Hotel Sustainability Benchmarking Index 2017:

Energy, Water, and Carbon

by Eric Ricaurte

EXECUTIVE SUMMARY

This report presents the results of the fourth annual Cornell Hotel Sustainability Benchmarking (CHSB) study, an update to last year's CHSB2016 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 report with historical trends and its accompanying index are intended to advance the knowledge base and data sets for benchmarking activities relating to energy, water, and greenhouse gas emissions for the industry's benefit. The data sets remain freely available for download from the Cornell Center for Hospitality Research. This fourth study builds on the framework, expands the data set's geographical coverage, presents historical trends across three years of similar data, and provides enhanced benchmarks and metrics – including a pilot of measures from the Hotel Water Measurement Initiative and percentage of energy generated from renewable sources – with an 80% increase in the global data set and adding segmentation by asset class and number of stars in the accompanying index.

ABOUT THE AUTHOR

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Overview

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

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

This index presents benchmark ranges for 12 different measures relating to energy, water, and carbon emissions, in 296 geographies defined by either metro area, country, climate zone, or other geographic or political region, and segmented by various hotel types including asset class, location, type of hotel, market segment, and categorization by stars.

Exhibit 1

Participating organizations

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

Uses of the CHSB Index

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

Industry Benefits

Default data. By aggregating data globally that is also segmented by geographic location and market segments, 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 uses in these countries.

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

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

Harmonized greenhouse gas emissions calculations. The protocols for greenhouse gas 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 singular, harmonized data set.

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

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

Industry trends and carbon balance. General knowledge of hotel environmental performance and industry trends can be explored in each year's industry report. With an established data set, overall performance on an industry level can be analyzed and communicated. With the Paris Climate Agreement signed in 2015, an increasing emphasis is placed on decarbonization aligned with climate science akin to a balance sheet. The data set can serve as a base for calculation of the industry-wide carbon footprint and trends over time along a path toward decarbonization by 2050 and provide insight on performance year-over-year.

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

Participant Benefits[1]

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

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

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.

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

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

[1] Participation is open and welcome for CHSB 2018, calling for 2016 data sets. For further information, please email [...].

Data Set

Input

We collected aggregate 2015 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 12,500 properties globally. Property data were received in aggregate data sets from each participating firm or its corresponding data provider. 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 and 7, 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 2:

Data collection points used to generate the external CHSB2017 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 (i.e. zip code) where the hotel is located.
Rooms	The total number of guestrooms for the hotel in 2015. If a hotel's room count changed during the year, the value most representative of the hotel's room count for 2015 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 2015 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 2015. Rooms sold may be used as a proxy.
Water	The total water consumption for each month in 2015 as provided by the utility provider.
Energy Consumption by Type	The total energy usage for each month in 2015 by type of energy source.

Output

We took the following five steps to arrive at the output tables for the CHSB2017 index.

Harmonization. First, all data were harmonized into 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 the appendix, page x 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. When 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 from 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.

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.

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 or was not open the entire 12-month period	N/A	N/A	Excluded from Measures 1-12	12.71%
Energy Per Occupied Room Outlier (kWh per occupied room)	1,250	25	Excluded from Measures 1,3,5,12	36.5%
Energy Per Square Meter outlier (kWh per m2)	1,500	80	Excluded from Measures 2,4,6,7,12	37.9%
Property did not have 12 separate electricity data points	N/A	N/A	Excluded from Measures 1-7,12	12.0%
Property did not have 12 separate occupancy data points	N/A	N/A	Excluded from Measures 13,5,8	4.5%
Occupancy outlier	104%	35%	Excluded from Measures 1,3,5,8,10,11	21.4%
Property did not have 12 separate water data points	N/A	N/A	Excluded from Measures 8-11	13.3%
Water Per Occupied Room outlier (L per occupied room)	13,500	45	Excluded from Measure 8,10,11	36.4%
Water Per Square Meter outlier (L per m2)	15,000	100	Excluded from Measures 9,11	37.7%
% of Floor Area attributed to Rooms Footprint	N/A	40%	Excluded from Measures 1,7,10,11	1.9%
% of Floor Area attributed to Meetings Footprint	99%	N/A	Excluded from Measures 1,7,10,11	16.64%

For the pilot 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.

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 CHSB2017 index, segmentation by climate zone was added to enable benchmarking based on climate zones that span several regions across the globe. CHSB uses the term geography, which may refer to one of the following:

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

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 and an overall grouping that combines all segments within that 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.

Minimum Output Thresholds. Finally, we set a minimum threshold of eight properties for output data to populate a geography. Where a specific segment within a geography returned at least eight properties, the results were populated in the tool. 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 represent data from up to 8,241 properties across 296 geographies. This represents a significant increase from the prior year data set, with 80% more properties added. The increase in data helped generate the minimum threshold required to add new geographies, with over 100 added for CHSB2017.

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
Airport
Resort
Convention
Timeshare
All Hotels (all properties within the geography)

Findings

The exercise of aggregating inputs and producing the outputs, as well as the resulting data set, continue to demonstrate several findings for consideration. Now in routine publication, the CHSB index is able to provide insight into some historical trends. A total of 1,938 hotels in the data set have produced valid benchmarks for energy and water measures to enable a like-for-like comparison from 2013 to 2015 calendar years. The approach to comparing the change over time depends on the intended view and use of the information, whether at a geography level or individual property level. Exhibit 5 presents the change from 2013 to 2015 in five measures using three types of average change. Most of the like-for-like data set (77%) is from the United States as the initial CHSB studies focused heavily on North America, though that will improve over time as the data set's reach has expanded global data significantly this year. Basic findings are provided below, with a subsequent publication foreseen to provide deeper analysis and findings using additional data sets for cross-analysis.

Energy usage and carbon emission have reduced consistently since 2013. With the exception of a few countries with less than 20 properties and by overall average change, the carbon intensity of the like-for-like data set has improved since 2013. Though carbon intensity is affected

significantly by the external variable of emission factors (See Exhibit 6), the reductions are also driven by reduced energy usage.

Energy intensity has reduced between 4% and 6% depending on the method used for calculating average change. However, such reductions of 1.33% to 2% per annum are formidable if they can be continued out over time.

Water usage intensity has not reduced consistently. Water usage per square meter ranges from a slight decrease to an increase of 4%-5.5% on average since 2013. On an aggregate level, the overall water usage intensity has reduced per occupied room, though further segmentation and additional types of average change calculations do not show reductions as consistently. Several possibilities exist that may explain why water intensity has not reduced as consistently as energy. First, energy costs generally are a higher percentage of a hotels' operating budget than water and as such, have received more investment in efficiency and conservation measures. Second, water is not likely as affected by climate, and weather may have been more favorable to reduce energy intensity than water intensity from 2013 to 2015 as an external influencer. Third, water consumption may be less controllable than energy usage within the data set due to guest use and more fixed use for amenities and outlets such as swimming pools, landscaping, and restaurants. Finally, it may be that the properties in the historical data set may have been leaders in managing their water usage, and obtained the majority of reductions obtainable through feasible efficiency investments at present. Should this final possibility prove true and intensity reductions stagnate, it will present new challenges for the hotel industry to continue improving its sustainability performance to levels needed to meet and align with global goals such as the UN Sustainable Development Goals and science-based carbon emissions reduction targets.

Some metro areas have achieved significant reductions within the data set. Notably, reductions in water intensity in Miami and New York City and energy reductions in Los Angeles and San Francisco when compared to other markets that have not reduced as consistently or have seen increases invites further study as to the additional drivers such as local policies and regulations, utility pricing, and capacity for investment in efficiency. 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.

EXHIBIT 5

Three-year average change by measure among 1,938 hotels and by service type

Measure	2013-2015 Average Change	All Hotels	Full Service	Limited Service
Measure 4: GHG Emissions per Square Meter	Weighted Avg Change	-6.5%	-4.7%	-1.7%
	Overall Avg Change	-11.7%	-11.6%	-12.1%
	Avg of Averages Change	-7.2%	-6.5%	-7.8%
Measure 5: Energy per Occupied Room	Weighted Avg Change	-4.4%	-3.4%	-1.0%
	Overall Avg Change	-5.9%	-5.5%	-7.9%
	Avg of Averages Change	-4.2%	-4.6%	-3.9%
Measure 6: Energy per Square Meter	Weighted Avg Change	-1.4%	-1.0%	-0.3%
	Overall Avg Change	-3.1%	-2.8%	-4.8%
	Avg of Averages Change	-0.9%	-1.3%	-0.6%
Measure 8: Water per Occupied Room	Weighted Avg Change	0.1%	-0.5%	0.7%
	Overall Avg Change	-3.4%	-3.4%	-3.1%
	Avg of Averages Change	1.5%	0.1%	2.6%
Measure 9: Water per Square Meter	Weighted Avg Change	3.9%	2.4%	1.6%
	Overall Avg Change	-0.6%	-2.8%	0.1%
	Avg of Averages Change	5.5%	3.9%	6.8%

Weighted Average Change = average change of the hotel multiplied by the percent 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

Average of Averages Change = mean of the average change of all hotels in the like-for-like data set.

Annual changes in carbon emissions intensity is largely due to external emission factors. This finding will seek to be analyzed more closely in a subsequent publication; however, a significant driver of the variance in carbon benchmarks across many major geographies from the prior index is attributable to a carbon emissions intensity of electric power generation. As utilities make their grids more efficient, change energy sources to renewables and lower-carbon fuels, adapt to increased demand, and change their calculation methodologies, the property carbon footprint will be positively or negatively affected from this external variable. This is particularly important since more than half of a hotel's energy footprint often is from electricity. Some examples of changes from the previous year.

EXHIBIT 6

Examples of GHG Emissions Intensity Changes in Purchased Electricity, CHSB2016 to CHSB2017

Geography	GHG Emissions Intensity Change	Change
California	-13%	Decrease
New York City	-4%	Decrease
China	-4%	Decrease
Brazil	19%	Increase
India	4%	Increase
Indonesia	10%	Increase
Mexico	-5%	Decrease
Germany	-3%	Decrease
France	-36%	Decrease
Kenya	-40%	Decrease
Myanmar	30%	Increase

Furthermore, depending on the emissions factor of electricity intensity, hotel reductions in electricity usage may have relatively higher or lower effect on the hotel's carbon footprint than from reductions in natural gas or other fuel usage. As trends are analyzed over time, the decoupling of change in carbon emissions from energy usage will offer more opportunities for analysis, particularly with the switch of focus from energy intensity reduction to absolute carbon reduction.

The use of renewable sources for energy is almost non-existent. Of over 8,000 properties in the data set, only 122 properties utilized renewable sources to generate energy. 40% of those properties had less than 10% of their total energy from renewable sources, and only 8% had at least 50% of the energy from renewables. Overall this indicates a nascent prevalence of renewable energy use. The measure does not include the renewable resources used by utilities to generate electric power or district heating and cooling, nor does it include the purchase of Renewable Energy Certificates (RECs) or other contractual instruments used to support the adding of renewable energy to the power grid. In addition, solar thermal energy used to heat water may not have been included in the data received as this energy source may not be quantified and tracked similarly. Therefore, the actual prevalence may be slightly higher with solar thermal, however in general the amount of energy resulting from solar thermal heating still may be negligible as a percentage of the property's overall footprint. Furthermore, given the path to decarbonization and the growth in the industry, in order to align with the Paris Agreement and make meaningful contributions to curbing climate change, the hotel industry will need to make enormous strides in either directly generating energy from renewables on-site, or indirectly by supporting the addition of renewables to its electric power grid. While numerous examples, especially recently, are emerging of hotels installing renewable energy or being built "off-grid," the prevalence of renewables needs to be accelerated to a much faster pace. 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.

EXHIBIT 7

Three-Year historical overall average change by selected country, 2013-2015

	FULL SERVICE HOTELS ONLY						LIMITED SERVICE						ALL HOTELS					
Country	**Count**	**Measure 4**	**Measure 5**	**Measure 6**	**Measure 8**	**Measure 9**	**Count**	**Measure 4**	**Measure 5**	**Measure 6**	**Measure 8**	**Measure 9**	**Count**	**Measure 4**	**Measure 5**	**Measure 6**	**Measure 8**	**Measure 9**
United States	504	-9.3%	-4.5%	-2.3%	-4.6%	-2.4%	988	-9.0%	-4.2%	-1.0%	-2.5%	0.8%	1,492	-9.2%	-4.6%	-2.0%	-4.2%	-1.6%
China	61	-40.4%	-9.0%	-3.7%	-4.7%	0.9%	9	-43.4%	-12.0%	-6.5%	-7.4%	-1.7%	70	-40.6%	-9.2%	-3.8%	-4.9%	0.7%
United Kingdom	49	-16.1%	-9.1%	-5.8%	-8.6%	-5.3%	3	-26.7%	-25.0%	-24.4%	-28.7%	-28.1%	52	-16.4%	-9.5%	-6.3%	-9.1%	-6.0%
India	15	-5.1%	-11.6%	-2.7%	-8.3%	0.9%	8	-34.2%	-53.6%	-50.1%	-15.9%	-9.5%	23	-11.5%	-22.9%	-15.7%	-9.4%	-0.9%
Canada	13	-8.9%	-7.2%	-4.2%	-9.2%	-6.3%	18	-12.9%	-4.0%	-4.7%	-5.2%	-5.9%	31	-10.1%	-6.0%	-4.3%	-7.8%	-6.2%
Germany	13	-10.8%	-15.8%	-10.4%	-12.2%	-6.5%							20	-9.6%	-13.4%	-8.9%	-10.7%	-6.1%
France	12	-5.8%	12.5%	7.9%	2.9%	-1.2%							18	-7.6%	8.9%	6.0%	1.9%	-0.7%
Thailand	11	5.2%	2.8%	5.8%	3.1%	6.1%							12	5.2%	3.0%	5.6%	3.3%	5.8%
Indonesia	10	-9.6%	-4.6%	-9.4%	10.5%	4.9%							11	-9.9%	-4.7%	-9.5%	11.3%	5.7%
Japan	10	15.7%	0.5%	9.3%	-6.0%	2.3%							11	15.5%	0.5%	9.0%	-5.8%	2.2%
United Arab Emirates	10	11.0%	-20.0%	-1.6%	-3.3%	18.9%							15	6.1%	-22.2%	-9.0%	0.5%	17.5%
Metro Area	**Count**	**Measure 4**	**Measure 5**	**Measure 6**	**Measure 8**	**Measure 9**	**Count**	**Measure 4**	**Measure 5**	**Measure 6**	**Measure 8**	**Measure 9**	**Count**	**Measure 4**	**Measure 5**	**Measure 6**	**Measure 8**	**Measure 9**
Washington, DC	39	-15.4%	-6.9%	-3.9%	-2.7%	0.4%	46	-13.6%	-3.5%	1.7%	-10.4%	-5.5%	85	-15.0%	-6.6%	-3.0%	-4.4%	-0.8%
New York, NY	32	-0.6%	-0.6%	-0.9%	-9.3%	-9.6%	24	-9.7%	0.1%	0.7%	6.4%	7.1%	56	-1.6%	-0.6%	-0.7%	-7.6%	-7.7%
Los Angeles, CA	30	-3.6%	-6.8%	-5.0%	-1.4%	0.5%	29	-1.6%	-6.9%	-3.2%	-8.9%	-5.2%	59	-3.3%	-7.0%	-4.7%	-3.2%	-0.8%
Miami, FL	24	-7.9%	-0.6%	-0.8%	-26.8%	-26.9%	22	-2.6%	-0.2%	5.2%	4.1%	9.7%	46	-7.0%	-1.3%	0.2%	-22.4%	-21.2%
Chicago, IL	20	-2.6%	-3.3%	-0.2%	0.0%	3.1%	27	-4.4%	-0.1%	-2.3%	5.2%	3.0%	47	-2.8%	-2.4%	-0.5%	1.1%	3.1%
Atlanta, GA	19	-15.6%	-8.3%	-3.4%	0.7%	6.1%	28	-10.6%	-3.9%	1.7%	0.3%	6.2%	47	-14.8%	-7.6%	-2.5%	0.6%	6.1%
San Francisco, CA	16	-2.9%	-7.2%	-4.6%	-8.9%	-6.4%	20	0.3%	-5.9%	-1.4%	-11.0%	-6.8%	36	-2.3%	-7.1%	-4.0%	-9.5%	-6.5%
Boston, MA	15	-13.7%	-1.6%	-0.3%	-7.6%	-6.3%	17	-11.3%	-4.5%	2.1%	-4.1%	2.6%	32	-13.3%	-2.4%	0.1%	-6.9%	-4.5%
Dallas, TX	14	-6.2%	-2.6%	5.4%	-4.0%	3.9%	35	-6.5%	-5.7%	2.0%	-12.1%	-4.9%	49	-6.2%	-3.2%	4.8%	-6.0%	1.8%
Houston, TX	12	-13.0%	3.9%	-2.6%	7.7%	0.9%	27	-9.4%	3.8%	1.2%	5.1%	2.4%	39	-12.3%	3.2%	-1.9%	6.7%	1.3%
Phoenix, AZ	12	-21.5%	-4.7%	-1.0%	-6.2%	-2.5%	24	-21.5%	-7.0%	1.1%	-5.7%	2.5%	36	-21.5%	-5.8%	-0.7%	-6.8%	-1.8%

Limitations

Several limitations are present in the second annual study given the data set and representation of participating companies:

The results are skewed toward the higher end of segment tiers. As CHSB2017 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. This year the brand data set increase was largely due to limited service hotels, however these are still within the range beginning with Upper Midscale or 3 stars. While this does not affect the benchmarking within other segments, on a whole the benchmarks for a metro area or country likely skew higher than the actual hotel supply of the same geography, given that economy hotels will consume less energy and water (with less public areas, amenities, and less space of guestrooms). As more participation is encouraged in future years, economy and midscale or 1-2 star properties will be sought.

The results are skewed toward branded chains. Similarly, given that the vast majority of the hotels are represented by branded flags, they may not represent the actual hotel supply. It is possible that branded hotels are more efficient than independent hotels, given the availability of capital to renovate and retrofit the building equipment and FF&E than independent hotels. CHSB will need to seek to include more independent hotels to balance out the range and be representative of the actual hotel supply in any given geography.

The majority of the data set covers the United States. Although the data set covers 45 countries, slightly over 50% of the benchmarks are within US geographies and the ratio of hotels in the data set to potential hotels in the country is lower in other countries. The coverage has improved this year, and in future years we will continue seeking data sets from outside the US.

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 the segmentation and geographic location. Fair comparison between two properties remains troublesome since properties may have very distinct attributes (i.e. laundry, swimming pool, spa, irrigated landscaping, etc.). Furthermore, the raw data generate a significantly wide range of "performance" within each geography and segment. This year we have attempted to improve the range of benchmarking to account for the basic asset class distinction of full service and limited service, however this broad generalization does not cover the range of amenities even within one hotel type or star level.

The data have not been verified. Even passing 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% accurate. Most of the data set does derive from participants who verify the data sets in their own respective corporate reporting, serving as a primary validation method. As data verification become 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.

District heating and cooling remain a challenge to harmonize. We see an increase in property data including energy usage from purchased district steam, heat, hot water, and chilled water. These sources of energy are not as easily harmonized into energy through common unit conversions or greenhouse gas emission factors. The common practice for large portfolios globally of applying default factors becomes less representative of those specific cities. Furthermore, unlike regional electricity grids which are based on averages, district heating and cooling is generally in a closed system with specific sources for specific hotel properties and should be characterized as such. Finally, some of the increase in district heating and cooling is generated from waste-to-energy facilities, where the application of greenhouse gas emission factors across the lifecycle of the waste is not as clear. For CHSB2017, we applied specific coefficients to district heating and cooling where data were available and for cities with more than 8 properties within the published data set (see Appendix for further detail). Going forward we will continue seeking further granularity to publish more precise energy conversions and greenhouse gas emission factors.

As CHSB evolves to understand the drivers of energy, water, and carbon within hotels, we will seek to enhance comparisons to incorporate additional attributes. However, it should be noted that only certain attributes of hotel operations are controllable by the owner or operator, either through procedures, capital equipment, FF&E, and amenities. The behavior of the guest may be a determining factor that will require additional study. For example, should hotels be compared based on the average duration of guests' showers?

Outlook for CHSB2018

As the CHSB study is an evolving index and process, the 2018 study will once again aim to provide an updated index with a larger data set, further segmentation, and additional filtering by attributes that are clear drivers of energy and water. We will continue seeking additional data from independents, smaller chains, and smaller properties currently underrepresented in the global data set.

Hotels are welcome to participate in CHSB 2018, calling for 2016 data sets. For further information, please email Eric Ricaurte at 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. 12 full data tables are provided, each a separate tab containing the benchmarks for a single measure.

Exhibit 8

Measures used in the CHSB Index (2015 calendar year data)

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

Each data table contains the list of geographies and the benchmarks per segment. The data tables can be 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.

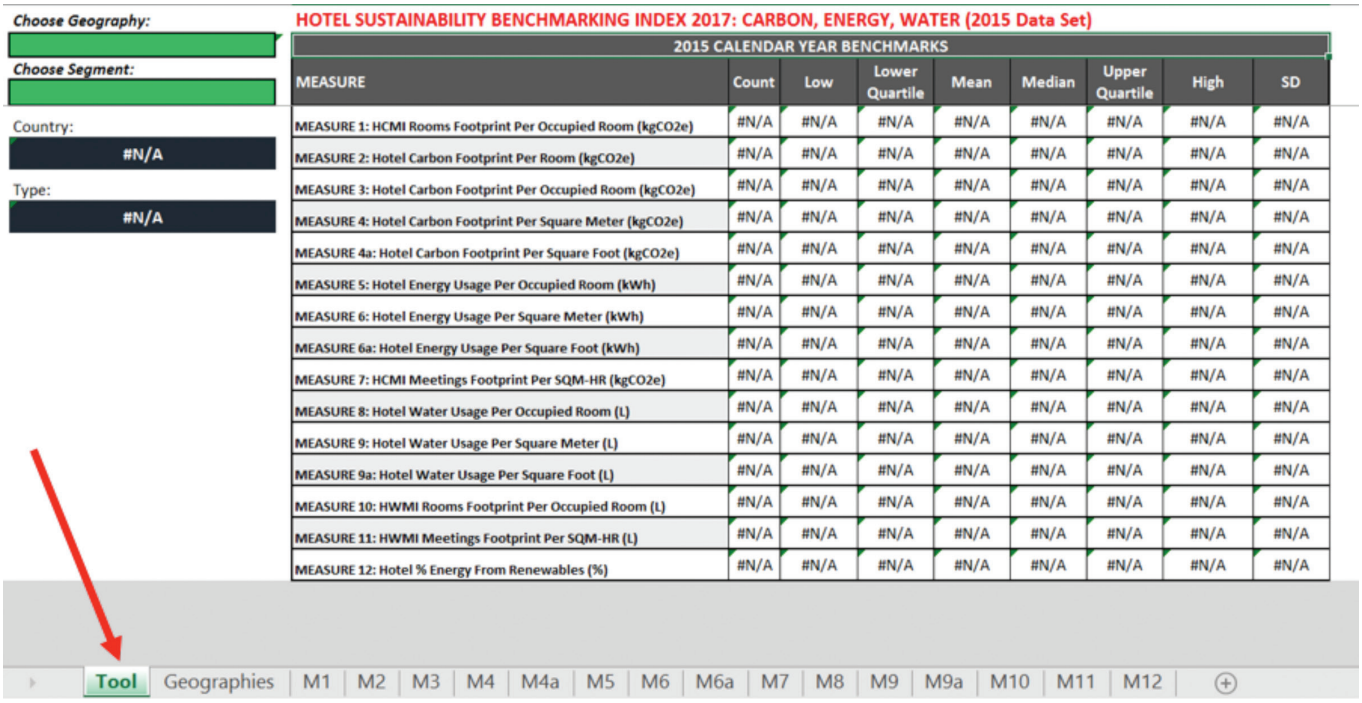
Measure Values

For each measure, values are broken down in the following:

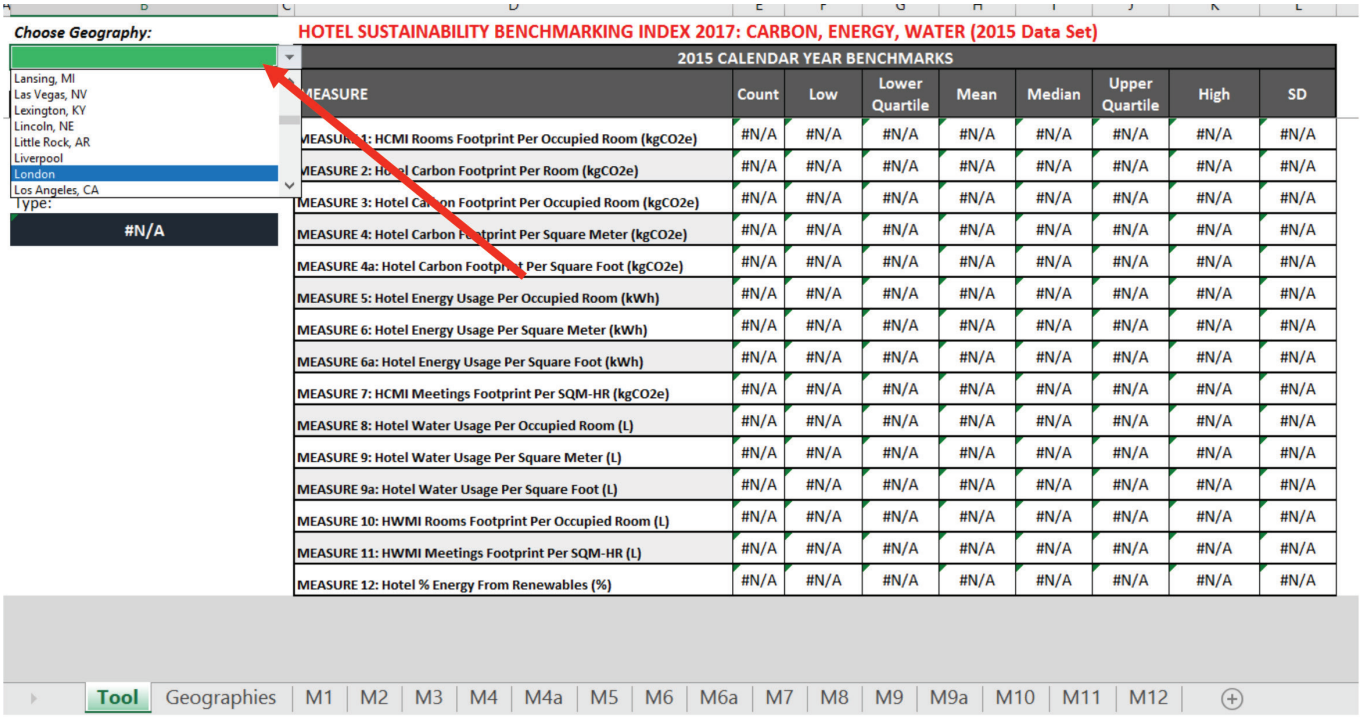
1. **Count** – the number of properties included within this geography and segment grouping
2. **Low** – the lowest value found within the geography segment grouping (this is the best performer of the group)
3. **Lower Quartile** – the 25% marker within the data set. 25% of the properties within the 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% marker within the data set. 75% 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)
8. **SD** – the standard deviation across the data set of properties within the geography and segment

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

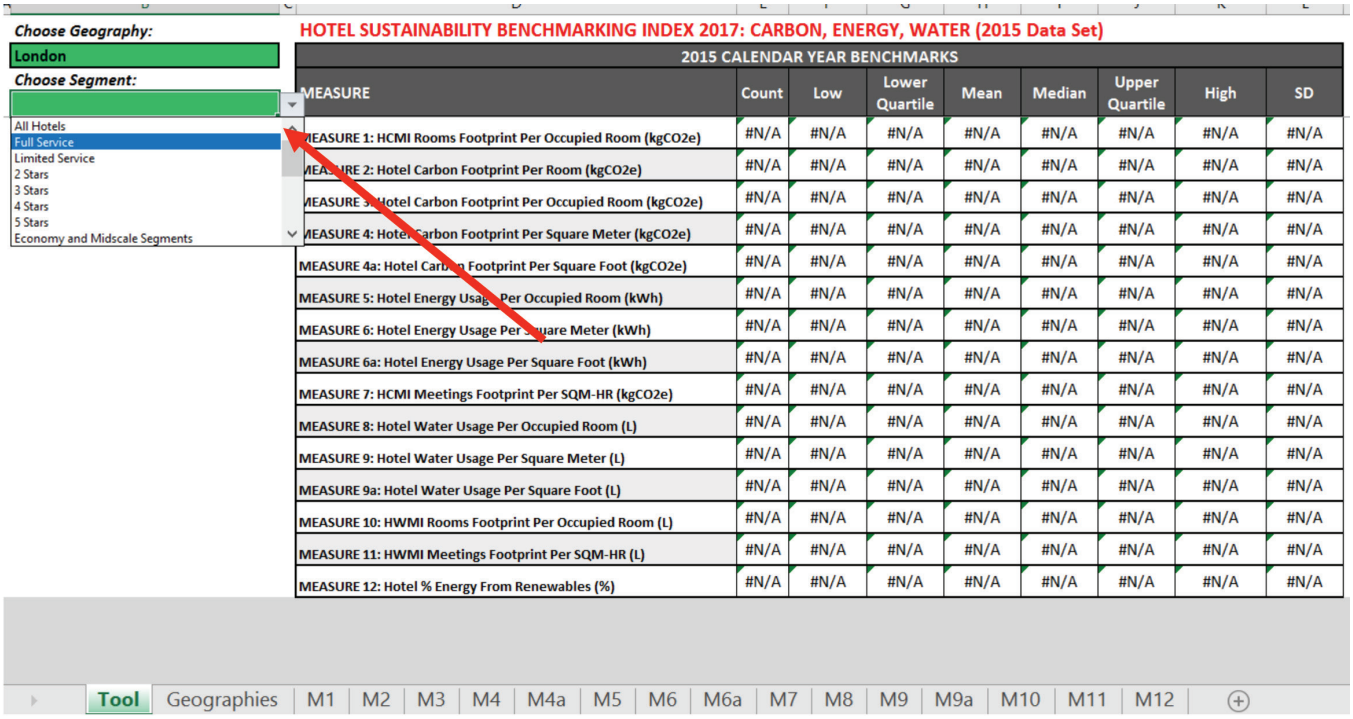
Step 1: click on the Tool tab.



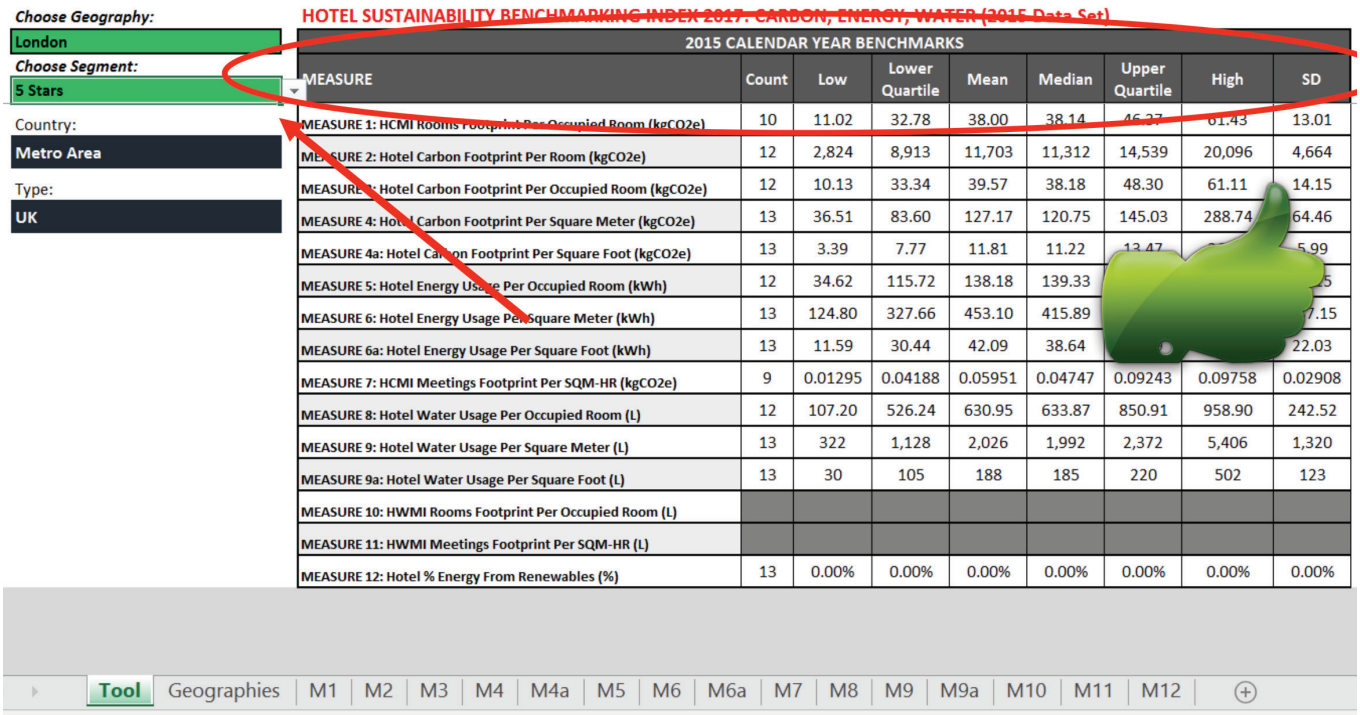
Step 2: Select the Geography to be used, choosing from the dropdown list. For further description of each geography, refer to the *Geographies* tab. Upon selecting the Geography, the *Geography Type* and *Country* will populate automatically in the dark gray-blue boxes.



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



Step 4: View the corresponding results in the gray table at the top "2015 Calendar Year Benchmarks." The example below is for a user that has selected to view the data set corresponding to properties within the upscale and upper upscale market segments in the MSA of Atlanta:



In this example:

- A possible 13 hotels within the London metro area of the UK, with a 5-star designation 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 7 is the lowest count with 9 hotels in the data set for that specific measure. Measures 10 and 11 did not have at least 8 properties within the London metro area with the 5-star designation, so the measures are left blank as benchmarks could not be generated for these.
- MEASURE 1: The mean (average) HCMI rooms footprint (guest footprint of a night stay) is 38.0 kgCO2e/OCRM
- MEASURE 2: The upper quartile carbon footprint per room in a calendar year is 14,539 kgCO2e/OCRM (meaning that of the 12 properties counted in the benchmark for this measure, 75% fell below 14,539 and 25% fell at or above 14,539)
- MEASURE 6a: The lowest energy usage per square foot is 11.59 kWh/Sqft
- MEASURE 8: The highest water usage per occupied room is 958.9 L/OCRM
- For all measures the quartiles, mean, and median all fall within the Low and High range

Interpreting and Using the Results

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

- An owner, operator, or potential buyer of a single hotel in the 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 controllable.
    - For additional analysis, the user may wish to choose a different segment or hotel type that relates to the hotel type (i.e. Full Service or Resort), 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
- A citywide event planner organizing an event in London – which will require accommodation for dozens of hotels – can use Measure 1, the HCMI rooms footprint (for example choosing a higher range benchmark) and multiply that figure by the total number of rooms in order to calculate the total carbon footprint of the room block. The event planner can also use Measure 7 to calculate the footprint of the meeting space utilized during the event.
    - If the event planner wanted to offer its attendees an option to offset the carbon footprint of their stay, it could incorporate the same figure as the base calculation for the attendee's carbon footprint.
- Researchers or policymakers from a municipality, region, or country seeking to understand the impact of water usage from hotels in their geography, they could obtain the current hotel supply and pipeline and run scenarios based on the statistics provided (high, low, mean etc.).

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 2016	2016 Climate Registry - Default Emissions Factors April 2016	International Energy Agency CO2 Emissions from Fuel Combustion 2016	International Energy Agency CO2 Emissions from Fuel Combustion 2016	HK Electric Investment Sustainability Report 2015, CLP Sustainability Report 2015	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	EPA eGRID 2014 V2 (updated February 27, 2017)	International Energy Agency CO2 Emissions from Fuel Combustion 2016
Natural Gas	National Greenhouse Accounts Factors August 2016	2015 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 2016 V1.0	EPA Emission Factors for GHG Inventories last modified 11/19/2015	WRI Stationary Combustion Tool V4.1
Butane, Propane	National Greenhouse Accounts Factors August 2016	2015 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 11/19/2015	WRI Stationary Combustion Tool V4.1
Liquefied Petroleum Gas (LPG)	National Greenhouse Accounts Factors August 2016	2015 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 2016 V1.0	EPA Emission Factors for GHG Inventories last modified 11/19/2015	WRI Stationary Combustion Tool V4.1
Liquefied Natural Gas (LNG)	National Greenhouse Accounts Factors August 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	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1
Compressed Natural Gas (CNG)	National Greenhouse Accounts Factors August 2016	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0
Stationary Gasoline/ Petrol	National Greenhouse Accounts Factors August 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	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	EPA Emission Factors for GHG Inventories last modified 11/19/2015	WRI Stationary Combustion Tool V4.1
Stationary Diesel, Fuel Oil #1-#6	National Greenhouse Accounts Factors August 2016	2015 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 2016 V1.0	EPA Emission Factors for GHG Inventories last modified 11/19/2015	WRI Stationary Combustion Tool V4.1

Appendix 1 (continued)

	Australia	Canada	China (including Macau)	Taiwan	Hong Kong	United Kingdom	United States, Puerto Rico, other US Territories	All Other Countries and Territories
City Gas / Towngas	National Greenhouse Accounts Factors August 2016	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	Towngas Sustainability Report + WRI Stationary Combustion Tool V4.1	WRI Stationary Combustion Tool V4.1	EPA Emission Factors for GHG Inventories last modified 11/19/2015 (Natural Gas)	WRI Stationary Combustion Tool V4.1
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 2016	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)
Purchased Steam, Heat, and Hot Water	Not Applicable	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	Not Applicable	UK Government GHG Conversion Factors for Company Reporting 2016 V1.0	US Energy Star Portfolio Manager Technical Reference: Greenhouse Gas Emissions, August 2016	Paris: Legifrance decree JORF n°0262 du 13 novembre 2014 page 19088; all other: UK Government GHG Conversion Factors for Company Reporting 2016 V1.0
Purchased Chilled Water	Not Applicable	Toronto: Enwave Toronto (deep water cooling), all other: 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 2016	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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