Hotel Sustainability

Benchmarking Index 2019: Carbon, Energy, and Water

by Eric Ricaurte and Rehmaashini Jagarajan

EXECUTIVE SUMMARY

The sixth annual Cornell Hotel Sustainability Benchmarking study finds that participating hotels generally have continued to reduce their energy and water use, although the energy intensity recorded by luxury hotels continues to be relatively high. With information from over 11,000 hotels, the study includes data from substantially more hotels than in all previous years. While the bulk of the data come from hotels in the United States, the study also recorded greater international participation, with forty-eight nations and seventeen international brands represented. Participating hotels contributed information regarding their energy and water use, as well as greenhouse gas emissions, with data complete as of 2017. While these data permit hoteliers and potential guests to see benchmarks for various hotel segments and locations, individual hotel amenities cannot be accounted for in terms of energy or water use. This year's study further analyzed the range among data sets to identify the common "efficiency gap range" between the upper and lower quartile among similar hotels, presenting the opportunity and business case for designing and operating energy- and water-efficient hotels. Data collection is now underway for CHSB2020 study, and the authors encourage additional hotels to participate, especially those in the lower tier segments, which are not as strongly represented in these data.

ABOUT THE AUTHOR

Eric Ricaurte is the founder of Greenview, an international consultancy helping the travel and tourism industry innovate to develop best practices, particularly regarding sustainability strategies. A graduate of the Cornell University School of Hotel Administration, he also holds an M.S. from New York University. With over 20 years of experience, he is a frequent industry speaker and has held a research fellowship at the Cornell University Center for Hospitality Research. With offices in the United States and Singapore, Greenview is a boutique sustainability firm that provides hospitality organizations with consulting and advisory services, the leading online sustainability data platform, and industry research studies. Greenview has a niche focus and expertise in the hotel industry and works with many of the hotel industry's leading chains. Beyond hotel companies, Greenview works with REITs and real estate portfolios, cruise lines, research institutions, industry bodies, and destinations to catalyze sustainability as the industry's thought leader.

Rehmaashini Jagarajan, PhD, specializes in sustainability data analytics and tools encompassing corporate inventories and industry research at Greenview. She has served as a property researcher at Raine & Horne International (Malaysia) specializing in market research and feasibility studies. She has experience conducting and preparing market research to determine the highest and best use of land, ascertaining appropriate development proposals, and preparing feasibility studies relating to new development projects, subdivisions, and renovation and refurbishment of existing buildings. She has also served as a valuation executive at JS Valuers Property Consultants Group Malaysia providing valuation services covering an extensive range of properties for various purposes. Rehma is a member of Malaysian Association of Facility Management (MAFM), a medium for the local facility management communities to interact and share knowledge or experience through activities co-organized with various parties both in public and private sectors. Rehma holds a PhD in facilities management as well as a bachelor's degree in property management from the University of Technology Malaysia.

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This report presents the results of the sixth annual Cornell Hotel Sustainability Benchmarking (CHSB) study. This is an update to CHSB2018 study, which was undertaken as a collaborative effort of the Cornell University Center for Hospitality Research, hotel participants, Greenview, and an industry advisory group. This year's report, with historical trends and its accompanying index, presents the industry's largest and latest data sets for benchmarking activities relating to energy, water, and greenhouse gas emissions. The data sets remain freely available for download from the Cornell Center for Hospitality Research. This sixth study continues to build upon the existing framework, expand the data set's geographical coverage, present historical trends across like-for-like change over the past year, as well as three years of similar data, and provide enhanced benchmarks and metrics. This year's report represents a 9-percent increase in the global data set, reaching over 11,000 hotels worldwide.

Overview

Now in its sixth year of data and presented as an index, this study is conducted annually for the following purposes:

- Provide credible benchmarks according to industry-specific segmentation and metrics globally;
- Provide industry data analysis, using a confidential data set not provided to third parties or used commercially; and
- Work toward establishing a commonly defined, transparent, and rigorous method for modeling energy, water, and carbon based on hotel-specific attributes and data that are applicable and current.

This index presents benchmark ranges for twelve different measures relating to energy, water, and carbon emissions in 506 geographies, which are defined by metro area, country, climate zone, or other geographic or political region. Data are segmented by various hotel types, including asset class, location, type of hotel, market segment, and classification by stars.

CHSB2019 Updates

This year's process and resulting index incorporated the following updates:

- Segmented validity testing for water, based on whether the hotel offers full service or limited service and whether it operates an onsite laundry;
- Addition of non-metropolitan areas within each U.S. state as metro area geographies;
- Enhanced version of a hotel-specific output report that allows participants to view a summary of benchmarks (in PDF) for specific hotel properties, in addition to the aggregate output;
- Increase in the number of geographies from 448 to 506 across metro areas, regions, countries, and climate zones;
- Increase in the number of hotels for which benchmarks are generated to 11,363 (increase of 9.2%); and
- An analysis of the performance range in energy per square meter and water per occupied room within a market and within a segment, as well as laundry specification for select markets.

Uses of the CHSB Index

The CHSB Index and output data sets serve multiple purposes to benefit both the study participants and the travel and tourism sector, as follows:

Industry Benefits

Default data. By aggregating data globally that are also segmented by geographic location and market segment, CHSB provides a publicly available, base industry data set. Furthermore, in countries without any formalized benchmarking process, the research fills the gap for basic environmental data.

Feasibility study support. Entities performing feasibility studies for hotel development, renovation, and acquisition can utilize the tool's market- and location-based ranges and benchmarks to support the forecasting of energy and water usage and in some cases carbon taxes.

Improving rating systems. Entities that rank or score hotels based on environmental performance can incorporate benchmarks from the report and quantification methods to tailor their own methodology.

Harmonized greenhouse gas emissions calculations. The protocols for greenhouse gas (GHG) emissions accounting allow for flexibility in selecting the emission factors for converting energy into carbon metrics. Different entities may select different factors which can invalidate the comparability across prop-

erties and companies. In receiving energy data and applying a uniform set of greenhouse gas emission factors, the index provides a single, harmonized data set.

Expediting carbon footprint calculations. Travelers, event organizers, and other travel buyers or intermediaries seeking to calculate the carbon footprint of their own hotel stays may make a credible calculation using the CHSB results. Carbon offset programs can use CHSB figures to develop credible and transparent estimates of carbon footprint values to establish standardized offset levels. This will expedite the calculation, thereby saving group customers and hoteliers time in transmitting property-specific data for a destination or global footprint.

Supporting municipal codes and regulations. Entities that wish to mandate performance specifications of energy, water, or GHG emissions in municipalities or regions will have more representative and accurate data from which to base their codes or regulations.

Industry trends and carbon balance. General knowledge of hotel environmental performance and industry trends can be explored in each year's industry report. With an established data set, overall performance on an industry level can be analyzed and communicated. With the Paris Climate Agreement signed in 2016, an increasing emphasis is placed on decarbonization aligned with climate science akin to a balance sheet. The data set can serve as a basis for calculating the industry-wide carbon footprint and trends over time along a path toward decarbonization by 2050, while also providing insight on year-over-year performance.

Eventual normalization and use indexing. Each study adds data to the index, and a significant data set with property attributes over time will support the further evaluation regarding the drivers of energy, water, and carbon emissions in hotel operations.

Participant Benefits[1]

Expediting validity testing. Validity tests are performed on the data sets submitted, which the participating companies can use to identify and address data-integrity issues to improve their own reporting.

Supporting portfolio data collection efforts. Entities with large hotel portfolios may employ the study to encourage properties to submit valid data in a timely manner to improve corporate reporting.

Exhibit 1

Participating organizations

Alila Hotels & Resorts
CPG Hospitality
DiamondRock Hospitality Company
Hilton Worldwide
Horwath HTL Asia Pacific
Hyatt Hotels Corporation
InterContinental Hotels Group
Mandarin Oriental Hotel Group
Marriott International
MGM Resorts International
Park Hotel Group
Park Hotels & Resorts
Pebblebrook Hotel Trust
Red Planet Hotels
Saunders Hotel Group
Six Senses Hotels Resorts Spas
Sunstone Hotel Investors, Inc
The Hongkong and Shanghai Hotels
Wyndham Hotels & Resorts

Enabling internal benchmarking. Hotel properties and companies wishing to compare performance against a general competitive set of peers may apply the benchmarks to their own performance.

Advancing internal modeling. Hotel companies with internal benchmarking systems may take lessons learned, correlations, and regression studies into consideration for improving their own internal regression modeling.

Calculating portfolio footprints. Participating companies that do not currently calculate carbon emissions or aggregate their energy footprint will receive the energy and carbon footprint of their portfolios in the individual reports, uniformly calculated across the entire data set in a cost-effective platform.

Data Set: Input

From the participating companies listed in Exhibit 1, we collected aggregate 2017 calendar-year data (the most recent complete year of data). In total, the participants provided data for over 17,000 properties globally. Property data were received in aggregate data sets from each participating firm or its corresponding data provider. As part of this process, we incorporated data collected by Horwath HTL Asia Pacific and then analyzed with similar validity testing by Greenview into this year's data set to add an additional 2,103 non-

[1] Participation is open and welcome for CHSB 2020, calling for 2018 data sets. For further information, please email eer3@cornell.edu

EXHIBIT 2

Data collection points used to generate the external CHSB2019 benchmarks

Data Point	Description	
Internal Brand Code	Unique identifier code used by the property's parent brand.	
Participant Code	Unique identifier code used by the participating entity, if different from the brand code. For example, an owner of a franchisee of a portfolio of hotels may use separate identifiers, to avoid duplication of properties within the data set.	
Hotel Name	Name of hotel.	
Address	Street address of hotel.	
City	City where the hotel is located.	
State or Province	State or province where the hotel is located.	
Country	Country where the hotel is located.	
Postal Code	Postal code (e.g., ZIP code) where the hotel is located.	
Rooms	The total number of guestrooms for the hotel in 2017. If a hotel's room count changed during the year, the value most representative of the hotel's room count for 2017 was used.	
Total Area	Total floor area of conditioned space of the property.	*Note*: *Total Area* value should equal *Rooms Area* + *Meeting Space Area* + *Other Area*
Rooms Area	Total area of conditioned space of the rooms and corridors, per the HCMI guidance.	
Meeting Space Area	Total area of conditioned space of the meeting space and pre-function space in the hotel, per HCMI guidance.	
Other Area	The total remaining area of conditioned space within the property not covered by rooms and meeting space.	
Location Type	The location segment of the property by selecting for each property among the following categories: urban, suburban, rural or highway, airport, convention, resort, timeshare, small metro or town, or bed & breakfast.	
12-Month Operation	Confirm with a "Yes" that the hotel was in operation for all of 2017 without any shutting down or major renovation that would significantly alter the energy consumption or occupancy (either rooms or meeting space) during the period.	
Laundry	Choose either "Included" or "Not Included" to denote whether the energy consumption includes the washing of bedroom linens. For properties with partial in-house wash, the determining factor is whether bedroom linens are included in that wash. For example, linen wash of restaurant linens or guest clothing only, would be considered "not included."	
Occupied Rooms	The total number of occupied rooms for the hotel for each month within 2017. Rooms sold may be used as a proxy.	
Water	The total water consumption for each month in 2017 as provided by the utility provider.	
Energy Consumption by Type	The total energy usage for each month in 2017 by type of energy source.	

duplicated property records. We used the data points shown in Exhibit 2 to generate the measures within the index. We did not, however, cross-check utility invoices nor verify the data, although most of the data set was verified by a third-party review for participant corporate reporting of GHG inventories. Other than laundry for measures 1,7,10, and 11, no additional data points were collected to filter or harmonize for coverage of amenities by the utilities. Consequently, for example, we do not identify whether energy and water bills included restaurants, spas, fitness centers, or areas shared with other tenants within the building.

EXHIBIT 3

Validity tests performed on the data set

Validity Test Description	High Threshold	Low Threshold	Action taken if beyond threshold or missing	% of Data Set Excluded
Property underwent significant renovation	N/A	N/A	Excluded from Measures 1-12	0.63%
FULL SERVICE Energy Per Occupied Room Outlier (kWh per occupied room)	700	25	Excluded from Measures 1,3,5,12	14.91%
LIMITED SERVICE Energy Per Occupied Room Outlier (kWh per occupied room)	200	20	Excluded from Measures 1,3,5,12	18.77%
FULL SERVICE Energy Per Square Meter outlier (kWh per m2)	1,300	80	Excluded from Measures 2,4,6,7,12	30.76%
LIMITED SERVICE Energy Per Square Meter outlier (kWh per m2)	700	65	Excluded from Measures 2,4,6,7,12	24.88%
FULL SERVICE Seasonal Energy Per Square Meter per month outlier (kWh/m2)	108	7	Excluded from Measures 2,4,6,7,12	N/A
LIMITED SERVICE Seasonal Energy Per Square Meter per month outlier (kWh/m2)	58	5	Excluded from Measures 2,4,6,7,12	N/A
Property did not provide any purchased electricity data	N/A	N/A	Excluded from Measures 1-7,12	7.82%
Property did not have 12 separate electricity data points	N/A	N/A	Excluded from Measures 1-7,12	24.87%
Property did not provide any occupied rooms data	N/A	N/A	Excluded from Measure, 1,3,5,8	3.81%
Property did not have 12 separate occupancy data points	N/A	N/A	Excluded from Measures 1,3,5,8	15.44%
Occupancy outlier	104%	35%	Excluded from Measures 1,3,5,8,10,11	12.30%
Property did not provide any water usage data	N/A	N/A	Excluded from Measures 8-11	9.16%
Property did not have 12 separate water data points	N/A	N/A	Excluded from Measures 8-11	28.97%
FULL SERVICE Water Per Occupied Room outlier with onsite laundry (L per occupied room)	5,000	275	Excluded from Measure 8,10,11	24.39%
FULL SERVICE Water Per Occupied Room outlier without onsite laundry (L per occupied room)	4,500	200	Excluded from Measure 8,10,11	30.84%
FULL SERVICE Water Per Occupied Room outlier without laundry data (L per occupied room)	5,000	275	Excluded from Measure 8,10,11	34.11%
LIMITED SERVICE Water Per Occupied Room outlier with onsite laundry (L per occupied room)	1,700	50	Excluded from Measure 8,10,11	23.18%
LIMITED SERVICE Water Per Occupied Room outlier without onsite laundry (L per occupied room)	1,500	40	Excluded from Measure 8,10,11	24.47%
LIMITED SERVICE Water Per Occupied Room outlier without laundry data (L per occupied room)	1,500	40	Excluded from Measure 8,10,11	21.74%
FULL SERVICE Water Per Square Meter outlier with onsite laundry (L per m2)	10,500	300	Excluded from Measures 9,11	22.41%
FULL SERVICE Water Per Square Meter outlier without onsite laundry (L per m2)	9,000	200	Excluded from Measures 9,11	29.15%
FULL SERVICE Water Per Square Meter outlier without laundry data (L per m2)	10,500	300	Excluded from Measures 9,11	82.03%
LIMITED SERVICE Water Per Square Meter outlier with onsite laundry (L per m2)	8,000	150	Excluded from Measures 9,11	24.00%
LIMITED SERVICE Water Per Square Meter outlier without onsite laundry (L per m2)	5,000	100	Excluded from Measures 9,11	29.50%
LIMITED SERVICE Water Per Square Meter outlier without laundry data (L per m2)	5,000	100	Excluded from Measures 9,11	39.34%
FULL SERVICE Seasonal Water Per Square Meter per month outlier (L/m2)	875	25	Excluded from Measures 9,11	N/A
LIMITED SERVICE Seasonal Water Per Square Meter per month outlier (L/m2)	667	6	Excluded from Measures 9,11	N/A
% of Floor Area attributed to Rooms Footprint	100%	40%	Excluded from Measures 1,7,10,11	24.72%
Average SqM per guestroom of entire building outlier	20	2,500	Excluded from Measures 1,2,4,6,7,10,11	11.98%
Average size of a guestroom outlier (M2)	15	750	Excluded from Measures 1,2,4,6,7,10,11	27.01%
At least one energy or water source had a high variance of a ratio of 3 to 1 between high/low months or 50% month-to-month	N/A	N/A	Notified, no action taken	51.12%

Data Set: Output

We took the following five steps to arrive at the output tables for the CHSB2019 index.

(1) Harmonization

First, all data were harmonized into the following common units of measure:

- energy in kilowatt-hours (kWh),
- water in Liters (L),
- floor area in square meters (m^2), and
- greenhouse gas emissions (also termed carbon footprint) in kilograms of carbon dioxide equivalent ($kgCO_2e$), converting each energy source of GHG emissions into $kgCO_2e$ (using only carbon dioxide, methane, and nitrous oxide).

The set of emission factors applied to each respective energy type was geographically based on available data (see the Appendix for emission factors referenced). When the emission factor was provided by the reference source in CO_2e, the source document's value of global warming potential (GWP) was used. For raw values of methane (CH_4) and nitrous oxide (N_2O) emissions, the following GWP was applied using the *IPCC Fifth Assessment Report*, 100-year horizon: GWP of CH_4 = 28; and GWP of N_2O = 265. For energy generated from renewable sources from wood or other biomass, the biogenic CO_2 was not included. However, per the Greenhouse Gas Protocol, emissions from CH_4 and N_2O were included. An emission factor of zero was assigned to other renewable sources, such as solar, wind, geothermal, or deep-water cooling.

(2) Validity Testing

Second, we performed validity tests to identify outliers or data which may have been incorrectly submitted. Participants received an initial output with validity test results and were given the option to correct and update data or to override validity flags by confirming that the data were correct (e.g., a utility that invoices and provides data on a bimonthly basis).

We repeated the tests with updated data, setting the thresholds to the highest or lowest values that had been re-confirmed by participants (see Exhibit 3). When a property did not pass a specific validity test, we removed it from the data set for each corresponding measure. While it is possible for a property to exist that exceeds the threshold due to expansive public areas or amenities, we implemented these limitations to maintain a representative data set.

For measures 10 and 11, using the methodology of the Hotel Water Measurement Initiative (HWMI), we took the remaining data sets after the validity testing and excluded properties that also **(1)** washed laundry off-site and **(2)** purchased district chilled water as an energy source. Though HWMI also allows for measurements per guest-night in addition to per occupied room, the lack of available guest-night data was addressed by only providing output metrics based on occupied rooms intensity.

(3) Geographic and Climate Zone Segmentation

Third, data sets were segmented by geographic location, first by geocoding each property and then by clustering based on unified boundaries. For the CHSB2019 index, segmentation by climate zone was added to enable benchmarking based on climate zones that span several regions across the globe. CHSB uses the term *geography*, which may refer to one of the following:

- **Metro Area**, which is generally a major city and its surrounding towns or jurisdictions as defined by a metropolitan statistical area (MSA), national capital region (NCR), or greater metropolitan area;
- **Country**;
- **Region**, which may be sub-national (a state or province, autonomous region, unincorporated territory, or national region) or trans-national (a major tourist or urban market that crosses national borders, or a similar regional grouping of countries). Various geographies are used to maximize the data output depending on the data received, and increase the ability to enable comparisons and benchmarking; or
- **Climate Zone**, using both the Köppen-Geiger climate classification system, as well as Bailey's Ecoregions of the World.

Exhibit 4

Segmentation categories

Asset Class
- Full Service
- Limited Service

Number of Stars
- 2 and 2.5 Stars
- 3 and 3.5 Stars
- 4 and 4.5 Stars
- 5 Stars

Market Segment
- Economy and Midscale
- Upper Midscale
- Upscale and Upper Upscale
- Luxury

Type
- Urban
- Suburban
- Small Metro/Town
- Rural/Highway
- Airport
- Resort—Year Round
- Resort—Summer Seasonal
- Resort—Winter Seasonal
- Convention
- Timeshare or Serviced Apartment
- Bed & Breakfast
- All Hotels (within a given geography)

(4) Property Segmentation

Fourth, properties were grouped by segments, applying the revenue-based approach and property-type segmentation used by STR Global (using 2018 global chain scales), the asset class segmentation of full-service and limited-service hotels, and a global data set of star levels for hotels as identified by Expedia. The final data set was grouped into categories together with an overall grouping that combines all segments within that geography, as shown in Exhibit 4.

We did not receive sufficient data to include separate categories for economy and midscale segments or hotels below 2 stars, as the data for those segments generally did not meet minimum thresholds in each geography to produce a meaningful output. However, the *All Hotels* option includes those properties in the output results.

(5) Minimum Output Thresholds

Finally, we set a minimum threshold of eight properties for output data to populate a geography. That is, where a specific segment within a geography contained at least eight properties, the results were populated in the tool. Consequently, data for cities, regions, climate zones, or countries with fewer than eight properties were excluded from the final outputs. After we applied the validity tests and removed geographies with fewer than eight properties, the final output tables in CHSB2019 comprise data from up to 11,363 properties across 506 geographies. This represents an increase from the prior year's data set (i.e., 2016 for CHSB 2018), with 9.2-percent more properties added in 2017. The increase in data helped generate the minimum threshold required to add new geographies, with nearly 58 new metro areas (including non-metropolitan areas) or countries added for CHSB2019.

Findings

The exercise of aggregating inputs and producing the outputs for the resulting data set continue to demonstrate several findings for consideration.

Historical and Year-over-year Trends

Having gained publication longevity, the CHSB index is able to provide insight into some historical trends. A total of 2,805 hotels in the data set have produced valid benchmarks for energy and water measures to enable a like-for-like comparison from calendar years 2015 through 2017. The approach to comparing the change over time depends on one's intended view and use of the information, whether at a geography level or individual-property level. Exhibit 5 presents the change from 2015 to 2017 in three measures using three types of average change. Most of the historical trend data set (69%) is from the United States, as the initial CHSB studies focused heavily on North America. That limitation will diminish over time as the data set's reach continues to expand with additional global data each year. Basic findings are provided below, with a subsequent publication foreseen to provide deeper analysis and findings using additional data sets for cross-analysis.

In addition, we continue the practice started last year of analyzing a year-over-year output of all properties within the data set for the past two years and passing all validity tests. The resulting year-over-year data set included a total of 3,448 properties, of which 67 percent are limited-service operations. Around 59 percent of the properties are from United States, constituting 1,649 limited-service properties (81%).

Exhibit 5

Three-year average change by measure among 2,805 hotels and by service type

Measure	2015-2017 Average Change	All Hotels	Full Service	Limited Service
Measure 4: GHG Emissions per Square Meter	Weighted Avg Change	-2.85%	0.57%	-3.42%
	Overall Avg Change	-5.07%	-0.71%	-12.83%
	Avg of Averages Change	-7.10%	-3.72%	-8.25%
Measure 6: Energy per Square Meter	Weighted Avg Change	-0.81%	2.22%	-3.02%
	Overall Avg Change	-3.03%	2.73%	-13.11%
	Avg of Averages Change	-5.97%	-0.92%	-7.68%
Measure 8: Water per Occupied Room	Weighted Avg Change	-1.49%	-1.07%	-0.42%
	Overall Avg Change	-8.77%	-8.22%	-10.80%
	Avg of Averages Change	-1.50%	-2.07%	-1.31%

Exhibit 6

Year-over-year average change by measure among 3,448 hotels overall and by service type

Measure	2016-2017 Average Change	All Hotels	Full Service	Limited Service
Measure 4: GHG Emissions per Square Meter	Weighted Avg Change	1.47%	1.70%	-0.23%
	Overall Avg Change	-0.65%	0.15%	-2.89%
	Avg of Averages Change	1.23%	4.08%	-0.15%
Measure 6: Energy per Square Meter	Weighted Avg Change	1.13%	1.44%	-0.30%
	Overall Avg Change	-2.44%	-2.16%	-3.20%
	Avg of Averages Change	0.64%	3.48%	-0.74%
Measure 8: Water per Occupied Room	Weighted Avg Change	7.74%	7.53%	0.20%
	Overall Avg Change	-1.72%	-0.98%	-4.56%
	Avg of Averages Change	4.40%	8.90%	2.21%

Notes: **Weighted Average Change** = average change of the hotel multiplied by the percentage of that hotel's floor area to the total floor area of the like-for-like data set; **Overall Average Change** = average change in the total usage or emissions of the entire data set divided by the total floor area of the like-for-like data set; and **Average of Averages Change** = mean of the average change of all hotels in the like-for-like data set.

Overall observations revealed limited-service properties to perform better than full-service properties in most of the hotels in the data set, including those in the United States.

Energy usage has reduced since 2015, though not uniformly and not year-over-year. The energy intensity of the like-for-like data set has reduced 3.03 percent overall and 0.81 percent weighted on average. The decrease is largely driven by limited-service hotels, which account for a larger portion of the data set and footprint. Among limited-service hotels, energy usage has consistently reduced over time in all measures. However, energy usage per square meter among all full-service hotels has increased 2.73 percent since 2015. Furthermore, in an average of averages, full-service hotels have seen increases in energy intensity since 2016.

Exhibit 7

Three-year historical overall average change by selected country, 2015-2017

	FULL SERVICE HOTELS ONLY					LIMITED SERVICE					ALL HOTELS				
Country	**Count**	**SqM**	**Measure 4**	**Measure 6**	**Measure 8**	**Count**	**SqM**	**Measure 4**	**Measure 6**	**Measure 8**	**Count**	**SqM**	**Measure 4**	**Measure 6**	**Measure 8**
United States	328	13,316,994	-1.2%	2.5%	-10.2%	1,609	12,357,093	-15.5%	-16.4%	-11.8%	1,937	25,674,087	-7.3%	-5.2%	-10.3%
China	50	3,361,964	-4.8%	-1.4%	-5.3%	83	3,020,821	-5.8%	-6.7%	-14.4%	133	6,382,785	-5.2%	-3.5%	-9.2%
United Kingdom	50	916,122	-10.7%	-1.1%	-0.6%	78	670,077	-27.5%	-20.8%	-8.1%	128	1,586,199	-17.9%	-9.7%	-4.0%
India	28	901,648	-21.6%	-15.5%	-17.8%	19	446,065	-9.1%	-3.6%	-35.7%	47	1,347,713	-18.2%	-12.2%	-23.5%
Mexico	14	491,159	10.2%	15.9%	-20.9%	49	679,672	-7.1%	-11.0%	-4.6%	63	1,170,831	2.5%	4.0%	-13.2%
United Arab Emirates	14	1,182,077	43.2%	64.6%	-9.5%	9	251,976	-14.8%	-7.4%	-17.8%	23	1,434,053	30.5%	49.3%	-10.3%
Germany	14	348,638	-1.0%	7.7%	-2.0%	19	237,792	-9.5%	-2.6%	-4.2%	33	586,430	-3.9%	3.8%	-2.8%
Japan	12	504,136	-8.1%	-4.5%	-7.8%	5	157,794	-2.1%	0.8%	2.9%	17	661,930	-7.0%	-3.4%	-5.2%
France	12	247,709	-7.6%	-9.2%	1.7%	14	95,459	2.8%	-4.7%	-1.7%	26	343,168	-5.6%	-8.3%	-3.2%
Thailand	12	462,685	-1.6%	-0.1%	-15.6%	11	338,590	-13.0%	-12.0%	0.2%	23	801,275	-5.4%	-4.0%	-9.3%
Canada	10	375,771	-14.5%	-13.1%	-1.9%	71	629,494	-2.2%	-8.4%	-1.0%	81	1,005,265	-7.0%	-10.4%	-1.4%
Russian Federation	8	258,525	-17.3%	-23.6%	7.1%	10	191,002	-10.8%	-19.1%	-10.7%	18	449,527	-14.8%	-22.0%	-2.7%
Metro Area	**Count**	**SqM**	**Measure 4**	**Measure 6**	**Measure 8**	**Count**	**SqM**	**Measure 4**	**Measure 6**	**Measure 8**	**Count**	**SqM**	**Measure 4**	**Measure 6**	**Measure 8**
Miami-Fort Lauderdale-Pompano Beach, FL MSA	23	786,558	-10.0%	-7.7%	-13.6%	26	202,000	-14.5%	-13.0%	-20.8%	49	988,558	-10.8%	-8.7%	-15.2%
Los Angeles-Long Beach-Santa Ana, CA MSA	23	936,700	12.6%	21.5%	-1.9%	38	450,434	-17.8%	-13.3%	-13.8%	61	1,387,133	2.6%	9.9%	-6.0%
London, UK	22	528,181	-5.3%	6.2%	11.2%	15	146,574	-50.9%	-46.2%	-19.9%	37	674,755	-20.1%	-11.4%	0.9%
New York-Northern New Jersey-Long Island, NY-NJ-PA M	18	578,766	7.9%	16.5%	-0.8%	42	398,648	-20.6%	-21.4%	-14.1%	60	977,414	-2.5%	2.5%	-4.2%
Chicago-Naperville-Joliet, IL-IN-WI MSA	18	974,859	-5.7%	2.6%	1.8%	64	628,942	-18.8%	-15.5%	-4.4%	82	1,603,801	-10.4%	-3.2%	0.0%
Atlanta-Sandy Springs-Marietta, GA MSA	16	801,477	11.0%	10.8%	-15.1%	44	369,348	-22.5%	-24.4%	-15.7%	60	1,170,826	-0.1%	-1.0%	-13.6%
Washington-Arlington-Alexandria, DC-VA-MD-WV MSA	14	475,323	-4.2%	-9.7%	-20.9%	37	347,399	-6.4%	-4.3%	-8.5%	51	822,722	-5.0%	-7.8%	-15.4%
Orlando-Kissimmee, FL MSA	14	1,173,273	3.1%	6.1%	-21.0%	25	378,107	-9.4%	-9.5%	-17.9%	39	1,551,380	1.1%	3.6%	-20.9%
Dallas-Fort Worth-Arlington, TX MSA	13	605,415	4.7%	5.7%	-25.2%	58	429,687	-17.4%	-22.0%	-23.2%	71	1,035,102	-2.8%	-2.9%	-23.3%
Boston-Cambridge-Quincy, MA-NH MSA	13	416,133	-16.1%	-14.5%	0.2%	22	173,129	-19.9%	-19.7%	-18.2%	35	589,262	-17.2%	-16.1%	-5.6%
Dubai	10	943,593	50.1%	75.2%	-5.7%	5	154,256	-22.7%	-18.5%	-9.2%	15	1,097,849	33.7%	54.2%	-5.8%
Houston-Sugar Land-Baytown, TX MSA	10	388,868	-12.8%	-18.4%	-15.0%	37	216,224	-6.5%	-15.2%	-27.4%	47	605,092	-11.1%	-17.6%	-20.4%
Denver-Aurora, CO MSA	10	332,139	-2.3%	3.3%	-2.0%	29	274,394	-23.1%	-21.9%	-15.5%	39	606,533	-11.4%	-6.4%	-8.0%
San Francisco-Oakland-Fremont, CA MSA	9	369,207	-4.1%	-2.2%	-3.4%	10	144,499	16.6%	22.7%	5.3%	19	513,706	0.7%	3.2%	-0.3%
Beijing	9	509,522	-9.5%	-2.2%	-7.3%	15	631,393	-10.2%	-10.4%	-20.2%	24	1,140,915	-9.8%	-6.2%	-14.1%
Shanghai	8	455,828	3.8%	10.9%	-0.3%	16	568,612	-1.3%	-4.0%	-16.1%	24	1,024,440	1.9%	5.0%	-8.6%
Paris	8	184,276	-10.5%	-11.6%	4.9%	4	37,232	2.3%	-7.8%	-2.3%	12	221,508	-8.9%	-11.1%	0.5%
Bangkok	8	351,919	2.0%	4.6%	-1.9%	7	209,247	-19.9%	-19.1%	-3.6%	15	561,166	-4.6%	-2.4%	-1.2%

Water usage intensity has reduced consistently. The water intensity of the like-for-like data set has reduced consistently since 2015. Since 2015 the overall average of water usage per occupied room has reduced 8.77 percent, with a weighted average drop of 1.49 percent. Water usage per occupied room of full-service hotels has reduced 8.22 percent overall, from 1.48 percent since 2015, and limited-service hotels recorded an overall average of -10.80 percent since 2015.

Year-over-year overall average change by selected country, 2016-2017

	FULL SERVICE HOTELS ONLY					LIMITED SERVICE					ALL HOTELS				
Country	Count	SqM	Measure 4	Measure 6	Measure 8	Count	SqM	Measure 4	Measure 6	Measure 8	Count	SqM	Measure 4	Measure 6	Measure 8
United States	379	16,568,560	-3.5%	-5.9%	-1.2%	1,649	13,257,278	-1.7%	-2.2%	-2.0%	2,028	29,825,838	-2.9%	-4.8%	-1.7%
China	192	11,382,870	8.0%	6.1%	-3.0%	127	4,488,940	-3.2%	-4.7%	-9.2%	319	15,871,810	5.5%	3.6%	-3.4%
Indonesia	74	1,838,799	1.7%	2.6%	-13.5%	19	271,049	-10.2%	-11.2%	-42.1%	93	2,109,848	0.2%	0.7%	-17.8%
United Kingdom	48	926,257	-3.2%	-3.1%	1.0%	127	869,398	-2.8%	-3.4%	2.6%	175	1,795,655	-3.0%	-3.2%	1.7%
Thailand	34	1,330,641	4.0%	5.5%	-2.9%	13	354,122	-17.6%	-19.1%	-10.9%	47	1,684,763	-0.3%	0.7%	-2.7%
India	31	862,534	-12.8%	-18.0%	-8.1%	16	367,584	2.9%	3.2%	-11.0%	47	1,230,118	-9.6%	-13.6%	-9.0%
Japan	28	1,167,059	12.6%	12.3%	1.0%	11	325,096	-0.6%	-0.3%	0.5%	39	1,492,155	9.9%	9.5%	1.3%
Singapore	26	945,186	15.3%	10.8%	-3.4%	5	90,051	-7.5%	-7.2%	1.8%	31	1,035,237	13.2%	9.3%	-0.9%
United Arab Emirates	22	1,369,632	-1.4%	-3.3%	-3.2%	12	349,149	-1.5%	-1.2%	-4.4%	34	1,718,781	-1.4%	-2.9%	-3.6%
Germany	17	459,809	1.8%	-0.9%	-0.2%	35	363,797	-4.9%	-3.7%	-1.9%	52	823,606	-0.5%	-1.9%	-1.4%
Australia	16	569,531	10.7%	6.8%	16.7%	1	2,200	-71.8%	-9.9%	-49.4%	17	571,731	10.5%	6.8%	15.6%
France	13	314,716	-9.1%	-8.5%	-0.6%	8	54,340	1.6%	-1.7%	-4.2%	21	369,056	-7.8%	-7.8%	-2.6%
Malaysia	13	585,558	-9.2%	-21.5%	-9.3%	2	45,273	-62.8%	-68.5%	-37.5%	15	630,831	-13.5%	-24.7%	-12.1%
Canada	12	455,204	-9.7%	-8.0%	3.9%	70	658,523	1.6%	-1.1%	-4.8%	82	1,113,727	-3.7%	-4.4%	-1.7%
Hong Kong, China	12	588,489	-4.0%	-8.2%	1.6%	8	148,532	-5.9%	-6.7%	-1.6%	20	737,021	-4.3%	-8.0%	1.4%
Turkey	11	434,148	5.3%	4.0%	-12.1%	16	332,598	0.5%	3.1%	-3.4%	27	766,746	3.8%	3.8%	-9.5%
Mexico	11	312,523	-10.6%	-11.0%	-3.5%	63	793,854	-5.2%	-7.0%	-6.9%	74	1,106,377	-7.5%	-8.8%	-5.5%
Saudi Arabia	10	547,184	-6.1%	-5.8%	0.0%	8	199,641	1.1%	0.3%	-0.7%	18	746,825	-4.5%	-4.3%	0.6%
Egypt	10	518,207	0.9%	1.9%	-18.9%	3	68,004	-6.0%	-1.9%	0.5%	13	586,211	0.2%	1.4%	-16.5%
Vietnam	9	545,872	23.4%	26.3%	-1.8%	1	5,240	-9.2%	-9.0%	5.2%	10	551,112	23.0%	25.8%	-1.0%
Korea	9	510,518	21.5%	18.8%	-6.1%	3	160,787	-43.1%	-40.6%	-50.6%	12	671,305	7.2%	5.6%	-13.2%
All	1,127	47,251,828	0.1%	-2.2%	-1.0%	2,321	25,003,100	-2.9%	-3.2%	-4.6%	3,448	72,254,928	-0.7%	-2.4%	-1.7%
Metro Area	Count	SqM	Measure 4	Measure 6	Measure 8	Count	SqM	Measure 4	Measure 6	Measure 8	Count	SqM	Measure 4	Measure 6	Measure 8
Shanghai	36	22,890,792	20.3%	17.4%	-1.1%	23	8,783,153	-1.5%	-4.3%	-12.9%	59	31,673,945	15.8%	12.9%	-2.0%
Washington-Arlington-Alexandria, DC-VA-MD-WV MSA	34	14,931,992	-1.4%	-4.8%	-5.5%	51	5,451,659	0.0%	-1.4%	-9.4%	85	20,383,652	-1.1%	-4.1%	-6.3%
New York-Northern New Jersey-Long Island, NY-NJ-PA M	32	11,918,583	-1.5%	-0.2%	1.7%	53	6,202,393	-1.5%	-1.5%	-1.7%	85	18,120,976	-1.5%	-0.5%	0.4%
Singapore	26	10,173,797	15.3%	10.8%	-3.4%	5	969,287	-7.5%	-7.2%	1.8%	31	11,143,084	13.2%	9.3%	-0.9%
London, UK	23	5,885,957	-2.5%	-2.0%	2.2%	23	1,788,481	-0.9%	-0.3%	2.0%	46	7,674,438	-2.2%	-1.7%	2.1%
Jakarta	23	7,603,396	47.7%	50.0%	15.5%	4	464,802	-16.7%	-17.4%	-44.2%	27	8,068,199	42.2%	43.8%	11.2%
Los Angeles-Long Beach-Santa Ana, CA MSA	21	9,082,671	-3.1%	-2.0%	0.8%	48	5,029,144	-5.9%	-6.4%	-3.4%	69	14,111,815	-3.9%	-3.3%	-1.0%
Miami-Fort Lauderdale-Pompano Beach, FL MSA	20	7,090,129	-6.0%	-10.1%	3.8%	26	2,264,825	-0.7%	-5.3%	-2.6%	46	9,354,955	-4.9%	-9.1%	1.9%
San Francisco-Oakland-Fremont, CA MSA	18	9,025,114	-3.3%	-2.0%	-2.3%	25	2,923,743	-4.0%	-3.1%	-2.7%	43	11,948,857	-3.4%	-2.2%	-2.5%
Bangkok	16	8,648,988	15.0%	9.4%	-9.4%	9	3,046,220	-19.5%	-19.7%	-22.9%	25	11,695,208	6.4%	2.5%	-9.1%
Chicago-Naperville-Joliet, IL-IN-WI MSA	16	8,991,015	-4.6%	-0.9%	5.3%	33	4,182,288	-9.4%	0.7%	4.8%	49	13,173,304	-5.8%	-0.6%	5.2%
Beijing	16	10,424,543	-9.2%	-10.6%	-25.9%	15	6,464,383	0.1%	-1.3%	-6.0%	31	16,888,926	-6.4%	-7.7%	-20.3%
South Bali	13	4,483,997	-12.3%	-19.0%	-14.0%	4	776,339	8.7%	10.0%	-1.4%	17	5,260,336	-9.9%	-16.1%	-13.3%
Orlando-Kissimmee, FL MSA	12	13,536,603	-2.3%	-4.5%	-1.2%	20	3,230,588	-1.5%	-3.2%	-5.9%	32	16,767,191	-2.2%	-4.4%	-2.4%
Hong Kong	12	6,334,379	-4.0%	-8.2%	1.6%	8	1,598,769	-5.9%	-6.7%	-1.6%	20	7,933,147	-4.3%	-8.0%	1.4%
Boston-Cambridge-Quincy, MA-NH MSA	12	3,398,156	-0.9%	-0.1%	19.1%	9	816,939	-3.6%	-3.2%	-12.3%	21	4,215,095	-1.5%	-0.8%	13.0%
San Diego-Carlsbad-San Marcos, CA MSA	11	6,369,733	-1.7%	2.2%	1.3%	21	2,086,061	-5.0%	-5.7%	-10.9%	32	8,455,794	-2.3%	0.7%	-2.0%
Houston-Sugar Land-Baytown, TX MSA	11	5,086,266	1.4%	-4.6%	-3.7%	26	1,787,864	3.8%	-4.9%	-13.3%	37	6,874,130	1.9%	-4.7%	-6.9%
Kuala Lumpur	10	5,539,421	-7.6%	-21.3%	-7.8%	1	204,512	-88.6%	-91.3%	-59.4%	11	5,743,933	-12.7%	-25.2%	-11.2%
Phoenix-Mesa-Scottsdale, AZ MSA	10	5,205,153	-24.1%	-29.1%	-1.8%	34	3,571,014	-8.0%	-3.9%	-1.2%	44	8,776,167	-20.0%	-23.2%	-2.4%
Tokyo	9	3,164,445	4.5%	4.5%	12.6%	-	-				9	3,164,445	4.5%	4.5%	12.6%
Shenzhen	9	5,399,045	-3.0%	-13.2%	-24.5%	5	2,029,202	-0.9%	-14.2%	-6.8%	14	7,428,247	-2.6%	-13.4%	-17.6%
Paris	9	2,478,720	-11.8%	-10.9%	-1.2%	4	396,657	-0.6%	-3.5%	-5.9%	13	2,875,377	-10.7%	-10.2%	-3.6%
Atlanta-Sandy Springs-Marietta, GA MSA	9	4,995,783	0.1%	-0.5%	2.4%	24	2,726,371	-3.3%	-2.8%	-3.3%	33	7,722,154	-0.8%	-1.1%	0.3%
Dallas-Fort Worth-Arlington, TX MSA	9	7,285,012	4.4%	-0.7%	-30.9%	35	3,267,372	1.3%	-1.4%	-9.0%	44	10,552,384	3.8%	-0.8%	-25.0%
Dubai	9	5,638,019	-2.0%	-2.9%	-2.1%	8	2,663,083	-0.4%	-0.1%	1.2%	17	8,301,101	-1.5%	-2.0%	-0.9%
Guangzhou	9	4,788,915	-1.6%	-3.0%	-3.8%	5	3,612,590	-0.6%	-3.1%	-1.5%	14	8,401,504	-1.4%	-3.0%	-3.1%
Austin-Round Rock, TX MSA	8	2,947,104	0.0%	-3.8%	-4.5%	15	1,203,769	4.4%	-0.7%	-17.2%	23	4,150,873	0.9%	-3.2%	-7.7%

EXHIBIT 9

Ratio of upper quartile to lower quartile

GEOGRAPHY	Energy Per Square Meter			Water Per Occupied Room		
	Full Service		Limited Service	Full Service		Limited Service
	Yes	No	Yes	Yes	No	Yes
Atlanta-Sandy Springs-Marietta, GA MSA	1.75		1.57	1.52		1.55
Austin-Round Rock, TX MSA			1.88			1.74
Baltimore-Towson, MD MSA			1.57			2.03
Bangkok	1.47			1.60		
Beijing	1.93	2.00		1.94	2.86	
Birmingham-Hoover, AL MSA			1.70			1.49
Boston-Cambridge-Quincy, MA-NH MSA			1.59			1.79
Charlotte-Gastonia-Concord, NC-SC MSA			1.50			1.49
Chicago-Naperville-Joliet, IL-IN-WI MSA	1.55	1.60	1.87	1.38	1.77	1.60
Cincinnati-Middletown, OH-KY-IN MSA			1.69			2.07
Cleveland-Elyria-Mentor, OH MSA			1.59			1.46
Columbus, OH MSA			1.61			1.42
Dallas-Fort Worth-Arlington, TX MSA	1.39		1.63	1.61		1.58
Denver-Aurora, CO MSA			1.56			1.53
Detroit-Warren-Livonia, MI MSA			2.19			1.58
Guangzhou	1.80			2.48		
Houston-Sugar Land-Baytown, TX MSA			1.81			2.16
Indianapolis-Carmel, IN MSA			1.94			1.72
Jacksonville, FL MSA			1.56			1.55
Jakarta		1.84			3.20	
Kansas City, MO-KS MSA			1.70			1.47
Knoxville, TN MSA			1.49			1.48
Las Vegas-Paradise, NV MSA			1.19			2.29
Lexington-Fayette, KY MSA			1.35			1.40
London, UK		1.68			1.75	
Los Angeles-Long Beach-Santa Ana, CA MSA	1.49	1.46	1.64	1.54	1.65	1.65
Louisville/Jefferson County, KY-IN MSA			1.50			1.79
Miami-Fort Lauderdale-Pompano Beach, FL MSA	1.79	1.59	1.44	2.31	2.83	1.64
Milwaukee-Waukesha-West Allis, WI MSA			2.48			1.96
Minneapolis-St. Paul-Bloomington, MN-WI MSA			1.67			1.40
Nashville-Davidson-Murfreesboro-Franklin, TN MSA			1.88			1.45
New Orleans-Metairie-Kenner, LA MSA			2.53			1.42
New York-Northern New Jersey-Long Island, NY-NJ-PA MSA		1.65	1.65		1.61	1.99
Oklahoma City, OK MSA			1.69			1.60
Omaha-Council Bluffs, NE-IA MSA			2.09			1.42
Orlando-Kissimmee, FL MSA			1.63			1.51
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA			1.68			1.51
Phoenix-Mesa-Scottsdale, AZ MSA			1.41			1.83
Pittsburgh, PA MSA			1.67			1.56
Portland-Vancouver-Beaverton, OR-WA MSA			1.79			1.37
Raleigh-Cary, NC MSA			1.39			1.45
Richmond, VA MSA			1.50			1.64
Riverside-San Bernardino-Ontario, CA MSA			2.22			1.73
Sacramento-Arden-Arcade-Roseville, CA MSA			1.50			1.51
Salt Lake City, UT MSA			2.09			1.75
San Antonio, TX MSA			1.83			1.99
San Diego-Carlsbad-San Marcos, CA MSA			2.11			1.56
San Francisco-Oakland-Fremont, CA MSA			1.55			1.60
San Jose-Sunnyvale-Santa Clara, CA MSA			1.57			1.77
Sanya	1.86			2.11		
Savannah, GA MSA			1.32			1.82
Seattle-Tacoma-Bellevue, WA MSA			1.73			1.45
Shanghai	1.97	1.67		1.54	1.56	
Singapore		1.64			1.92	
South Bali		2.18			5.32	
St. Louis, MO-IL MSA			1.48			1.83
Tampa-St. Petersburg-Clearwater, FL			1.62			1.40
Toronto			1.88			1.92
Tulsa, OK MSA			1.72			1.46
Virginia Beach-Norfolk-Newport News, VA-NC MSA			1.66			1.55
Washington-Arlington-Alexandria, DC-VA-MD-WV MSA	1.57	1.71	1.49	1.52	1.39	1.54

In year-over-year change, the average change from 2016 is up significantly from the previous year.

The "Efficiency Gap" in Each Market

This year's analysis included a review of the ranges of performance within a market and segment, now adding the specification of laundry to the boundary (comparing only those with onsite laundry among themselves, and those without a laundry among themselves). The results for full-service hotels show a consistently wide range of performance in energy per square meter and water per occupied room. As Exhibit 9 shows, the ratio of upper quartile of performance to lower quartile of performance (upper quartile intensity divided by lower quartile intensity) is consistently over 1.5 for both energy per square meter and water per occupied room. On average, full-service hotels without an onsite laundry recorded a performance ratio of 1.73 for energy per square meter and 2.35 for water per occupied room. In contrast, full-service hotels with an onsite laundry recorded a performance ratio of 1.69 for energy per square meter and 1.78 for water per occupied room. Similarly, limited-service hotels, although performing better than full-service hotels, have a performance ratio on average of 1.70 for energy per square meter and 1.64 for water per occupied room.

These empirical data show the opportunity that exists across all markets for hotels to reduce their utility use. Some of the drivers will be amenities, such as pools, restaurants of various sizes, and public areas. However, the results and the wider CHSB data set can be used in modeling and for the business case to develop hotels toward a scenario of greater efficiency.

Limitations

Several limitations are present in this study given the data set and participating companies:

The results remain skewed toward the higher end of segment tiers.

As CHSB2019 relies heavily on large owners or operators of hotels to submit aggregate data sets, these data trend toward hotels that are managed by the same operators and not franchised. Although this year's brand data set increase was largely due to limited-service hotels, these properties are still within the range beginning with upper midscale or 3 stars. While this does not affect the benchmarking within other segments, on a whole the benchmarks for a metro area or country likely skew higher than the actual hotel supply of the same geography, given that economy hotels will consume less energy and water. As more participation is encouraged in future years, we will continue to seek data from economy and midscale or 1- and 2-star properties.

The results are skewed toward branded chains.

Similarly, given that the vast majority of the hotels in this study are represented by branded flags, the results may not represent those of the full hotel supply. It is possible, for instance, that branded hotels are more efficient than independent hotels, given the availability of capital that would allow brands to renovate and retrofit the building equipment and FF&E—an avenue not always available to independent hotels. The CHSB index still has a need to include more independent hotels to balance out the range and be representative of the actual hotel supply in any given geography.

The bulk of the data set covers the United States.

Although the data set covers forty-eight countries, 65 percent of the benchmarks are within U.S. geographies, and the ratio of hotels in the data set to overall hotels in the country is lower outside of the U.S. countries. The coverage has improved this year, and as indicated above, in future years we will continue to seek data sets from outside the U.S.

The data have not been verified.

Even considering our validity tests, unless all data have been verified using a third-party provider that assures the data, it cannot be concluded that the data sets are 100-percent accurate. Over 70 percent of the data set is submitted from participants whose data sets undergo external third-party verification in their own corporate reporting, which serves as a primary validation method. As data verification becomes more common and even mandated, CHSB may be able to include verification in a validity test, or to analyze subsets of verified vs. non-verified data.

As CHSB evolves to understand the drivers of energy, water, and carbon within hotels, we will seek to enhance comparisons to incorporate additional attributes and normalize for fair and meaningful comparison.

Outlook for CHSB2020

As we have outlined throughout this report, the CHSB study is an evolving index and process. Thus, the 2020 study will once again aim to provide an updated index with continually increasing data sets, segmentation, and granularity for participant benchmarking. We especially will continue to seek additional data from independents, smaller chains, and smaller properties currently underrepresented in the global data set.

Appendix

Greenhouse gas emission factors applied for measures 1, 2, 3, 4, and 7

	Australia	Canada	China (including Macau)	Taiwan	Hong Kong	United Kingdom	United States, Puerto Rico, other US Territories	All Other Countries and Territories
Purchased Electricity	National Greenhouse Accounts Factors July 2017	2016 Climate Registry - Default Emissions Factors April 2016	International Energy Agency CO2 Emissions from Fuel Combustion 2017	International Energy Agency CO2 Emissions from Fuel Combustion 2017	International Energy Agency CO2 Emissions from Fuel Combustion 2017	UK Government GHG Conversion Factors for Company Reporting 2017 v02	EPA eGRID 2014 V2 (updated February 27, 2017)	International Energy Agency CO2 Emissions from Fuel Combustion 2017
Natural Gas	National Greenhouse Accounts Factors July 2017	2016 Climate Registry - Default Emissions Factors April 2016	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	UK Government GHG Conversion Factors for Company Reporting 2017 v02	EPA Emission Factors for GHG Inventories last modified 12/14/2017	WRI Stationary Combustion Tool V4.1
Butane, Propane	National Greenhouse Accounts Factors July 2017	2016 Climate Registry - Default Emissions Factors April 2016	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	EPA Emission Factors for GHG Inventories last modified 12/14/2017	WRI Stationary Combustion Tool V4.1
Liquefied Petroleum Gas (LPG)	National Greenhouse Accounts Factors July 2017	2016 Climate Registry - Default Emissions Factors April 2016	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	Hong Kong Carbon Accounting guidelines. Table 1.1 - 1.3 (revised 2010)	UK Government GHG Conversion Factors for Company Reporting 2017 v02	EPA Emission Factors for GHG Inventories last modified 12/14/2017	WRI Stationary Combustion Tool V4.1
Liquefied Natural Gas (LNG)	National Greenhouse Accounts Factors July 2017	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	UK Government GHG Conversion Factors for Company Reporting 2017 v02	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1

Greenhouse gas emission factors applied for measures 1, 2, 3, 4, and 7 (continued)

Compressed Natural Gas (CNG)	National Greenhouse Accounts Factors July 2017	UK Government GHG Conversion Factors for Company Reporting 2017 V02	UK Government GHG Conversion Factors for Company Reporting 2017 v02	UK Government GHG Conversion Factors for Company Reporting 2017 v02	UK Government GHG Conversion Factors for Company Reporting 2017 v02	UK Government GHG Conversion Factors for Company Reporting 2017 v02	UK Government GHG Conversion Factors for Company Reporting 2017 v02	UK Government GHG Conversion Factors for Company Reporting 2017 v02
Stationary Gasoline/ Petrol	National Greenhouse Accounts Factors July 2017	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	UK Government GHG Conversion Factors for Company Reporting 2017 v02	EPA Emission Factors for GHG Inventories last modified 12/14/2017	WRI Stationary Combustion Tool V4.1
Stationary Diesel, Fuel Oil #1-#6	National Greenhouse Accounts Factors July 2017	2016 Climate Registry - Default Emissions Factors April 2016	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	Hong Kong Carbon Accounting guidelines. Table 1.1 - 1.3 (revised 2010)	UK Government GHG Conversion Factors for Company Reporting 2017 v02	EPA Emission Factors for GHG Inventories last modified 12/14/2017	WRI Stationary Combustion Tool V4.1
City Gas / Towngas	National Greenhouse Accounts Factors July 2017	WRI Stationary Combustion Tool V4.1 (Natural Gas as a proxy)	WRI Stationary Combustion Tool V4.1 (Natural Gas as a proxy)	WRI Stationary Combustion Tool V4.1 (Natural Gas as a proxy)	WRI Stationary Combustion Tool V4.1 (Natural Gas as a proxy)	WRI Stationary Combustion Tool V4.1 (Natural Gas as a proxy)	WRI Stationary Combustion Tool V4.1 (Natural Gas as a proxy)	WRI Stationary Combustion Tool V4.1 (Natural Gas as a proxy)
Biomass	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)
Charcoal	National Greenhouse Accounts Factors July 2017	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)	WRI Stationary Combustion Tool V4.1 (CH4 and N20 Only)

Greenhouse gas emission factors applied for measures 1, 2, 3, 4, and 7 (concluded)

Kerosene	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1
Ethanol	National Greenhouse Accounts Factors July 2017	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N20 Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N20 Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N20 Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N20 Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N20 Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N20 Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N20 Emissions only)
Purchased Steam, Heat, and Hot Water	UK Government GHG Conversion Factors for Company Reporting 2017 v02	US Energy Star Portfolio Manager Technical Reference: Greenhouse Gas Emissions, August 2017	UK Government GHG Conversion Factors for Company Reporting 2017 v02	UK Government GHG Conversion Factors for Company Reporting 2017 v02	UK Government GHG Conversion Factors for Company Reporting 2017 v02	UK Government GHG Conversion Factors for Company Reporting 2017 v02	US Energy Star Portfolio Manager Technical Reference: Greenhouse Gas Emissions, August 2017	Paris: Legifrance decree JORF n°0262 du 13 novembre 2014 page 19088; all other: UK Government GHG Conversion Factors for Company Reporting 2017 v02
Purchased Chilled Water	US EIA form 1605 (2010). Appendix N	US Energy Star Portfolio Manager Technical Reference: Greenhouse Gas Emissions, August 2017	US EIA form 1605 (2010). Appendix N	US EIA form 1605 (2010). Appendix N	US EIA form 1605 (2010). Appendix N	US EIA form 1605 (2010). Appendix N	US Energy Star Portfolio Manager Technical Reference: Greenhouse Gas Emissions, August 2017	Paris: Legifrance decree JORF n°0262 du 13 novembre 2014 page 19088; all other: US EIA form 1605 (2010). Appendix N

How to Use the Index

The index consists of two outputs: full data tables, and a search tool for accessing the index. Twelve full data tables are provided, each a separate tab containing the benchmarks for a single measure.

Exhibit 10

Measures used in the CHSB Index (2017 calendar-year data)

Measure 1	Carbon footprint of 1 room-night stay, per the Hotel Carbon Measurement Initiative (HCMI) methodology
Measure 2	Total carbon footprint of a property for the calendar year, divided by its number of rooms
Measure 3	Total carbon footprint of a property for the calendar year, divided by its number of OCCUPIED rooms within the same calendar year period
Measure 4	Total carbon footprint of a property for the calendar year, divided by its total floor area in SQUARE METERS
Measure 4a	Total carbon footprint of a property divided by its total floor area in SQUARE FEET
Measure 5	Total energy usage of a property for the calendar year, divided by its number of OCCUPIED rooms within the same calendar year period
Measure 6	Total energy usage of a property for the calendar year, divided by its floor area in SQUARE METERS
Measure 6a	Total energy usage of a property for the calendar year, divided by its floor area in SQUARE FEET
Measure 7	Carbon footprint of 1 square meter of meeting space occupied for 1 hour, per the Hotel Carbon Measurement Initiative (HCMI) methodology
Measure 8	Total water usage of a property for the calendar year, divided by its total number of OCCUPIED ROOMS within the same calendar year period
Measure 9	Total water usage of a property for the calendar year, divided by its floor area in SQUARE METERS
Measure 9a	Total water usage of a property for the calendar year, divided by its floor area in SQUARE FEET
Measure 10	Water usage of 1 room night stay, per the Hotel Water Measurement Initiative (HWMI) methodology
Measure 11	Water usage of 1 square meter of meeting space occupied for 1 hour, per the Hotel Water Measurement Initiative (HWMI) methodology
Measure 12	Percentage of a property's total energy usage within the calendar year that was generated onsite from renewable sources

Each data table contains the list of geographies and the benchmarks per segment. The data tables can be used for research and calculation purposes for multiple properties and regions.

Geographies

Benchmarks are provided for cities, regions, countries, or climate zones. See the *Geographies* tab in the tool for a complete listing.

Measure Values

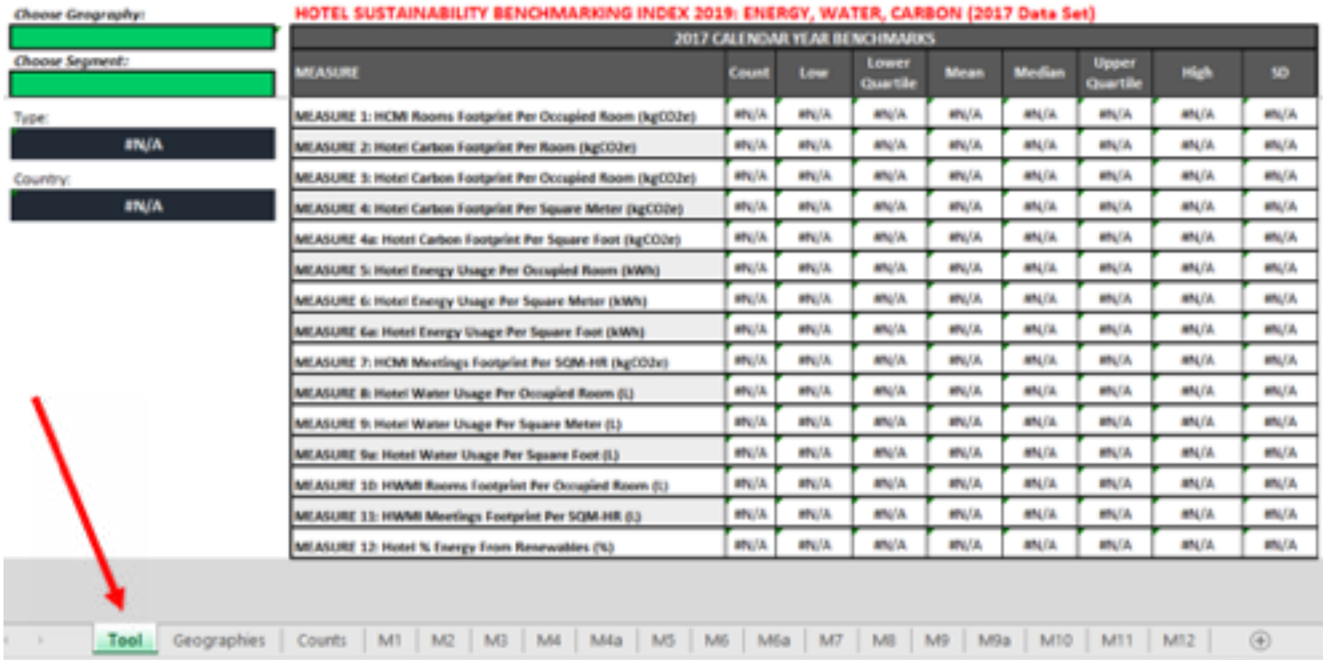
For each measure, values are broken down as follows:

1. **Count**—the number of properties included within this geography and segment grouping;
2. **Low**—the lowest value found within the geography segment grouping (this is the best performer of the group);
3. **Lower Quartile**—the 25-percent marker within the data set. Twenty-five percent of the properties within the geography and segment were at or below this figure;
4. **Mean**—the "average" or total output for the corresponding measure for the properties within the geography and segment, divided by the number of corresponding properties;
5. **Median**—the middle value found within the geography and segment grouping;
6. **Upper Quartile**—the 75-percent marker within the data set. Seventy-five percent of the properties within the geography and segment were at or below this figure;
7. **High**—the highest value found within the geography segment grouping (this is the worst performer of the group); and
8. **SD**—the standard deviation across the data set of properties within the geography and segment.

The Tool tab contains a searchable index per geography, segment, and measure. Steps to use the tool are outlined below.

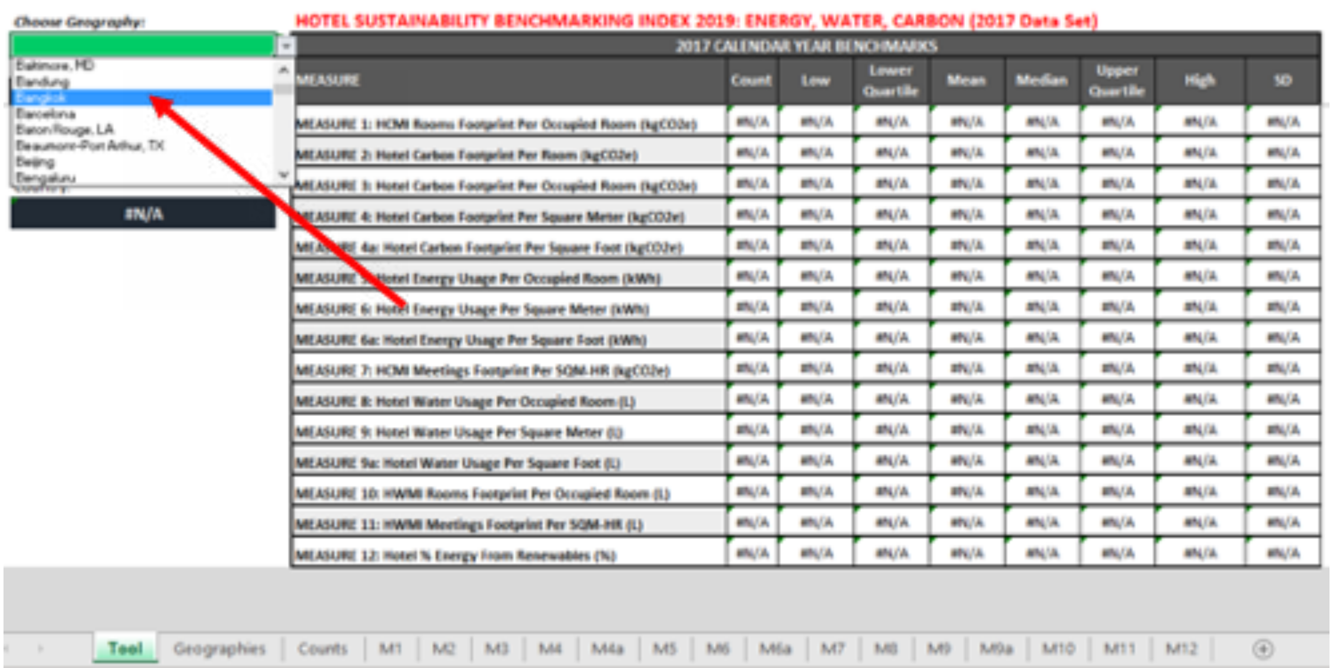
Hotels are welcome to participate in CHSB2020, calling for 2018 data sets. For further information, [illegible]@cornell.edu.

STEP 1: Click on the Tool tab.



2017 CALENDAR YEAR BENCHMARKS								
MEASURE	Count	Low	Lower Quartile	Mean	Median	Upper Quartile	High	SD
MEASURE 1: HCMI Rooms Footprint Per Occupied Room (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 2: Hotel Carbon Footprint Per Room (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 3: Hotel Carbon Footprint Per Occupied Room (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 4: Hotel Carbon Footprint Per Square Meter (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 4a: Hotel Carbon Footprint Per Square Foot (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 5: Hotel Energy Usage Per Occupied Room (kWh)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 6: Hotel Energy Usage Per Square Meter (kWh)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 6a: Hotel Energy Usage Per Square Foot (kWh)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 7: HCMI Meetings Footprint Per SQM-HR (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 8: Hotel Water Usage Per Occupied Room (L)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 9: Hotel Water Usage Per Square Meter (L)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 9a: Hotel Water Usage Per Square Foot (L)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 10: HWMI Rooms Footprint Per Occupied Room (L)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 11: HWMI Meetings Footprint Per SQM-HR (L)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 12: Hotel % Energy From Renewables (%)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

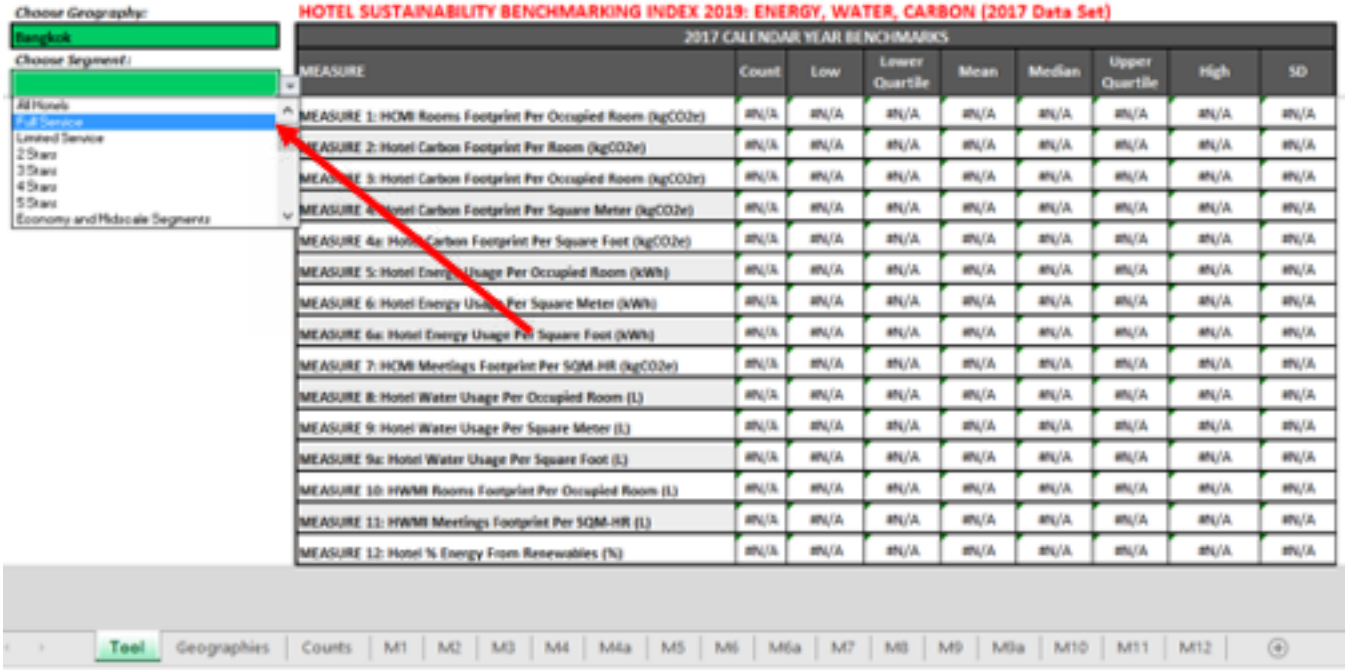
Step 2: Select the Geography to be used, choosing from the dropdown list. For further description of each geography, refer to the **Geographies** tab. Upon selecting the Geography, the Geography Type and Country will populate automatically in the dark gray-blue boxes.



2017 CALENDAR YEAR BENCHMARKS								
MEASURE	Count	Low	Lower Quartile	Mean	Median	Upper Quartile	High	SD
MEASURE 1: HCMI Rooms Footprint Per Occupied Room (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 2: Hotel Carbon Footprint Per Room (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 3: Hotel Carbon Footprint Per Occupied Room (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 4: Hotel Carbon Footprint Per Square Meter (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 4a: Hotel Carbon Footprint Per Square Foot (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 5: Hotel Energy Usage Per Occupied Room (kWh)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 6: Hotel Energy Usage Per Square Meter (kWh)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 6a: Hotel Energy Usage Per Square Foot (kWh)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 7: HCMI Meetings Footprint Per SQM-HR (kgCO2e)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 8: Hotel Water Usage Per Occupied Room (L)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 9: Hotel Water Usage Per Square Meter (L)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 9a: Hotel Water Usage Per Square Foot (L)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 10: HWMI Rooms Footprint Per Occupied Room (L)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 11: HWMI Meetings Footprint Per SQM-HR (L)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
MEASURE 12: Hotel % Energy From Renewables (%)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

How to Use the Tool (continued)

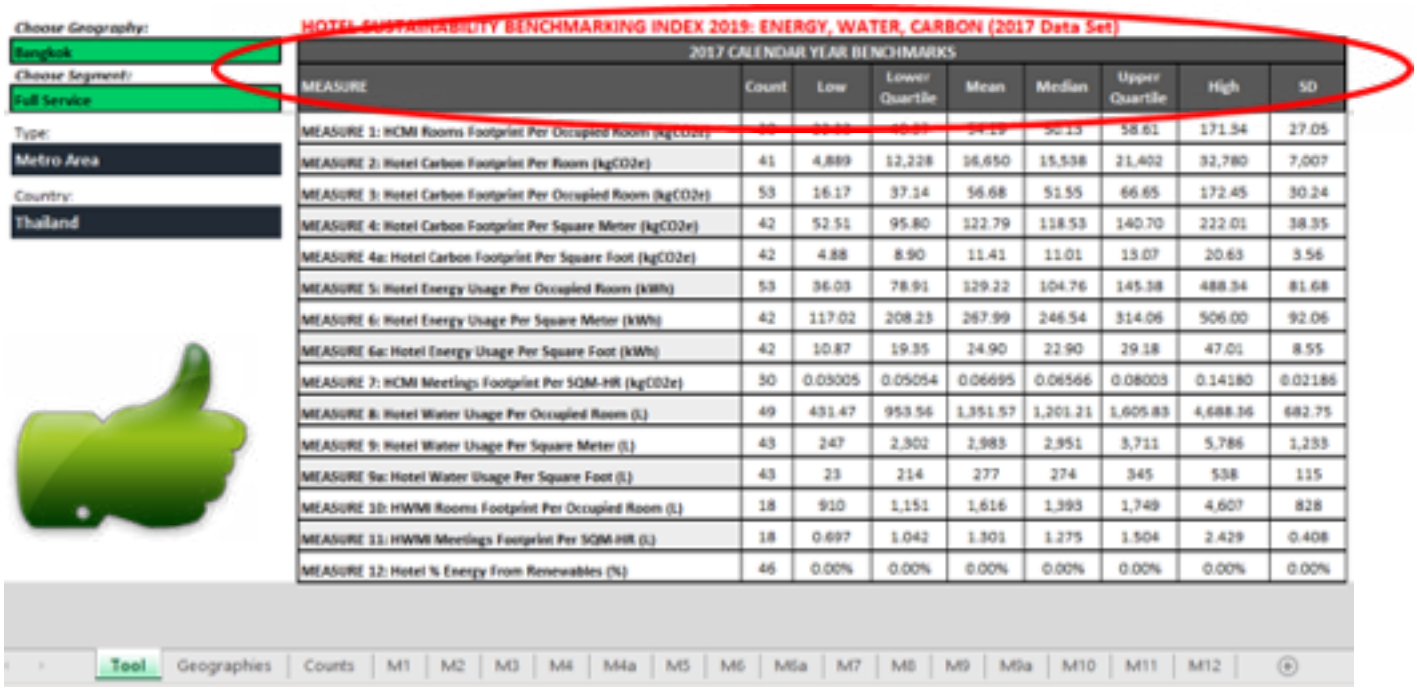
Step 3: Select the segment to be filtered from the dropdown list.



How to Use the Tool (continued)

Step 4: View the corresponding results in the gray table at the top "2017 Calendar Year Benchmarks."

The example below is for a user that has selected to view the data set corresponding to properties within the upscale and upper upscale market segments in the MSA of Bangkok,Thailand:



Choose Geography: Bangkok
Choose Segment: Full Service
Type: Metro Area
Country: Thailand

HOTEL SUSTAINABILITY BENCHMARKING INDEX 2019: ENERGY, WATER, CARBON (2017 Data Set)

2017 CALENDAR YEAR BENCHMARKS

MEASURE	Count	Low	Lower Quartile	Mean	Median	Upper Quartile	High	SD
MEASURE 1: HCMI Rooms Footprint Per Occupied Room (kgCO2e)	53	22.02	40.89	54.19	50.15	58.61	171.54	27.05
MEASURE 2: Hotel Carbon Footprint Per Room (kgCO2e)	41	4,889	12,228	16,650	15,538	21,402	32,780	7,007
MEASURE 3: Hotel Carbon Footprint Per Occupied Room (kgCO2e)	53	16.17	37.14	56.68	51.55	66.65	172.45	30.24
MEASURE 4: Hotel Carbon Footprint Per Square Meter (kgCO2e)	42	52.51	95.80	122.79	118.53	140.70	222.01	38.35
MEASURE 4a: Hotel Carbon Footprint Per Square Foot (kgCO2e)	42	4.88	8.90	11.41	11.01	13.07	20.63	3.56
MEASURE 5: Hotel Energy Usage Per Occupied Room (kWh)	53	36.03	78.91	129.22	104.76	145.38	488.34	81.68
MEASURE 6: Hotel Energy Usage Per Square Meter (kWh)	42	117.02	208.23	267.99	246.54	314.06	506.00	92.06
MEASURE 6a: Hotel Energy Usage Per Square Foot (kWh)	42	10.87	19.35	24.90	22.90	29.18	47.01	8.55
MEASURE 7: HCMI Meetings Footprint Per SQM-HR (kgCO2e)	30	0.03005	0.05054	0.06695	0.06566	0.08003	0.14180	0.02186
MEASURE 8: Hotel Water Usage Per Occupied Room (L)	49	431.47	953.56	1,351.57	1,201.21	1,605.83	4,688.36	682.75
MEASURE 9: Hotel Water Usage Per Square Meter (L)	43	247	2,302	2,983	2,951	3,711	5,786	1,233
MEASURE 9a: Hotel Water Usage Per Square Foot (L)	43	23	214	277	274	345	538	115
MEASURE 10: HWMI Rooms Footprint Per Occupied Room (L)	18	910	1,151	1,616	1,393	1,749	4,607	828
MEASURE 11: HWMI Meetings Footprint Per SQM-HR (L)	18	0.697	1.042	1.301	1.275	1.504	2.429	0.408
MEASURE 12: Hotel % Energy From Renewables (%)	46	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Tool | Geographies | Counts | M1 | M2 | M3 | M4 | M4a | M5 | M6 | M6a | M7 | M8 | M9 | M9a | M10 | M11 | M12

In this example:

- A possible 53 full-service hotels within the Bangkok metro area of Thailand constitute the benchmarks, though for each there may be less if some hotels did not have complete data that passed all validity tests. For example, Measure 10 and 11 are the lowest count, with 18 hotels in the data set for those specific measures.
- **Measure 1**: The mean (average) HCMI rooms footprint (guest footprint of a night stay) is 54.19 $kgCO_2e$/OCRM
- **Measure 2**: The upper quartile carbon footprint per room in a calendar year is 21,402 $kgCO_2e$/OCRM (meaning that of the 41 properties counted in the benchmark for this measure, 75% fell below 21,402 and 25% fell at or above 21,402)
- **Measure 6a:** The lowest energy usage per square foot is 10.87 kWh/Sqft
- **Measure 8**: The highest water usage per occupied room is 4,688.36 L/OCRM
- For all measures the quartiles, mean, and median all fall within the Low and High range.

Interpreting and Using the Results

Some examples of how these figures can be used to benefit from the tool:

- An owner, operator, or potential buyer of a single hotel in the Bangkok metro area can find where the hotel falls along the energy range.
- If the hotel is in the Upper Quartile, it can analyze internally what drivers are causing it to be in the high quartile. Some may be controllable, others not so.
- For additional analysis, the user may wish to choose a different segment or hotel type that relates to the hotel type (e.g., full service or resort), or a specific climate zone as available.
- A feasibility study for developing a hotel in the Bangkok metro area can choose where along this range to use the benchmark to estimate energy usage per occupied room, and conversely by changing to Measure 6, can perform further analysis based on floor area.
- An event planner organizing a citywide event in Bangkok which will require accommodations in dozens of hotels can use Measure 1, the HCMI rooms footprint (for example, choosing a higher range benchmark) and multiply that figure by the total number of rooms in order to calculate the total carbon footprint of the room block. The event planner can also use Measure 7 to calculate the footprint of the meeting space utilized during the event.
- If the event planner wanted to offer its attendees an option to offset the carbon footprint of their stay, it could incorporate the same figure as the base calculation for the attendee's carbon footprint.
- Researchers or policymakers from a municipality, region, or country seeking to understand the impact of water usage from hotels in their geography, they could obtain the current hotel supply and pipeline and run scenarios based on the statistics provided (e.g., high, low, mean).

CHR Advisory Board

Cornell Hospitality Report
Vol. 19, No. 4 (July 2019)

Cornell Hospitality Tools and *Cornell Hospitality Report* are produced for the benefit of the hospitality and service industries by
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at Cornell University

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