

Hotel Sustainability Benchmarking Index 2020: Carbon, Energy, and Water

By Eric Ricaurte & Rehmaashini Jagarajan

EXECUTIVE SUMMARY

The seventh annual Cornell Hotel Sustainability Benchmarking study includes data from considerably more hotels than last year. While the bulk of the data still come from hotels in the United States, the study also recorded a greater international participation, with 55 nations and 20 international hotel chains represented. More than 18,000 hotels contributed information regarding their energy and water usage, as well as their greenhouse gas emissions. Complete as of 2018, the data show that the participating hotels have generally continued to reduce their energy and water usage. While the 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 usage. Data collection is now underway for CHSB2021 study, and the authors encourage additional hotels to participate, especially those in the lower-tier segments which are not as strongly represented here.

ABOUT THE AUTHORS



Eric Ricaurte founded Greenview as a boutique firm specializing in the metrics, measurement, and reporting of carbon and other sustainability performance indicators within travel & tourism. He is a frequent speaker, organizer, researcher, and generally ubiquitous character in the topic of sustainability measurement.

Eric began his career canoeing people through the jungle. He spent 10 years working in ecotourism across Costa Rica, Mexico and Brazil in operations and as a consultant. He started out managing eco lodges and nature park operations, and then naïvely decided to go on his own as an independent consultant. Eric built his client list to include hotels, parks, nature & cultural tour operators, receptive tour companies, and eventually destinations. During this time, he went 6 years straight without wearing a tie and his entrepreneurial ventures included co-owning a failed speedboat & outrigger canoeing tour business in Bahia, Brazil.

Throughout these formative years Eric spent plenty of time in forests and parks, and became fascinated with the concept of carbon sequestration for value it placed on nature and the opportunities it provided for conservation as well as tourism. He started researching the topic in 2001 and won a student research award at Cornell University for his paper titled “Carbon Offsetting, Trading, and Sequestration and their Relation to Travel & Tourism.” Fast forward 10 years later, as a research fellow at Cornell, Eric authored the study “Developing a Sustainability Measurement Framework for Hotels: Toward an Industry-wide Reporting Structure” and was selected as the technical consultant to facilitate the development of the methodology for the Hotel Carbon Measurement Initiative.

Throughout his career Eric has consulted globally for hotel properties; hotel companies; REITs; hospitality vendors; tourism operators, attractions and complexes; cruise lines; the UNWTO, WTTC, and AHLA; event organizers; and tourism destination organizations. Eric earned a Bachelor of Science degree from the Cornell University School of Hotel Administration and a Master of Science degree in Tourism & Travel Management from New York University.

Eric is a member of the UFI Committee on Sustainable Development, the International Standards Working Group of the GSTC, and on the judging panel of the HICAP Sustainable Hotel Awards. He has held a research fellowship at the Cornell University Center for Hospitality Research and been an adjunct instructor at the NYU University Tisch Center for Hospitality and Tourism. Eric is an active board member of the Orphaned Starfish Foundation. In his spare time, Eric still hangs out in forests and has enjoyed playing Capoeira for over 12 years.

Rehmaashini Jagarajan, Ph.D., is a Manager at Greenview. Prior to 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 for the purpose of determining 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 to existing buildings. She has also served as a valuation executive at JS Valuers Property Consultants Group Malaysia providing valuation services covering extensive range of properties for various different purposes. Rehma is a member of Malaysian Association of Facility Management (MAFM), a medium for the local Facility Management (FM) communities to interact and share knowledge or experience through activities co-organized with various parties both in public and private sectors. Rehma holds a Doctorate Degree (PhD) in Facilities Management as well as a Bachelor’s Degree in Property Management from the University of Technology Malaysia.



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The seventh annual report presents the results of Cornell Hotel Sustainability Benchmarking (CHSB) study of 2018 calendar-year data. This is an update to the CHSB2019 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 seventh study continues to build upon the existing framework, expand the data sets' geographical coverage, present historical trends across like-for-like change over the past year, as well as four years of similar data, and provide enhanced benchmarks and metrics. This year's report represents a 25-percent increase in the global data sets, comprised of over 14,000 hotels worldwide.

OVERVIEW

This annual study, now in its seventh year, is presented as an index to provide credible benchmarks according to industry-specific segmentation and metrics globally; industry data analysis with a confidential data set; and advancement toward commonly defined, transparent, and rigorous methods 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 574 geographies, which are defined by metro area, country, climate zone, and other geographic or political regions. Data are segmented by various hotel types, including asset class, location, type of hotel, market segment, and classification by stars.

CHSB2020 UPDATES

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

- Increased the granularity of segmentation in validity testing for energy, in addition to asset class, to incorporate by STR Chain Scale Segments – Luxury, Upper Upscale, Upscale, Upper Midscale, Midscale, and Economy;
- Enhanced the hotel-specific output report that allows participants to view a summary of energy, carbon, and water benchmarks in PDF for each property submitted, in addition to the aggregate output;
- Presented an analysis of the performance range in carbon per square meter within a market, segment and laundry specification for select markets;
- Added the hotel type “Integrated Resort” to encompass large hotels that have more public space and entertainment amenities such as casinos or parks;
- Reconfigured the outputs to avoid applying a coefficient of performance (COP) for purchased chilled water in the public benchmark data set. For confidential participant reports, the benchmarking model separately applies a uniform COP of 4.0 to all purchased chilled water data when comparing against peer hotels;
- Increased the number of geographies from 506 to 574 across metro areas, regions, countries, and climate zones; and
- Increased the number of hotels for which benchmarks are generated to 14,212 (increase of 25.1%).

USES OF THE CHSB INDEX

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

Industry Benefits

1. **Default data.** By aggregating data globally that is also segmented by geographic location and market segment, CHSB provides publicly available, industry-based data sets. Furthermore, in countries without any formalized benchmarking process, the research fills the gap for basic environmental data uses in these countries.

2. **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.

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

4. **Harmonized greenhouse gas emissions calculations.** The protocols for greenhouse gas emissions accounting and verification do not provide standardized greenhouse gas 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 carbon data set enabling comparability.

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 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 established data sets, overall performance on an industry level can be analyzed and communicated. With the Paris Climate Agreement signed in 2016, an increasing emphasis is now placed on decarbonization aligned with climate science akin to a balance sheet, including "Science-based Targets." The data sets 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 significant data sets with property attributes over time will support further evaluation regarding the drivers of energy, water, and carbon emissions in hotel operations.

Participant Benefits¹

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.

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.

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 sets in a cost-effective platform.

¹ Participation is open and welcome for CHSB 2021, calling for 2019 data sets. For further information, please email eer3@cornell.edu.

DATA SETS

Input

We collected aggregate 2018 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 18,042 properties globally. Property data were received in aggregate data sets from each participating firm or its corresponding data provider. As part of this process, 2018 calendar-year data collected by Horwath HTL Asia Pacific and then analyzed with similar validity testing by Greenview was incorporated into the data sets to add an additional 2,307 non-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 sets were verified by a third-party review for participant corporate reporting of GHG inventories. Other than presence of onside laundry for main linen wash 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 shared areas with other tenants within the building.

EXHIBIT 1

Participating Organizations

AINA Hospitality
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
Ryman Hospitality Properties
Six Senses Hotels Resorts Spas
Sunstone Hotel Investors, Inc
Wyndham Hotels & Resorts
Xenia Hotels & Resorts

EXHIBIT 2

Data collection points used to generate the external CHSB2020 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 sets.
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 (i.e. zip code) where the hotel is located.
Room Count	The total number of guestrooms for the hotel in 2018. If a hotel's room count changed during the year, the value most representative of the hotel's room count for 2018 was used.
Area Unit	Choose either "sqft" or "sqm" to indicate the units of measurement of the floor area data being entered (either square feet or square meters).
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/highway, airport, convention, resort, timeshare, small metro/town, bed & breakfast.
Year Opened	The year the property originally opened, regardless of whether major renovations have occurred since that year.
12-Month Operation	Confirm with a "Yes" that the hotel was in operation for all of 2018 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."
Energy Verification	Indicate whether the energy data for each property has been 3rd party verified per the following choices: Limited, Reasonable, Full, No, Don't know. Limited refers to a company-wide 3rd party "limited assurance", Reasonable refers to a companywide 3rd party "reasonable assurance" and "full" indicates that the specific property's data have been 3rd party verified onsite or through direct examination of billing and consumption.
Water Verification	Indicate whether the water data has been 3rd party verified per the following choices: Limited, Reasonable, Full, No, Don't know. Limited refers to a company-wide 3rd party "limited assurance" Reasonable refers to a companywide 3rd party "reasonable assurance" and "full" indicates that the specific property's data have been 3rd party verified onsite or through direct examination of billing and consumption.
Unit	Enter the unit of measurement for the data entered.
Occupied Rooms	The total number of occupied rooms for the hotel for each month within 2018. Rooms sold may be used as a proxy.
Water Consumption by Type	The total water consumption for each month in 2018 as provided by the utility provider by type of water source.
Energy Consumption by Type	The total energy usage for each month in 2018 as provided by the utility provider by type of energy source.

Output

We took the following five steps to arrive at the output tables for the CHSB2020 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 (m²), and
- greenhouse gas (GHG) emissions (also termed carbon footprint) in kilograms of carbon dioxide equivalent (kgCO₂e), converting each energy source of GHG emissions into kgCO₂e (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 Appendix 1, page 29 for emission factors referenced). When the emission factor was provided by the reference source in CO₂e, the source document's value of global warming potential (GWP) was used. With raw values of methane (CH₄) and nitrous oxide (N₂O) emissions, the following GWP was applied using the IPCC Fifth Assessment Report, 100 Year horizon: GWP of CH₄: 28; and GWP of N₂O: 265. For energy generated from renewable sources (wood or other biomass) the biogenic CO₂ was not included. However, per the Greenhouse Gas Protocol, emissions from CH₄ and N₂O 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 sets 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 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 CHSB2020 index, segmentation by climate zone was added to enable benchmarking based on climate zones that span several regions across the globe. We use the term *geography*, which may refer to one of the following:

- **Metro Area** 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 to increase the ability to enable comparisons and benchmarking; or
- **Climate Zone**, using both the Köppen-Geiger climate classification system and 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 2019 global chain scales), the asset class segmentation of full-service and limited-service hotels, and a global data sets of star levels for hotels as listed 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.

EXHIBIT 3
Validity tests performed on the data sets

Validity Test Description	High Threshold	Low Threshold	Action taken if beyond threshold or missing	% of Data sets Excluded
Property underwent significant renovation or closed all or significant part of floor area for a portion of the year	N/A	N/A	Excluded from Measures 1-12	0.80%
Energy Per Occupied Room Outlier (kWh/OCRM) for Full-Service Luxury hotels	800	25	Excluded from Measures 1,3,5,12	13.15%
Energy Per Occupied Room Outlier (kWh/OCRM) for Full-Service Upper Upscale hotels	700	45	Excluded from Measures 1,3,5,12	17.77%
Energy Per Occupied Room Outlier (kWh/OCRM) for Full-Service Upscale hotels	600	40	Excluded from Measures 1,3,5,12	16.91%
Energy Per Occupied Room Outlier (kWh/OCRM) for Full-Service Upper Midscale hotels	600	35	Excluded from Measures 1,3,5,12	24.19%
Energy Per Occupied Room Outlier (kWh/OCRM) for Full-Service Midscale hotels	500	30	Excluded from Measures 1,3,5,12	29.32%
Energy Per Occupied Room Outlier (kWh/OCRM) for Full-Service Economy hotels	400	25	Excluded from Measures 1,3,5,12	53.57%
Energy Per Occupied Room Outlier (kWh/OCRM) for Limited Service Upscale hotels	200	20	Excluded from Measures 1,3,5,12	9.54%
Energy Per Occupied Room Outlier (kWh/OCRM) for Limited Service Upper Midscale hotels	150	17	Excluded from Measures 1,3,5,12	16.56%
Energy Per Occupied Room Outlier (kWh/OCRM) for Limited Service Midscale and Economy hotels	100	13	Excluded from Measures 1,3,5,12	15.77%
Energy Per Occupied Room Outlier (kWh/OCRM) for Limited Service Midscale and Economy hotels	75	10	Excluded from Measures 1,3,5,12	7.27%
Energy Per Square Meter outlier (kWh/m ²) for Full-Service hotels	1,300	80	Excluded from Measures 2,4,6,7,12	27.58%
Energy Per Square Meter outlier (kWh/m ²) for Limited Service hotels	700	65	Excluded from Measures 2,4,6,7,12	19.13%
Property did not provide any purchased electricity data	N/A	N/A	Excluded from Measures 1-7,12	5.03%
Data did not have 12 separate electricity data points	N/A	N/A	Excluded from Measures 1-7,12	10.23%
Property did not provide any occupied rooms data	N/A	N/A	Excluded from Measures 1,3,5,8	4.64%
Data did not have 12 separate occupancy data points	N/A	N/A	Excluded from Measures 1,3,5,8	9.11%
Occupancy outlier	104%	35%	Excluded from Measures 1,3,5,8,10,11	9.09%
Property did not provide any water usage data	N/A	N/A	Excluded from Measures 8-11	8.46%

Validity Test Description	High Threshold	Low Threshold	Action taken if beyond threshold or missing	% of Data sets Excluded
Data did not have 12 separate water data points	N/A	N/A	Excluded from Measures 8-11	14.75%
Water Per Occupied Room outlier (L/OCRM) for full-Service hotels with onsite laundry	5,000	275	Excluded from Measure 8,10,11	24.51%
Water Per Occupied Room outlier (L/OCRM) for Full-Service hotels without onsite laundry	4,500	200	Excluded from Measure 8,10,11	26.29%
Water Per Occupied Room outlier (L/OCRM) for Full-Service hotels without laundry data	5,000	275	Excluded from Measure 8,10,11	46.96%
Water Per Occupied Room outlier (L/OCRM) for Limited Service hotels with onsite laundry	1,700	50	Excluded from Measure 8,10,11	21.82%
Water Per Occupied Room outlier (L/ocrm) for Limited Service hotels without onsite laundry	1,500	40	Excluded from Measure 8,10,11	17.72%
Water Per Occupied Room outlier (L/ocrm) for Limited Service hotels without laundry data	1,500	40	Excluded from Measure 8,10,11	31.30%
Water Per Square Meter outlier (L/m2) for Full-Service hotels with onsite laundry	10,500	300	Excluded from Measures 9,11	19.10%
Water Per Square Meter outlier (L/m2) for Full-Service hotels without onsite laundry	9,000	200	Excluded from Measures 9,11	24.43%
Water Per Square Meter outlier (L/m2) for Full-Service hotels without laundry data	10,500	300	Excluded from Measures 9,11	69.55%
Water Per Square Meter outlier (L/m2) for Limited Service hotels with onsite laundry	8,000	150	Excluded from Measures 9,11	20.11%
Water Per Square Meter outlier (L/m2) for Limited Service hotels without onsite laundry	5,000	100	Excluded from Measures 9,11	24.99%
Water Per Square Meter outlier (L/m2) for Limited Service hotels without laundry data	5,000	100	Excluded from Measures 9,11	38.90%
% of Floor Area attributed to Rooms Foot-print	100%	40%	Excluded from Measures 1,7,10,11	30.94%
Average SqM per guestroom of entire building outlier	20	2,500	Excluded from Measures 1,2,4,6,7,10,11	12.69%
Average size of a guestroom outlier	15	750	Excluded from Measures 1,2,4,6,7,10,11	33.12%
Only one source of energy was indicated for calculating total energy	N/A	N/A	Notified only, no action taken	3.94%
At least one energy or water source had a high variance of a ratio of 4 to 1 between high/low months or 80% month-to-month	N/A	N/A	Notified only, no action taken	40.72%

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
- Integrated Resort
- Convention
- Timeshare / Serviced Apartment
- Bed & Breakfast
- All Hotels (within a given geography)

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 CHSB2020 encompass 14,212 properties across 574 geographies. This represents an increase from the prior year's data sets (i.e., 2017 calendar-year data for CHSB 2019), with 25.1% more properties added in 2018. The increase in data helped generate the minimum threshold required to add new geographies, with nearly 68 added for CHSB2020, either new metro areas (including non-metropolitan areas) or countries.

FINDINGS

The exercise of aggregating inputs and producing the outputs, as well as the resulting data sets, 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 2,824 hotels in the data sets have produced valid benchmarks for energy and water measures to enable a like-for-like comparison among the 2015 to 2018 calendar years. The approach of 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 2018 in three measures using three types of average change. Most of the historical trend data sets (67%) is from the United States, as the initial CHSB studies focused heavily on North America. That limitation will diminish over time as the data sets continue 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 are analyzing a year-over-year output of all properties within the data sets for the past two years and passing all validity tests. The resulting year-over-year data sets included a total of 6,311 properties, of which 77 percent are limited service operations. Seventy-six percent of the properties are from United States, comprising 1,649 limited service properties (82%). Overall observations revealed that limited service properties have reduced their energy and water intensity more over time in most of the countries, including the United States.

Energy usage has reduced since 2015, though not uniformly. The energy intensity of the like-for-like data sets has reduced 3.70 percent overall and 1.83 percent weighted on average. The decrease is largely driven by limited-service hotels which account for a larger portion of the data sets and footprint. Among limited-ser-

vice hotels, energy usage has consistently been reduced by 11.47 percent overall since 2015. However, limited service hotels have seen slight increases in energy intensities in 2018 by 0.93 percent compared to 2017. Energy usage per square meter among all full-service hotels has reduced since 2016. Nevertheless, in an average of averages and weighted on average, full-service hotels have seen reduced energy intensity since 2015.

Water usage intensity has reduced consistently since 2015. The water intensity of the like-for-like data sets has reduced consistently since 2015. The overall average of water usage per occupied room has reduced 6.87 percent since 2015. Water usage per occupied room of full-service hotels has reduced by 5.72 percent overall and limited-service hotels recorded an overall average of -10.63% since 2015. However, limited service hotels marked continuous increase in average of averages

and weighted average of water usage per occupied room since 2015 by 4.41 percent and 0.26% respectively.

The “Efficiency Gap” in each Market

In addition, starting last year, we have included a review of the ranges of performance within a market and segment, adding the specification of laundry to the boundary (comparing those with onsite laundry among themselves, and those without among themselves). 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 nevertheless over 1.5 for both energy per square meter and water per occupied room. This year the results for both full-service and limited-service hotels show a widened efficiency gap in energy per square meter and water per occupied room. On average, full-service hotels without

EXHIBIT 5

Four-year average change by measure among 2,824 hotels and by service type

Measure	2015-2018 Average Change	All Hotels	Full Service	Limited Service
Measure 4: GHG Emissions per Square Meter	Weighted Avg Change	-5.39%	-3.29%	-2.10%
	Overall Avg Change	-10.01%	-6.19%	-16.39%
	Avg of Averages Change	-4.45%	-4.87%	-4.30%
Measure 6: Energy per Square Meter	Weighted Avg Change	-1.83%	-1.76%	-0.07%
	Overall Avg Change	-3.70%	1.15%	-11.47%
	Avg of Averages Change	0.28%	-2.56%	1.30%
Measure 8: Water per Occupied Room	Weighted Avg Change	0.60%	0.34%	0.26%
	Overall Avg Change	-6.87%	-5.72%	-10.63%
	Avg of Averages Change	3.49%	0.87%	4.41%

EXHIBIT 6

Year-Over-Year average change by measure among 6,311 hotels and by service type

Measure	2017-2018 Average Change	All Hotels	Full Service	Limited Service
Measure 4: GHG Emissions per Square Meter	Weighted Avg Change	-3.33%	-1.80%	-1.54%
	Overall Avg Change	-4.96%	-4.75%	-5.32%
	Avg of Averages Change	-3.49%	-3.68%	-3.43%
Measure 6: Energy per Square Meter	Weighted Avg Change	1.42%	0.14%	1.28%
	Overall Avg Change	-0.41%	-1.18%	0.93%
	Avg of Averages Change	3.13%	1.03%	3.77%
Measure 8: Water per Occupied Room	Weighted Avg Change	2.17%	0.49%	1.68%
	Overall Avg Change	-0.48%	-0.50%	-0.75%
	Avg of Averages Change	4.21%	1.19%	5.13%

Note: 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 sets; Overall Average Change = average change in the total usage or emissions of the entire data sets divided by the total floor area of the like-for-like data sets; and Average of Averages Change = mean of the average change of all hotels in the like-for-like data sets.

EXHIBIT 7

Four-Year historical overall average change by selected country, 2015-2018

Country	FULL SERVICE HOTELS ONLY					LIMITED SERVICE					ALL HOTELS				
	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	317	12,568,680	-6.7%	1.1%	-6.7%	1,589	12,378,550	-18.9%	-14.0%	-10.2%	1,906	24,947,230	-12.1%	-5.5%	-7.5%
United Kingdom	59	1,118,479	-17.6%	3.5%	3.0%	136	945,508	-30.9%	-15.2%	-5.7%	195	2,063,987	-23.4%	-4.6%	-1.2%
China	56	3,207,896	-5.3%	1.4%	-7.8%	82	2,987,099	-10.9%	-7.9%	-16.0%	138	6,194,995	-7.4%	-2.3%	-10.3%
India	24	763,507	-14.7%	7.6%	-5.4%	7	170,901	-12.5%	5.3%	-27.1%	31	934,408	-14.4%	7.3%	-9.2%
Mexico	14	489,794	-1.2%	1.0%	-7.6%	45	564,976	4.5%	3.1%	-4.1%	59	1,054,770	0.9%	1.8%	-6.5%
Germany	12	284,701	18.5%	47.5%	-7.1%	29	319,793	7.0%	16.0%	-5.6%	41	604,494	13.4%	31.5%	-8.0%
Canada	11	393,338	-19.3%	-10.0%	2.5%	74	695,508	-9.1%	-5.9%	-8.9%	85	1,088,846	-13.6%	-7.7%	-5.0%
France	11	216,615	7.9%	-5.5%	-3.0%	17	112,631	21.4%	-0.3%	0.2%	28	329,246	11.0%	-4.1%	-1.3%
Turkey	8	285,421	-14.8%	-5.7%	-11.6%	6	123,713	-20.1%	-14.7%	1.4%	14	409,134	-15.9%	-7.4%	-8.8%
Russian Federation	8	206,579	0.2%	6.8%	-16.3%	10	182,457	-15.4%	-9.4%	-8.7%	18	389,036	-5.4%	1.6%	-12.7%
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
Washington-Arlington-Alexandria, DC-VA-MD-WV MSA	27	1,035,631	-8.5%	-3.9%	-15.4%	57	588,689	-11.4%	-4.6%	-15.4%	84	1,624,320	-9.4%	-4.1%	-11.8%
London, UK	27	676,690	-16.4%	6.0%	8.1%	26	252,745	-46.3%	-34.4%	-20.6%	53	929,435	-26.1%	-7.3%	-2.4%
New York-Northern New Jersey-Long Island, NY-NJ-PA MSA	22	834,582	-2.8%	7.0%	1.7%	51	440,336	-28.5%	-29.4%	-5.5%	73	1,274,918	-11.0%	-5.2%	0.4%
Miami-Fort Lauderdale-Pompano Beach, FL MSA	22	848,221	-14.3%	-8.5%	-6.2%	26	205,170	-26.7%	-19.9%	-20.0%	48	1,053,395	-16.9%	-10.9%	-8.7%
Los Angeles-Long Beach-Santa Ana, CA MSA	20	789,878	4.7%	18.8%	-5.6%	49	499,718	-27.7%	-20.3%	-3.6%	69	1,289,596	-8.7%	2.3%	-4.4%
Shanghai	16	757,670	-0.8%	9.5%	1.2%	17	573,199	-3.9%	-1.3%	-17.9%	33	1,330,869	-1.7%	6.3%	-5.4%
Atlanta-Sandy Springs-Marietta, GA MSA	15	791,037	10.1%	16.9%	-16.5%	33	243,946	-34.2%	-34.1%	-5.6%	48	1,034,982	-2.2%	2.6%	-11.0%
San Francisco-Oakland-Fremont, CA MSA	14	601,761	-10.1%	-2.0%	-6.4%	22	220,537	-15.9%	-7.0%	5.2%	36	822,298	-11.5%	-3.2%	-2.6%
Chicago-Naperville-Joliet, IL-IN-WI MSA	14	777,146	-11.8%	3.8%	-5.1%	36	396,397	-21.7%	-13.1%	-15.3%	50	1,173,544	-14.7%	-0.7%	-8.6%
Phoenix-Mesa-Scottsdale, AZ MSA	11	530,698	9.5%	4.6%	-9.7%	30	283,267	5.5%	-8.2%	-9.4%	41	813,965	8.5%	-5.5%	-6.8%
Boston-Cambridge-Quincy, MA-NH MSA	11	306,383	-19.2%	-16.0%	-6.1%	18	127,926	-30.4%	-28.4%	-14.4%	29	434,309	-22.7%	-20.0%	-8.9%
Paris	8	165,182	6.3%	-6.5%	-3.6%	7	54,404	18.4%	-2.8%	-9.8%	15	219,586	8.4%	-5.8%	-4.5%
San Diego-Carlsbad-San Marcos, CA MSA	8	406,230	-5.6%	5.8%	-10.0%	19	155,889	-43.1%	-38.5%	-19.6%	27	562,099	-16.2%	-7.0%	-12.1%

EXHIBIT 8

Year-Over-Year overall average change by selected country, 2017-2018

Country	FULL SERVICE HOTELS ONLY					LIMITED SERVICE					ALL HOTELS				
	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	861	28,214,547	-6.3%	-2.3%	0.3%	3,962	27,553,375	-5.9%	1.7%	-0.4%	4,823	55,767,923	-6.1%	-0.6%	0.1%
China	111	6,968,958	-5.1%	-2.0%	-1.7%	153	5,325,907	-3.1%	-0.2%	-1.4%	264	12,294,866	-4.4%	-1.4%	-1.5%
United Kingdom	77	1,392,471	-7.3%	5.6%	-1.0%	187	1,392,323	-10.3%	1.1%	-2.6%	264	2,784,794	-8.6%	3.6%	-1.7%
India	27	783,712	-2.7%	20.9%	-0.4%	14	301,880	-7.0%	-0.1%	-6.9%	41	1,085,592	-3.7%	15.7%	-1.7%
Canada	23	749,251	-9.6%	0.4%	-4.6%	130	1,114,452	-8.5%	1.2%	-0.6%	153	1,863,703	-9.0%	0.8%	-2.4%
Mexico	20	753,920	-7.0%	-8.8%	7.0%	73	852,440	1.9%	2.1%	-0.9%	93	1,606,359	-3.7%	-4.9%	2.9%
Thailand	16	752,518	-6.1%	1.2%	2.7%	11	320,624	-4.1%	4.4%	-4.1%	27	1,073,142	-5.7%	1.9%	-0.5%
Egypt	16	754,275	0.5%	4.0%	-10.6%	3	68,004	-3.5%	-0.8%	-8.4%	19	822,279	0.2%	3.6%	-10.4%
Turkey	16	529,986	4.8%	0.9%	-1.9%	18	371,264	5.4%	-0.4%	-6.4%	34	901,250	4.9%	0.5%	-3.4%
Germany	16	479,621	-5.0%	-2.2%	-7.5%	40	406,851	-5.1%	-2.3%	1.3%	56	886,472	-5.0%	-2.2%	-3.8%
Australia	15	507,610	-3.1%	-1.5%	-1.5%	14	231,902	-4.3%	-4.4%	9.2%	29	739,512	-3.5%	-2.5%	2.2%
United Arab Emirates	14	888,342	12.6%	-2.6%	-6.3%	8	194,347	12.0%	-3.6%	-2.5%	22	1,082,689	12.5%	-2.8%	-5.9%
France	12	262,899	13.4%	1.2%	-2.6%	21	131,945	11.4%	-0.5%	-1.8%	33	394,844	12.8%	0.7%	-2.0%
Japan	11	421,566	7.8%	13.7%	0.1%	9	242,580	0.1%	1.7%	-0.2%	20	664,146	4.8%	8.7%	0.0%
Korea	10	681,563	-2.6%	-3.4%	0.1%	3	152,123	24.2%	31.7%	-3.9%	13	833,686	-0.3%	-0.3%	-0.5%
Indonesia	8	332,512	-4.2%	-6.7%	4.0%	7	153,106	-14.5%	-18.4%	16.4%	15	485,618	-7.1%	-10.5%	3.2%
Malaysia	8	374,014	-3.1%	1.2%	4.2%	2	27,460	2.1%	9.5%	-0.8%	10	401,474	-2.8%	1.7%	4.3%
ALL	1,475	51,423,379	-4.7%	-1.2%	-0.5%	4,836	41,468,698	-5.3%	0.9%	-0.7%	6,311	92,892,077	-5.0%	-0.4%	-0.5%
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
Los Angeles-Long Beach-Santa Ana, CA MSA	59	1,695,106	-10.5%	-7.1%	0.5%	78	682,486	-5.1%	0.1%	4.3%	137	2,377,592	-9.3%	-5.5%	1.7%
Washington-Arlington-Alexandria, DC-VA-MD-WV MSA	42	1,530,181	-5.0%	3.1%	-4.4%	98	860,045	-3.4%	1.9%	1.2%	140	2,390,226	-4.5%	2.7%	-2.2%
New York-Northern New Jersey-Long Island, NY-NJ-PA MSA	42	1,323,276	-4.1%	-0.6%	7.5%	97	890,745	0.7%	7.0%	-0.7%	139	2,214,022	-2.7%	1.5%	4.5%
Chicago-Naperville-Joliet, IL-IN-WI MSA	37	1,466,677	-18.1%	-11.3%	-5.5%	86	784,540	-3.2%	6.2%	-7.1%	123	2,251,217	-14.1%	-7.2%	-5.9%
Miami-Fort Lauderdale-Pompano Beach, FL MSA	34	965,150	-6.9%	-1.0%	-0.5%	63	466,486	-5.7%	-0.3%	1.8%	97	1,431,635	-6.5%	-0.8%	0.2%
Atlanta-Sandy Springs-Marietta, GA MSA	30	1,033,858	-3.9%	1.7%	-2.0%	89	776,567	-2.4%	1.9%	-0.3%	119	1,810,425	-3.4%	1.8%	-1.3%
London, UK	29	688,858	-8.2%	4.6%	-3.2%	31	239,186	-11.3%	0.2%	-8.0%	60	928,044	-8.9%	3.6%	-4.6%
Houston-Sugar Land-Baytown, TX MSA	23	825,283	-8.7%	4.0%	-1.1%	64	401,855	-11.5%	-0.4%	7.3%	87	1,227,138	-9.5%	2.8%	2.2%
Dallas-Fort Worth-Arlington, TX MSA	23	805,623	-9.0%	2.3%	0.2%	104	774,137	-8.9%	2.7%	5.3%	127	1,579,760	-9.0%	2.5%	2.6%
San Francisco-Oakland-Fremont, CA MSA	22	949,845	-13.7%	-8.6%	-1.9%	34	319,301	-8.7%	-5.0%	6.2%	56	1,269,146	-12.8%	-7.9%	0.4%
San Diego-Carlsbad-San Marcos, CA MSA	22	757,880	-2.0%	2.0%	6.1%	36	288,532	-6.2%	-1.1%	6.1%	58	1,046,411	-2.9%	1.4%	5.9%
Shanghai	21	1,294,969	-4.9%	-1.4%	-1.8%	24	819,039	-4.8%	-1.9%	-1.3%	45	2,114,008	-4.9%	-1.5%	-1.3%
Phoenix-Mesa-Scottsdale, AZ MSA	21	679,535	11.3%	-2.1%	-1.4%	62	515,114	11.8%	-2.8%	-0.7%	83	1,194,649	11.4%	-2.3%	-1.4%
Boston-Cambridge-Quincy, MA-NH MSA	20	566,560	-0.6%	0.8%	-10.3%	35	276,118	-5.5%	-2.9%	-6.6%	55	842,678	-2.2%	-0.4%	-9.2%
Orlando-Kissimmee, FL MSA	19	1,131,214	-11.7%	-9.9%	-2.0%	46	487,211	-5.0%	-2.3%	1.2%	65	1,618,425	-10.3%	-8.3%	-0.7%
Tampa-St. Petersburg-Clearwater, FL	17	427,693	-6.6%	-2.2%	-2.9%	35	201,923	-2.7%	2.7%	13.6%	52	629,615	-5.7%	-1.0%	2.4%
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA	15	414,139	-4.9%	0.3%	-8.0%	59	502,857	-4.8%	2.0%	2.0%	74	916,996	-4.8%	1.1%	-2.4%
Seattle-Tacoma-Bellevue, WA MSA	15	428,754	-23.4%	-5.1%	2.4%	30	289,863	-25.0%	-3.7%	5.6%	45	718,617	-24.0%	-4.6%	3.8%
Austin-Round Rock, TX MSA	13	321,620	-10.6%	-1.3%	-2.5%	47	314,063	-7.4%	4.9%	11.2%	60	635,683	-9.3%	1.0%	4.0%
Denver-Aurora, CO MSA	13	368,409	-18.2%	-0.6%	2.8%	54	455,047	-20.2%	-1.8%	5.4%	67	823,456	-19.2%	-1.2%	4.3%
St. Louis, MO-IL MSA	12	505,016	-9.0%	1.0%	-7.7%	26	163,892	-3.4%	6.0%	4.1%	38	688,908	-7.9%	2.0%	-4.2%
Minneapolis-St. Paul-Bloomington, MN-WI MSA	12	378,143	-3.2%	5.6%	-2.7%	39	403,168	-6.1%	-0.9%	-2.9%	51	781,311	-4.5%	2.9%	-2.8%
Las Vegas-Paradise, NV MSA	11	3,155,460	12.4%	-1.1%	-0.5%	20	192,492	13.9%	0.2%	-5.0%	31	3,347,952	12.5%	-1.0%	-0.7%
Beijing	11	588,757	-5.9%	-6.1%	-1.2%	19	711,913	-4.5%	-1.2%	-3.5%	30	1,300,670	-5.3%	-3.9%	-2.6%
San Antonio, TX MSA	10	306,195	-8.4%	2.7%	-8.6%	50	353,477	-9.3%	2.2%	-2.8%	60	659,672	-8.8%	2.5%	-5.3%
Nashville-Davidson-Murfreesboro-Franklin, TN MSA	10	202,162	-4.5%	4.2%	2.4%	43	326,203	-6.5%	2.9%	-3.4%	53	528,365	-5.5%	3.6%	-0.4%
Portland-Vancouver-Beaverton, OR-WA MSA	9	258,637	-30.2%	-12.7%	-8.4%	19	197,836	-22.1%	-3.5%	2.5%	28	456,473	-2		

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
Albany-Schenectady-Troy, NY MSA			1.82			
Albuquerque, NM MSA			1.94			1.58
Atlanta-Sandy Springs-Marietta, GA MSA	1.48		1.74	1.46		1.49
Augusta-Richmond County, GA-SC MSA			1.65			
Austin-Round Rock, TX MSA			1.86			1.53
Baltimore-Towson, MD MSA			1.47			1.69
Bangkok	1.50	1.57		1.85	2.34	
Baton Rouge, LA MSA			1.96			
Beijing	2.19	1.89		1.79	2.21	
Birmingham-Hoover, AL MSA			1.63			1.32
Boston-Cambridge-Quincy, MA-NH MSA		2.16	1.54			2.26
Buffalo-Niagara Falls, NY MSA			1.54			
Charlotte-Gastonia-Concord, NC-SC MSA			1.56			1.42
Chicago-Naperville-Joliet, IL-IN-WI MSA	1.43	1.71	1.68		1.68	1.57
Cincinnati-Middletown, OH-KY-IN MSA			1.78			1.78
Cleveland-Elyria-Mentor, OH MSA			1.53			1.33
Columbus, OH MSA			1.49			1.51
Dallas-Fort Worth-Arlington, TX MSA	1.46		1.55	1.64		1.82
Denver-Aurora, CO MSA			1.57			1.44
Des Moines-West Des Moines, IA MSA			1.50			
Detroit-Warren-Livonia, MI MSA			2.15			1.40
Guangzhou	1.46			1.75		
Hangzhou	2.10					
Harrisburg-Carlisle, PA MSA			1.58			1.42
Houston-Sugar Land-Baytown, TX MSA			1.71			1.63
Indianapolis-Carmel, IN MSA			1.67			1.43
Jackson, MS MSA			1.44			
Jacksonville, FL MSA			1.47			1.51
Jakarta		1.79			2.82	
Kansas City, MO-KS MSA			1.66			1.45
Las Vegas-Paradise, NV MSA			1.24			
Lexington-Fayette, KY MSA			1.75			
London, UK		1.81			1.71	
Los Angeles-Long Beach-Santa Ana, CA MSA	1.57	1.43	1.77	1.45	1.78	1.52
Louisville/Jefferson County, KY-IN MSA			1.49			
Madison, WI MSA			1.58			
Memphis, TN-AR-MS MSA			1.47			
Milwaukee-Waukesha-West Allis, WI MSA			2.10			1.63
Minneapolis-St. Paul-Bloomington, MN-WI MSA			1.67			1.66
Nashville-Davidson-Murfreesboro-Franklin, TN MSA			1.72			1.52
New Orleans-Metairie-Kenner, LA MSA			2.32			2.18
Oklahoma City, OK MSA			1.62			1.64
Omaha-Council Bluffs, NE-IA MSA			1.89			1.78
Orlando-Kissimmee, FL MSA			1.47			1.69
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA			1.70			1.48
Phoenix-Mesa-Scottsdale, AZ MSA	1.44		1.39	2.66		1.85
Pittsburgh, PA MSA			1.87			1.47
Portland-Vancouver-Beaverton, OR-WA MSA			1.55			1.41
Providence-New Bedford-Fall River, RI-MA MSA			1.39			
Raleigh-Cary, NC MSA			1.39			1.40
Richmond, VA MSA			1.56			1.50
Rochester, NY MSA			1.27			1.56
Sacramento-Arden-Arcade-Roseville, CA MSA			1.61			1.58
Salt Lake City, UT MSA			2.19			1.92
San Antonio, TX MSA			1.67			1.86
San Diego-Carlsbad-San Marcos, CA MSA			2.13			1.47
San Francisco-Oakland-Fremont, CA MSA		1.71	1.51			1.66
San Jose-Sunnyvale-Santa Clara, CA MSA			1.74			1.60
Sanya	1.58			2.17		
Savannah, GA MSA			1.37			
Seattle-Tacoma-Bellevue, WA MSA			1.54			1.32
Shanghai	1.88	1.56		1.72	2.04	
Shenzhen	1.79			1.80		
Singapore		1.66			2.43	
South Bali		1.69			2.58	
St. Louis, MO-IL MSA			1.46			2.21
Tampa-St. Petersburg-Clearwater, FL			1.55			1.51
Toronto			1.78			1.54
Tulsa, OK MSA			1.71			
Washington-Arlington-Alexandria, DC-VA-MD-WV MSA	1.64	1.66	1.52	1.65	1.35	1.52
AVERAGE	1.66	1.72	1.65	1.81	2.09	1.60

onsite laundry recorded performance ratios of 1.72 and 2.09 for energy per square meter and water per occupied room compared to 1.71 and 1.39 last year, respectively. Similarly, full-service hotels with onsite laundry recorded lower performance ratios of 1.57 and 1.52 last year for energy per square meter and water per occupied room, however this year the number increased to 1.66 and 1.81, respectively. Likewise, limited-service hotels recorded continuous reductions in energy and water intensity over time compared to full-service hotels, yet performance ratios of limited-service hotels on average were 1.65 and 1.60 for energy per square meter and water per occupied room which is comparably higher than last year's number, 1.49 and 1.54 respectively.

LIMITATIONS

Several limitations are present in this study given the data sets and representation of participating companies:

1. **The results remain skewed toward the higher end of segment tiers.** As CHSB2020 relies heavily on large owners or operators of hotels to submit aggregate data sets, these trend toward hotels that are managed by the same operators and not franchised. Although this year's brand data sets 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 branded 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 needs 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 sets cover the United States.** This year, the data sets cover 55 countries compared to 48 countries in 2017. The percentage of the data

sets within the U.S. geographies has improved slightly since 2015 from 69% to 65% this year, and the ratio of the hotels in the data sets to potential hotels in the country is lower outside of the U.S. countries. However, the coverage recorded this year remains the same compared to 2017, emphasizing that we have continuously added new properties both in the U.S. geographies as well as outside the U.S. In future years, we will continue to seek data sets from outside the U.S. geographies.

4. **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 sets are 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.

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 CHSB2021

As we have outlined throughout this report, the CHSB study is an evolving index and process. Thus, the 2021 study will once again aim to provide an updated index with continually increasing data sets, segmentation, and granularity for participant benchmarking. We will especially continue to seek additional data from independents, smaller chains, and smaller properties currently underrepresented in the global data sets.

Hotels are welcome to participate in CHSB2021, calling for 2019 data sets. For further information, please email eer3@cornell.edu.

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.

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.

EXHIBIT 10

Measures used in the CHSB Index (2018 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

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 sets. 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 sets. 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 sets 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.

EXHIBIT 11

Step 1: click on the Tool tab.

Choose Geography:

Choose Segment:

Type:

#N/A

Country:

#N/A

HOTEL SUSTAINABILITY BENCHMARKING INDEX 2020: ENERGY, WATER, CARBON (2018 Data Set)

2018 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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#N/A
MEASURE 12: Hotel % Energy From Renewables (%)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

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

EXHIBIT 12

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.

Choose Geography:

Bangkok

Bakersfield, CA

Baltimore, MD

Bandung

Bangkok

Barcelona

Baton Rouge, LA

Beaumont-Port Arthur, TX

Beijing

Country:

Thailand

HOTEL SUSTAINABILITY BENCHMARKING INDEX 2020: ENERGY, WATER, CARBON (2018 Data Set)

2018 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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#N/A
MEASURE 12: Hotel % Energy From Renewables (%)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

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

EXHIBIT 13

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

Choose Geography: **Bangkok**

Choose Segment: **Full Service**

HOTEL SUSTAINABILITY BENCHMARKING INDEX 2020: ENERGY, WATER, CARBON (2018 Data Set)

2018 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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#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	#N/A
MEASURE 12: Hotel % Energy From Renewables (%)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

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

EXHIBIT 14

Step 4: View the corresponding results in the gray table at the top “2018 Calendar Year Benchmarks.” The example below is for a user that has selected to view the data sets corresponding to properties within the full-service market segments in the MSA of Bangkok:

Choose Geography: **Bangkok**

Choose Segment: **Full Service**

Type: **Metro Area**

Country: **Thailand**

HOTEL SUSTAINABILITY BENCHMARKING INDEX 2020: ENERGY, WATER, CARBON (2018 Data Set)

2018 CALENDAR YEAR BENCHMARKS									
MEASURE	Count	Low	Lower Quartile	Mean	Median	Upper Quartile	High	SD	
MEASURE 1: HCMI Rooms Footprint Per Occupied Room (kgCO2e)	37	21.10	35.20	50.35	43.97	58.80	153.78	25.17	
MEASURE 2: Hotel Carbon Footprint Per Room (kgCO2e)	48	6,755	11,148	15,191	10,008	19,565	26,520	5,873	
MEASURE 3: Hotel Carbon Footprint Per Occupied Room (kgCO2e)	61	22.08	35.49	53.62	37.77	61.90	159.28	28.01	
MEASURE 4: Hotel Carbon Footprint Per Square Meter (kgCO2e)	53	49.10	100.00	150.00	75.00	132.15	220.44	36.43	
MEASURE 4a: Hotel Carbon Footprint Per Square Foot (kgCO2e)	53	4.56	11.11	16.67	11.11	12.28	20.48	3.38	
MEASURE 5: Hotel Energy Usage Per Occupied Room (kWh)	61	46.46	77.42	110.84	77.42	145.18	378.50	69.41	
MEASURE 6: Hotel Energy Usage Per Square Meter (kWh)	53	102.89	205.78	308.67	205.78	328.63	690.42	105.53	
MEASURE 6a: Hotel Energy Usage Per Square Foot (kWh)	53	9.56	19.99	25.95	23.71	30.53	64.14	9.80	
MEASURE 7: HCMI Meetings Footprint Per SQM-HR (kgCO2e)	37	0.02135	0.05340	0.06737	0.06178	0.08758	0.11603	0.02271	
MEASURE 8: Hotel Water Usage Per Occupied Room (L)	58	212.07	933.09	1,398.23	1,311.03	1,852.65	3,988.26	685.80	
MEASURE 9: Hotel Water Usage Per Square Meter (L)	48	247	2,248	2,997	3,163	3,736	6,705	1,254	
MEASURE 9a: Hotel Water Usage Per Square Foot (L)	48	23	209	278	294	347	623	117	
MEASURE 10: HWMI Rooms Footprint Per Occupied Room (L)	21	832	1,184	1,581	1,538	1,815	3,919	659	
MEASURE 11: HWMI Meetings Footprint Per SQM-HR (L)	21	0.941	1.075	1.408	1.296	1.647	2.427	0.415	
MEASURE 12: Hotel % Energy From Renewables (%)	56	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 +

In this example:

- A possible 61 full-service hotels within the Bangkok metro area of Thailand comprise 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 21 hotels in the data sets for those specific measures.
- MEASURE 1: The mean (average) HCMI rooms footprint (guest footprint of a night stay) is 50.35 kgCO₂e/OCRM
- MEASURE 2: The upper quartile carbon footprint per room in a calendar year is 19,565 kg-CO₂e/OCRM (meaning that of the 48 properties counted in the benchmark for this measure, 75% fell below 19,565 and 25% fell at or above 19,565)
- MEASURE 6a: The lowest energy usage per square foot is 9.56 kWh/Sqft
- MEASURE 8: The highest water usage per occupied room is 3,988.26 L/OCRM
- For all measures the quartiles, mean, and median 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 London 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, resort, or stars), or a specific climate zone as available.
- A feasibility study for developing a hotel in the London 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 London 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 can obtain the current hotel supply and pipeline and run scenarios based on the statistics provided (e.g., high, low, mean). ■

Appendix 1: 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 2018	National Inventory Report 1990-2016 (Submitted 13 Apr 2018)	International Energy Agency CO2 Emissions from Fuel Combustion 2018	International Energy Agency CO2 Emissions from Fuel Combustion 2018	International Energy Agency CO2 Emissions from Fuel Combustion 2018	UK Government GHG Conversion Factors for Company Reporting 2018	EPA eGRID 2016 (updated February 15, 2018)	International Energy Agency CO2 Emissions from Fuel Combustion 2018
Natural Gas	National Greenhouse Accounts Factors July 2018	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 2018	EPA Emission Factors for GHG Inventories January 2016, last modified 14 Dec 2017	WRI Stationary Combustion Tool V4.1
Butane, Propane	National Greenhouse Accounts Factors July 2018	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 January 2016, last modified 14 Dec 2017	WRI Stationary Combustion Tool V4.1
Liquefied Petroleum Gas (LPG)	National Greenhouse Accounts Factors July 2018	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 2018	EPA Emission Factors for GHG Inventories January 2016, last modified 14 Dec 2017	WRI Stationary Combustion Tool V4.1
Liquefied Natural Gas (LNG)	National Greenhouse Accounts Factors July 2018	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 2018	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1

	Australia	Canada	China (including Macau)	Taiwan	Hong Kong	United Kingdom	United States, Puerto Rico, other US Territories	All Other Countries and Territories
Compressed Natural Gas (CNG)	National Greenhouse Accounts Factors July 2018	UK Government GHG Conversion Factors for Company Reporting 2018	UK Government GHG Conversion Factors for Company Reporting 2018	UK Government GHG Conversion Factors for Company Reporting 2018	UK Government GHG Conversion Factors for Company Reporting 2018	UK Government GHG Conversion Factors for Company Reporting 2018	UK Government GHG Conversion Factors for Company Reporting 2018	UK Government GHG Conversion Factors for Company Reporting 2018
Stationary Gasoline/Petrol	National Greenhouse Accounts Factors July 2018	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 January 2016, last modified 14 Dec 2017	WRI Stationary Combustion Tool V4.1
Stationary Diesel, Fuel Oil #1-#6	National Greenhouse Accounts Factors July 2018	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 2018	EPA Emission Factors for GHG Inventories January 2016, last modified 14 Dec 2017	WRI Stationary Combustion Tool V4.1
City Gas / Towngas	National Greenhouse Accounts Factors July 2018	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 2018	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

	Australia	Canada	China (including Macau)	Taiwan	Hong Kong	United Kingdom	United States, Puerto Rico, other US Territories	All Other Countries and Territories
Ethanol	National Greenhouse Accounts Factors July 2018	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N2O Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N2O Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N2O Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N2O Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N2O Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N2O Emissions only)	US EPA Direct Emissions from Stationary Combustion Sources Jan2016 (CH4 and N2O Emissions only)
Purchased Steam, Heat, and Hot Water	UK Government GHG Conversion Factors for Company Reporting 2018	US Energy Star Portfolio Manager Technical Reference: Greenhouse Gas Emissions, August 2017	UK Government GHG Conversion Factors for Company Reporting 2018	UK Government GHG Conversion Factors for Company Reporting 2018	UK Government GHG Conversion Factors for Company Reporting 2018	UK Government GHG Conversion Factors for Company Reporting 2018	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

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