Hotel Sustainability

Benchmarking Index 2018: Carbon, Energy, and Water

by Eric Ricaurte

EXECUTIVE SUMMARY

The fifth annual Cornell Hotel Sustainability Benchmarking 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 a greater international participation, with fifty-one nations and thirteen international brands represented. More than 10,400 hotels contributed information regarding their energy and water use, as well as greenhouse gas emissions. Complete as of 2016, the data show that the participating hotels generally have continued to reduce their energy and water usage, although the energy intensity recorded by luxury hotels continues to be relatively high. While these data will 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. The study was supported by over a dozen international hotel firms, namely, Club Med Resorts, Hilton Worldwide, Host Hotels & Resorts, Hyatt Hotels Corporation, InterContinental Hotels Group, Mandarin Oriental Hotel Group, Marriott International, MGM Resorts International, Park Hotel Group, Saunders Hotel Group, Six Senses Hotels Resorts Spas, The Hongkong and Shanghai Hotels, and Wyndham Worldwide. Data collection is now underway for the 2019 study, and the author encourages 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.

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This report presents the results of the fifth annual Cornell Hotel Sustainability Benchmarking (CHSB) study. This is an update to last year's CHSB2017 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 fifth study continues to build upon the existing framework, expand the data set's geographical coverage, present historical trends across like-for-like hotel changes over the past year (as well as four years of similar data), and provide enhanced benchmarks and metrics—this year including additional climate zones and adding data from seasonal resorts. This year's report represents a 48-percent increase in the global data set, reaching over 10,000 hotels worldwide.

OVERVIEW

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

(1) Provide credible benchmarks according to industry-specific segmentation and metrics globally;

(2) Provide industry data analysis, using a confidential data set not provided to third parties or used commercially; and

(3) 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 448 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.

CHSB2018 Updates

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

(1) Segmented validity testing for energy and water, based on whether the hotel offers full service or limited service;

(2) Additional validity testing based on the ratio of guestrooms to total floor area (gross and net rooms and corridors only);

(3) Secondary climate zones added for benchmarking outputs using Bailey's Ecoregions of the World to address the limitations of the Koeppen-Geiger climate zones in segmenting temperate climates;

(4) A hotel-specific output tool that allows participants to output a summary of benchmarks for specific hotel properties, in addition to the aggregate output;

(5) Additional participant benchmarking outputs to add segmentation by more hotel attributes and a composite benchmark based on like-for-like attributes of hotels worldwide;

(6) Enhanced default hotel type designations based on county classifications for the United States from the U.S. National Center for Health Statistics Urban–Rural Classification Scheme for Counties;[1]

(7) Adding seasonal resort categories for hotel type (i.e., winter and summer) with annualized comparisons externally based on energy and water usage per month for the number of months corresponding to each season;

(8) Adding a bed and breakfast category for hotel type;

(9) Adding serviced apartments in combination with the timeshare hotel type;

(10) Breaking out further segmentation for non-urban areas into small metro/town and rural/highway;

(11) Adding U.S. state geographies as CHSB regions (even though they may have differing climate zones and greenhouse gas emission factors within the political boundary, the results have use in comparing against various state ordinances and benchmarking initiatives);

(12) Increase in the number of geographies from 296 to 448 across metro areas, regions, countries, and climate zones;

(13) Increase in the number of hotels for which benchmarks are generated to 10,401 (increase of 47.5%); and

(14) Analysis of comparative energy and water intensity for the full data set of full-service hotels, as compared to limited-service hotels.

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

(1) Default data. By aggregating data globally that are also segmented by geographic location and market segment, CSHB 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 applications in these countries.

(2) Feasibility study support. Entities performing feasibility studies for hotel development, renovation, and acquisition can utilize the tool's market- and

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[1] For further information, see: Ingram DD and Franco SJ. 2013 NCHS urban–rural classification scheme for counties. National Center for Health Statistics. *Vital Health Stat* 2 (166) 2014.

location-based ranges and benchmarks to support the forecasting of energy and water usage, and in some cases carbon taxes.

(3) 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.

(4) Harmonized greenhouse gas emissions calculations. The protocols for greenhouse gas 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 properties and companies. In receiving energy data and applying a uniform set of greenhouse gas emission factors, the index provides a single, harmonized data set.

(5) 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.

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

(7) 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 performance year-over-year.

(8) 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.

EXHIBIT 1

Participating organizations

Club Med Resorts
Hilton Worldwide
Host Hotels & Resorts
Hyatt Hotels Corporation
InterContinental Hotels Group
Mandarin Oriental Hotel Group
Marriott International
MGM Resorts International
Park Hotel Group
Saunders Hotel Group
Six Senses Hotels Resorts Spas
The Hongkong and Shanghai Hotels
Wyndham Worldwide

Participant Benefits[2]

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

(2) 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.

(3) Enabling internal benchmarking. Hotel properties and companies wishing to compare performance against a general competitive set across peers may use the benchmarks against their own performance.

[2] Participation is open and welcome for CHSB 2019, calling for 2017 data sets. For further information, please email eer3@cornell.edu.

Exhibit 2

Data collection points used to generate the external CHSB2018 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, so as 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 2016. If a hotel's room count changed during the year, the value most representative of the hotel's room count for 2016 was used.
Total Area	Total floor area of conditioned space of the property. 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/low-density, airport, convention, resort, timeshare.
12-Month Operation	Confirm with a "Yes" that the hotel was in operation for all of 2016 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 2016. Rooms sold may be used as a proxy.
Water	The total water consumption for each month in 2016 as provided by the utility provider.
Energy Consumption by Type	The total energy usage for each month in 2016 by type of energy source.

(4) 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.

(5) 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

We collected aggregate 2016 calendar-year data from the participating companies listed in Exhibit 1 (the most recent complete year of data). In total, the participants provided data for over 15,200 properties globally. Property data were received in aggregate data sets from each participating firm or its corresponding data provider. As part of this process, data collected by Horwath HTL Asia Pacific and then analyzed with similar validity testing by Greenview was incorporated into this year's data set to add another 1,300 non-

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	2.45%
FULL SERVICE Energy Per Occupied Room Outlier (kWh per occupied room)	700	25	Excluded from Measures 1,3,5,12	28.75%
LIMITED SERVICE Energy Per Occupied Room Outlier (kWh per occupied room)	200	20	Excluded from Measures 1,3,5,12	N/A (incorporated above)
FULL SERVICE Energy Per Square Meter outlier (kWh per m2)	1,300	80	Excluded from Measures 2,4,6,7,12	20.35%
LIMITED SERVICE Energy Per Square Meter outlier (kWh per m2)	700	65	Excluded from Measures 2,4,6,7,12	N/A
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 have 12 separate electricity data points	N/A	N/A	Excluded from Measures 1-7,12	9.94%
Property did not have 12 separate occupancy data points	N/A	N/A	Excluded from Measures 1,3,5,8	8.26%
Occupancy outlier	104%	35%	Excluded from Measures 1,3,5,8,10,11	22.33%
Property did not have 12 separate water data points	N/A	N/A	Excluded from Measures 8-11	17.71%
FULL SERVICE Water Per Occupied Room outlier (L per occupied room)	8,000	100	Excluded from Measure 8,10,11	39.53%
LIMITED SERVICE Water Per Occupied Room outlier (L per occupied room)	2,200	38	Excluded from Measure 8,10,11	N/A
FULL SERVICE Water Per Square Meter outlier (L per m2)	10,500	300	Excluded from Measures 9,11	34.47%
LIMITED SERVICE Water Per Square Meter outlier (L per m2)	8,000	70	Excluded from Measures 9,11	N/A
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
Percentage of Floor Area attributed to Rooms Footprint	100%	40%	Excluded from Measures 1,7,10,11	32.89%
Average SqM per guestroom of entire building outlier	20	2,500	Excluded from Measures 2,4,6,7,12	10.02%
Average size of a guestroom outlier (M2)	15	750	Excluded from Measures 1,7,10,11	36.32%
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	36.44%

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, we do not, for example, identify whether energy and water bills included restaurants, spas, fitness centers, or shared areas with other tenants within the building.

Output

We took the following five steps to arrive at the output tables for the CHSB2018 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 (GHG) 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, page 21, for a listing of 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. For other renewable sources such as solar, wind, geothermal, or deep-water cooling, an emission factor of zero was assigned to the energy type.

(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 metrics of 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 CHSB2018 index, segmentation by climate zone was added to enable benchmarking based on climate zones that span several regions across the globe. For this purpose, 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.

(4) Property segmentation. Fourth, properties were grouped by segments, applying the revenue-based approach and property-type segmentation used by STR Global (using 2016 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* 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 CHSB 2018 comprise data from up to 10,401 properties across 448 geographies. This represents a substantial increase from the prior year's data set (i.e., 2015 data for CHSB 2017), with 47.5-percent more properties added in 2016. The increase in data helped generate the minimum threshold required to add a host of new geographies, with nearly 200 added for CHSB2018, of which 51 were either new metro areas or countries.

FINDINGS

The exercise of aggregating inputs and producing the outputs, as well as 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 1,027 hotels in the data set have produced valid benchmarks for energy and water measures to enable a like-for-like comparison from calendar years 2013 to 2016. The approach to comparing the change over time depends on one's intended view and use

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 / Serviced Apartment
- Bed & Breakfast

All Hotels (within a given geography)

Exhibit 5

Four-year average change by measure among 1,027 hotels and by service type

Measure	2015-2016 Average Change	All Hotels	Full Service	Limited Service
Measure 4: GHG Emissions per Square Meter	Weighted Avg Change	-1.12%	0.33%	-1.43%
	Overall Avg Change	-2.12%	0.22%	-8.99%
	Avg of Averages Change	-2.67%	1.01%	-4.82%
Measure 5: Energy per Occupied Room	Weighted Avg Change	-1.33%	-0.32%	-0.92%
	Overall Avg Change	-8.60%	8.81%	-2.10%
	Avg of Averages Change	-2.29%	-0.70%	-2.93%
Measure 6: Energy per Square Meter	Weighted Avg Change	2.12%	2.86%	-0.75%
	Overall Avg Change	1.66%	4.95%	-7.89%
	Avg of Averages Change	0.09%	4.12%	-2.28%
Measure 8: Water per Occupied Room	Weighted Avg Change	-4.36%	-4.33%	0.08%
	Overall Avg Change	-12.61%	1.48%	1.72%
	Avg of Averages Change	-1.59%	-6.57%	1.63%
Measure 9: Water per Square Meter	Weighted Avg Change	-0.07%	-0.70%	0.65%
	Overall Avg Change	-2.81%	-2.12%	-4.30%
	Avg of Averages Change	1.41%	-1.21%	2.96%

Exhibit 6

Year-over-year average change by measure among 3,226 hotels and by service type

Measure	2015-2016 Average Change	All Hotels	Full Service	Limited Service
Measure 4: GHG Emissions per Square Meter	Weighted Avg Change	-1.12%	0.33%	-1.43%
	Overall Avg Change	-2.12%	0.22%	-8.99%
	Avg of Averages Change	-2.67%	1.01%	-4.82%
Measure 5: Energy per Occupied Room	Weighted Avg Change	-1.33%	-0.32%	-0.92%
	Overall Avg Change	-8.60%	8.81%	-2.10%
	Avg of Averages Change	-2.29%	-0.70%	-2.93%
Measure 6: Energy per Square Meter	Weighted Avg Change	2.12%	2.86%	-0.75%
	Overall Avg Change	1.66%	4.95%	-7.89%
	Avg of Averages Change	0.09%	4.12%	-2.28%
Measure 8: Water per Occupied Room	Weighted Avg Change	-4.36%	-4.33%	0.08%
	Overall Avg Change	-12.61%	1.48%	1.72%
	Avg of Averages Change	-1.59%	-6.57%	1.63%
Measure 9: Water per Square Meter	Weighted Avg Change	-0.07%	-0.70%	0.65%
	Overall Avg Change	-2.81%	-2.12%	-4.30%
	Avg of Averages Change	1.41%	-1.21%	2.96%

of the information, whether at a geography level or individual-property level. Exhibit 5 presents the change from 2013 to 2016 in five measures using three types of average change. Most of the historical trend data set (82%) 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.

EXHIBIT 7

Four-year historical overall average change by selected geography, 2013-2016

	FULL SERVICE HOTELS ONLY							LIMITED SERVICE							ALL HOTELS						
Country	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9
United States	359	16,202,058	-7.5%	0.5%	6.0%	-9.6%	-4.6%	486	3,727,413	-25.4%	-14.5%	-15.3%	-7.0%	-8.0%	845	19,929,471	-10.6%	-1.1%	2.6%	-8.6%	-5.2%
China	24	1,374,422	-18.4%	-11.0%	2.3%	-6.4%	7.6%								25	1,384,225	-20.3%	-11.5%	0.0%	-7.0%	5.0%
Canada	10	403,190	-12.1%	-11.9%	-8.8%	-8.7%	-5.5%	9	90,723	2.2%	3.4%	17.5%	24.7%	41.6%	19	493,914	-10.4%	-10.5%	-5.4%	-3.3%	2.3%
India	10	486,157	-12.2%	-15.7%	-6.2%	-13.2%	-3.4%								12	534,909	-19.9%	-29.7%	-22.1%	-15.9%	-6.9%
United Arab Emirates															8	474,368	-9.5%	-12.2%	-13.8%	1.3%	-0.6%
United Kingdom															8	134,577	-58.2%	-40.8%	-49.3%	-34.9%	-44.2%
Japan	8	342,572	19.7%	14.2%	19.0%	-6.5%	-2.6%								8	342,572	19.7%	14.2%	19.0%	-6.5%	-2.6%
All	512	22,624,098	-7.7%	-1.1%	4.1%	-8.0%	-3.2%	510	4,110,143	-29.5%	-19.5%	-21.0%	-8.1%	-9.7%	1,022	26,734,240	-10.7%	-2.8%	0.7%	-7.4%	-4.1%
Metro Area	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9
Washington-Arlington-Alexandria, DC-VA-MD-WV MSA	32	1,394,114	-18.0%	-10.6%	-2.7%	-9.1%	-1.1%	19	188,984	-42.0%	-34.9%	-31.6%	-11.0%	-6.6%	51	1,583,098	-20.8%	-13.1%	-6.0%	-9.2%	-1.7%
Los Angeles-Long Beach-Santa Ana, CA MSA	26	1,026,435	3.6%	-2.7%	7.6%	-6.0%	3.9%	22	240,791	-20.3%	-15.4%	-15.1%	-12.0%	-11.7%	48	1,267,226	-1.5%	-4.5%	2.7%	-7.2%	-0.2%
New York-Northern New Jersey-Long Island, NY-NJ-PA MSA	28	1,316,563	-1.2%	3.6%	4.6%	-11.7%	-10.9%	18	132,950	-18.4%	0.7%	-3.4%	4.0%	-0.2%	46	1,449,512	-2.7%	3.6%	4.0%	-10.3%	-10.0%
Miami-Fort Lauderdale-Pompano Beach, FL MSA	21	615,054	-12.1%	2.1%	1.0%	-7.4%	-8.4%	15	126,215	-15.9%	-3.6%	-3.3%	-19.8%	-19.5%	36	741,269	-12.7%	1.1%	0.4%	-9.7%	-10.3%
San Francisco-Oakland-Fremont, CA MSA	16	663,599	-9.8%	-11.7%	-6.7%	-15.2%	-10.5%	17	201,103	2.6%	-11.1%	6.6%	-16.7%	-0.2%	33	864,702	-7.6%	-12.6%	-4.3%	-15.7%	-7.7%
Phoenix-Mesa-Scottsdale, AZ MSA	9	494,516	-6.5%	19.1%	24.0%	-6.5%	-2.6%	20	157,272	2.3%	2.1%	18.1%	7.9%	24.8%	29	651,788	-5.2%	13.9%	23.2%	-6.4%	1.3%
Houston-Sugar Land-Baytown, TX MSA	9	376,571	-19.9%	1.1%	-7.2%	2.5%	-5.9%	16	100,581	-20.7%	4.3%	-6.9%	10.2%	-1.6%	25	477,152	-20.0%	1.9%	-7.2%	4.4%	-4.9%
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA								17	161,512	-23.8%	-14.2%	-9.3%	-4.9%	0.6%	23	407,473	-19.0%	-6.8%	-2.1%	-2.3%	2.6%
Chicago-Naperville-Joliet, IL-IN-WI MSA	11	719,080	-3.7%	-1.0%	2.0%	4.9%	8.2%	10	70,334	-32.2%	-26.6%	-37.7%	17.0%	-0.6%	21	789,413	-6.6%	-2.0%	-1.8%	7.1%	7.2%
Orlando-Kissimmee, FL MSA	8	720,462	-13.6%	-6.3%	0.3%	-26.8%	-21.7%	11	124,319	5.2%	-4.2%	16.7%	-20.6%	-3.3%	19	844,781	-11.9%	-8.0%	1.6%	-27.1%	-19.4%
Atlanta-Sandy Springs-Marietta, GA MSA	9	542,308	4.3%	-15.9%	20.7%	-12.4%	25.7%	9	106,185	-43.4%	-28.5%	-41.9%	-4.5%	-22.5%	18	648,493	-7.8%	-15.1%	3.6%	-8.0%	12.2%
Seattle-Tacoma-Bellevue, WA MSA	9	361,620	-3.8%	-7.8%	-5.4%	-8.4%	-5.9%	8	73,725	-43.2%	-26.1%	-35.6%	-14.7%	-25.7%	17	435,346	-11.8%	-10.3%	-11.9%	-9.2%	-10.8%
San Antonio, TX MSA								9	83,603	-14.9%	-6.0%	-2.5%	-17.8%	-14.7%	16	538,957	-13.5%	8.0%	9.0%	-12.8%	-11.9%
Tampa-St. Petersburg-Clearwater, FL								9	49,861	-56.9%	-35.6%	-46.8%	-26.5%	-39.2%	16	304,010	-18.3%	-12.3%	-6.8%	-6.6%	-0.6%
Nashville-Davidson-Murfreesboro-Franklin, TN MSA								11	71,335	-43.3%	-22.1%	-38.8%	-17.1%	-34.9%	16	581,706	23.7%	62.9%	58.3%	2.7%	-0.2%
Minneapolis-St. Paul-Bloomington, MN-WI MSA								9	62,307	-17.7%	3.9%	-0.2%	-10.2%	-13.8%	16	355,884	17.4%	6.9%	39.8%	5.6%	38.1%
San Diego-Carlsbad-San Marcos, CA MSA	9	650,753	-11.0%	-17.5%	-11.0%	-21.5%	-15.4%								15	719,892	-10.3%	-16.1%	-9.8%	-21.4%	-15.6%
Dallas-Fort Worth-Arlington, TX MSA								8	59,190	-9.8%	-8.5%	4.6%	-20.0%	-8.5%	13	393,986	-5.0%	-3.7%	10.2%	26.4%	44.7%
Boston-Cambridge-Quincy, MA-NH MSA	12	479,135	-29.1%	-9.4%	-17.5%	-17.1%	-24.6%								13	483,037	-29.6%	-9.8%	-18.1%	-17.8%	-25.4%
Denver-Aurora, CO MSA															12	300,679	-8.8%	8.4%	12.2%	6.3%	10.1%
Kansas City, MO-KS MSA								10	69,518	-26.2%	-18.5%	-15.0%	-2.0%	2.2%	11	93,859	-27.6%	-19.2%	-17.0%	-4.2%	-1.6%
Shanghai	11	577,711	-19.1%	-16.7%	-1.2%	-10.3%	6.4%								11	577,711	-19.1%	-16.7%	-1.2%	-10.3%	6.4%
Indianapolis-Carmel, IN MSA															11	236,887	-12.5%	-1.4%	1.7%	-10.0%	-7.2%
New Orleans-Metairie-Kenner, LA MSA															11	469,595	-17.2%	-11.8%	-17.2%	10.4%	3.7%
Jacksonville, FL MSA															10	264,099	-7.3%	2.4%	8.7%	-21.5%	-16.7%
San Jose-Sunnyvale-Santa Clara, CA MSA															10	212,826	-12.4%	-7.3%	-9.0%	-12.6%	-14.2%
HI NONMETROPOLITAN AREA	8	510,086	-19.6%	-0.9%	5.1%	0.2%	6.3%								10	539,013	-18.9%	-0.9%	5.1%	-0.4%	5.6%
Portland-Vancouver-Beaverton, OR-WA MSA															8	82,551	-12.0%	-6.1%	-7.1%	-4.5%	-5.6%
Raleigh-Cary, NC MSA								8	47,922	-39.4%	-15.4%	-20.3%	-7.6%	-12.9%	8	47,922	-39.4%	-15.4%	-20.3%	-7.6%	-12.9%
St. Louis, MO-IL MSA															8	210,690	-3.7%	9.2%	11.0%	7.8%	9.6%

EXHIBIT 8

Year-over-year overall average change by selected geography, 2015-2016

	FULL SERVICE HOTELS ONLY							LIMITED SERVICE							ALL HOTELS						
Country	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9
United States	562	23,991,264	2.3%	0.3%	7.3%	-9.2%	-2.9%	1,565	12,321,405	-11.1%	-8.9%	-10.0%	-4.4%	-5.5%	2,127	36,312,669	-1.6%	-0.9%	2.5%	-7.0%	-3.7%
China	123	7,434,509	-2.0%	-14.5%	2.4%	-16.2%	0.3%	91	3,564,878	-4.1%	-11.7%	-3.0%	-10.4%	-1.5%	214	10,999,387	-2.5%	-12.8%	1.0%	-13.9%	-0.2%
United Kingdom	49	954,157	-5.7%	8.3%	5.4%	3.6%	0.8%	47	436,848	-30.3%	-20.6%	-23.7%	-11.2%	-14.6%	96	1,391,005	-13.8%	-1.3%	-4.4%	-1.2%	-4.3%
India	30	1,100,135	-4.8%	-10.7%	0.8%	-10.2%	1.4%	14	290,683	-5.4%	-18.8%	-2.3%	-33.5%	-20.1%	44	1,390,819	-4.9%	-12.3%	0.3%	-14.8%	-2.5%
Canada	26	894,717	-3.6%	-8.8%	-3.5%	-14.1%	-9.2%	81	796,232	-2.8%	-8.7%	-5.1%	2.4%	6.5%	107	1,690,949	-3.3%	-8.6%	-4.2%	-6.1%	-1.6%
Germany	25	648,050	3.0%	-0.1%	13.6%	-13.6%	-1.8%	17	238,308	-7.0%	-2.8%	-1.3%	-2.1%	-0.7%	42	886,358	1.0%	0.3%	10.0%	-10.2%	-1.5%
Japan	20	971,631	2.1%	-3.4%	5.8%	-9.6%	-1.0%								26	1,158,026	1.6%	-1.5%	4.9%	-7.0%	-0.9%
Mexico	18	580,458	13.5%	6.8%	18.9%	-4.2%	6.7%	47	637,189	-0.1%	-7.1%	-2.1%	1.0%	6.5%	65	1,217,647	7.9%	2.0%	10.0%	-1.2%	6.6%
France	16	322,864	12.1%	12.1%	1.5%	-3.0%	-12.2%	8	66,350	5.1%	11.1%	-1.8%	1.8%	-10.0%	24	389,214	11.2%	12.2%	1.1%	-2.1%	-11.8%
United Arab Emirates	16	1,110,015	-4.5%	-13.6%	8.6%	-18.8%	2.1%								23	1,329,850	-6.5%	-10.3%	6.1%	-15.6%	-0.2%
Thailand	15	603,716	7.3%	-12.2%	12.1%	-13.3%	10.6%	8	231,822	-15.2%	-17.6%	-14.2%	-1.4%	2.5%	23	835,538	2.0%	-11.7%	5.6%	-9.2%	8.7%
Turkey	15	601,780	-13.1%	19.1%	-4.8%	4.8%	-16.2%								21	735,295	-13.5%	15.6%	-5.3%	5.1%	-13.9%
Italy	12	294,590	4.6%	-10.8%	3.3%	-15.9%	-2.7%	12	134,538	2.8%	6.2%	2.7%	-0.8%	-4.1%	24	429,128	4.2%	-4.7%	3.1%	-10.3%	-2.9%
Russian Federation	12	343,593	13.8%	-0.6%	14.2%	-3.5%	10.7%								19	492,853	9.1%	-1.8%	9.3%	-4.1%	6.8%
Singapore	12	382,985	-2.2%	-6.9%	-1.8%	-10.6%	-5.6%								14	445,825	-1.9%	-6.3%	-1.4%	-10.0%	-5.2%
Indonesia	11	477,122	-0.9%	-4.5%	-1.0%	-8.9%	-5.5%								14	527,767	0.1%	-6.9%	-0.1%	-12.0%	-5.5%
Korea	10	492,044	2.5%	-13.2%	0.8%	-11.1%	3.2%								12	603,263	1.5%	-14.3%	-0.9%	-11.9%	1.8%
Spain	9	178,686	13.8%	-19.2%	2.8%	-20.3%	1.4%								14	252,423	12.8%	-14.8%	2.1%	-15.6%	1.0%
Hong Kong, China	9	421,370	-12.5%	-5.0%	-1.2%	-15.3%	-11.9%								13	514,203	-11.0%	-3.8%	-0.1%	-14.1%	-10.8%
Argentina	9	311,034	-2.5%	-12.8%	-0.5%	-12.3%	0.1%								10	316,407	-2.6%	-13.0%	-0.5%	-11.8%	0.9%
Netherlands	8	156,416	6.2%	7.0%	11.6%	-6.4%	-2.4%	11	133,672	18.4%	24.8%	19.4%	3.3%	-1.2%	19	290,088	11.5%	15.7%	15.3%	-1.5%	-1.8%
Poland	8	241,376	-26.0%	-26.3%	-15.2%	-10.5%	2.9%								10	268,225	-24.6%	-24.2%	-14.2%	-9.2%	2.7%
Austria	8	178,284	4.4%	-7.6%	-1.0%	-9.1%	-2.6%								8	178,284	4.4%	-7.6%	-1.0%	-9.1%	-2.6%
All	1,179	48,218,164	0.2%	-3.2%	5.0%	-9.7%	-2.1%	2,013	21,322,095	-9.0%	-8.4%	-7.9%	-4.8%	-4.3%	3,192	69,540,259	-2.1%	-3.4%	1.8%	-7.6%	-2.7%
Metro Area	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9	Count	SqM	Measure 4	Measure 5	Measure 6	Measure 8	Measure 9
Washington-Arlington-Alexandria, DC-VA-MD-WV MSA	44	1,755,114	-2.1%	-4.9%	2.3%	-7.6%	-0.5%	49	472,955	-19.9%	-19.5%	-16.7%	-8.7%	-5.5%	93	2,228,069	-5.5%	-7.2%	-1.1%	-7.6%	-1.5%
New York-Northern New Jersey-Long Island, NY-NJ-PA MSA	42	1,646,360	-2.4%	-1.2%	3.0%	-5.1%	-1.1%	45	393,150	-12.5%	-4.2%	-10.3%	2.6%	-3.8%	87	2,039,510	-4.0%	-0.6%	1.0%	-3.2%	-1.6%
Los Angeles-Long Beach-Santa Ana, CA MSA	35	1,401,858	9.2%	5.2%	15.1%	-4.4%	4.7%	41	452,756	-16.6%	-10.9%	-12.2%	-7.9%	-9.2%	76	1,854,614	2.7%	2.2%	8.1%	-5.2%	0.4%
Miami-Fort Lauderdale-Pompano Beach, FL MSA	28	1,000,770	-4.7%	0.9%	-1.1%	-7.7%	-9.6%	29	289,318	-8.3%	0.6%	-3.1%	-14.1%	-17.3%	57	1,290,088	-5.3%	1.1%	-1.5%	-8.9%	-11.2%
Chicago-Naperville-Joliet, IL-IN-WI MSA	23	1,197,711	1.1%	-6.0%	2.5%	-3.4%	5.3%	27	344,430	-12.1%	-10.7%	-16.4%	2.3%	-4.2%	50	1,542,141	-1.3%	-5.4%	-0.6%	-1.8%	3.3%
London, UK	23	545,130	-2.5%	11.9%	9.2%	10.1%	7.4%	10	74,022	-62.7%	-50.4%	-59.3%	-35.6%	-47.2%	33	619,151	-17.2%	-2.4%	-7.9%	0.0%	-5.6%
San Francisco-Oakland-Fremont, CA MSA	22	963,909	-15.8%	-11.6%	-10.6%	-9.0%	-7.9%	29	310,099	2.3%	-1.4%	7.4%	0.8%	9.8%	51	1,274,008	-12.5%	-10.4%	-7.3%	-6.0%	-2.8%
Shanghai	21	1,173,601	0.8%	-4.9%	5.1%	-4.5%	5.5%	19	673,502	0.8%	-6.1%	1.0%	-4.7%	2.5%	40	1,847,103	0.8%	-4.8%	4.1%	-4.3%	4.7%
Phoenix-Mesa-Scottsdale, AZ MSA	17	835,952	25.9%	7.2%	30.2%	-4.4%	16.0%	40	359,856	15.8%	4.0%	10.5%	2.2%	8.6%	57	1,195,808	23.6%	9.3%	25.8%	-0.8%	14.2%
Houston-Sugar Land-Baytown, TX MSA	17	582,003	-2.6%	-2.7%	1.4%	-10.0%	-6.3%	36	214,941	-5.2%	9.1%	0.2%	3.9%	-4.6%	53	796,944	-3.2%	1.4%	1.2%	-5.5%	-5.8%
Boston-Cambridge-Quincy, MA-NH MSA	17	696,262	-19.8%	-16.3%	-19.2%	-13.9%	-16.8%								22	719,559	-19.8%	-15.3%	-19.2%	-13.0%	-17.0%
Atlanta-Sandy Springs-Marietta, GA MSA	15	781,974	20.2%	-5.9%	20.7%	-4.1%	23.0%	18	188,738	-25.0%	-17.8%	-29.1%	-5.1%	-18.2%	33	970,712	8.9%	-4.5%	7.9%	-2.7%	9.9%
Dallas-Fort Worth-Arlington, TX MSA	14	831,963	-0.4%	-10.5%	5.3%	7.9%	26.9%	29	292,184	-10.6%	-18.4%	-14.2%	-16.9%	-12.7%	43	1,124,147	-2.4%	-10.5%	1.5%	4.0%	18.0%
Seattle-Tacoma-Bellevue, WA MSA	13	593,544	-5.3%	-9.4%	-2.1%	-10.2%	-3.0%	22	198,741	-29.2%	-12.3%	-16.9%	-5.8%	-10.7%	35	792,285	-11.1%	-9.2%	-5.9%	-8.8%	-5.6%
Minneapolis-St. Paul-Bloomington, MN-WI MSA	13	424,010	32.0%	-0.2%	34.7%	0.5%	35.6%	20	226,280	3.7%	7.7%	6.3%	-4.3%	-5.6%	33	650,290	22.7%	5.2%	25.8%	0.0%	19.6%
Denver-Aurora, CO MSA	13	588,342	2.5%	-1.0%	8.3%	-4.0%	5.0%	11	121,313	-27.4%	-10.8%	-26.7%	-0.1%	-18.0%	24	709,656	-3.4%	-0.2%	2.2%	-3.5%	-1.2%
Orlando-Kissimmee, FL MSA	12	1,369,345	5.9%	9.4%	11.0%	-13.6%	-12.4%	20	305,146	3.7%	-3.0%	5.6%	-3.6%	5.0%	32	1,674,491	5.7%	7.0%	10.4%	-13.3%	-10.5%
San Diego-Carlsbad-San Marcos, CA MSA	12	848,922	1.1%	0.7%	3.8%	-9.4%	-6.6%	18	177,661	-4.6%	-0.4%	3.0%	-7.6%	-4.4%	30	1,026,582	0.3%	0.5%	3.7%	-9.0%	-6.2%
Paris	12	255,031	15.3%	15.4%	2.4%	-4.1%	-14.9%								16	303,891	13.8%	16.8%	1.8%	-2.1%	-14.7%
Singapore	12	382,985	-2.2%	-6.9%	-1.8%	-10.6%	-5.6%								14	445,825	-1.9%	-6.3%	-1.4%	-10.0%	-5.2%
Istanbul	11	412,791	-14.0%	30.3%	-4.1%	12.5%	-17.2%								13	461,792	-15.0%	29.5%	-4.9%	12.6%	-17.3%
San Antonio, TX MSA	10	630,924	-1.8%	-1.0%	2.2%	-7.6%	-4.6%	22	167,832	-5.7%	-3.4%	-1.4%	-14.6%	-12.8%	32	798,756	-2.5%	-1.2%	1.6%	-9.2%	-6.6%
Indianapolis-Carmel, IN MSA	10	384,074	3.7%	5.1%	11.6%	1.7%	8.1%	22	139,848	-8.6%	-1.4%	0.1%	-8.7%	-7.4%	32	523,922	1.1%	4.6%	9.2%	-0.9%	3.5%
Tampa-St. Petersburg-Clearwater, FL	10	323,867	1.6%	-5.6%	6.2%	5.8%	19.0%	16	107,941	-34.0%	-17.6%	-28.3%	-13.8%	-25.1%	26	431,808	-7.8%	-5.0%	-2.8%	2.4%	4.8%
New Orleans-Metairie-Kenner, LA MSA	9	535,024	-9.3%	-5.1%	-0.7%	-3.2%	1.4%	13	160,441	-35.6%	-27.2%	-38.6%	28.8%	8.6%	22	695,465	-16.2%	-7.9%	-10.0%	5.6%	3.2%
Dubai	9	775,242	-3.0%	-12.4%	11.1%	-20.9%	0.3%								13	913,499	-5.9%	-11.0%	7.3%	-18.3%	-1.6%
Frankfurt	9	246,595	1.2%	-5.3%	11.3%	-17.8%	-3.4%								9	246,595	1.2%	-5.3%	11.3%	-17.8%	-3.4%
Toronto	8	260,591	-8.7%	-7.8%	-6.7%	-10.3%	-9.4%	17	193,599	-6.7%	-12.3%	-5.7%	2.4%	10.0%	25	454,190	-8.0%	-10.2%	-6.4%	-4.8%	-0.7%
Beijing	8	544,082	-4.4%	-13.2%	-0.6%	-15.8%	-3.6%	11	526,633	-12.0%	-13.5%	-11.5%	-14.2%	-12.3%	19	1,070,715	-7.4%	-12.0%	-5.1%	-13.8%	-7.0%
Bangkok	8	411,381	11.0%	-12.5%	15.9%	-12.5%	15.9%								13	575,819	3.4%	-13.9%	7.0%	-9.0%	13.0%
Mexico City	8	289,460	23.4%	11.8%	29.6%	-8.5%	6.1%								11	336,003	22.0%	12.2%	27.6%	-7.4%	5.3%
HI NONMETROPOLITAN AREA	8	414,169	11.8%	12.5%	17.2%	-5.3%	-1.3%								10	443,095	12.6%	12.1%	16.7%	-5.5%	-1.6%

EXHIBIT 9

Frequency and ratio of energy and water intensity for full-service and limited-service hotels

Full Service vs. Limited Service	Measure 5 (Energy per OCRM)	Measure 6 (Energy per M^2)	Measure 8 (Water per OCRM)	Measure 9 (Water per M^2)
Number of Geographies	159	175	137	145
Full Service Higher Intensity Frequency	100%	98%	98%	66%
Average Full-Service intensity above Limited Service	112%	50%	64%	15%

In addition, starting this year we are analyzing a year-over-year output of all properties within the data set for the past two years that also pass all validity tests (see Exhibit 6). The resulting year-over-year data set included a total of 3,226 properties, of which 62 percent are limited-service operations. Around 66 percent of the properties are from United States, comprising 1,565 limited-service properties (74%). Overall observations reveal that limited-service properties perform better than full-service properties in most of the countries, including the United States.

Exhibits 5 and 6 employ the following three terms:

- *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.

Energy usage has not reduced consistently since 2013. The energy intensity of the like-for-like data set has reduced slightly to an increase of 0.54 percent overall and 1.73 percent weighted on average since 2013. This increase is driven by full-service hotels, which account for a larger portion of the data set and footprint. Among limited-service hotels however, energy usage has consistently reduced over time in all measures.

Water usage intensity, by contrast, has reduced consistently. With exception of a few countries with fewer than twenty properties and by overall average change, the water intensity of the like-for-like data set has reduced consistently since 2013. The overall average water usage per occupied room has reduced to -7.47 percent from -3.4 percent. Elsewhere, overall average of water intensity per square meter also has reduced consistently to -4.37 percent from -0.6 percent since 2013.

Some metro areas within the data set have achieved significant reductions. Notably, consistent reductions in water intensity, energy intensity, and carbon emission are observed in Washington, D.C., San Francisco, and Boston since 2013. Similar to the existence of many considerations and local drivers affecting a market's average daily rate (ADR) and occupancy rate, performance relating to sustainability metrics may require local market analysis to truly understand the drivers and competitive positioning. It is not the intention of the CHSB Index to identify each driver. However, use of the annual benchmarks as a basis for deeper market-based analysis can support the understanding of sustainability benchmarking immensely and such collaboration opportunities are welcome.

Full Service vs. Limited Service

Full-service hotels consistently use more energy and water intensity than limited-service hotels. This comparison is rarely, if ever disputed, nor should it be considered in a negative light. Full-service hotels by definition provide more amenities and generally offer more services to guests. This year we analyzed the full data set in each comparable geography to understand the ratio of energy and water usage of each type. In all instances, full-service hotels have higher energy and

water intensity than that of limited-service operations. In the key intensity metrics of floor area (for energy) and occupied rooms (for water), 98 percent of the geographies demonstrated higher full-service intensity, with an average increase in intensity of 50 percent for energy and 64 percent for water. Interesting to note, however, was the water intensity by floor area, which only showed higher full-service intensity in 66 percent of the markets and an average increase of 15 percent overall. This variance is understandable, as most water usage comes from guest rooms, but full-service hotels will have more floor area in the denominator to drive intensity. Overall, benchmarking initiatives can utilize this information to segment and harmonize data comparisons, under the basic premise of separating full-service hotels from limited-service hotels in basic categorization, regression, and benchmarking models.

Renewable Energy

The use of renewable sources for energy continues to be anecdotal. Of over 15,000 properties in the data set, only 130 properties utilized renewable sources to generate energy. Of those properties 56 percent reported less than 10 percent of their total energy from renewable sources, while only 7.7 percent had at least 50 percent of their energy from renewables. The actual prevalence may be slightly higher if solar thermal water heating and Renewable Energy Certificate (REC) purchases were included. Overall, there is not much improvement in the use of renewable resources for energy since 2013. Hence, the prevalence of renewables needs to be accelerated to a much faster pace to meet the level of decarbonization called for by the Paris Agreement. The CHSB Index will be able to track annually the uptake of renewable energy use, and in future years may be able to include external renewable energy mix percentages for purchased electricity to depict more accurately the actual energy usage in hotels that is generated from renewables on- and off-site.

LIMITATIONS

Several limitations apply to this study given the data set and representation of participating companies:

(1) The results remain skewed toward the higher end of segment tiers. As CHSB2018 relies heavily on large owners or operators of hotels to submit aggregate data sets, the data tend to come from 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 the 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 (with smaller public areas, fewer amenities, and less spacious guestrooms). As more participation is encouraged in future years, economy and midscale or 1- and 2-star properties will be sought.

(2) The results are skewed toward branded chains. Similarly, given that the vast majority of the hotels in this study are represented by brand flags, the results may not represent those of the full hotel supply. It is possible 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.

(3) The bulk of the data set covers the United States. Although the data set covers 51 countries, 75 percent of the benchmarks are within U.S. geographies, and the ratio of hotels in the data set to potential hotels in the country is lower outside of the U.S. countries. This year's coverage has improved by 17.6 percent from last year, and, as indicated above, in future years we will continue to seek data sets from outside the U.S.

(4) The results do not distinguish a property's amenities. With the exception of Measures 1, 7, 10, and 11, which adjust for outsourced laundry, the benchmarks are collective of all types of hotels within a particular segment and geographic location. Fair comparison between two properties remains troublesome, since each property may have distinct attributes (e.g., a laundry, swimming pool, spa, or irrigated landscaping may be present in some hotels but absent in others). Furthermore, the raw data generate a significantly wide range of "performance" within each geography and segment. Each year we continue to improve the range of benchmarking. This year, for instance, we added more types of hotels and census databases to segment locations. Nevertheless, this broad generalization does not cover the range of amenities even within one hotel type or star level.

(5) The data have not been verified. Even considering our validity tests, unless all data have been veri-

fied 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 respective 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.

(6) Onsite generation of electricity may skew fair comparison. For this year's report, we conducted additional research to assess the performance of properties with onsite electricity generation. Of more than 15,000 properties benchmarked, 149 had onsite electricity generation or cogeneration. Metro area, climate zone, and composite benchmarking reports revealed that onsite electricity generation properties perform consistently poorly against peer properties that purchase all of their electricity. On average, onsite generation properties' performance falls in the 50th percentile of performance in energy usage intensity, with over 70 percent in the bottom half for energy per square meter in the composite comparison data set of all benchmarkable attributes, and only 17 percent in the top quartile. This skewing toward lower performance is likely not representative of their inefficiency, but rather the quantified energy content of fuel used to generate electricity. Properties purchasing electricity are providing data based on "site energy," or the amount delivered to the property, but not "source energy," or the proportionate amount of fuel or other energy sources needed to produce and distribute the electricity received.

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 CHSB2019

As we have outlined throughout this report, the CHSB study is an evolving index and process. Thus, the 2019 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. ■

Invitation to Participate

Hotels are welcome to participate in CHSB2019. We are calling for 2017 data sets. For further information, please email eer3@cornell.edu.

EXHIBIT 10

Measures used in the CHSB Index (2016 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

ABOUT 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. Each data table contains the list of geographies and the benchmarks per segment. The data tables can be accessed for research and calculation purchases 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 of the properties within the geography and segment were at or below this figure;

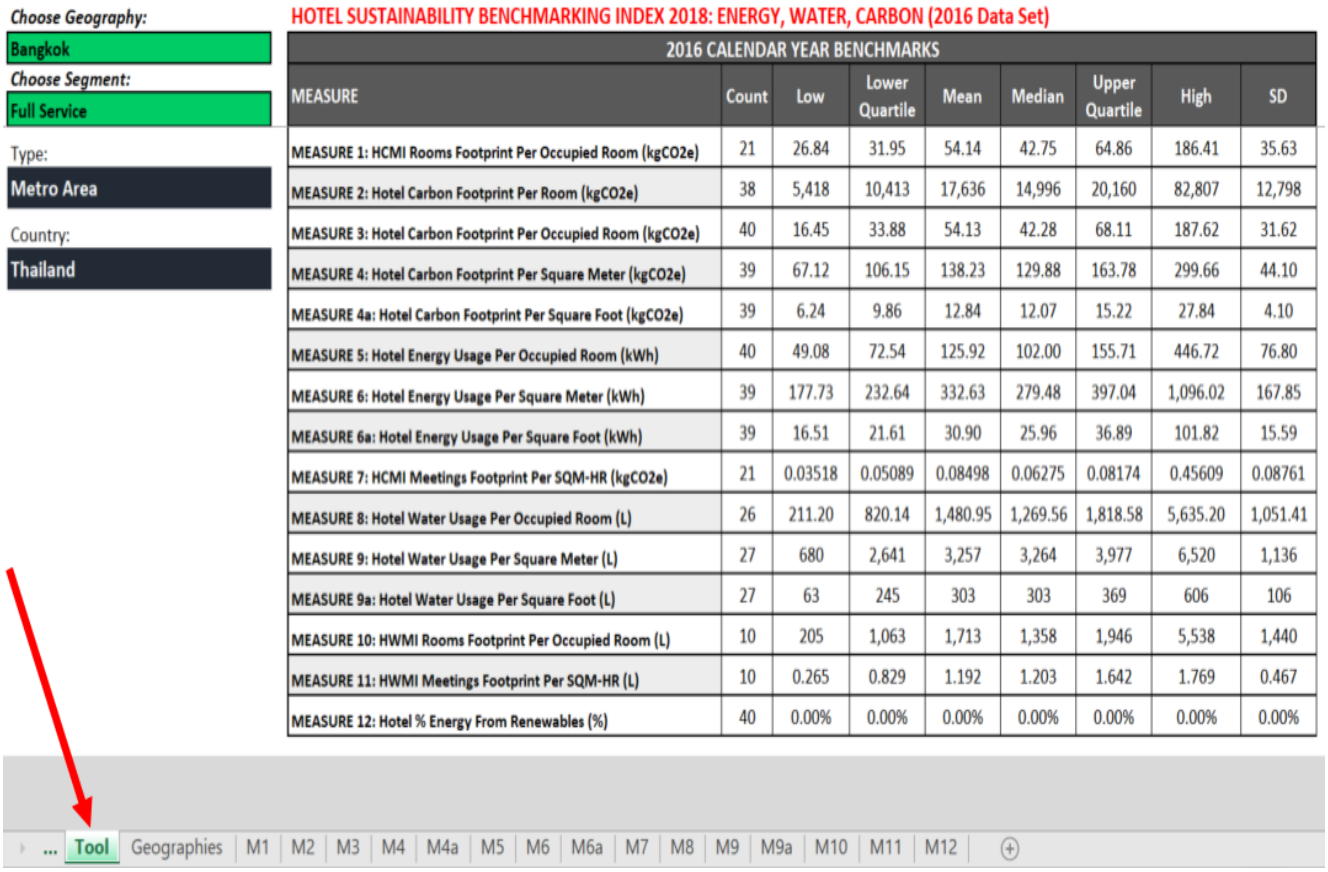
(7) High—the highest value found within the geography segment grouping (this is the worst performer of the group); and

(8) SD—the standard deviation across the data set of properties within the geography and segment.

HOW TO USE THE TOOL

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

Step 1: Click on the Tool tab.



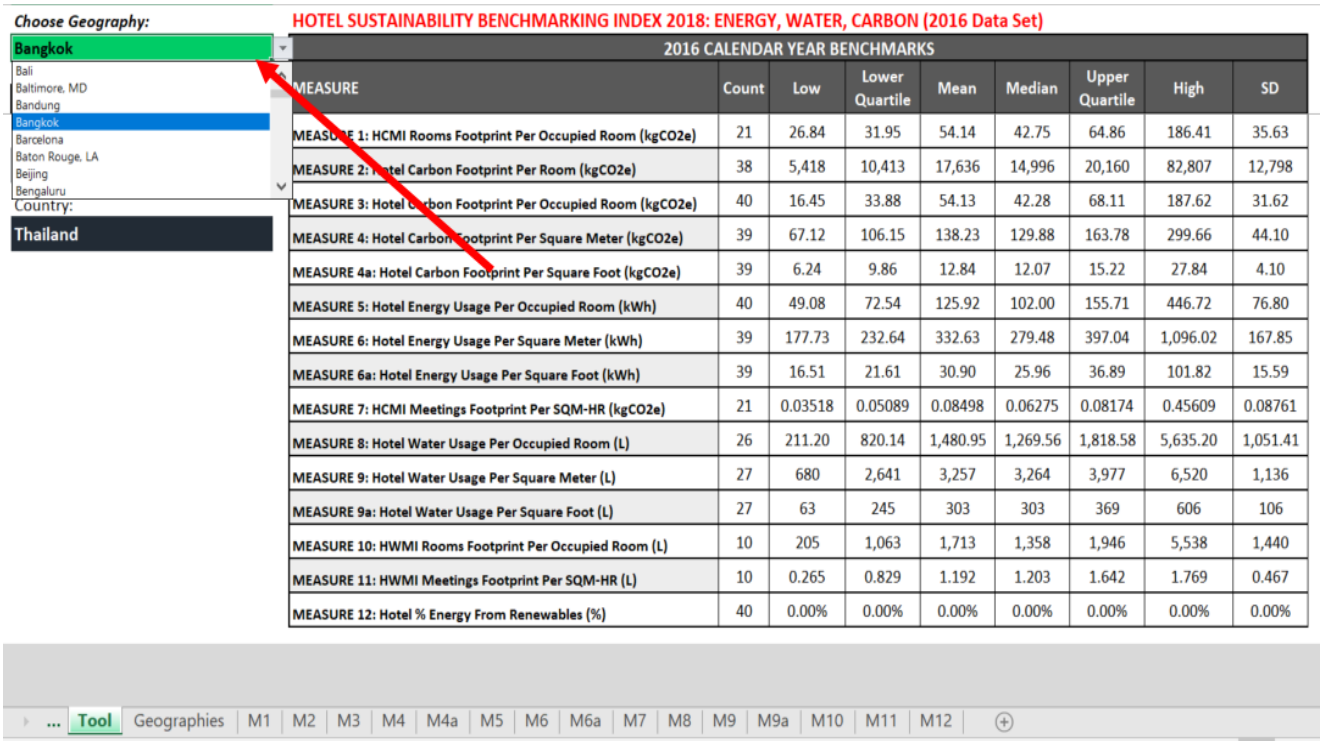
Choose Geography:
Bangkok
Choose Segment:
Full Service
Type:
Metro Area
Country:
Thailand

HOTEL SUSTAINABILITY BENCHMARKING INDEX 2018: ENERGY, WATER, CARBON (2016 Data Set)

2016 CALENDAR YEAR BENCHMARKS								
MEASURE	Count	Low	Lower Quartile	Mean	Median	Upper Quartile	High	SD
MEASURE 1: HCMI Rooms Footprint Per Occupied Room (kgCO2e)	21	26.84	31.95	54.14	42.75	64.86	186.41	35.63
MEASURE 2: Hotel Carbon Footprint Per Room (kgCO2e)	38	5,418	10,413	17,636	14,996	20,160	82,807	12,798
MEASURE 3: Hotel Carbon Footprint Per Occupied Room (kgCO2e)	40	16.45	33.88	54.13	42.28	68.11	187.62	31.62
MEASURE 4: Hotel Carbon Footprint Per Square Meter (kgCO2e)	39	67.12	106.15	138.23	129.88	163.78	299.66	44.10
MEASURE 4a: Hotel Carbon Footprint Per Square Foot (kgCO2e)	39	6.24	9.86	12.84	12.07	15.22	27.84	4.10
MEASURE 5: Hotel Energy Usage Per Occupied Room (kWh)	40	49.08	72.54	125.92	102.00	155.71	446.72	76.80
MEASURE 6: Hotel Energy Usage Per Square Meter (kWh)	39	177.73	232.64	332.63	279.48	397.04	1,096.02	167.85
MEASURE 6a: Hotel Energy Usage Per Square Foot (kWh)	39	16.51	21.61	30.90	25.96	36.89	101.82	15.59
MEASURE 7: HCMI Meetings Footprint Per SQM-HR (kgCO2e)	21	0.03518	0.05089	0.08498	0.06275	0.08174	0.45609	0.08761
MEASURE 8: Hotel Water Usage Per Occupied Room (L)	26	211.20	820.14	1,480.95	1,269.56	1,818.58	5,635.20	1,051.41
MEASURE 9: Hotel Water Usage Per Square Meter (L)	27	680	2,641	3,257	3,264	3,977	6,520	1,136
MEASURE 9a: Hotel Water Usage Per Square Foot (L)	27	63	245	303	303	369	606	106
MEASURE 10: HWMI Rooms Footprint Per Occupied Room (L)	10	205	1,063	1,713	1,358	1,946	5,538	1,440
MEASURE 11: HWMI Meetings Footprint Per SQM-HR (L)	10	0.265	0.829	1.192	1.203	1.642	1.769	0.467
MEASURE 12: Hotel % Energy From Renewables (%)	40	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

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

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.



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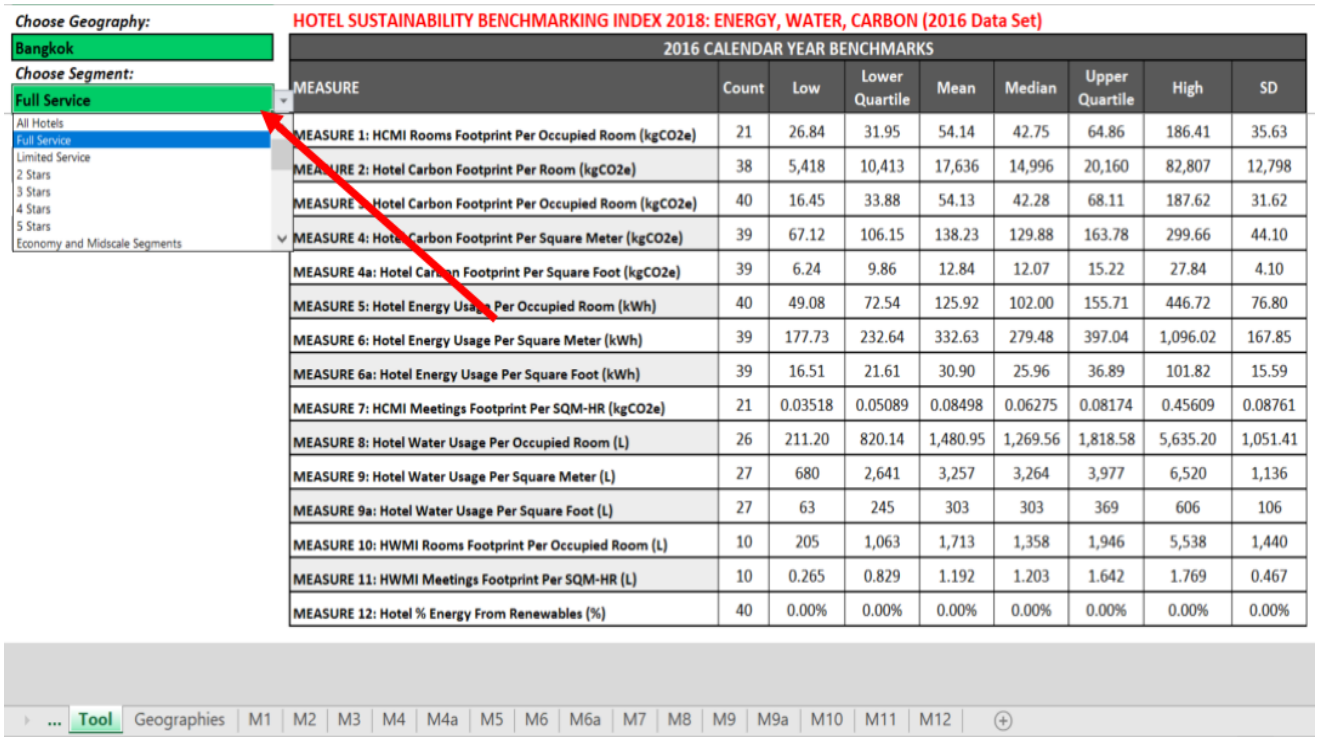
MEASURE 12: Hotel % Energy From Renewables (%)	40	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

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



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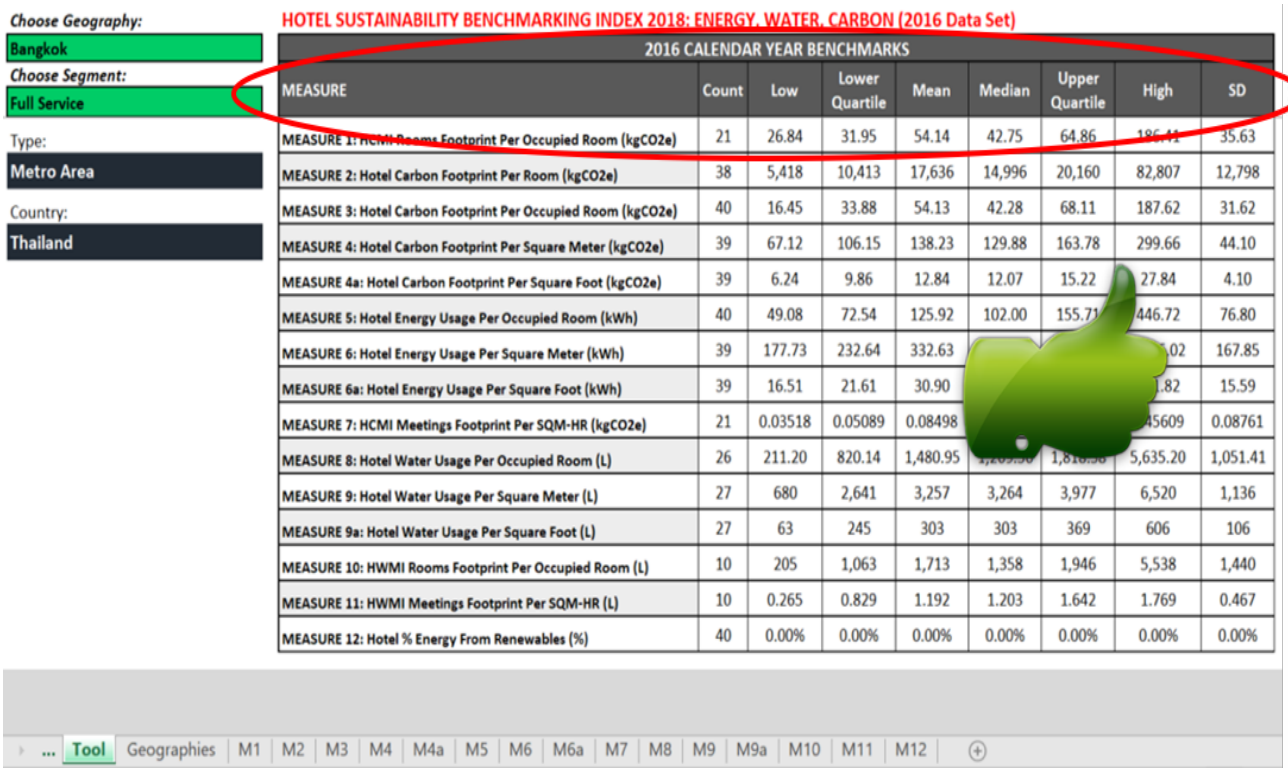
MEASURE 12: Hotel % Energy From Renewables (%)	40	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Step 4: View the corresponding results in the gray table at the top "2016 Calendar Year Benchmarks."

The example below is for a user who 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 2018: ENERGY, WATER, CARBON (2016 Data Set)

2016 CALENDAR YEAR BENCHMARKS

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

In this example:

A possible 40 full-service hotels within the Bangkok metro area of Thailand constitute the benchmarks, though for each benchmark there may be fewer hotels if some of them did not have complete data that passed all validity tests. For example, Measures 10 and 11 include the lowest count, with 10 hotels in the data set for those specific measures.

MEASURE 1: The mean (average) HCMI rooms footprint (guest footprint of a night stay) is 54.14 kgCO_2e/OCRM.

MEASURE 2: The upper quartile carbon footprint per room in a calendar year is 20,160 kgCO_2e/OCRM (meaning that of the 38 properties counted in the benchmark for this measure, 75 percent fell below 20,160 and 25 percent fell at or above 20,160).

MEASURE 6a: The lowest energy usage per square foot is 16.51 kWh/sqft.

MEASURE 8: The highest water usage per occupied room is 5,635.20 L/OCRM.

For all measures the quartiles, mean, and median all fall within the Low and High range.

INTERPRETING AND USING THE RESULTS

The following are 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 participants an option to offset the carbon footprint of their stay, it could incorporate the same figure as the base calculation for the participants' carbon footprint.
- Researchers or policymakers from a municipality, region, or country seeking to understand the impact of water usage from hotels in their geography could obtain the current hotel supply and pipeline and run scenarios based on the statistics provided (e.g., high, low, mean).

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 August 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	HK Electric Investment Sustainability Report 2017, CLP Sustainability Report 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 August 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 11/19/2016	WRI Stationary Combustion Tool V4.1
Butane, Propane	National Greenhouse Accounts Factors August 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 11/19/2016	WRI Stationary Combustion Tool V4.1
Liquefied Petroleum Gas (LPG)	National Greenhouse Accounts Factors August 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 11/19/2016	WRI Stationary Combustion Tool V4.1
Liquefied Natural Gas (LNG)	National Greenhouse Accounts Factors August 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
Compressed Natural Gas (CNG)	National Greenhouse Accounts Factors 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	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

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Stationary Gasoline/ Petrol	National Greenhouse Accounts Factors August 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 11/19/2016	WRI Stationary Combustion Tool V4.1
Stationary Diesel, Fuel Oil #1-#6	National Greenhouse Accounts Factors August 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 11/19/2016	WRI Stationary Combustion Tool V4.1
City Gas / Towngas	National Greenhouse Accounts Factors August 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)	EPA Emission Factors for GHG Inventories last modified 11/19/2016 (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 August 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)
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	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)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N20 Emissions only)

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APPENDIX (CONCLUDED)

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Purchased Steam, Heat, and Hot Water	Not Applicable	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	Not Applicable	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	Not Applicable	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 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

CHR Advisory Board

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