Using Performance Metrics to Deliver Highly Energy Efficient Healthcare Facilities

Applying Lessons Learned from Ontario's New P3 Hospitals

December 2022

Energy performance results from new hospitals opened in Ontario since 2007 have been mixed, with some exceptional performers setting new standards for energy efficiency. This Guide presents high performance energy metrics derived from these top-ranked hospitals. The Guide has been developed for use by hospitals and their design teams to inform evidence-based modeling, energy targets and building system designs, and by government policy makers and program designers to help establish performance outcomes and guidance for achieving consistently high energy performance in hospital facilities.

The Guide builds on currently available data and the best of performance outcomes so far. Additional information on the research can be found in the 2022 GHC New Hospital Report, and webinar recordings. There is at present limited data on some hospital types and engineering judgment has been used to estimate some metrics based on similar types of facilities. The work is ongoing as more hospitals and jurisdictions become involved. It is intended that the Guide will be periodically updated as more and better information becomes available. The latest version will always be found under Publications on the Greening Health Care website.

The Guide is the product of applied research conducted from 2020 to 2022 by Greening Health Care, a non-profit network of leading hospitals, healthcare groups and related organizations across North America working together to achieve deep energy and greenhouse gas emissions reductions in healthcare facilities. We recognize the technical and financial support provided by Ontario's Independent Electricity System Operator, QMC Integrated Submetering Solutions, Belimo, and Shift Energy. Technical direction of the project was by Enerlife Consulting.

Questions, comments and suggestions are always welcome. Please contact us at info@greeninghc.com.

1. Total Energy Use Targets

While site-specific variables may require minor adjustments, total energy use targets are standards that every new hospital should meet or improve upon. Figure 1 presents current high performance standard total energy intensities for different hospital types based on Toronto Airport weather conditions in 2020. Corresponding greenhouse gas emissions intensities using Ontario factors are shown for reference. The metrics are based on heat recovery chillers recycling internal heat and should be modified (reduced) for geothermal and other renewable energy sources.

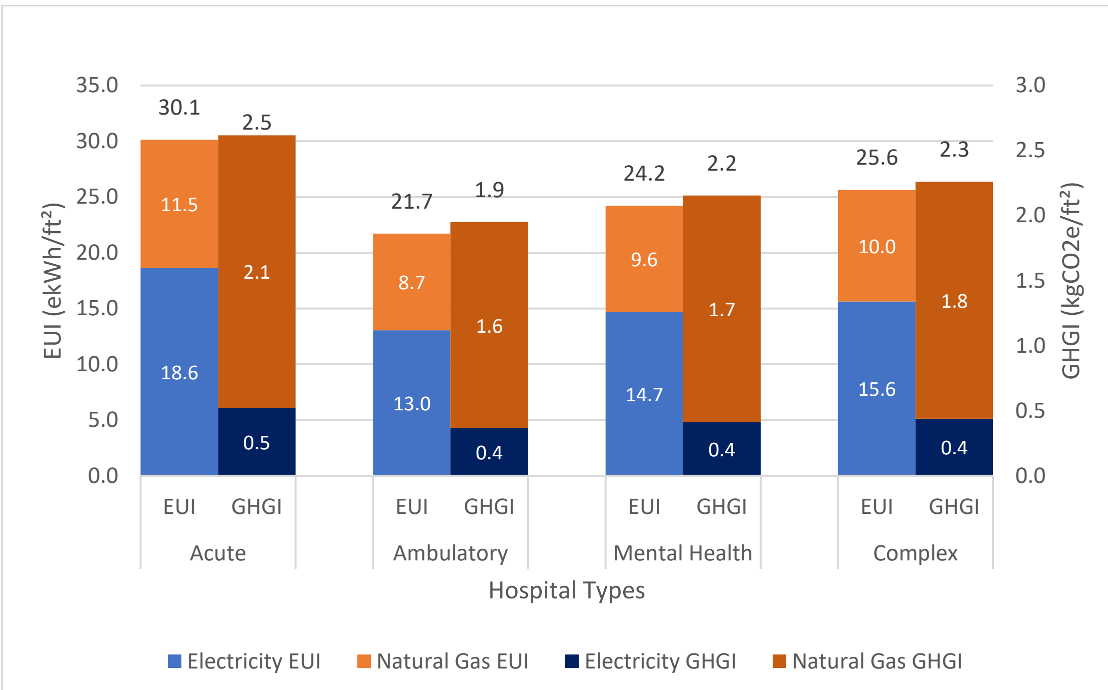
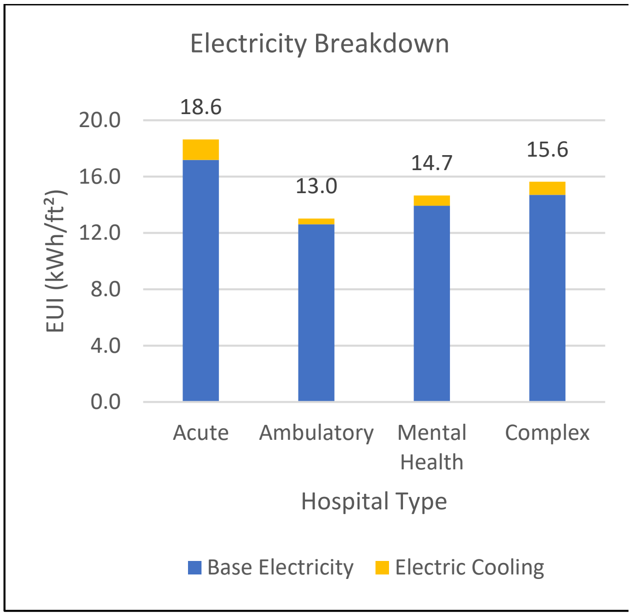


Figure 1. Total Energy Best Practice EUI and GHGI Targets for different hospital types[1,2]

[1] Based on Toronto Airport 2020 weather, to be adjusted to local weather conditions. Heating season has 2,742 HDD (°C) using a balance point of 15°C and cooling season has 1,557 HDD (°C) using a balance point of 10°C.
[2] GHG emissions factors are 0.028 $kgCO_2e/kWh$ for electricity and 1.88 $kgCO_2e/m^3$ for natural gas in Ontario.

2. Component Energy Use

Energy components provide greater granularity for calibrating energy models and evaluating performance. Figure 2 presents graphically the breakdowns of the Total Energy Use targets for each hospital type between baseload and weather sensitive energy use for electricity (base and cooling) and thermal (base and heating). Table 1 provides the corresponding numbers. Note that base electricity includes year-round heat recovery chiller operation, and that electric heating is not discernable from analysis so that heating pumps and any electric heat are included in the baseload.



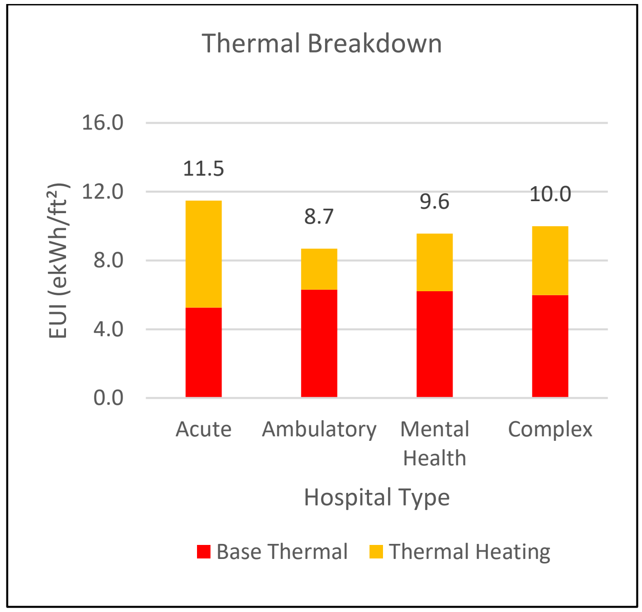


Figure 2. Electricity and Thermal Best Practice EUI Targets with base and weather dependent energy use breakdown[1]

Table 1. Best Practice Base and Weather Dependent Component EUIs (ekWh/ft²)

Hospital Type	Base Electricity (kWh/ft²)	Electric Cooling (kWh/ft²)	Base Thermal (ekWh/ft²)	Thermal Heating (ekWh/ft²)
Acute	17.2	1.5	5.3	6.2
Ambulatory	12.6	0.4	6.3	2.4
Mental Health	13.9	0.7	6.2	3.3
Complex	14.7	0.9	6.0	4.0

3. Interval Meter Standard Profiles – Electric

Hourly electricity profiles can be derived from energy models and verified post construction using data from the local distribution company metering to confirm required system design and operation. Figure 3 presents standard demand intensity (Watts/sf) profiles for February 2021 (winter operation) corresponding to the Electricity Best Practice EUI targets for acute care and ambulatory care hospitals. Daily peaks reflect system design factors including lighting, heat recovery chiller and fan power and the valleys show the effects of scheduling. Table 2 and Table 3 present corresponding metrics for winter and summer operation which can be used to calibrate energy models during design development and evaluate actual performance for operational hospitals. Profiles and metrics for other hospital types will be added as data become available.

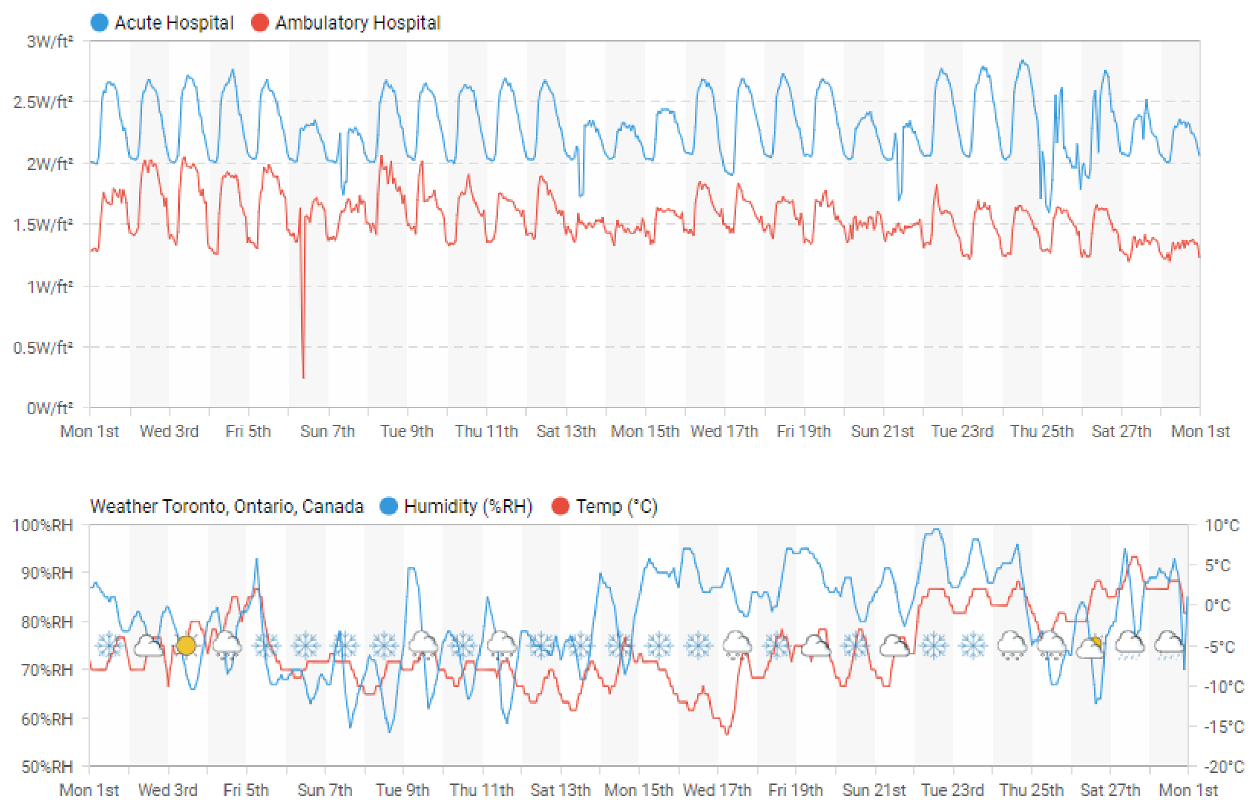


Figure 3. Electricity Best Practice Profiles for Acute and Ambulatory Care Hospitals – February 2021

Table 2. 4-Week Average Electricity Demand: (February) Winter 2021

Hospital	Average daily max W/sf		Average daily min W/sf		Min / max ratio	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
Ambulatory	1.8	1.5	1.4	1.2	0.7	0.8
Acute	2.7	2.4	2.0	2.0	0.8	0.9

Table 3. 4-Week Average Electricity Demand: (August) Summer 2021

Hospital	Average daily max W/sf		Average daily min W/sf		Min / max ratio	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
Ambulatory	2.2	1.8	1.5	1.4	0.7	0.8
Acute	3.3	3.1	2.4	2.5	0.7	0.8

4. Interval Meter Standard Profiles – Thermal (Gas)

Hourly thermal energy (natural gas) profiles can also be derived from energy models and verified post construction using data from the distribution company or submetering. Figure 4 presents the daily standard demand intensity (m3/,000sf) profiles for 2021 corresponding to the Thermal Best Practice EUI targets for acute care and ambulatory care hospitals. While some operational variances are apparent in spikes and seasonal pattern changes, the daily peaks and valleys can be used to calibrate energy models during design development and evaluate actual performance for operational hospitals. Additional profiles and metrics for other hospital types will be added as data become available.

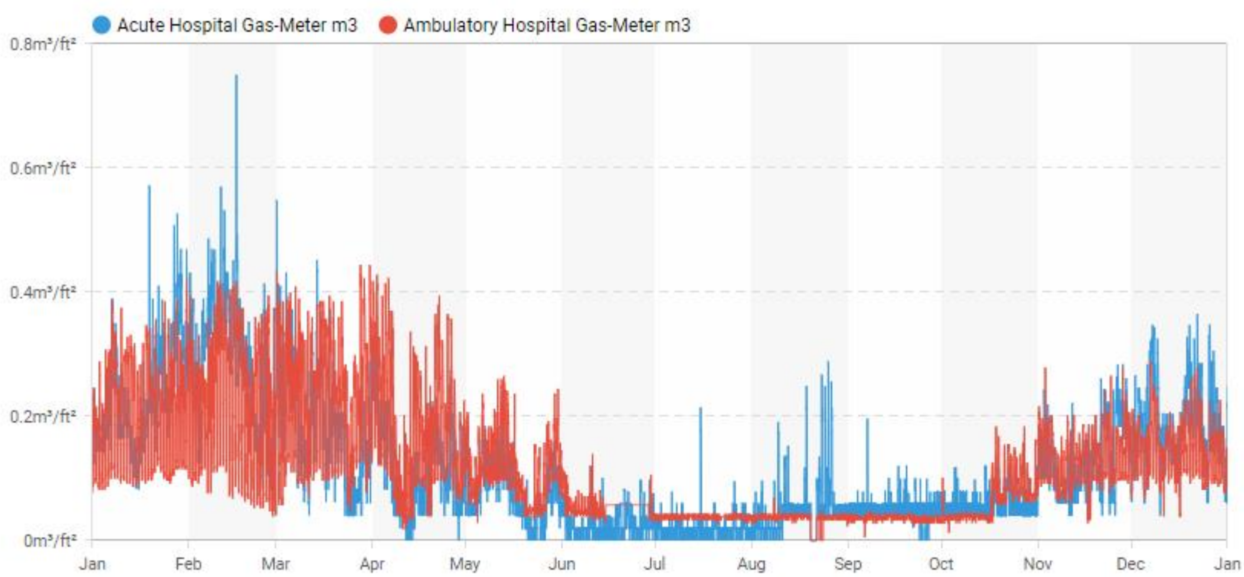


Figure 4. Thermal Best Practice Profiles for Acute and Ambulatory Care Hospitals – 2021

5. System-Level Energy Standards (Sub-Metering)

Figures 5 to 12 present best practice target energy use components for electricity and thermal systems which can be used to calibrate energy models, inform system design, and evaluate post occupancy operating performance of hospitals. Table 4 and Table 5 summarize the corresponding metrics.

Sub-Metered End Uses – Electricity

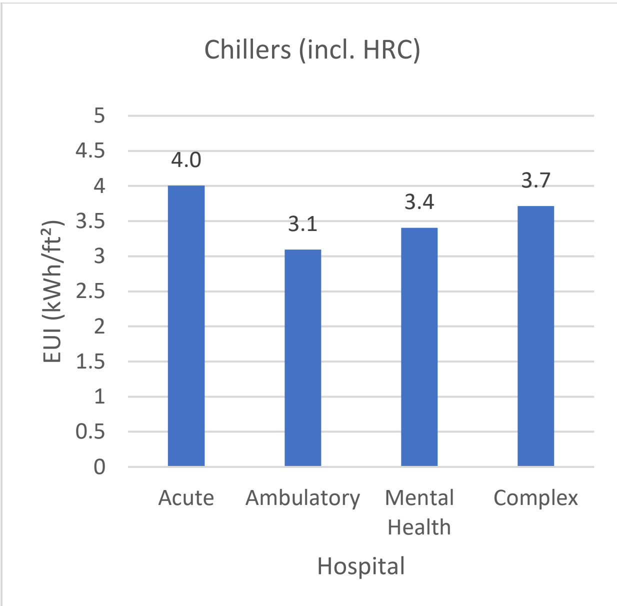


Figure 5. Chiller Plant (with Heat Recovery Chiller) Best Practice Targets[1]

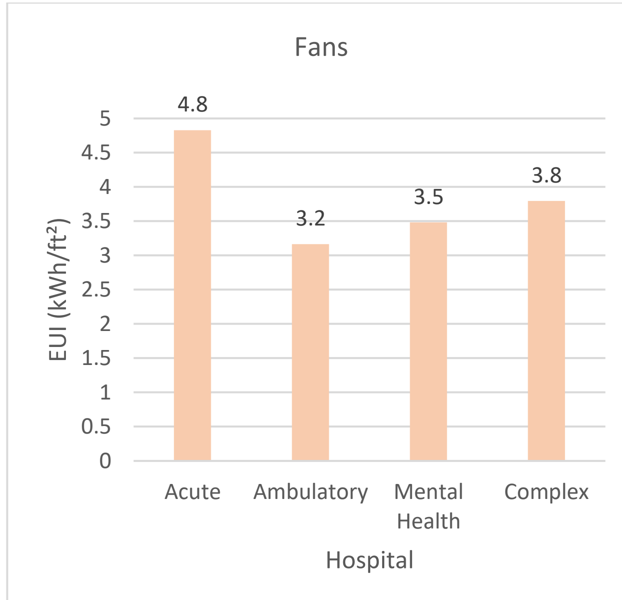


Figure 7. Fans Best Practice Targets[1]

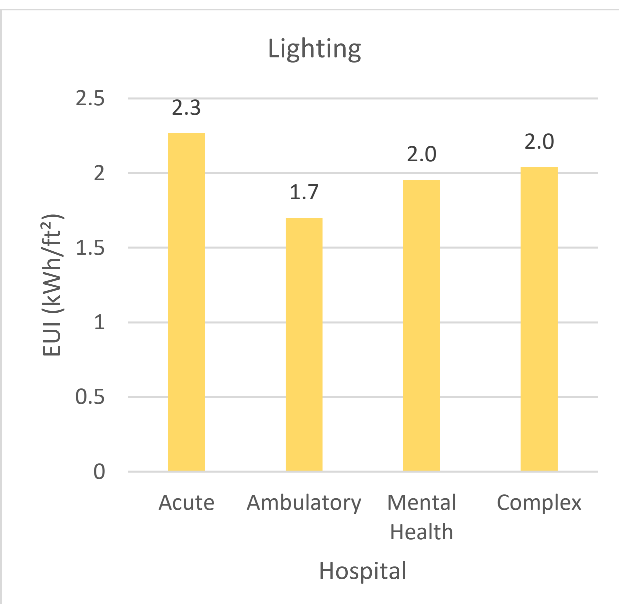


Figure 6. Lighting Best Practice Targets[1]

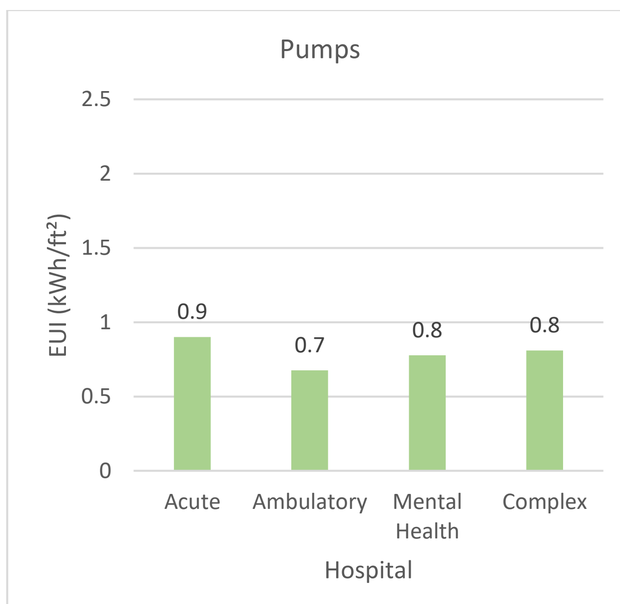


Figure 8. Pumps Best Practice Targets[1]

Sub-Metered End Uses – Thermal

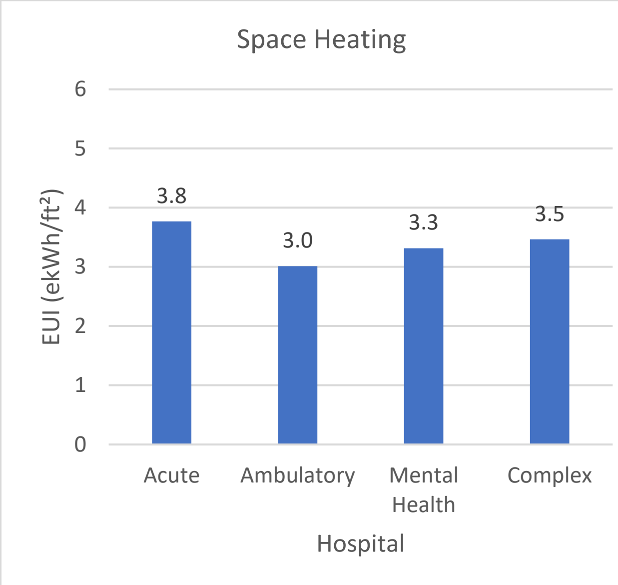


Figure 9. Space Heating Best Practice Targets[1]

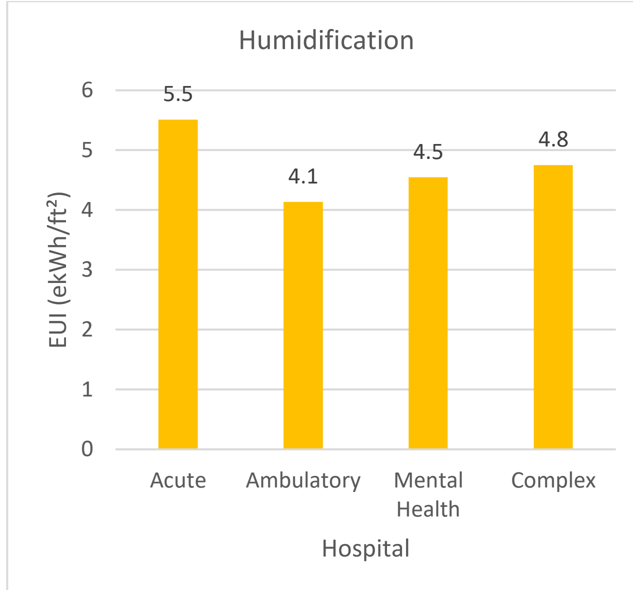


Figure 11. Humidification Best Practice Targets[1]

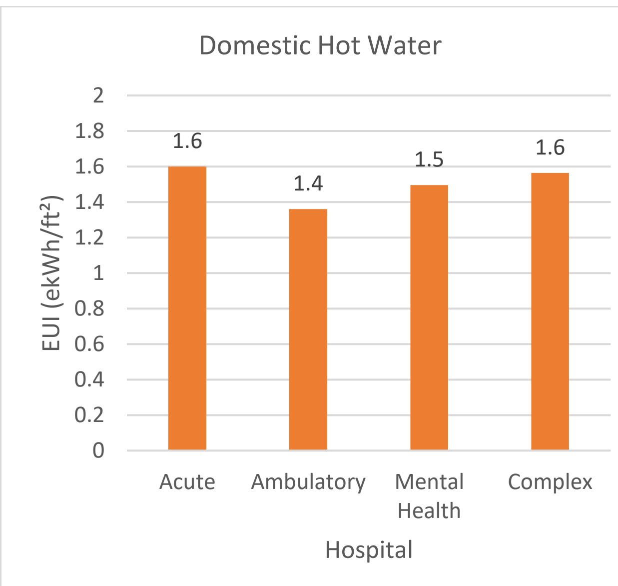


Figure 10. Domestic Hot Water Best Practice Targets[1]

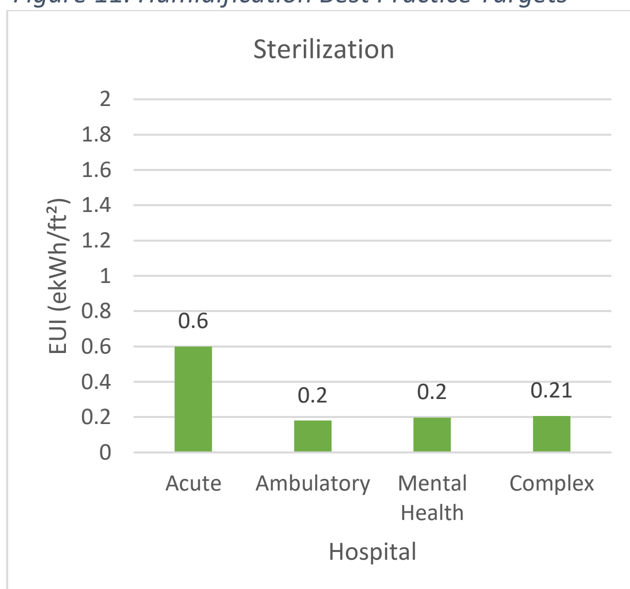


Figure 12. Sterilization Best Practice Targets[1]

Table 4. Best Practice End Use EUIs by Hospital Type - Electricity[1]

Hospital	Greening Health Care Best Practice – Electricity (kWh/ft²)			
Component	**Acute**	**Ambulatory**	**Mental Health**	**Complex**
Chillers (incl. HRC)	4.0	3.1	3.4	3.7
Pumps	0.9	0.7	0.8	0.8
Fans	4.8	3.2	3.5	3.8
Lighting	2.3	1.7	2.0	2.0
Elevators	0.1	0.1	0.1	0.1
Receptacle	0.8	2.6	3.0	3.2
Process	5.8	1.7	2.0	2.0

Table 5. Best Practice End Use EUIs by Hospital Type - Thermal[1]

Hospital	Greening Health Care Best Practice – Thermal (ekWh/ft²)			
Component	**Acute**	**Ambulatory**	**Mental Health**	**Complex**
Space Heating	3.8	3.0	3.3	3.5
Humidification	5.5	4.1	4.5	4.7
DHW	1.6	1.4	1.5	1.5
Sterilization	0.6	0.2	0.2	0.2

6. Conclusions and Recommendations

Getting it Right the First Time

New hospitals represent very large generational investments which we simply have to make as energy efficient as possible. Less than half of Ontario's 19 new P3 hospitals meets this standard. Similar pictures are emerging from other jurisdictions. Applying best practice metrics from the most efficient of these operational hospitals is considered the best way to achieve consistently high energy performance in future hospitals and drive continuous improvement. Using these metrics to formally assess the energy performance of less efficient new hospitals can help them make improvements and add further to the overall understanding and practice of high-performance design, commissioning and operations.

The key factors associated with the top performing hospitals are:

Design and Operations

- Scheduling – zoning and setback during unoccupied periods.
- Controls – programmed for setpoint adjustments based on demand feedback. Control valves on local heating units to shut off flow when not running.

- Central Plant – advanced heat recovery, right-sizing to actual loads and sequencing to maximize overall plant efficiency.
- Air Handling Units – low static pressure design and high efficiency exhaust air heat recovery.
- Space heating – low temperature hot water (design extended to the entire facility).
- Domestic hot water preheat with the heat recovery chiller.
- Comprehensive lighting controls.

Energy Modeling and Targets

- Set high performance targets based on empirical best practices.
- Calibrate energy models to meet high performance targets.
- Use empirical standards to set realistic user loads.
- Engage hospital departments early to establish occupancy patterns and scheduling.
- Generate whole building and system-level load profiles as inputs to performance-based commissioning.

Metering Standards

- Install primary system sub-metering to verify performance, identify system-level inefficiencies and support performance-based commissioning.
- Favour direct metering over inferred (subtractive) or BAS calculations.
- Monitor supply/return heating and chilled water temperature differentials as an indicator of excessive flow rates,

Lessons for Existing Hospitals

- Use capital planning and infrastructure renewal funding to transition towards low carbon operations.
- Determine low carbon alternatives to like for like plant and equipment replacements.
- Use interval meter metering (electric and gas) to highlight and quantify potential for peak load reductions and operational savings.
- Use HVAC and lighting system testing to produce system-level metrics for comparison against high-performance standards which point to identify opportunities for efficiency improvements.