening Health Care targets and imply good performance. Yellow indicates energy use between 10% and 25% above the targets and requires attention. Orange cells are more that 25% over the targets and point to the primary areas for improvement.

7 Water Use Benchmarks and Targets

Figure 5 presents the corresponding actual and target water consumption metrics for the hospitals which reported on water use.

Figure 5 Hospital water savings potential

Hospitals	Water (litres/ft2)				Total Water (litres/ft2)		Savings Potential	
	Base		Cooling		Actual	Target	%	Cost
	Actual	Target	Actual	Target				
A6	128.0	128.0	19.6	19.6	147.6	147.6	0.0%	\$0
A1	104.8	104.8	9.4	9.4	114.2	114.2	0.0%	\$0
C8	53.4	53.4	3.7	3.7	57.0	57.0	0.0%	\$0
A2	138.0	138.0	0.0	0.0	138.0	138.0	0.0%	\$0
C4	61.6	61.6	14.7	12.3	76.2	73.9	3.1%	\$5,251
A4	170.7	140.1	7.1	7.1	177.7	147.1	17.2%	\$152,310
A3	236.2	140.1	19.8	19.8	256.0	159.8	37.6%	\$125,238
A7	260.2	140.1	22.9	21.6	283.1	161.7	42.9%	\$236,113

Base water for domestic fixtures, kitchens and other year-round uses is separated from the additional use in summer, typically associated with cooling towers and grounds watering. The two sites showing cooling water savings potential also have high cooling electricity use.

8 Areas for Energy and Water Efficiency Improvement

Figure 4 and Figure 5 serve to quantify the energy and water savings potential for each hospital, ranging from a few thousand to more than a million dollars per year. Contractual gain and pain share provisions, in which the parties equitably share in the financial “gain” of a project's success or the financial “pain” of a project's underachievement, provide all parties with incentives to achieve, maintain and improve upon these targets. The building systems and technology installed should enable all hospitals to meet their targets through improved operations, controls and systems’ optimization, without significant capital investment. Total costs to meet the savings targets can be expected to be recovered in less than 5 years with an ROI of 20% - 50%.

The colour-coding in the charts points to where the savings are to be found. Red components have the greatest potential and indicate substantial inefficiencies in the corresponding energy systems which should be readily uncovered through testing and energy analysis. The biggest savings are found in the following areas:

- Base Electricity savings from correcting excessive fan power and operation, and upgraded control of year-round heat pump operation (where applicable);
- Cooling Electricity savings from avoiding simultaneous cooling and reheat in air handling systems, and correcting cooling plant inefficiencies;
- Base Thermal savings from avoiding simultaneous cooling and reheat in air handling systems, and correcting heating plant and distribution inefficiencies; and

- Heating Thermal savings from correcting ventilation system imbalances and repairing failed dampers or control valves.

9 Performance Trends

Figure 6 presents weather-normalized changes in energy and water use compared to the indicated baseline year for the hospitals which have been in operation for two or more years. Two hospitals are showing significant savings and two others significant increases. Water use has gone up in all but one of the sites. The performance trends were not able to be calculated for all hospitals, due to the time since opening being less than two years.

Figure 6 Changes in energy and water use

Hospital Type	2017 Performance Results				Baseline Year
	Total Energy	Electricity	Gas	Water	
C1	-11.2%	-26.9%	7.0%	-	2016
C2	-	-	-	-	N/A
A1	3.4%	7.5%	-1.6%	-7.4%	2015/16
C3	-3.9%	-1.7%	-6.1%	-	2016
A2	1.2%	5.2%	-1.7%	-9.8%	2014
C4	-	-	-	-	N/A
C5	-	-	-	-	N/A
A3	0.6%	-3.1%	3.1%	-26.1%	2014
A4	17.0%	6.2%	23.0%	-	2011
A5	-	-	-	-	N/A
A6	-0.9%	0.2%	-1.4%	-4.6%	2016
C6	13.7%	7.9%	17.3%	-	2013
A7	-2.5%	-2.8%	-2.3%	3.1%	2016
C7	5.3%	-1.4%	8.3%	-	2016
C8	-15.6%	-12.0%	-17.6%	-47.3%	2015

The variances over time may be due to changes in occupancy, but often point to operational and controls changes which are helping or worsening overall performance.

10 Getting There from Here – Greening Health Care

The hospitals with the biggest savings shown in Figure 6 are Greening Health Care members. The program will continue to support this unique membership subset in working towards their targets and sharing knowledge and results. Additionally, the program will be offering site-specific charrettes with the hospital teams going deeper into interval meter and trend log diagnostics to develop action plans with budgets and timelines to meet the targets.

This research into energy performance of new hospitals will continue, inviting non-member hospitals to submit their data annually and reporting on overall performance trends over time. The goal is to support all parties working together towards achieving straight greens (meeting all component targets) for all existing facilities and getting it right the first time with all new ones.

11 Recommendations and Next Steps

For new hospitals, the following actions are recommended:

- Adopt consistent, evidence-based total energy use intensity (TEUI), thermal energy demand intensity (TEDI) and greenhouse gas emissions intensity (GHGI) targets which will further improve over time as best practices emerge.
- Engage the “Integrated Building Performance Team” at every stage of the development process in the design metrics, operational practices and occupant engagement necessary to meet the energy and emissions standards.
- Require LEED certification with mandatory energy efficiency and water credits.
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For hospitals already in operation, the following actions are recommended:

- Support hospital teams working towards meeting and exceeding targets with training, best practices and case studies from top-performers.
- Work in collaboration with other hospitals and organizations (such as Greening Health Care) to support shared learning, monitoring and reporting of results and systematic, evidence-based progress towards the consistent high performance of which these hospitals are capable.

Workshop Participants

Greening Health Care workshop, May 31, 2018, Markham Stouffville Hospital

Name	Organization
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