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Developing a Sustainability Measurement Framework for Hotels:

Toward an Industry-wide Reporting Structure

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by Eric Ricaurte

Cornell University
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Rohit Verma, *Executive Director*
Jennifer Macera, *Associate Director*
Glenn Withiam, *Director of Publications*

Center for Hospitality Research
Cornell University
School of Hotel Administration
489 Statler Hall
Ithaca, NY 14853

Phone: 607-255-9780
Fax: 607-254-2922
www.chr.cornell.edu

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ABOUT THE AUTHOR

Eric Ricaurte works to advance sustainability by helping the world's leading global hospitality companies measure and report on key issues of corporate responsibility and sustainability (eer3@cornell.edu). He adds this to his 10 years of experience in operations and consulting for hotels, hospitality vendors, tourism operators, attractions, and tourism boards in Latin America. Eric is actively involved as a speaker, roundtable organizer, and writer in the topic of sustainability within the hotel industry. His work includes the first hotel property GRI sustainability report and the first hotel report following the Global Sustainable Tourism Criteria. Eric's research focuses on standardizing sustainability measurement within hospitality and tourism, beginning as a finalist in the Hotel School's student research competition in 2001 for his paper titled, "Carbon sequestration, offsetting, and trading, and their relation to travel and tourism." Eric holds a Bachelor of Science from the Cornell School of Hotel Administration and is a candidate for a Master of Science degree in Tourism Management from New York University.

W*hat is the carbon footprint of my hotel stay?* Surprisingly, each global lodging company currently provides the answer to this question in a different format, inhibiting aggregate corporate or event travel carbon footprinting and comparison. Third parties have attempted to help answer this question uniformly but their proposals have not gained traction, and no single method for calculation has been widely adopted.

The need for uniform carbon footprint calculation of a hotel stay is paramount, yet it is not the only sustainability performance metric. Other issues such as energy, water, and waste are also at the forefront of stakeholder requests and manifested through sustainability reporting and certifications.

The emergence of such questions, combined with the global trends of sustainable development and corporate responsibility, point toward a broader need for addressing non-financial performance data collectively and uniformly within the hotel industry. In response to requests from guests, investors, and other stakeholders regarding sustainability, most hotel companies have developed platforms to address these needs. Despite this promising development, the individual chains' reports, assumptions, and measures are not always communicated uniformly—although it's clear that stakeholders seek to use the data to make comparisons.

Taking a historical context for sustainability measurement within the industry and globally, this report presents a conceptual framework for developing sustainability performance indicators to address present stakeholder requests, as well as others that may arise. The framework developed and tested in this report is designed to provide an avenue for industry collaboration and discussion toward a uniform set of metrics that are highly practical in application. The framework is tested using actual 2010 data from 20 hotels operated by InterContinental Hotels Group, Marriott International, or Wyndham Worldwide, all of which assisted with data collection. The study applied the framework seeking to evaluate the boundaries, quantification methods, and metrics for performance indicators of carbon, energy, water, and waste derived from hotel stays, which currently are the most common requests from external stakeholders. In addition, the practicality of data collection was considered as currently practiced.

Based on the study's methods and results as an example, standard metrics are certainly feasible, yet several issues required for collaborative industry agreement remain. Hotels will need to agree on boundary specifications such as addressing differences in laundry wash handling, the quantification of values such as which emission factors to use and how to allocate rooms versus function space footprints, and the metrics utilized such as per occupied room or per available room.

Further issues to enable comparability are discussed. No one catch-all industry benchmark will adequately represent the environmental footprint of hotel stays. Normalization based on amenities or outlets, climate zones, and chain scale segment can help various stakeholders understand the complexity of hotel footprinting, provided that industry collaboration coincides with the proprietary sustainability systems lodging companies are developing internally.

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"The race to shape sustainability standards will transform the competitive landscape and the social and environmental practices of companies in every industry."*

Foreword

In 2009, Professor David Sherwyn, former academic director of the Center for Hospitality Research, responded to a stated hospitalty industry need to address sustainability issues. Working with Eric Ricaurte and other industry participants, Professor Sherwyn organized the first CHR Sustainability Roundtable. We received a extremely positive feedback from the roundtable participants along with the recommendation that CHR should regularly organize sustainability roundtables and undertake research projects to explore different aspects of this complex topic. CHR has also issued a sustainability white paper.

During the Cornell Hospitality Research Summit (October 2010) and the second Sustainability Roundtable (November 2010) a diverse group of industry leaders expressed the need for consistent reporting standards for sustainability. Consequently, CHR commissioned a study for which Eric Ricaurte took the lead, with the guidance and assistance of David Jerome, senior vice president of corporate responsibility for InterContinental Hotels Group, Faith Taylor, vice president of sustainability and innovation for Wyndham Worldwide, and Paul Hildreth, director, engineering & facilities management, Marriott International. This study is part of a continuing research effort by CHR on topics related to sustainability, which includes a study supported by Philips Hospitality a CHR Senior Partner, another study supported by PKF Consulting, a CHR Friend, and an ongoing study supported by Schneider Electric, a CHR Partner.

We look forward to your continued support and feedback as we continue follow-up research projects on sustainability and other topics of interest and relevance to the industry.

Sincerely,

Rohit Verma, Ph.D., Professor, Service Operations Management
Executive Director, Center for Hospitality Research
School of Hotel Administration, Cornell University

*Gregory Unruh and Richard Ettenson, "Winning in the Green Frenzy," *Harvard Business Review*, November 2010, pp. 110-116.

The genesis of this paper is the clear need for an industry-wide framework that allows for uniform measurement of the sustainability performance between individual hotel properties and among their parent chains. Hotel companies are well aware of their stakeholders' interest in the carbon footprint and other aspects of a hotel's operation, whether that interest stems from their own environmental footprinting, plans to use the hotel's services, or interest in investing in the property. To that end, most hotel companies have developed their own framework for measuring and communicating environmental footprints and reporting on sustainability. However, as I explain in this paper, the industry lacks a common ground that allows for comparison across hotels and chains. This paper seeks to provide the catalyst for cooperative discourse across the industry to provide a comprehensive measurement scheme that will be at once comprehensive, practical, and intuitive. In outlining and demonstrating the boundaries for such a common comparison framework, I emphasize the need for industry-wide cooperation in establishing a sustainability measure.

Nearly every contemporary examination or discussion of sustainability involves some form of performance measurement and metrics. At the global level, the concept of ecosystem services is taking hold and framing the context of GHG emissions mitigation as one component of Payments for Ecosystem Services (PES). Within business, seminal works such as "The Economics of Ecosystems and Biodiversity"[1] are being used to explore measurable relationships between humans and the natural environment. Stock exchanges can trade sustainability indexes, and investment rating systems now include "intangible value" and environmental, social, and governance (ESG) disclosures. The top global companies provide annual sustainability reports using a number of non-financial performance indicators around a framework resembling the triple bottom line, and some companies provide sustainability reports to international bodies to quantify and measure risks associated with the driving causes of sustainability's call. Additionally, investors and clients are asking for precise measures of a company's sustainability performance, often right down to the product level, to provide an understanding of the environmental footprint of goods and services. Similarly, supply chain initiatives and indexes have companies asking each other for measurable performance data, and consortiums and working groups are collaborating to define how the environmental impacts of goods and services may be quantified, measured, and communicated in labeling and procurement. These are the so-called "scope 3" impacts that extend beyond immediate operational data.

Parallel to the emergence of environmental footprinting is the attention paid to engaging stakeholders. The theory that companies have integral and complex relationships with the stakeholders who define their existence has gained much ground over the past 30 years since such models arose.[2] Stakeholder groups are diverse, but sustainability performance requests from clients and investors in particular are driving the need for uniform measurement.

As with other industries, hotels are being asked by casual guests and corporate clients alike to quantify the environmental impact of their stay, often in terms of the carbon footprint of a room-night and the related consumption of energy, water, and waste. Similarly, investors request the same information from hotel companies. Consequently, hotels are among the many companies that produce sustainability reports that include ESG disclosure. In so doing, however, hotels typically provide the information in diverse formats making it difficult for the client or stakeholder to roll up the data or compare different operations in any meaningful way. Second, different stakeholders' sustainability requests encompass a multitude of issues, impacts, and measurements which can only escalate as more stakeholders ask more frequent and more diverse questions. For these and other reasons, any standardization of the calculation of the environmental footprint of a hotel stay needs to fit a framework that will satisfy not only today's questions, but the questions of tomorrow as well.

The hotel industry has no commonly accepted guideline for disclosing standardized sustainability information to allow for comparison among properties and companies.

[1] See: www.teebweb.org/.

[2] See: Donaldson, Thomas and Lee E. Preston. "The Stakeholder Theory of the Corporation: Concepts, Evidence, and Implications." *Academy of Management Review* 20.1 (1995): 65-91

That vacuum may well be filled by measurement standards and guidelines developed by third parties with a focus that is not hotel-specific, and which did not engage hotel companies themselves as stakeholders in defining the methods. This study aims to serve the hotel industry's need for a practical conceptual framework for measuring the material aspects of sustainability within hotel operations. In doing so this study attempts to advance the body of knowledge in sustainability by developing transparent and clear methods of measuring the most material impacts from hotel operations. Hotels, hotel companies, and industry associations will be able to immediately use this framework to build data sets and discuss common acceptance in the immediate areas of requests. Furthermore, the framework may be expanded to include other performance indicators and more in-depth parameters for the ones currently examined by using its points of discussion.

Where the Industry Stands

Before discussing the measurement framework, I examine the present state of hotel sustainability measurement as found in the academic literature; industry initiatives; sustainability certifications, criteria, and guidelines; hotel sustainability reporting; and available third-party resources.

My review of existing material identified the following five general categories of sustainability measurement relating to hotel operations: policies, processes, specifications, consumption (usage), and impacts.[3]

Policies. Whether a hotel has written policies addressing specific issues is often measured in a yes-or-no checklist format, for example, the presence or absence of a policy regarding sustainable purchasing. The policy may stipulate specific weighting of factors in decision making, provisions for meeting and updating the criteria, and evaluating vendors.

Processes. The performance of managerial or behavioral processes is often measured, for example by recording that the green team met at least once a month over a calendar year. Staff training statistics could be tallied, and records kept for practices such as toilet and faucet revision, lighting procedures, or waste separation.

Specifications. Also termed technical as a component of measurement, these criteria are most commonly found as specifications of FF&E or building design. Wide-ranging specifications might include faucet flow rates, efficiency of lighting, and chemical composition of materials. Specifications are rated according to a yes-or-no checklist, or according to the percentage of an item or specification found at the property.

Consumption (usage). The familiar metrics of utility use, consumption of goods and supplies, and generation of waste or discarded materials can be measured directly, or indirectly according to the percentage of the different types of consumption.

Impacts. A typical impact measure is carbon footprint (typically, greenhouse gas emissions), and this category includes other impacts on people or the Earth and its ecosystem services. Impacts are measurable through characterization and normalization, and derived from consumption.

Although I specify five measurement categories, I must note that the policies, processes, and specifications are often measured, but they are usually introduced with the intention of reducing consumption and impacts. So a property may have a policy containing showerhead flow rate specifications or lighting wattage which are measured as criteria for reducing energy and water consumption (and in turn carbon emissions as an impact). Similarly, specification of the percentage of FF&E, materials, and supplies with VOCs, toxic, or non-biodegradable ingredients serves to reduce impacts on environmental health and safety.

Measurement in Historical Context

Hotels have long been monitoring and measuring items now associated with sustainability, and it would be highly inaccurate to insinuate that sustainability performance measurement in the hotel industry is a new concept. The hotel industry has been measuring, benchmarking, and improving performance in areas such as energy, waste, water, indoor air quality, noise, and contaminants for nearly 100 years that we know of.[4] Hoteliers did not need environmental groups or climate change to work on improving energy efficiency. As just one example, ROI analysis of fluorescent light bulb change-out is decades old, and original studies had to take into consideration the cost of changing the ballast to accommodate a fluorescent.

Academic studies to measure sustainability in hospitality have addressed energy, water, waste, air quality,[5] and more recently GHG emissions. Evaluations of hotel performance also have used the ISO 14001 standard to examine energy, waste, and water consumption, applying per-occupied-room

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[3] Some components adapted from: Eric Ricaurte, "A Guide to Measuring Sustainability," *Hotel Sustainable Development: Principles and Best Practices*, ed. A.J. Singh and Hervé Houdré (Washington, DC: AHLA Educational Institute, 2011).

[4] D.M. Stipanuk, "The U.S. Lodging Industry and the Environment—A Historical View, *Cornell Hotel and Restaurant Administration Quarterly*, Vol. 37, No. 5 (1996), pp. 39-45.

[5] Bohdanowicz, Paulina, and Martinac, Ivo (2007). Determinants and benchmarking of resource consumption in hotels—Case study of Hilton International and Scandic in Europe. Energy and Buildings, 39, 82-95; and L.A. Jackson, (2010). Toward a framework for the components of green lodging. Journal of Retail and Leisure Property, 9(3), 211-230.

metrics.[6] Benchmarking studies in energy, water, and GHG emissions have incorporated per-guestroom, square footage, and per-guest comparisons.[7] A key insight from benchmarking studies is the variances in normalized utility consumption among hotels, as well as between company benchmarks and individual property performance.[8] Several studies examine the influences of climate on the comparability of hotel environmental performance.[9] One noticeable oversight in the measurement studies involves the social components of sustainability. Though difficult to measure, some platforms have included a social pillar, which has yet to gain industry-wide acceptance.[10]

Though academic studies on sustainability measurement, models, and frameworks exist, they do not necessarily address the need for comparisons and common measurement among properties on a global level in practical industry application. Moreover, most studies did not focus on carbon emissions, and in any event, no framework or lodging-specific measurement methodology from academic literature has been adopted by the hotel industry or cited in third-party hotel sustainability criteria.

Despite the lack of standard benchmarks, hotel companies have developed in-house environmental performance measurement systems for internal benchmarking and measurement. Prior to its current LightStay program, Hilton International's Hilton Environmental Reporting (HER) database was implemented in 2004 and has been highlighted and studied, notably in benchmarking of energy and water use.[11] HER was built off the Scandic Utility System (SUS), as developed in 1997.[12] In 1990, nearly two decades before IHG launched Green Engage, InterContinental (when owned by Bass Hotels and Resorts) developed an environmental operating manual[13] with a formalized system of spreadsheets tracking utility use comparing against company benchmarks.[14] Accor rolled out its Environmental Guide for Hotel Managers in 1998, which had guidance on measuring and tracking energy consumption against performance benchmarks.[15] Rezidor introduced a tool for measuring and reporting consumption in its portfolio,[16] and Hyatt has had a tracking system for energy and water in place since 1994.[17] The Westin chain has been using Energard Technologies' Envision energy accounting system since the mid-'80s, and in 2000, Starwood (owner of the Westin brand) adopted its use for all brands in its North America division.[18]

The industry has supported discussion of environmental performance for over four decades,[19] together with proposed collaborative industry benchmarking initiatives. Hotel Energy and Water Consumption Benchmarks was a study performed by David Stipanuk, the AHLA, and the AHLF, using 2000–01 data from hotels in several major U.S. chains.[20] The study analyzed energy and water usage per property and per square foot by chain scale segment with regional considerations, demonstrating a variance in energy usage depending on a number of factors. As the century began, the World Wildlife Fund and the International Hotels Environmental Initiative began developing an interactive environmental benchmarking tool and guide for hotels to measure and compare performance in energy, waste, and water

6 Chan, W. W. (2009). Environmental measures for hotels' environmental management systems. International Journal of Contemporary Hospitality Management, 21(5), 542-560.

7 Deng, Shiming (2003). Energy and water uses and their performance explanatory indicators in hotels in Hong Kong. Energy and Buildings, 35(8), 775-784; and Beccali, M., Gennusa, M. L., Coco, L. L., Rizzo, G. (2009). An empirical approach for ranking environmental and energy saving measures in the hotel sector. Renewable Energy, 34, 82-90.

8 Scanlon, N. L. (2007). An analysis and assessment of environmental operating practices in hotel and resort properties. International Journal of Hospitality Management, 26(3), 711-723.

9 Chan, W.W. (2005). Predicting and saving the consumption of electricity in sub-tropical hotels. International Journal of Contemporary Hospitality Management, 17(3), 228-37; Redlin, M.H. and de Roos, J.A. (1980). Gauging energy savings: further applications of multiple-regression analysis. Cornell Hotel and Restaurant Administration Quarterly, 20.4, 48-52; Zmeureanu, R.G. (1994). Energy performance of hotels in Ottawa. ASHRAE Transactions, 100(1), 314-22; and Bohdanowicz, Paula, Martinac, Ivo (2007). Determinants and benchmarking of resource consumption in hotels—Case study of Hilton International and Scandic in Europe. Energy and Buildings, 39, 82-95.

10 See: Houdré, Hervé (2008). Sustainable Hospitality©: Sustainable Development in the Hotel Industry. Cornell Hospitality Industry Perspectives, August, 4-20; and Levy, Stuart E., Duverger, Philippe (2010). Consumer Perceptions of Sustainability in the Lodging Industry: Examination of Sustainable Tourism Criteria. International CHRIE Conference-Refereed Track. Paper 31. http://scholarworks.umass.edu/refereed/CHRIE_2010/Friday/31

11 Bohdanowicz, Paulina, Martinac, Ivo (2007). Determinants and benchmarking of resource consumption in hotels—Case study of Hilton International and Scandic in Europe. Energy and Buildings, 39, 82-95.

12 Bohdanowicz, Paulina. Hilton Environmental Reporting as a tool of Corporate Social Responsibility. Royal Institute of Technology.

13 Faulk, E. Saskia (2000). A survey of environmental management by hotels and related tourism businesses. Paper prepared for presentation OIKOS PhD Summer Academy 2000, University of St. Gallen.

14 IBLF & WWF. (2005). Why Environmental Benchmarking Will Help Your Hotel. London: International Business Leaders Forum.

15 *Ibid.*

16 *Ibid.*

17 See: Hyatt Earth Website, www.hyattearth.com/our_progress/tracking_measurement.html.

18 Information received via Gus Newbury, Vice President, Engineering, Starwood Hotels & Resorts Worldwide, Inc.

19 Stipanuk, D.M. (1996), The U.S. lodging industry and the environment—A historical view. Cornell Hotel and Restaurant Administration Quarterly, 37(5), 39-45.

20 David M. Stipanuk, AH&LA Energy Management and Conservation Guide (Washington, DC: American Hotel and Lodging Association, 2001).

Exhibit 1

Common performance indicators in lodging firms' Global Reporting Initiative

All 9 reports disclosed qualitative information on:	• Programs related to training and professional development (LA11)
	• Initiatives to reduce GHG emissions (EN18)
8 of 9 reports disclosed performance on:	• Energy consumption (EN3 or EN4)
	• (Some form of) initiatives to reduce energy consumption and the reductions achieved (EN5 or EN6)
	• Water usage or withdrawal (EN8)
	• Composition of the organization's governance bodies and breakdown of labor force by indicators of diversity (LA13)
7 of 9 reports disclosed performance on :	• Scope 1 and 2 GHG emissions (EN16)
	• The size of their workforce by type (LA1)
	• Percentages of workforce receiving performance reviews (LA12)

consumption,[21] as well as GHG emissions.[22] The WWF also highlighted other potential environmental performance indicators for tourism vacation footprinting such as average earthshare and consumption of meat.[23] Neither the tool nor the footprinting methods gained traction, however, and the hotel benchmarking initiative has not been active lately.

One substantive change of recent years is that the terminology for discussing the topics has coalesced. Prior to the 1960s, hotel environmental issues were addressed by their own individual categories.[24] More recently, individual factors are grouped under the rubric of sustainability, which embraces a broad scope of metrics.

Shifting Drivers of Measurement

The chief difference in today's dialogue and measurement frameworks stems from increased stakeholder requests, including investors, shareholders, governments at all levels, and corporate clients and other organizations. Questions relating to measurements of environmental and social aspects have proliferated in RFPs to hotels at both property and corporate levels.

These concerns underscore the hotel industry's need to adopt a uniform approach to measuring and quantifying the various aspects of sustainability, and communicate them to stakeholders. In some cases the measurement methodology is dictated, but others require collaborative industry agreement. Within this dialogue, diverse responses to stakeholder requests exist. The two most commonly discussed approaches, certification and sustainability reporting, were developed outside of the industry and serve some but not all stakeholder requests for sustainability performance. Measures of non-financial performance in hotels have moved well beyond internal portfolio comparisons and ROI calculations. One primary evolution of measurement has been the inclusion of carbon emissions as a key performance indicator. Like its 1980s' predecessor, ozone depletion, the global discussion on GHG emissions and climate change has urgently spotlighted non-financial performance indicators on a global scale, to the point where the entire world now has a collective performance target of 350 parts per million of CO_2 in the atmosphere.[25]

Corporate Responsibility and Sustainability Reporting

In response to stakeholder requests, in 2008 and 2009 all of the top 100 U.S. companies by revenue, and 80 percent of the Global *Fortune* 250 companies produced sustainability reports disclosing ESG performance, based on the Global Reporting Initiative (GRI).[26] This GRI content is developed based on stakeholders' requests.

Specific to the topic of climate change and GHG emissions, the Carbon Disclosure Project (CDP) surveyed 3,000 organizations worldwide,[27] and added questions regarding

21 Dodds, Rachel. Why Environmental Benchmarking will help your hotel. London, UK: The Prince of Wales International Business Leaders Forum (IBLF), 2005.

22 See: www.benchmarkhotel.com, which is no longer in use by the organizations mentioned.

23 WWF-UK Business and Consumption Unit (2002). Holiday Footprinting: A Practical Tool for Responsible Tourism. WWF-UK.

24 *Ibid.*

25 For more information see www.350.org.

26 Brown-Smatlan, A. & Sparks A. (2010, May 12). The Evolution of Greenhouse Gas Reporting by Business: Addressing Product and Supply Chain Emissions. Presentation through KPMG & WBCSD. Los Angeles & Geneva.

27 Carbon Disclosure Project. (2011). CDP: What we do. Retrieved April 14, 2011, from https://www.cdproject.net/en-US/WhatWeDo/Pages/overview.aspx.

Exhibit 2

Presence of measurement criteria in hotel certifications and guidelines

Criteria	GHG Emissions	Energy Usage	Water Usage	Waste Generation and Disposal	Materials Purchasing	Food and Beverage items	Toxicity / Biodegradability of Cleaning Supplies	Guest Satisfaction
GSTC	●	●	●	●	●			●
Green Key	○	●	●	○	○		○	
Green Seal (GS-33)	○	○	●	○	○			
LEED (EB): O&M	●	●	●	●	○	○		
AHLA		●	●	●				

● = Directly stated; ○ = Implied or precursor

water use in 2010, similar to carbon reporting. As of 2009 approximately nine global hotel companies produced GRI reports and six had responded to a CDP questionnaire. As shown in the evaluation in Exhibit 1 (previous page), these nine hotel GRI reports typically involved the following performance indicators:[28] energy consumption and reduction, water use, and diversity indicators. In addition, although only five reports disclosed performance on total waste (EN22), all reports contained sections on waste minimization with some form of localized or per-unit waste data. Most noteworthy in my evaluation of GRI reports is the lack of standardization in reporting. For example, intensity of usage, when disclosed, can be found in values per square meter, per guest night, per occupied room, per room-night, and per hotel, without specific definitions of what exactly the denominators represent. Furthermore, specific documentation is lacking on what resources have been used in calculating GHG emissions, or the emissions factors used in performing the calculation. Therefore although two companies may declare the same metric, the boundaries of the denominator may differ. For a list of reporting companies and a full breakdown of metrics found in GRI reports, see Appendix A.

Certifications

Sustainability certifications of various types have proliferated in the past two decades. For hotels, the advantage of certification lies in the certification's ability to validate the hotel's sustainability efforts and serve as a response to stakeholders' sustainability concerns, using one label with which the stakeholder is already familiar. Each certification scheme carries its own methodology, and the criteria for these schemes are generally transparent and publicly available.

One outcome of the industry's interest in certification is apparent in the establishment of the Global Sustainable Tourism Criteria (GSTC) and its initial objectives of helping to harmonize tourism sustainability certification platforms. The GSTC stipulates that tourism businesses should measure their guest satisfaction, purchases of disposable and consumable goods, energy consumption, water consumption, and GHG emissions, as well as non-diverted waste. While the GSTC takes into account the broad range of tourism businesses, it does not, however, specify instructions on how the boundaries of measurement or the metrics will be delineated in each sector. Although the GSTC aims to be a framework for use by many stakeholders including certification bodies, it does not delve into technical specifications which are needed for standardization of measurement. Nor do the predominant hotel certifications found in the U.S. completely adhere to the GSTC.

In North America, the three most prevalent certification frameworks in hotels are Green Key, Green Seal, and the USGBC's LEED, modified for use by hotels. In another approach, the American Hotel and Lodging Association developed its Green Guidelines as criteria applicable for hotel operations. These most closely resemble the criteria found in the dozens of state-level certifications. An analysis finds that the certifications and guidelines consistently call for measurement of consumption or impacts in energy, waste, water, and GHG emissions, as shown in Exhibit 2. Only four additional criteria are mentioned as specifically necessitating measurement, albeit not consistently. In addition, internal performance measurement as a component of a broad-based management platform is also common. Much like the GSTC, however, specific technical protocols or guidelines for quan-

[28] Evaluation includes Marriott, IHG, Accor, NH, Jumeirah, Sol Meliá, Rezidor, Taj, and Hong Kong & Shanghai Hotels. Accor reported according to French disclosure requirements and not GRI Framework, but provided a linkage document for its report to the GRI guidelines.

Exhibit 3

ISO 26000 subjects and practices

Core Subjects
Organizational governance
Human rights
Labor practices
The environment
Fair operating practices
Consumer Issues
Community involvement and development

Practices
Recognizing social responsibility
Stakeholder identification and engagement
The relationship of an organization's characteristics to social responsibility
Understanding the social responsibility of an organization
Integrating social responsibility throughout an organization
Communication on social responsibility
Enhancing credibility regarding social responsibility
Reviewing and improving an organization's actions and practices related to social responsibility

Note: Adapted from ISO 26000

tification are lacking. The only exception is LEED certification, which specifies measurements by square footage but not room-nights.

Certification criteria do not always match stakeholder concerns. First, the multitude of certifications worldwide inhibits the uniformity in criteria that stakeholders seek. Second, certifications do not generally stipulate disclosure of performance as part of their criteria and thus do not offer standardized guidance on measurement methods. Finally, not all certifications call for measurement of the same performance indicators. My examination of certifications found them to be relatively narrow within the overall umbrella of corporate responsibility and sustainability.

By contrast, the comprehensiveness of sustainability topics can be seen in ISO 26000, which offers guidance on the subjects and practices for integrating social responsibility, as shown in Exhibit 3. ISO 26000, however, explicitly states that it is a guidance document and not a standard to be used for certification purposes, and nowhere does it mention hotels. This standard examines 40 separate cross-sectoral initiatives including reporting frameworks and certification schemes, evaluating the content of each with regard to its corporate responsibility guidelines. In addition, 35 sector-specific initiatives are listed and cross-evaluated. Travel and tourism is listed as a sector, with only two initiatives mentioned: the ECPAT Code of Conduct and the GSTC. Of the 15 core subjects and practices available per ISO 26000, ECPAT addresses only three, and GSTC touches on five.

Sustainability certification and sustainability reports notwithstanding, the current gap in making an appropriate response to stakeholders' sustainability requests lies in providing specific hotel performance data that provides a product-level quantification of an environmental footprint. Since corporate travel is a driver of GHG emissions and other environmental impacts, companies tracking their own environmental footprints are asking hotels for data relating to their hotel stays; meetings and events clients also wish to know the environmental footprint of the rooms and the event they are booking; and even some transient guests want to know the carbon footprint of their hotel stay.

Performance Measurement

Although the complexity of variables among hotels can constrain the usefulness of wide-scale benchmarking,[29] the industry still needs a uniform measurement scale. This could begin with the type of effort that created the GRI, which provides the opportunity and forum for different industrial sectors to develop sector-specific supplements through collaborative, transparent, multistakeholder efforts. Fifteen such supplements have been developed or are in development at present.[30] None addresses hotels, and additional sector supplements will not be developed in the near future.

The Greenhouse Gas Protocol Corporate Accounting and Reporting Standard is the most widely accepted and referenced guide for quantifying and reporting GHG emissions, and the corresponding ISO 14064 standard also provides guidance on quantification. Both resources are, however, targeted at the organizational level, and a draft of the GHG protocol does not specifically spell out how a hotel property would quantify the carbon footprint of a hotel stay. The Climate Registry General Reporting Protocol comes much closer by providing guidance, quantification methods, and emissions factors for facility-level reporting. It even gives an example of how a hotel chain might quantify the carbon footprint of the organization,[31] but the example is cursory and does not provide comparative metrics at the product

29 Bohdanowicz, Paulina, and Martinac, Ivo (2007). Determinants and benchmarking of resource consumption in hotels—Case study of Hilton International and Scandic in Europe. Energy and Buildings, 39, 82-95.

30 Global Reporting Initiative. (2011). Sector Supplements. Retrieved April 14, 2011, from http://www.globalreporting.org/ReportingFramework/SectorSupplements/.

31 Climate Registry. (2008). General Reporting Protocol, v 1.1. Los Angeles.

level. To date, no global chain-affiliated hotel property has reported to the Climate Registry.

Because of the cost of energy, businesses of all types have monitored energy use for decades, and consequently energy use measurement has seen the best attempts at standardization. Most relevant for hotels is the EPA Energy Star Portfolio Manager, which may well be the only environmental performance measurement tool that is relatively available and used within the hotel sector. Offering a tool to track and measure energy and water use, Portfolio Manager also calculates GHG emissions for buildings and offers uniform boundaries and metrics which enable comparisons. In addition to being utilized as a component of LEED EB certification, Energy Star itself also serves as another type of certification available for hotels. Well known in the U.S. in a number of contexts, Energy Star is used by many state and local governments as a platform for disclosing energy performance of buildings.[32]

Portfolio Manager provides insight as to some key elements necessary for achieving success as a standard for measurement. First, it offers a publicly available quantification method which is derived from public data. Second, it offers uniform boundaries and metrics which enable comparisons, with extensive guidance on how the boundaries and metrics are set. Both the boundaries and guidance are tailored for different types of facilities, including hotels. Third, it offers a common, freely available software platform. Finally, it represents an important advancement toward a type of rating or index for hotel sustainability.

Portfolio Manager also has several distinct limitations for application in global hotel sustainability measurement. It was not designed for hotels, it was not designed for global use, and it was designed only to address energy use. As an example of these issues, Portfolio Manager's metrics are rendered per square foot, which can be helpful for building operators, but not for would-be guests attempting to account for the impact of a room-night. Its calculation methods, moreover, did not test occupancy as one of the 32 independent variables. Though it has robust data in aggregate, its rating model was developed using 2003 CBECS data from 142 U.S. properties, and was tested with 64 properties.[33]

One would not expect that the U.S. EPA would create an international application, but the fact is that for the purpose of benchmarking, international hotel data are not widely available. Portfolio Manager's national-level focus also makes quantification problematic at global levels. Just as regional EnergyStar data are adjusted for region in the U.S., comparisons among several nations would require application of some sort of coefficient of adjustment or other normalization factors.

One can use Portfolio Manager to track operational water consumption, but GHG emissions can be calculated only by inference. Energy site-source calculations are taken at national averages, but carbon emissions from purchased electricity are taken using emission factors from regional grid characteristics. Even though water is tracked, no mention of a similar site-source consideration for a water footprint is mentioned.

While we can expect to see more interest in water sustainability quantification, there is no single standard to date. The World Business Council for Sustainable Development (WBCSD) offers a Global Water Tool which enables analysis of water usage at an organizational level. This tool offers metrics developed based on country-specific resources, and it distinguishes among types of water, but it is not product specific. The most comprehensive examination of water in a sustainability measurement context is the Water Footprint Assessment Manual, which provides a range of guidance and quantification for water footprints at various levels, at all life cycle stages, and for different types of water resources (e.g., green water, blue water, and grey water).[34]

Current performance measurement within hospitality is widely used for other types of performance indicators, with the work of Smith Travel Research as a signal example. The hotel industry is effectively addicted to measuring, tracking, benchmarking, and utilizing performance indicators of ADR, occupancy, and RevPAR. Each metric comes with a well-defined and agreed-upon set of boundaries and quantification rules that enable comparability. Industry capacity, capability, and willingness to collaborate on performance measurement clearly exist, and drawing upon their currently accepted metrics for performance comparison can ease the adoption of sustainability indicators.

This review of various sustainability rubrics delineates the breadth of topics that must be considered for an integrated sustainability measurement. For the lodging industry, the current lack of standard does not mean that standardization attempts do not exist, or that industry discussion and collaboration are not taking place. At a global level industry

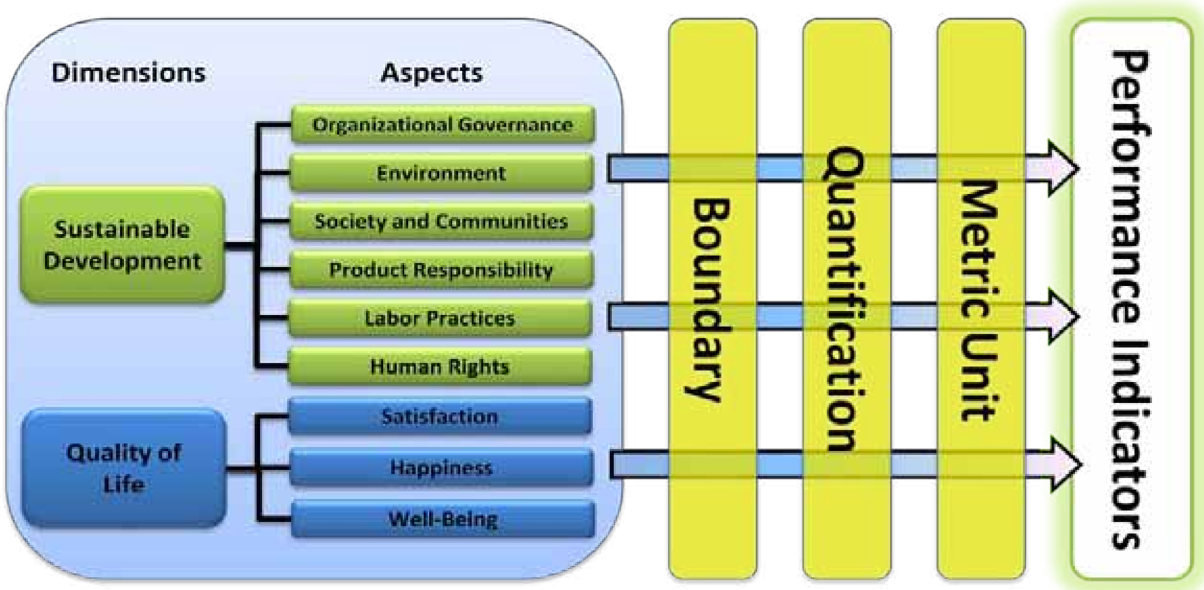
32 See: www.energystar.gov/ia/business/government/State_Local_Govts_Leveraging_ES.pdf.

33 Environmental Protection Agency (2009, February). Energy Star Performance Ratings Technical Methodology for Hotel.

34 Hoekstra, A. Y., Chapagain, A. K., Aldaya, M. M., Mekonnen, M. M. (2011). The Water Footprint Assessment Manual: Setting the Global Standard. Washington, DC: Earthscan.

Exhibit 4

Sustainability measurement framework



roundtables are discussing the topic,[35] and working groups for developing standard sustainability performance metrics are currently underway. In addition, third parties have developed their own quantification methods or benchmarks to provide uniform solutions for carbon footprinting of hotel stays. One goal of such solutions is to provide a calculation of the corresponding carbon offsets. Some travel agents, tour operators, and back-of-house travel services providers also provide carbon footprint calculations for travel that includes hotel stays. Sustainability reporting firms also have made attempts to define methods and produce relevant metrics in property-level sustainability reports.[36] Finally, opportunistic carbon firms have attempted to fill the gap in uniformity by offering proprietary quantification methods and indexes.

Hotel companies have so far been reluctant to adopt third-party solutions due to the lack of transparent and industry-engaged boundary and quantification or rating methods, the limited scope of sustainability metrics, the risk of extravagant fees resulting for large chains, and the implausibility of handing over invaluable occupancy data—and also because they have already invested substantial time and effort into developing their own sustainability software platforms. Third-party calculation of performance metrics requires a second data entry or interface, which would represent an extra step for hotel companies.

Despite all the research and development in both academe and the industry, no transparent third-party, academic, or industry method for uniformly measuring and communicating the sustainability performance of hotel stays has so far been both clearly defined and widely adopted. At the same time, the convergence of increased stakeholder inclusiveness, technological advances, and global issues relating to sustainable development and the future well-being of society points clearly to the need for uniformly measuring and communicating the most salient performance indicators. Such efforts can serve as a roadmap toward standardization of sustainability performance measurement. For example, should a GRI Hotel Sector Supplement be convened in two years, the same methods and discussion can be carried forward to facilitate discussion in a larger context and with a more inclusive approach.

The Measurement Framework

To address the lack of an overall sustainability measurement rubric, I offer the framework presented in Exhibit 4 as a means of identifying, refining, and standardizing performance sustainability indicators both now and in the future.[37]

35 Sherwyn, David ed. (2010). The Hotel Industry Seeks Elusive "Green Bullet." Cornell Hospitality Roundtable Proceedings, 2(1).

36 See: Willard InterContinental Washington, DC, 2007 and 2008 sustainability reports.

37 See: United Nations World Commission on Environment and Development. (1987). Our Common Future. Oxford: Oxford University Press.

Dimensions and Aspects

Two overarching considerations were used to structure the framework: specific guidance from existing guidelines relating to sustainable development, and general guidance from considerations about quality of life. The framework proposes to include the full range of potential performance indicators relating to sustainable development. Non-financial performance indicators for sustainability reporting based on the GRI guidelines and ISO 26000 encompass aspects relating to organizational governance, society and communities, product responsibility, labor practices, human rights, and the environment.[38] Aspects already stipulated within the GRI are provided with robust protocols, specific methodology references, and relevance to sustainable development. Such indicators are more readily transferrable to a hotel platform.

To ensure practical future application, the framework also includes measurements related to quality of life, and the resulting performance indicators. Though less specific or directly transferrable, measurement relating to quality of life should be included if sustainability is to be achieved. Non-financial measurements of life satisfaction, well-being, and happiness are seen as performance indicators that when harnessed can help society make transitions toward sustainable living.[39] Such non-financial measurements have been put forth in several instances, including the Happy Planet Index,[40] Bhutan's Gross National Happiness,[41] and the Quality of Life Index,[42] as well as academic and other institutions studying this type of performance measurement.[43] More closely related, the USGBC has begun to study green buildings within the context of the human experience.[44] The integration of quality of life indicators within hospitality and tourism performance measurement is advantageous given the travel industry's contribution to one's quality of life—usually with less resource consumption than purchasing goods for quality of life purposes.

Boundaries

Once a particular aspect has been defined, its boundary and its measurement need to be set. For example, environment is a general aspect that encompasses dozens of specific topics (including most of those described as ecosystem services), yet it is a necessary categorization for framing the issues. Within environment, the specific topics can be chosen as areas of focus.

The boundary also refers to the lines drawn along the chain of operations and life cycle of the service. Sustainability implies a holistic approach to understanding the interrelated impacts of human activities. It is necessary to define specific boundaries for performance measurement as they are not as clear as those of financial accounting. The matter of boundary issues is comprehensively discussed in the GHG protocol and GRI guidelines.

Quantification Methods

The second step for developing sustainability performance indicators is to define the quantification methods, which present definitional issues similar to boundaries in that some quantification methods are widely accepted and others are disputed. Emission factors, coefficients, and the terms of quantification should be transparently defined and communicated. Timeliness is key here as emission factors will change and evolve over time and are not always agreed upon. As examples, the GWP of methane and nitrous oxide changed over the course of IPCC annual reports, and the GHG emissions from air travel vary in how they are quantified (in a range from 1.9 to 2.7) based on the application of radiative forcing.[45] This type of quantification assumption should be defined and communicated in any measurement protocol.

Metrics

Finally, the metrics used to monitor, track, and communicate performance require clear definition. In hotels, the framework's metrics begin as a function of the hotel facility

38 For a complete list of disclosures and performance indicators, see the GRI guidelines at www.globalreporting.org.

39 World Business Council for Sustainable Development (2010). Vision 2050: The New Agenda for Business. Washington, DC.

40 Abdallah, S., Thompson, S., Michaelson, J., Marks, N. and Steuer, N. (2009). The (un)Happy Planet Index 2.0: Why Good Lives Don't Have to Cost the Earth. London: New Economics Foundation.

41 Braun, A. A. (2009). Gross National Happiness in Bhutan: A Living Example of an Alternative Approach to Progress. Wharton International Research Experience. Retrieved from Wharton University of Pennsylvania: http://repository.upenn.edu/cgi/viewcontent.cgi?article=1077&context=wharton_research_scholars; and Revkin, A. (2005, October 4). A new measure of well-being from a happy little kingdom. The New York Times. Retrieved from http://www.nytimes.com/2005/10/04/science/04happ.html?_r=2&pagewanted=all.

42 Economist Intelligence Unit. (2005). The Economist Intelligence Unit's quality-of-life index. The Economist: The World in 2005. Retrieved from http://www.economist.com/media/pdf/quality_of_life.pdf

43 Inter-American Development Bank. (2008). Beyond Facts: Understanding Quality of Life (Executive Summary). Cambridge: Harvard University Press; and Joseph Stiglitz, Amartya Sen, Jean-Paul Fitoussi (2009). The Commission on the Measurement of Economic Performance and Social Progress.

44 Pyke, C., McMahon, S., Dietsche, T. (2010). Green Building and Human Experience: Testing Green Building Strategies with Volunteered Geographic Information. Washington, DC: U.S. Green Building Council.

45 For more information see Penner, J.E. et al. (eds.) (1999), Aviation and the Global Atmosphere. A Special Report of IPCC Working Groups I and III in collaboration with the Scientific Assessment Panel to the Montreal Protocol on Substances that Deplete the Ozone Layer. Cambridge (UK): Cambridge University Press.

as the basic unit of measurement. All data exist primarily per hotel, with subsequent calculations based on a rational rubric, including square feet or square meters, rooms, or guests. As appropriate, hotel units may be aggregated to measure overall performance and footprint. Metrics chosen are directly correlated to the nature of the stakeholder request.

Framework Application

The framework is carried out by first identifying the performance measurement components and then defining filters of boundaries, quantification methods, and metrics. The following two key considerations are necessary for the resulting performance indicators to reach any type of industry agreement: collaboration and practicality. Collaboration in the hotel industry has existed for decades on numerous issues, and it seems clear that the industry is further willing to collaborate on sustainability and corporate responsibility measures. Let me underline the concept of collaboration. It seems that the previous attempts at standardizing sustainability metrics by third parties failed specifically because they developed a method and then attempted to impose it upon the industry. As I pointed out, most major hotel companies have already developed internal methods for performance measurement. But the lack of collaboration in platform development has brought the industry to where it is today, unable to uniformly communicate sustainability performance to external stakeholders and thus pressured to accept a third-party solution.

Any solution needs a high degree of practicality. It should take into account the availability of property data and the scientific and technical data or resources available for quantification and calculation, and it should address the issue of specific, granular data collection versus benchmark values based on materiality thresholds. Just because obtaining data or scientific information about certain issues is currently impractical does not mean that such indicators should be abandoned. As a precursor to indicator development, however, collaboration with peers, stakeholders, and the supply chain should be sought to help advance the practicality of data collection.

Framework Application and Study Design

Based on the conceptual framework, I conducted a study to develop aspects, boundaries, quantification methods, and metrics for comparable indicators for the most commonly cited hotel sustainability performance factors. Three major industry organizations participated and helped evaluate the practicality of data collection and quantification methods for arriving at the performance indicators.

To test the practicality and usefulness of the defined performance indicators, the study examined 2010 data from 20 hotel properties affiliated with InterContinental Hotels Group, Marriott International, or Wyndham Worldwide. The data comprised a variety of segments and global regions. Participating properties completed a 65-item questionnaire, asking which data were available, how data points were measured (including the existence of sub-metering and subcategory specificity), and the actual values. Data were then analyzed to produce and compare the performance indicators among the properties, with feedback from the three firms on the study method and results.

Dimensions and Aspects

The environment aspect of sustainable development included the commonly cited indicators, GHG emissions, energy, water, and waste. These were limited entirely to consumption and impact areas of sustainability measurement, because measurement is more straightforward and more easily agreed on than such matters as policies, processes, and specifications, which were not included. The wide range of criteria falling under those latter categories would delay the process of collaborative effort and industry standardization for the purposes of this study.

To obtain data for these areas to develop performance indicators the following data points were collected (in addition to data on property profile and qualitative information on facilities and outlets):

1. Energy usage,
    - 1.1 Fuels burned on-site (separated by fuel type),
    - 1.2 Electricity,
    - 1.3 Municipal Steam,
    - 1.4 Renewable Energy Certificates (RECs) purchased,
2. Water usage,
    - 2.1 Municipal water,
    - 2.2 Municipal chilled water,
    - 2.3 Well water,
3. Waste tonnage,
    - 3.1 Diverted (separated by category as available),
    - 3.2 Non-Diverted,
4. Refrigerant usage for refilling of cooling equipment (separate by refrigerant type),
5. Carbon Offsets purchased.

Boundary Specification

Property Operations

Specifications for the boundary of GHG emissions and the like were driven by the purpose of the study, which was to determine the measurement units resulting from property operations. Therefore the consumption data and resulting environmental impacts in GHG emissions were considered from the operation of the building, and not its life cycle or its supply chain. As a consequence, the following were not included:

- Consumption and resulting GHG emissions from the construction and remodeling of the building;
- Consumption by the guest when outside the property (e.g., air or ground travel to the hotel);
- Consumption by corporate offices or regional staff that operates outside the building, though they are necessarily involved in the overall functioning of the hotel; or
- Consumption from operations of vendors or suppliers.

Data as Boundary

For the purpose of this study, the utility data submitted were the same data analyzed. No consideration was made as to the operational or financial control of any outlets, facilities, amenities, or other public spaces that may be included in the utility data but are technically outside the hotel management's operations. Inclusion of outlets and facilities was analyzed qualitatively in the study to determine which are generally included and which, if any, are sub-metered.

Likewise, if a property resold any energy to a third party or its original provider and that had not been adjusted in the data provided, then it was not reflected in the analysis. Conversely, if a property outsourced operations such as laundry, then utility consumption from those outsourced services were not included because they were not represented in the utility bills presented. No validation of the data were sought, so the actual data were analyzed, regardless of whether they included minute instances of fuel burning such as from shuttle services, landscaping, or small heating stations.

Data were collected on an annual basis, for the previous calendar year of operations. Collecting and analyzing data on an annual basis by calendar year allowed for uniform comparison and smoothed fluctuations based on weather and demand seasonality. In the case of a new property or a property that underwent a significant renovation, data were collected for the prior 12-month period rather than the calendar year. In addition to consistency of seasonal fluctuations, a calendar year is preferable in this case to a rolling 12-month period because the latter would require 12 instances of data collection, while a calendar year data set only requires one data point.

Recognizing that utility billing is not uniform in monthly cut-off dates and shifts depending on when meters are read or on which dates days of the week fall, the study used one of two methods:

1. Using the 12-period data set closest to January–December, usage was to be divided by the number of days in the 12 periods, and then the resulting value was multiplied by 365 to arrive at an annual figure proximate to the calendar year; or
2. Using each period on the beginning and final ends of the calendar year, each instance was to be divided by the usage by the number of days within the period, and then the value multiplied by the number of days occurring within the calendar year of the billing period. As an example, usage billed from December 10, 2009, through January 9, 2010, would be divided by 31 and then multiplied by 9 to arrive at the January value.

The boundary of utility consumption and environmental impacts followed the Greenhouse Gas Protocol's definition of scope, using scope 1 (direct emissions) and 2 (indirect emissions) only, and not considering scope 3 emissions (those of third parties), as specified in the quantification section below. Rationale for limiting the study to scope 1 and 2 was drawn from the following considerations:

1. Scope 3 emissions from hotel operations is invariably complex, given the inputs of materials, labor, and guests, and would require extensive data gathering;
2. The same invariability would inhibit uniform quantification and measurement by hotels to stakeholders in the short- and mid-term, undermining the current basic needs and requests of the same stakeholders;
3. The difficulty in scope 3 emissions standardization in hotel environmental footprinting is compounded by the issues of uncertainty and lack of a widely accepted standard regarding quantification of GHG emissions a (PAS 2050:2008 exists in the UK for product footprinting, but ISO 14067 and the GHG Protocol Corporate Value Chain and Product Accounting and Reporting Standards are not finalized to date); and
4. Once scope 1 and 2 data are available for all vendors and life cycles of products, they can be readily aggregated to determine their overall materiality.

Consumption of energy and water and waste generation all followed the same considerations for scope. As a result, operational GHG emissions, utility consumption, and waste generation were not included in the study's boundary as associated with:

1. Treatment of wastewater effluent,
2. Water purification of purchased potable water,
3. Offsite IT servers,
4. Employee commutes,
5. Travel of property employees,
6. Corporate, regional, and satellite facilities,
7. Guest travel,
8. Guest consumption off-site,
9. Vendors and suppliers,
10. Outsourced laundry wash,
11. Life cycles of materials and supplies used in ongoing operations, and
12. Life cycles of durable materials and supplies (i.e. FF&E).

Quantification

The predominant resource for GHG emissions quantification and inventorying is provided by the World Resources Institute (WRI) and its Greenhouse Gas Protocol. These cite the Intergovernmental Panel on Climate Change (IPCC) on certain methods and data, but the IPCC does not provide the tools or guidelines for national, corporate, or facility inventory calculation. While many countries will use their own greenhouse gas inventories to arrive at default emissions factors, others use the WRI's guidelines for GHG inventories. This includes national or regional bodies (such as the Climate Registry in North America).

Greenhouse Gases

In accordance with the Greenhouse Gas Protocol, the following gases were considered greenhouse gases in emissions inventories:

- Carbon Dioxide (CO_2),
- Methane (CH_4),
- Nitrous Oxide (N_20),
- Hydrofluorocarbons (HFCs),
- Perfluorocarbons (PFCs), and
- Sulfur Hexafluoride (SF_6).

Because hotel operations do not generally emit perfluorocarbons or sulfur hexafluoride those two gases were not included in this study. Although water vapor has been characterized as a greenhouse gas and many hotels emit water vapor as part of waste heat from cooling towers, the waste heat is considered surface-level and not atmospheric, and therefore this vapor was not quantified.

For the previously delineated boundary and scope, the following sources of GHG emissions in a hotel's operation were included in the quantification of a carbon footprint:

1. Emissions resulting from the burning of fossil fuels (Scope 1),
2. Emissions resulting from the generation of purchased electricity (Scope 2),
3. Emissions resulting from purchased heat and steam, and chilled water (Scope 2), and
4. Fugitive emissions (Scope 1).

The following stipulations were used in quantifying GHG emissions:

1. Site energy was used (as opposed to source energy) for fuel and electricity consumption;
2. GHG emissions are expressed in carbon dioxide equivalent (CO2e);
3. Fuel emission factors were converted at high heating values (HHV);
4. Emission factors were prioritized as follows:
   1. Global (universal),
   2. National, and
   3. Regional, provincial, or state factors;
5. WRI emission factors were used as the primary source when available; and
6. Country-sourced emission factors were used when WRI emission factors are not available.

1. Burning Fossil Fuels

The following six fuel types generally consumed in hotel operations were included in GHG emissions calculation: natural gas, gasoline, diesel, propane, fuel oil (including six subtypes), and liquefied petroleum gas (LPG) and some of its subtype mixes of propane, liquid propane, and butane. GHG emissions from fuel burning were calculated by multiplying the consumption of each fuel type by its emission factor.

For the quantification of GHG emissions from fuel burning, the standard unit of measurement used was metric tons of carbon dioxide equivalent (Mt CO_2e) for aggregate values, and later normalized as kilograms of carbon dioxide equivalent (kg CO_2e) when the value was less than one metric ton. Although data regarding each fuel source were gathered in distinct units of measurement, the most convenient approach was to convert all fuel consumption to a single unit (i.e., MBtu or kWh) for GHG emissions quantification and then convert that result to kg upon final calculation. As fuels are often provided in different forms from the utility provider, conversion factors were applied, although conversion values vary per source of conversion data.[46]

Emissions Factors from Fuel Burning

The WRI's Stationary Combustion Tool Version 4.0, using emission factors from the IPCC Guidelines for National

[46] U.S. Department of the Interior BTUs Conversion Table. http://www.doi.gov/pam/eneratt2.html.

Exhibit 5

GHG emissions (commercial and institutional sector) using high heating values of fuel

Fuel Type	Mt CO_2/MBtu	Mt CH_4/MBtu	Mt N_2O/MBtu	kg CO_2e/MBtu
Natural Gas	0.053272	0.0000047480	0.0000000950	53.4011432
Motor Gasoline	0.0694625	0.0000100235	0.0000006014	69.8594371
Liquefied Petroleum Gases (LPG)	0.0599191	0.0000047480	0.0000000950	60.0482732
Residual Fuel Oil (Fuel Oil No. 5)	0.0775815	0.0000100235	0.0000006014	77.9784316

Source: World Resources Institute (2008). GHG Protocol tool for stationary combustion. Version 4.0.

Exhibit 6

Direct greenhouse gas emission factors, using high heating values of fuel

Fuel Type	kg CO_2/MBtu	kg CH_4/Mbtu	kg N_2O/MBtu	kg CO_2e/MBtu
Propane	63.0667	0.0105419	0.0006325	63.484124
Liquid Propane	63.1620	0.0105419	0.0006325	63.579457
Fuel Oil No.1	73.1500	0.0105419	0.0006325	73.567457
Fuel Oil No.2	73.1500	0.0105419	0.0006325	73.567457
Fuel Oil No.4	73.1500	0.0105419	0.0006325	73.567457
Diesel	73.1500	0.0105419	0.0006325	73.567457

Source: U.S. Environmental Protection Agency, Climate Leaders Program, Direct Emissions from Stationary Combustion Sources, Appendix B (May 2008) in U.S. Environmental Protection Agency, Greenhouse Gas Inventory and Tracking in Portfolio Manager (August 31, 2009).

Greenhouse Gas Inventories, identifies the GHG emission factors in common fuel types, as found in Exhibit 5. In the United States, the EPA provides the emission factors shown in Exhibit 6.

As a result, GHG emissions from fuel burning were quantified by multiplying the amount of fuel consumed in MBTU by its corresponding emission factor (WRI when available, U.S. EPA otherwise), and then converting the aggregate units to arrive at a value of GHG emissions in Mt CO_2 units, as outlined in the following equation:

$$FT \text{ MtCO}_2\text{e} = n\text{MBTU} \times \frac{EF\ kg\ \text{CO}_2\text{e}}{1\ \text{MBTU}} \times \frac{1\ \text{kg}}{1000\ \text{Mt}}$$

Where:
FT = GHG emissions from fuel type
n = volume of fuel consumption
EF = Emission Factor

2. Purchased Electricity

GHG emissions from purchased electricity are indirect emissions (scope 2) because using the electricity drives its production, but the greenhouse gases are emitted during the process of generating and distributing electricity at the source, not from its consumption onsite. Electricity consumed on property that was generated onsite through combined heat and power (cogeneration) was not considered here because it would have been accounted for in connection with fuel burning.

Electricity consumption was provided in kWh, which is directly convertible to GHG emissions by multiplying consumption in kWh by the corresponding country emission factor, which is driven by the wide range of fuel mixes used to generate the electricity and power plant efficiency. France for example has countrywide emission factor of .085 kg of CO_2 per kWh of electricity produced, while China's emission factor is .788 kg of CO_2 per kWh.[47] Country emission factors (CO_2 only) from electricity generation as available from the WRI GHG Protocol Tool for Stationary Combustion are in Appendix B for reference. GHG emissions from purchased electricity in the U.S. were quantified by multiplying the amount of kWh consumed by .000593718.

[47] Calculated using the GHG Protocol tool for stationary combustion, World Resources Institute (2009), Version 4.0.

To convert the emission factors to Mt CO_2/kWh:

$$EC\ MtCO_2e = nkWh \times \frac{1\ kWh}{1000\ MWh} \times \frac{EF\ lb\ CO_2e}{1\ MWh} \times \frac{1\ kg}{2.2\ lb} \times \frac{1\ Mt}{1000\ kg}$$

Where:
EC = GHG emissions from electricity
n = amount of electricity consumption
EF = Country Emission Factor

3. Purchased Steam and Hot or Chilled Water

As is the case with electricity, energy required to generate steam, hot water, and chilled water which is purchased by the hotel is included as a Scope 2 emission. Also similar to electricity, emission factors for purchased steam or water vary by country and region. The WRI provides guidance on how such inventories and emission factors may be calculated, but does not provide country data or emission factors. The U.S. Energy Information Administration provided generic emission factors for steam and chilled water based on national averages under its Voluntary Reporting of Greenhouse Gases initiative. Steam or hot water emission factors were provided without country-specific distinction.

Steam and Hot Water

Emission factors for steam and hot water are dependent on how the water was heated and distributed. According to the U.S. Energy Information Administration, the national emission factor used in inventory accounting for purchased steam and hot water in the U.S. is 96.952 $kgCO_2e$ /MMBTU.[48] To normalize the unit of measure:

$$SE\ MtCO_2e = nMMBTU \times \frac{1\ kg}{1000\ Mt} \times \frac{EF\ kg\ CO_2e}{1\ MMBTU}$$

Where:
SE = GHG emissions from steam
n = amount of steam consumption
EF = Country Emission Factor

As a result, GHG emissions from purchased steam in the U.S. were quantified by multiplying the amount of MBTU consumed by 0.096952 to arrive at a value of GHG emissions in Mt CO_2e units.

Chilled Water

Considerations for chilled water are similar to those of purchased steam or electricity. Because natural gas may be either absorption or engine-driven, the U.S. benchmark domestic chilled water emission factors for natural gas as identified by the Energy Information Administration are as follows:

- Absorption chiller: 0.0665 MtCO2e/MBTU, and
- Engine-driven chiller: 0.04433 MtCO2e/MBTU.

For electric-driven chillers, the emission factor again depends on the fuel mix used to generate electricity, which is multiplied by .238095 in the U.S. Following the same arguments as outlined above in quantifying emissions from purchased electricity, GHG emissions from purchased electric-driven chilled water in the U.S. were to be quantified by multiplying the amount of MBTU consumed by 0.04155978.

For emission factors by country, the Energy Information Administration offered guidance on determining emission factors in foreign countries by multiplying their electricity emission factors (expressed in MT CO_2/MWh, kg CH_4/ton-hour, and kg N_2O/ton-hour of cooling purchased) by 0.921, using its foreign electricity emission factors. Those factors, however, are dated 1999–2002; therefore the WRI country electricity emission factors can be substituted for more accurate data.

4. Fugitive Emissions

Emissions from substances with significant global warming potential (GWP), such as those found in refrigeration equipment, were included in the quantification of a hotel's carbon footprint. This includes chillers, decentralized air conditioning units, and F&B temperature-regulated storage. Common refrigerants are HFC-22 (R-22), HFC-123, HFC-134a, R-410a, and R-404a. Though the operational use of these gases themselves does not generate GHG emissions, their leakage into the atmosphere constitutes fugitive emissions, a Scope 1 source of GHG emissions according to the Greenhouse Gas Protocol.[49]

In hotel operations the data from fugitive emissions were gathered not necessarily when the leakage occurs, but when the equipment's refrigerant was refilled through corrective maintenance on property. If refrigerant was recycled by the vendor without actual leakage, then it was not counted, since offsite use of the gas is not within the specified scope. Likewise, this amount does not refer to the amount of refrigerant circulating in the cooling equipment.

Emission factors for refrigerants are specified by engineering and scientific organizations. Emission factors used for quantification in this study represent the GWP over a 100-year lifespan of the gases in the atmosphere. A full list of refrigerants and their GWP is found in Appendix C. GHG emissions from fugitive refrigerant were quantified by multiplying the amount (in Mt) of each refrigerant replaced

[48] Instructions for Form EIA-1605, Voluntary Reporting of Greenhouse Gases, Energy Information Administration, Department of Energy. October 15, 2007. Appendix N; Emissions Benchmarks for Purchased Steam and Chilled/Hot Water.

[49] World Resource Institute & World Business Council for Sustainable Development (2004). The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard. Geneva: Earthprint Limited.

(because of leakage) by its GWP, then summing the GHG emissions from each, to arrive at a value of GHG emissions in Mt CO_2 units.

GHG Emissions Reductions

For the purposes of this study, emission reductions represent purchases of Renewable Energy Certificates (RECs) only within the data set period and not reductions achieved from one period against another. Data for RECs purchased through a utility provider were collected in kWh of RECs purchased for inclusion in the final carbon footprint calculations. If a property generated renewable energy on-site, then the energy usage was later accounted for in the subsequent energy quantification section.

The CO_2e reductions resulting from the RECs purchased are generally only applicable to the energy source they generate (in most cases electricity). Therefore the same emission factors are applied to the kWh of RECs within the same category of the energy source emissions they are reducing. Multiplying the emission factor by the Mt of kWh will produce the value of CO_2e reduced.

Carbon Offsets

Carbon offsets as a form of GHG emissions mitigation were tallied in Mt CO_2e purchased so they may be included in final carbon footprint calculations. Carbon offsets are mitigation techniques however, and are not directly associated with fuel purchase or grid systems from which the hotel sources its energy.

GHG Emissions Calculation

Using the four categories of GHG emissions source data above, the following calculations were performed:

A. $\sum FB_{CO_2e} + \sum FE_{CO_2e} - \sum REC_{1 CO_2e}$ = Scope 1 GHG Emissions

B. $\sum EC_{CO_2e} + \sum PS_{CO_2e} + \sum CW_{CO_2e} - \sum REC_{2 CO_2e}$ = Scope 2 GHG Emissions

C. A + B = Gross Carbon Footprint

D. C – CO_{CO_2e} = Net Carbon Footprint

Where:

FB = Fuel Burned
FE = Fugitive Emissions
EC = Purchased Electricity
PS = Purchased Steam and Hot Water
CW = Purchased Chilled Water
REC_1 = Scope 1 Renewable Energy Certificates
REC_2 = Scope 2 Renewable Energy Certificates
CO = Carbon Offsets

Energy Usage

The same data collected for GHG emissions boundary and quantification were used to calculate the hotel's energy performance, with two additions. First, also considered was any renewable energy generated onsite that did not factor into the GHG emissions quantification. The energy generated on-site from renewable sources was to be quantified in the same unit of measurement as the other fuels burned. Second, energy consumed by chilled water or fuel would need conversion to units of energy (but not GHG emissions) in the case that it were provided in volume.

For energy usage, the three units of measurement for providing energy data were MBTU, kWh, and J. Given the prevalence of electricity use in hotels, kWh was used as the unit of measurement.

To measure energy usage in the data set, the following calculations were performed:

A. $\sum FB_{kWh} + \sum RFB_{kWh}$ = Direct Energy Usage

B. $\sum EC_{kWh} + \sum PS_{kWh} + \sum CW_{kWh}$ = Indirect Energy Usage

C. A + B = Total Energy Usage

Where:

FB = Fuel Burned
RFB = Renewable Fuel Burned
EC = Purchased Electricity
PS = Purchased Steam and Hot Water
CW = Purchased Chilled Water

Note that RECs and carbon offsets do not enter into energy usage calculations as they do not represent reductions in actual usage.

Water Usage

Four instances of water usage were addressed, as follows:

1. Purchased steam or hot water,
2. Purchased chilled water,
3. Purchased water, and
4. Well water withdrawn

Of these four, the first two were addressed in terms of the energy requirements for their heating and cooling, and not water usage. For the scope of the study, the first two categories of water usage above do not factor into water consumption because they were assumed to be in a closed loop system with the district, and thus no water gains or losses occur. Water withdrawals occurring for purchased district water, chilled water, or steam were beyond the scope of the study, and therefore water withdrawal data refers only to water withdrawn onsite.

Data on water consumption were collected based on the values of water used on property, and not the values of water treated by the district. Sub-metering for irrigation and cooling tower vapor may present a discrepancy in the water usage if not property counted, as both are instances of water usage and should be counted (but not double counted).

Exhibit 7

Potential sustainability performance metrics

Aggregate Measure	÷	Metric Unit	=	Performance Metric
Scope 1 GHG Emissions	÷	Available Rooms	=	Scope 1 GHG Emissions PAR
Scope 2 GHG emissions	÷	Available Rooms	=	Scope 2 GHG emissions PAR
Gross Carbon Footprint	÷	Available Rooms	=	Gross Carbon Footprint PAR
Net Carbon Footprint	÷	Available Rooms	=	Net Carbon Footprint PAR
Direct Energy Usage	÷	Available Rooms	=	Direct Energy Usage PAR
Indirect Energy Usage	÷	Available Rooms	=	Indirect Energy Usage PAR
Total Energy Usage	÷	Available Rooms	=	Total Energy Usage PAR
Purchased District Water	÷	Available Rooms	=	Purchased District Water PAR
Well Water Withdrawn	÷	Available Rooms	=	Well Water Withdrawn PAR
Total Water Usage	÷	Available Rooms	=	Total Water Usage PAR
Diverted Waste	÷	Available Rooms	=	Diverted Waste PAR
Non-Diverted Waste	÷	Available Rooms	=	Non-Diverted Waste PAR
Total Waste	÷	Available Roos	=	Total Waste PAR
Scope 1 GHG Emissions	÷	Occupied Rooms	=	Scope 1 GHG Emissions POR
Scope 2 GHG emissions	÷	Occupied Rooms	=	Scope 2 GHG emissions POR
Gross Carbon Footprint	÷	Occupied Rooms	=	Gross Carbon Footprint POR
Net Carbon Footprint	÷	Occupied Rooms	=	Net Carbon Footprint POR
Direct Energy Usage	÷	Occupied Rooms	=	Direct Energy Usage POR
Indirect Energy Usage	÷	Occupied Rooms	=	Indirect Energy Usage POR
Total Energy Usage	÷	Occupied Rooms	=	Total Energy Usage POR
Purchased District Water	÷	Occupied Rooms	=	Purchased District Water POR
Well Water Withdrawn	÷	Occupied Rooms	=	Well Water Withdrawn POR
Total Water Usage	÷	Occupied Rooms	=	Total Water Usage POR
Diverted Waste	÷	Occupied Rooms	=	Diverted Waste POR
Non-Diverted Waste	÷	Occupied Rooms	=	Non-Diverted Waste POR
Total Waste	÷	Occupied Rooms	=	Total Waste POR
Scope 1 GHG Emissions	÷	Rooms Sold	=	Scope 1 GHG Emissions PRS
Scope 2 GHG emissions	÷	Rooms Sold	=	Scope 2 GHG emissions PRS
Gross Carbon Footprint	÷	Rooms Sold	=	Gross Carbon Footprint PRS
Net Carbon Footprint	÷	Rooms Sold	=	Net Carbon Footprint PRS
Direct Energy Usage	÷	Rooms Sold	=	Direct Energy Usage PRS
Indirect Energy Usage	÷	Rooms Sold	=	Indirect Energy Usage PRS
Total Energy Usage	÷	Rooms Sold	=	Total Energy Usage PRS
Purchased District Water	÷	Rooms Sold	=	Purchased District Water PRS
Well Water Withdrawn	÷	Rooms Sold	=	Well Water Withdrawn PRS
Total Water Usage	÷	Rooms Sold	=	Total Water Usage PRS
Diverted Waste	÷	Rooms Sold	=	Diverted Waste PRS
Non-Diverted Waste	÷	Rooms Sold	=	Non-Diverted Waste PRS
Total Waste	÷	Rooms Sold	=	Total Waste PRS
Scope 1 GHG Emissions	÷	Square Feet	=	Scope 1 GHG Emissions PSF
Scope 2 GHG emissions	÷	Square Feet	=	Scope 2 GHG emissions PSF
Gross Carbon Footprint	÷	Square Feet	=	Gross Carbon Footprint PSF
Net Carbon Footprint	÷	Square Feet	=	Net Carbon Footprint PSF
Direct Energy Usage	÷	Square Feet	=	Direct Energy Usage PSF
Indirect Energy Usage	÷	Square Feet	=	Indirect Energy Usage PSF
Total Energy Usage	÷	Square Feet	=	Total Energy Usage PSF
Purchased District Water	÷	Square Feet	=	Purchased District Water PSF
Well Water Withdrawn	÷	Square Feet	=	Well Water Withdrawn PSF
Total Water Usage	÷	Square Feet	=	Total Water Usage PSF
Diverted Waste	÷	Square Feet	=	Diverted Waste PSF
Non-Diverted Waste	÷	Square Feet	=	Non-Diverted Waste PSF
Total Waste	÷	Square Feet	=	Total Waste PSF

For water usage, the common units of measurement for providing water data were Cubic Feet (Ft^3), Cubic Meters (M^3), Liters (l), and Gallons (g). M^3 was used as the unit of aggregate measurement, converted to liters as the unit in normalized metrics.

To measure water usage in the data set once normalizing the units of measurement, the following calculations were performed:

A. Purchased district water,
B. Well water withdrawn, and
C. A + B = Total Water Usage.

Waste Generation

The definition of performance metrics for waste is much more extensive than those for energy, water, or carbon because of the broad scope of materials covered within the waste stream and the lack of data currently available. Waste data were not considered within the operational boundary for the scope 3 carbon emissions or any associated energy flows. Likewise, water extracted from organic waste was not addressed in boundary or quantification definitions.

The most common quantification is the tonnage of waste, whether landfilled, burned, or diverted. This serves both as a quantification method as well as a metric, although studies have shown that diverted waste data are not always readily available.[50] Furthermore, consumption and impacts related to different types of diverted waste lessen the significance of a catch-all category of diversion. The study therefore sought out to qualitatively assess the availability of waste data, understanding that issues of quantification, boundary, and metrics needed further study for final performance metrics to be determined.

Metrics

A critical issue for a lodging industry sustainability measure is to render it in terms that are appropriate to hotel operation. In particular, since stakeholders have requested measurements of sustainability-related data as connected to their hotel stays, annual

[50] Chan, W. W. (2009). Environmental measures for hotels' environmental management systems. International Journal of Contemporary Hospitality Management, 21(5), 542-560.

values of GHG emissions and usage are not relevant to their specific data request.

Therefore the measurements need to be converted into metrics that are:

1. comprehensible and relevant to the stakeholder;
2. common throughout the industry;
3. representative of individual consumption;
4. practical for calculation and communication; and
5. incentivizing in improving performance across all sustainability aspects.

Four potential values of performance metrics were identified for common use. Their application in sustainability measurement is derived from dividing any of the above GHG emissions, energy, water, and waste values by common industry metrics:

Rooms available—the total rooms available (room inventory) during the calendar year (i.e., impact per available room or PAR);

Rooms sold—the total rooms sold during the calendar year (not including comp rooms or no-shows) (or impact per room sold or PRS);

Rooms occupied—the total rooms occupied during the calendar year (sold rooms + comp rooms) (or impact per occupied room or POR); and

Area—the total area of the building (or impact per square feet, PSF, or per square meter, or PSM).

The only additional denominators considered were per guest or per guest-night. A per-guest metric may be relevant to activity within the hotel (e.g., a meeting), but not necessarily for a room-night. Should a per-guest value be requested, it is easier to divide a room-based metric by the number of guests (as is the same case in ground and air transportation) to arrive at the corresponding value rather than build a metric around the number of guests and extrapolate to a per-room metric. This study examined the potential performance metrics shown in Exhibit 7, on the previous page.

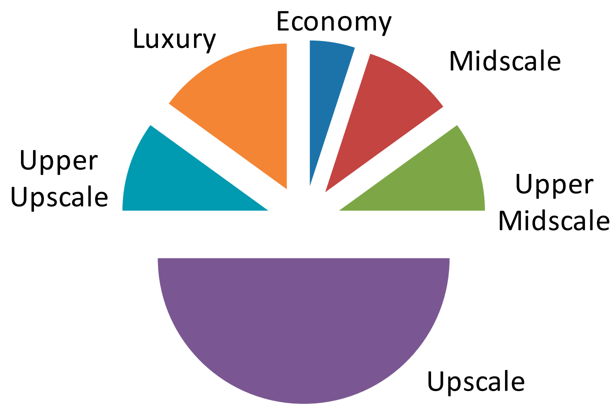
Study Results

Data

Hotel data represented every STR chain scale segment (except independent), in every major climate zone. As shown in Exhibit 8, the sample was represented most heavily by upscale and upper upscale properties. Although most hotels were in the U.S., the data included nine international properties across Europe, the Middle East, and Asia. All hotels reported number of guestrooms, chain scale segment, and heating and cooling degree days (HDDs and CDDs), although the percentage of responses diminished as the questions became more detailed (i.e., gross floor area, average square footage per guestroom, square footage of function space, occupied rooms). Though nearly every hotel reported rooms sold in the period, less than half provided the occupied room count (rooms sold + comp rooms). Less than half of the properties specified the facilities and amenities (other than laundry) that were included in the utility totals. Most hotels reported total water but most properties did not report water usage broken down into sub-categories of district water, well water, or chilled water.

Exhibit 8

Sample composition



Fourteen hotels responded to waste questions. Of those, 11 were able to report waste data in tonnage, but only four hotels were able to provide waste diversion rates. Two hotels diverted organic waste through composting. Though diversion rates were reported, only one property was able to provide actual diverted waste (in cubic yards). No properties provided diverted waste data by specific stream.

No hotels had purchased RECs or carbon offsets.

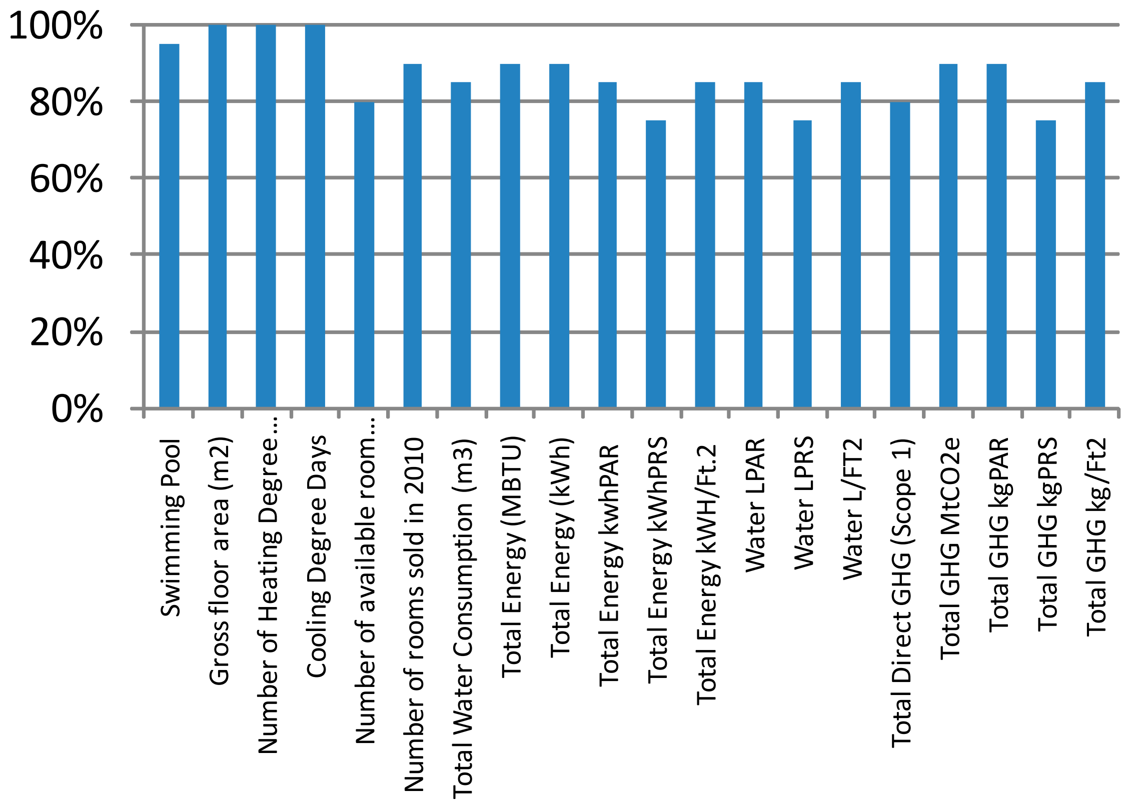
Boundaries

Boundary variations arose in the data collection. For example, four hotels included data on utility consumption from outsourced amenities such as cafés and restaurants. Of the four, three were sub-metered. The difficulties in verifying the facilities and amenities included in utility totals also present boundary variations. Though laundry and swimming pools were easily verified, other facilities that could affect performance metrics (such as a fitness center, spa, or a gift shop or other retail outlets) were not commonly specified.

Finally, of the 19 hotels reporting whether laundry was included in consumption totals, six hotels reported that they

Exhibit 9

Number of respondents per survey question



washed linens and towels in-house, and four hotels outsourced their laundry to a third-party vendor. I note, however, that laundry was included in the twelve hotels' utility consumption. This indicates the possibility that laundry could have been included in consumption totals even though it was outsourced. The variances of energy, water, and GHG performance metrics due to in-house vs. outsourced laundry wash are discussed below, although any conclusion is tenuous because of the limited data sample. (Exhibit 9 specifies the number of respondents to each question.)

Performance Metrics

Some form of per available room or per square measure values were available for all 20 hotels. Per-room-sold values were possible for 17 hotels, yet per-occupied-room values were only available for 8 hotels in the data set. Performance varied widely among properties, as did property size and chain scale. The breakdown by metric and chain scale segment can be found in Appendix E.

GHG emissions per available room ranged from 3kg to 75kg, or 4.4kg to 76kg per room sold. Ranges and variances in energy consumption mimicked those of GHG emissions, which is not surprising given their strong connection. Water variances did not show as much of a range or deviation as energy or GHG emissions, ranging from 565 to 1,117 liters PAR, or 846 to 1,673 liters PRS. The mean increment in occupied rooms sold was .7%. In the highest case, the occupied room count was 1.5 percent higher than the count of rooms sold.

Though smaller through segment filters, when separating the hotels out by STR chain scale, the ranges and variances also lessen. This is logical since similar properties (i.e., comp sets) of rate categories may have similar attributes. Any type of benchmarks taken from the study may be more representative by chain scale.

The study did not include year-over-year performance to allow for analysis of fluctuations in values due to occupancy changes. However, it is clear that PAR and PSR

Exhibit 10

Sample data

Chain scale segment	Number of guestrooms	Gross floor area m2	Number of Heating Degree Days	Cooling Degree Days	Number of available room nights in 2010	Number of rooms sold in 2010
Economy	56	1755.77	4226.00	1237.00	20440.00	12604.67
Midscale	143	7659.58	3008.50	2912.00	52052.00	30748.00
Upper Midscale	683	41409.72	2036.00	2111.00	249026.50	101643.00
Upscale	289	27525.86	1502.30	4040.40	103882.30	84789.89
Upper Upscale	908	84886.95	2101.00	1607.00	331968.00	228314.00
Luxury	530	52731.99	2504.33	2645.67	193120.00	131762.00
Total (n=20)	400	35156.14	2052.65	3141.90	145235.80	99487.04

Chain scale segment	Total Energy (MBTU)	Total Energy (kWh)	Total Energy kwhPAR	Total Energy kWhPRS	Total Energy kWH/Ft.2
Economy	1206.63	353643.64	17.30	28.06	18.71
Midscale	5125.43	1502179.02	28.68	49.13	18.15
Upper Midscale	44814.11	13134263.38	54.91	66.12	32.76
Upscale	25947.15	7604673.46	72.94	100.60	40.84
Upper Upscale	72578.85	21271643.46	64.02	93.06	27.06
Luxury	65577.08	19219542.60	89.35	127.76	31.56
Total (n=20)	36141.77	10592546.16	64.19	91.03	32.66

Chain scale segment	Total Water Consumption (m3)	Water LPAR	Water LPRS	Water L/FT2	Swimming Pool
Economy					0
Midscale	16886.72	335.41	546.69	214.19	1
Upper Midscale	105743.25	213.19	454.76	246.82	1
Upscale	72609.32	102661.48	827.59	271.23	9
Upper Upscale	126709.09	355.04	516.15	145.11	2
Luxury (	190498.32	648.60	1247.31	312.42	1
Total (n=20)	97120.45	48532.05	807.70	254.08	14

Concluded on next page

metrics cannot be used interchangeably. A summary of the sample data is found in Exhibit 10, on this page and the next.

Regarding waste, performance was difficult to evaluate given the lack of response and boundary or quantification parameter issues. It is interesting to note that among the four hotels reporting waste diversion rates, top performance in diversion rates was not correlated with performance in waste generation, suggesting that diversion rates alone may not be

Exhibit 10

Sample data

Chain scale segment	Total Direct GHG (Scope 1)	Total GHG MtCO2e	Total GHG kgPAR	Total GHG kgPRS	Total GHG kg/Ft2
Economy	35.38	130.06	6.36	10.32	6.88
Midscale	96.14	674.81	12.81	22.10	8.10
Upper Midscale	966.15	5476.78	21.18	22.08	12.46
Upscale	724.82	4502.87	34.18	46.74	18.39
Upper Upscale	1983.41	8149.79	24.17	35.13	10.15
Luxury	1511.32	7788.07	36.40	52.62	12.82
Total (n=20)	938.10	4918.65	27.72	39.01	13.85

Exhibit 11

Analysis of waste measurement

Metric	Hotel A	Hotel B	Hotel C	Hotel D
Diversion Rate	39.2%	16%	21%	21%
Total Waste PAR	2.97	1.40	3.24	1.72
Total Waste POR	N/A	2.01	4.65	2.49
Total Waste PRS	3.33	2.01	4.71	2.50
Total Waste PSF	1.92	0.95	1.07	0.89

the most appropriate indicator of performance to communicate consumption and impacts (Exhibit 11).

Discussion

The variations in performance indicator values clearly demonstrate the need for more precise footprinting than a catch-all value used in generic carbon calculators. Using one generic industry-wide average and multiplying by the number of room-nights to footprint a stakeholder's hotel stays would be no more valid than applying a single daily rate for all room-nights. These findings underline the need for collaborative agreement on the performance metrics. The following discussion outlines the points where agreement would benefit the industry as it attempts to tell its sustainability story.

Boundary

Several boundary issues merit further discussion. To begin with, capital expenditures are not included because these measures are intended to address operating impacts. Though a hotel's P&L includes debt service, the "environmental debt service" of amortizing or allocating the footprint of building or renovating the hotel was not considered. Second, although the study applied the calendar year expenses to the extent possible, a rolling 12-month average or quarterly update as the standard data boundary may be more relevant to a stakeholder request if monthly calculation is practical.

Facility-Level Data

The study only took into account facility-level data, not considering the upstream or downstream footprints. Needless to say, if every business, including the hotel's suppliers, measured Scope 1 and 2 emissions in aggregate and normalized metrics, then hotels would not have to calculate scope 3 emissions themselves. Therefore if hotels would measure the scope 1 and 2 emissions from operations in a uniform metric for their clients, and then require the same from their suppliers, then the goal of measurement and comparability would be more effectively addressed. A sustainability measure might include the effects of the parent brand's structure. If a hotel company were to enter into a large-scale carbon offsetting scheme or REC initiative, one would have to determine how to distribute the effects of reductions among constituent properties.

Likewise, the utility data were analyzed as submitted, with an overall assumption of a data-as-boundary parameter. No distinctions were made for facilities or amenities and how those may have affected performance or been allocated to third-party operators. As an example, laundry data were treated as reported, even though some operations washed laundry in-house and others outsourced. Some hotels included utility usage from the laundry and others did not. Drawing a boundary of only operational control may skew footprints depending on how laundry is handled. This is especially important considering the ubiquitous linen-reuse programs now in place. To turn around and indicate that a footprint did not include laundry data because it was outsourced may seem counterintuitive (or even disingenuous) to stakeholders.

The matter of how to record laundry impacts provides key insight to the importance of agreement regarding inclusion of data from amenities and facilities. Some are handled by the hotel operator, and some are outsourced, and the structure is never uniform across all hotels. As well, most operations do not have sub-metered utility billing and will need agreement on how to allocate or disaggregate data as needed. Perhaps the best way to frame this boundary issue is to bear in mind the stakeholder perception of guest consumption.

With regard to the footprint of a guest stay, it seems clear that basing performance indicators on average consumption is the preferable approach, rather than attempt to account for what hotel features the guest did or did not use. In fact, at the moment it is impractical to provide guest-specific data(e.g., whether the guest used the pool, or turned on the room air conditioner). The sub-metering and monitoring systems required to confirm actual use and consumption would be a technological, financial, and operational burden. Moreover, consumption-based accounting will complicate the comparability of performance indicators among hotels by guest stay. Aside from increased cost, installing such monitoring devices would ironically increase the hotel's environmental footprint due to manufacturing, installing, maintaining, and using the systems. I do not argue here against sub-metering in certain situations, but tracking the data from each guest stay does not seem cost-effective or environmentally sound for the benefit provided.

A second reason for applying an average-guest-stay footprint lies in the unparallel structure of amenity consumption and rates charged. Guests feel more free to use amenities at a hotel that includes those services in daily rates, such as a complimentary breakfast, wi-fi, or a fitness center. On the other hand, guests are more judicious in using amenities when they are charged in addition to the room rate.[51] At still other properties, guests pay a resort fee or similar amount in addition to the room rate, and those guests are not quoted an *á la carte* rate for amenities chosen. Likewise all the public areas, FF&E, and aesthetics are included in the value proposition and contribute to the footprint, regardless of whether the guest expressly appreciates these amenities.

Finally, the reductions in footprints if guests reduced their consumption at the margin may be negligible when one considers the energy and water used in public areas. Beyond that issue, small changes in the guest-stay footprint may also disappear when an entire trip is considered, given the components that make up the carbon footprint of travel. In that light, even the proportion represented by lodging is negligible in comparison to the transportation. As shown in Appendix G, emissions from flying to the destinations of hotel location in the data set ranged from 115 $kgCO_2e$ to 2,555 $kgCO_2e$. When comparing the mean carbon footprint of the air emissions with the mean footprint of hotel stays per room sold (assuming a 3-night stay), the hotel stay represented 13 percent of the carbon footprint. This was without accounting for the footprint of ground transportation, or any related business event. Therefore, even if the guest and hotel combined to reduce by 15 percent the guests' consumption-based footprint for the hotel stay, that would account for less than a 2-percent change in the total travel footprint.

It should be noted that the above arguments are intended for the discussion of industry-wide performance indicator development, and not value creation for the guest. Certainly options and possibilities exist to engage with guests, use innovative technology, and create pricing structures that add value to the guest experience. Those discussions are, however, outside the boundaries of standardizing the carbon footprint calculation of a hotel stay.

Quantification

The lodging industry will need to agree on several quantification parameters to allow for uniform footprinting and comparability. They are listed below, along with the definitions used in this study:

- Source or site energy as base values for energy and carbon (site energy was used);
- Emission factors for fuel burning and fugitive emissions (WRI emission factors were used, derived from IPCC data);
- GWP years for fugitive emissions sources (100-year factors were used);

[51] Chekitan S. Dev and Glenn Withiam, "Fresh Thinking about the Box," Cornell Hospitality Roundtable Proceedings, Vol. 3, No. 6, p. 10 (Cornell Center for Hospitality Research), quoting a study by Rebecca Hamilton on predicted and actual use of amenities in U.S. hotels.

Exhibit 12

Evaluation of potential sustainability performance metrics based on sample data set

Metric	Relevance to Guest	Current Industry Use	Representative of Room Consumption	Practical Data Gathering	Incentivizes Performance
Per Available Room	Medium	High	Medium	High	Low
Per Room Sold	High	High	High	High	High
Per Occupied Room	High	Medium	High	Medium	High
Per Square Foot/ Meter	Low	High	Medium	High	Medium

- High or low heating values of fuel burning (high values were used);
- Country or sub-national emission factors and how to account for CH_4 and N_2O uniformly for electricity (national emission factors were used and only CO_2 outside the U.S.);
- Emission factors for energy and GHG emissions from steam and chilled water (U.S. EPA emission factors were used, based on EIA data);
- Conversion factors for standardizing energy units to Btu or kWh (factors from the U.S. Energy Information Administration were used); and
- The integration of RECs and offsets into carbon performance indicators (RECs were to be subtracted from energy pre-quantification of carbon; offsets were to be subtracted post-quantification in a net value).

For GHG emissions quantification, the WRI states that the most specific emission factors available should be used.[52] Although region-specific emission factors would certainly add precision to the carbon footprint calculation those data are not readily available in most countries. Therefore a GHG inventory for a hotel chain with thousands of properties in dozens of countries would most likely want to take the only standardized approach currently available of using national-level emission factors. The other choice would be to disclose country-by-country the specificity levels and references cited for emission factors used.

Even in the United States, where regional emission factors are available, any large-scale comparison among hotel properties would become unintelligible and impractical given the large role of electricity in hotel energy consumption and the wide mix of fuel sources used to generate that power. The EPA eGRID platform provides emission factors by region based on fuel mixes and the grid structure. According to the 2010 eGRID summary tables, a hotel in Denver would have a Scope 2 carbon footprint over 3 times that of a hotel in Los Angeles for the same electricity consumption (2,198.35 lb/MWh in Colorado vs. 683.53 lb/MWh in California).[53] If the eGRID national average of 1,306.18 lb/MWh is used as the emission factor in both properties' calculation, however, the two hotels may be compared.

Metrics

Although the industry commonly applies a per-available-room analysis of its revenues, PAR is probably not the most useful GHG measure from the guest's point of view, based on a comparison of the four footprint "denominators." PAR does not reflect consumption incurred for a room-night as effectively as other metrics. Also, PAR values may be inversely correlated with occupancy, because the PAR performance would improve as occupancy rates decline.

Per Room Sold (PRS)

Given the industry's current widespread use of STR definitions of rooms sold, the PRS metric is far more practical and is more representative of individual room consumption and does not fluctuate as highly with occupancy. The range of the utility fluctuations however within the scope and boundary of the study would need analyzing with a larger data set to investigate the validity of this measure.

Per Occupied Room (POR)

POR is the measure that most accurately represents consumption per room because it includes comp rooms, which are not part of the STR calculations of rooms sold. Comp rooms do, of course, generate utility usage and GHG emis-

52 World Resource Institute & World Business Council for Sustainable Development. (2004). The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard. Geneva: Earthprint Limited.

53 Calculated using the EPA eGRID2010 Summary Tables, Environmental Protection Agency (2010). Version 1.0.

sions. In the study's results, comp rooms represented an additional .7% to rooms sold on average. If comp room data are not readily available, then benchmark factors for comp rooms could be added to PRS.

Per Square Foot (PSF) or Per Square Meter (PSM)

For operations purposes a PSF/PSM metric is the most practical, given the unchanging denominator of area. An area-based measurement allows for comparability among properties with similar occupancies because it would immediately normalize for differences in public areas and outlets. Although it does not directly address occupancy-related consumption, with an appropriate adjustment (i.e., multiplying by the average area per guestroom, gross or net) it would be relevant for stakeholders asking to know the environmental footprint of their stay.

A comparison of the four potential sustainability performance metrics is shown in Exhibit 12. Theoretically the metrics most relevant for client footprinting will represent the closest actual consumption and impacts resulting from the hotel stay. A PRS or POR metric is consumption-based at a larger level, since it divides the hotel's consumption and impacts by the number of rooms utilized by the hotel's guests. Useful though they may be, PAR and PSF values do not necessary reflect a footprint of the guest. Therefore some elements of guest consumption need to be taken into account. From this perspective, comp rooms could be considered as a part of the hotel's general footprint from BOH operation.

The difficulty in PRS metrics is that they vary widely by the amount of public space and facilities and amenities. In this instance, the differences in hotel size and scale may be best communicated in PSF/PSM metrics. Just as in the case of guests and room-nights, multiple metrics may be used and communicated, but if all performance indicators were disclosed collectively they would compromise the hotel's occupancy data. Specifically, if PAR and PRS were both given, then a stakeholder could divide the PAR value by the PRS value and arrive at the hotel's occupancy. Given the competitive value of property-level occupancy data, it is not practical to provide both metrics to external stakeholders.

In the end, PSF/PSM and per-room metrics do not compromise the hotel's data. Based on this reason and the sample set results of data availability, PSF and PRS metrics appear to be best for footprinting and comparing sustainability performance in carbon, energy, and water from hotel stays. Further research may provide a hybrid metric of PSF and PRS to provide increased comparability.

Comparability and Benchmarking

To ensure comparability of the analysis, the footprint data need to be filtered through two attributes: revenue class such as chain scale, and normalization factors (notably, weather and outlets or facilities).

Normalization

Because climate is a critical input to energy performance, the study collected data on geographic region, climate zone, heating degree days, and cooling degree days. as a precursor to future weather normalization. Normalization based on climate zone and specifically HDDs and CDDs is needed to allow meaningful comparisons not only across hotels, but for the same hotel across time.

The data-as-boundary specification presents a limitation in the existence and operation of certain outlets. In addition to the issue of an on-premises laundry, whether the property has a spa, fitness center, or F&B outlets all affect its performance. Research will determine whether these require normalization. At the minimum, a normalization factor to be added to the footprint of hotels which outsource laundry may be appropriate as further research could define appropriate benchmark values.

Chain Scale Benchmarks

Since we have each property's chain scale, it is possible that issues of amenities and public areas can be smoothed by normalizing or enabling comparisons among segments, and a PSF proxy may thus be unnecessary. In any event, it makes little sense to compare a limited service hotel to a full-service property.

A final consideration for comparability is the type of guestroom occupied by the client, which was not included in this study. A suite or deluxe room may have a higher footprint than a standard guestroom. The air travel emissions calculation found that the footprint of a business or first class seat was on average higher than an economy seat by a factor of 2.2. Further study could determine whether that is also true with regard to the additional consumption associated with a suite.

Just as the premise of Energy Star ratings is to provide an overall performance rating based on a benchmarking and rating system, an overall sustainability rating or index of performance for hotels is a potential path toward comparability. It is beyond the current framework to develop a comprehensive index scheme, as the current industry need is to standardize the parameters of performance indicators individually. Further research on benchmarking, stakeholder requests, and performance indicator development would help advance a benchmark index.

Stakeholders

As we have seen from this study, sustainability performance measurement involves a complex series of assumptions and parameters. To increase transparency, these assumptions can be provided when performance indicators are given to stakeholders. The stakeholder can then evaluate the indicators and assumptions in making a comparison among peer hotels. As an example, a reference sheet for this study was included in Appendix E.

This study's quantification method is limited because the data represent the footprint of the entire building, but not its component services. As a result, this methodology would not provide information for stakeholder groups that request footprints of meetings and events. The footprint of the room-night is one part of an event footprint, but how meeting footprints are handled will also affect room-night quantification. One way to do this is to calculate a per-square-foot or -meter footprint and then allocate the meeting's footprint proportionate to the area of the function space and duration of the event. Unfortunately, simplified square footage (meter) allocations do not necessarily represent proportionate consumption (i.e., a ballroom representing 10 percent of a hotel's gross floor area does not necessarily use 10 percent of its overall energy and water consumption). At the same time, per-room metrics are not representative of meeting footprints. Regardless of how the event footprint is quantified, it would result in double counting of consumption and impacts within the performance indicators provided to the client if room-night footprints are quantified separately from function space footprints using the same total energy or water balance. Footprints for meetings are strongly tied to footprints of guestrooms for specific stakeholder requests and will need further research to be uniformly presented in performance metrics.

With this issue in mind, potential solutions for generating industry agreement in uniform boundary and quantification for facilities and amenities are:

1. Further study to determine proportions and impact of each boundary issue to overall consumption and impacts of the sustainability aspects;
2. Analysis of consumption percentages to determine their materiality in whether they need precise measurement or can have a benchmark industry percentage allocated to them (i.e., by chain scale segment and normalized for climate zone) without granular, event-specific data; or
3. Analysis of the proximity of current allocation structures in rental or operating agreements to determine their application in allocating corresponding consumption.

Conclusion

This study's purpose was to address the lodging industry's need to answer external stakeholder requests for standardized sustainability performance indicators. It started by proposing a conceptual framework for developing performance indicators in sustainability measurement and then offered a process by which performance indicators are defined by passing specific aspects of sustainability through defining characteristics of boundary, quantification, and metrics while considering the issues of industry collaboration and practicality.

The study applied the framework to determine the boundary, quantification methods, and metrics for performance indicators of carbon, energy, water, and waste derived from hotel stays, representing the most common request by external stakeholders. Metrics for these four aspects were conclusively studied with the result of a uniform recommendation for measurement in carbon, energy, and water. Waste, however, requires further parameter specification by both industry and stakeholders to proceed with performance indicator development by means of the framework. For the remaining three, the multitude of boundary and facility allocation issues also require further parameter specification to arrive at uniform performance indicators that can be applied industry-wide.

In addition to satisfying client requests for footprints of hotel stays, the study's set performance indicators could be included as supplemental, sector-specific measurements of intensity or product-level footprints in sustainability reports. The prevalence of requests by stakeholders for this type of information leads to the conclusion that they would pass a materiality test for being deemed core performance indicators by a working group. Likewise, the performance indicators have specific linkages to certifications and frameworks previously reviewed in the background section. A linkage table is included in Appendix F.

Further work is needed to advance the framework and the proposed performance indicators. Industry discussion and collaboration is paramount in this regard. Further research with more comprehensive data sets, tests of boundary and quantification issues, and stakeholder needs will also help advance both the framework and the standardization of sustainability performance measurement in hotel operations.

One potential barrier to collaboration is that nearly every major hotel company already has developed internal system-wide performance measurement software without prior industry agreement on boundaries, quantification, and data sets to be communicated to external stakeholders. Such systems represent considerable investment. At present many are still in a phase of evolving and gaining buy-in, but the delaying of collaborative agreement could result in increased costs should systems need to be modified according to a common standard. In the long run however, the cost of harmonizing data reporting from internal systems would be lower than the instance of a continued fee (and analytical leverage) paid to third parties for external normalization. ■

Performance disclosed and metrics used in hotel GRI reports through 2009

METRICS BREAKDOWN	**Accor**	**HK-Shanghai**	**IHG**	**Jumeirah**
Total Energy (EN3 and/or EN4)	MWh	Gj	kWh	kWh (elec only)
Energy Intensity	kWh Per Available Room	MJ per m2	kWh Per Available Room	Not Reported
Total Water (EN8)	Mm3	m3	m3	m3
Water Intensity	Per Occupied Room Mm3	L. Per Guest Night	Not Reported	Not Reported
Total Waste (EN22)	Tons	Not Reported	Not Reported	Not Reported
Waste Intensity	Tons Per Hotel	Not Reported	Not Reported	Not Reported
Total GHG Emissions (EN16)	Metric Tons	Metric Tons	Approximate Metric Tons	Not Reported
GHG Emissions Intensity	Not Reported	Not Reported	kg. Per Room Night	Not Reported
Boundaries	As available from reporting properties (owned, managed, leased, and franchised)	Headquarters + Operational Control + Some External Employees	Managed and Franchised properties	Dubai-based managed properties and those of influence

	Marriott	**NH**	**Rezidor**	**Sol Meliá**	**Taj**
Total Energy (EN3 and/or EN4)	MWh	MWh	Not Reported	Gj	Gj
Energy Intensity	kWh Per Available Room	kWh Per Guest Night	kWh per m2	Not Reported	Not Reported
Total Water (EN8)	Mm3	m3	Not Reported	m3	m3
Water Intensity	Per Available Room Mm3	L. Per Guest Night	L. Per Guest Night	Not Reported	Not Reported
Total Waste (EN22)	Tons	kg.	Not Reported	Not Reported	Not Reported
Waste Intensity	Not Reported	kg. Per Guest Night	kg. Per Guest Night	Tons or kg per Hotel	Not Reported
Total GHG Emissions (EN16)	Metric Tons	Metric Tons	Metric Tons	kg	Metric Tons
GHG Emissions Intensity	Lb. Per Available Room	kg. Per Guest Night	kg. Per Guest Night	Not Reported	Not Reported
Boundaries	Energy/Water/GHG: Global Managed, Waste: US Managed	As available (sometimes partial) among owned, leased, and managed	Managed and Leased Properties (that reported)	Not Specified	Cites brands that are included

Emission factors of kg CO_2 per kWh of electricity generated per country

Country	Emission Factor	Country	Emission Factor	Country	Emission Factor	Country	Emission Factor	Country	Emission Factor
Albania	0.0324402	Cuba	1.0194389	Israel	0.773651	Nicaragua	0.5497637	Togo	0.4586697
Algeria	0.6881182	Cyprus	0.7582802	Italy	0.403512	Nigeria	0.3861378	Trinidad and Tobago	0.7243096
Angola	0.0982004	Czech Republic	0.526629	Jamaica	0.8297551	Norway	0.006867	Tunisia	0.5458586
Argentina	0.3033696	Denmark	0.341339	Japan	0.418346	Oman	0.8561127	Turkey	0.438222
Armenia	0.1382909	Dominican Republic	0.6238551	Jordan	0.6018739	Pakistan	0.4128082	Turkmenistan	0.7951304
Australia	0.920527	Ecuador	0.3957349	Kazakhstan	0.5200265	Panama	0.2288439	Ukraine	0.3443288
Austria	0.214471	Egypt	0.4698084	Kenya	0.3174905	Paraguay	0	United Arab Emirates	0.8199856
Azerbaijan	0.4734752	El Salvador	0.2167277	North Korea	0.5331955	Peru	0.1723235	United Kingdom	0.504733
Bahrain	0.8248637	Eritrea	0.690342	South Korea	0.464337	Philippines	0.4350061	United States	0.55866
Bangladesh	0.5843308	Estonia	0.6401581	Kuwait	0.6429168	Poland	0.65865	Uruguay	0.2963499
Belarus	0.2963771	Ethiopia	0.002914	Kyrgyzstan	0.079161	Portugal	0.416424	Uzbekistan	0.44636
Belgium	0.260036	Finland	0.241592	Latvia	0.1673881	Qatar	0.6257141	Venezuela	0.2084422
Benin	0.6962126	France	0.084953	Lebanon	0.6946497	Romania	0.428605	Vietnam	0.3963138
Bolivia	0.5049688	Gabon	0.3466605	Libya	0.8788286	Russia	0.3285654	Yemen	0.8230311
Bosnia and Herzegovina	0.801958	Georgia	0.1449678	Lithuania	0.139482	Saudi Arabia	0.7553734	Zambia	0.0067574
Botswana	1.8514539	Germany	0.403629	Luxembourg	0.326047	Senegal	0.7258949	Zimbabwe	0.5727689
Brazil	0.0814376	Ghana	0.2756985	Macedonia	0.6189059	Serbia	0.7155911	Other Africa	0.4886113
Brunei Darussalam	0.8210049	Gibraltar	0.7304305	Malaysia	0.6553582	Singapore	0.5360586	Other Latin America	0.5089928
Bulgaria	0.4479618	Greece	0.724964	Malta	0.8340854	Slovak Republic	0.223412	Other Asia	0.3078166
Cambodia	1.0049344	Guatemala	0.3344147	Mexico	0.541285	Slovenia	0.3317589		
Cameroon	0.0425357	Haiti	0.3051825	Moldova	0.475568	South Africa	0.8689996		
Canada	0.184179	Honduras	0.4132526	Mongolia	0.52331	Spain	0.349794		
Chile	0.2942425	Hong Kong, China	0.8546126	Morocco	0.7079012	Sri Lanka	0.3137244		
China (including Hong Kong)	0.7883087	Hungary	0.343927	Mozambique	0.0010178	Sudan	0.6139183		
Colombia	0.1496172	Iceland	0.000542	Myanmar	0.3382211	Sweden	0.047966		
Congo	0.1023289	India	0.9440385	Namibia	0.0756469	Switzerland	0.025723		
Democratic Republic of Congo	0.0027816	Indonesia	0.6767253	Nepal	0.0037996	Syria	0.6043992		
Costa Rica	0.0473985	Iran	0.5143547	Netherlands	0.394315	Tajikistan	0.0280183		
Côte d'Ivoire	0.4362172	Iraq	0.7009096	Netherlands Antilles	0.7170685	Tanzania	0.3155122		
Croatia	0.318398	Ireland	0.535333	New Zealand	0.3091	Thailand	0.5109283		

Source: World Resources Institute (2009). GHG Protocol tool for stationary combustion. Version 4.1.

GWP of common refrigerants

Gas or Blend	GWP	Source		Gas or Blend	GWP	Source
CO_2	1	IPCC Second Assessment Report (1995)		R-410A	1,725	ASHRAE Standard 34
HFC-23	11,700	IPCC Second Assessment Report (1995)		R-410B	1,833	ASHRAE Standard 34
HFC-32	650	IPCC Second Assessment Report (1995)		R-411A	15	ASHRAE Standard 34
HFC-125	2,800	IPCC Second Assessment Report (1995)		R-411B	4	ASHRAE Standard 34
HFC-134a	1,300	IPCC Second Assessment Report (1995)		R-412A	350	ASHRAE Standard 34
HFC-143a	3,800	IPCC Second Assessment Report (1995)		R-413A	1,774	ASHRAE Standard 34
HFC-152a	140	IPCC Second Assessment Report (1995)		R-414A	0	ASHRAE Standard 34
HFC-236fa	6,300	IPCC Second Assessment Report (1995)		R-414B	0	ASHRAE Standard 34
R-401A	18	ASHRAE Standard 34		R-415A	25	ASHRAE Standard 34
R-401B	15	ASHRAE Standard 34		R-415B	105	ASHRAE Standard 34
R-401C	21	ASHRAE Standard 34		R-416A	767	ASHRAE Standard 34
R-402A	1,680	ASHRAE Standard 34		R-417A	1,955	ASHRAE Standard 34
R-402B	1,064	ASHRAE Standard 34		R-418A	4	ASHRAE Standard 34
R-403A	1,400	ASHRAE Standard 34		R-419A	2,403	ASHRAE Standard 34
R-403B	2,730	ASHRAE Standard 34		R-420A	1,144	ASHRAE Standard 34
R-404A	3,260	ASHRAE Standard 34		R-500	37	ASHRAE Standard 34
R-406A	0	ASHRAE Standard 34		R-501	0	ASHRAE Standard 34
R-407A	1,770	ASHRAE Standard 34		R-502	0	ASHRAE Standard 34
R-407B	2,285	ASHRAE Standard 34		R-503	4,692	ASHRAE Standard 34
R-407C	1,526	ASHRAE Standard 34		R-504	313	ASHRAE Standard 34
R-407D	1,428	ASHRAE Standard 34		R-505	0	ASHRAE Standard 34
R-407E	1,363	ASHRAE Standard 34		R-506	0	ASHRAE Standard 34
R-408A	1,944	ASHRAE Standard 34		R-507(A)	3,300	ASHRAE Standard 34
R-409A	0	ASHRAE Standard 34		R-508A	10,175	ASHRAE Standard 34
R-409B	0	ASHRAE Standard 34		R-508B	10,350	ASHRAE Standard 34

Adapted from: World Resources Institute, Calculating HFC and PFC Emissions from the Manufacturing, Installation, Operation and Disposal of Refrigeration & Air-conditioning Equipment (Version 1.0): Guide to calculation worksheets (January 2005)

Results from data set

Profile Data	Data Set	Mean	Min	Max	Standard Deviation
Guestrooms	20	394	56	1,354	343
Gross floor area (Ft.2)	20	378,418	18,899	1,500,000	381,740
Ft.2 total function space	6	65,212	1,236	206,154	90,802
Ft.2 per guestroom	8	601	254	969	250
Heating Degree Days	20	2,053	24	4,352	1,670
Cooling Degree Days	20	3,142	864	6,254	2,185
Rooms Available	20	143,908	20,440	495,040	125,113
Rooms Sold	18	97,024	12,605	340,392	78,227
Occupied Rooms	8	111,948	30,017	344,948	112,716
Comp % Increment	8	0.7%	0.2%	1.5%	0.5%
Performance Metrics	**Data Set**	**Mean**	**Min**	**Max**	**Standard Deviation**
Total Energy (kWh)	18	10,592,546	353,644	37,650,364	10,801,452
Total Energy PAR	17	64	17	131	31
Total Energy POR	8	85	39	176	42
Total Energy PRS	15	91	28	178	44
Total Energy PSF	17	33	18	97	18
Total Water (M3)	17	97,120	3,672	353,694	94,975
Water LPAR	17	565	52	1,117	333
Water LPOR	8	722	435	1,653	397
Water LPRS	15	846	351	1,673	468
Water L PSF	17	254	31	600	131
Total Waste (Tons)	11	665	42	3,019	888
Total Waste kgPAR	11	4.9	0.7	26.2	7.4
Total Waste kgPOR	4	2.6	1.4	4.6	1.4
Total Waste kgPRS	9	6.4	1.4	33.3	10.2
Total Waste kg PSF	11	2.5	0.4	13.9	4.0
Total Direct GHG (Scope 1)	16	938.10	35.38	2,879.04	1,006
% Fugitive of Scope 1	10	0.022%	0.000%	0.140%	0.044%
Total GHG Emissions (Scope 1 & 2)	17	4,919	130	16,067	5,270
Total GHG kgPAR	17	28	6	77	18
Total GHG kgPOR	8	35	17	75	18
Total GHG kgPRS	15	39	10	102	25
Total GHG kg PSF	17	14	7	36	8

Results from data set (continued)

Mean Values by STR Segment						
Performance Metrics	**Economy**	**Midscale**	**Upper Midscale**	**Upscale**	**Upper Upscale**	**Luxury**
Total Energy (kWh)	353,644	1,502,179	13,134,263	7,604,673	21,271,643	19,219,543
Total Energy PAR	17	29	55	73	64	89
Total Energy POR	N/A	49	N/A	66	92	132
Total Energy PRS	N/A	49	66	102	93	128
Total Energy PSF	N/A	18	38	41	27	32
Total Water (M3)	N/A	16,887	105,743	72,609	126,709	190,498
Water LPAR	114	335	418	592	355	882
Water LPOR	N/A	545	N/A	664	511	1,169
Water LPRS	N/A	547	455	910	516	1,247
Water L PSF	N/A	214	247	271	145	312
Total Waste (Tons)	N/A	42	419	756	948	N/A
Total Waste kgPAR	1.3	0.7	2.1	7.3	2.5	N/A
Total Waste kgPOR	N/A	1.4	N/A	2.0	3.6	N/A
Total Waste kgPRS	N/A	1.4	3.3	9.2	3.6	N/A
Total Waste kg PSF	1.5	0.4	6.5	3.8	1.0	N/A
Total Direct GHG (Scope 1)	35	96	966	649	1,983	1,511
% Fugitive of Scope 1	0.0214%	0.0200%	0.0214%	N/A	N/A	0.0046%
Total GHG Emissions (Scope 1 & 2)	130	675	5,477	4,503	8,150	7,788
Total GHG kgPAR	6	13	21	34	24	36
Total GHG kgPOR	N/A	22	N/A	26	35	59
Total GHG kgPRS	10	22	22	47	35	53
Total GHG kg PSF	7	8	12	18	10	13

Hotel Locations: USA, 11 properties; United Arab Emirates, 4 properties; UK, 2 properties; China, 2 properties; and Netherlands, 1 property.
Energy Source: Natural Gas, 16 hotels, Electricity, 15 hotels, and Propane, LPG, Fuel Oil, and Steam, 1 property each.

Sample hotel property reference sheet for external stakeholders

Performance Metrics [to be filled in per hotel]	
Gross Carbon Footprint PRS	[value]kg
Gross Carbon Footprint PSF	[value]kg
Net Carbon Footprint PRS	[value]kg
Net Carbon Footprint PSF	[value]kg
Total Energy PRS	[value]kWh
Total Energy PSF	[value]kWh
Water PRS	[value]L
Water PSF	[value]L

Attributes [to be filled in per hotel]	
# Guestrooms	[#]
STR Segment	[list chain scale segment]
HDDs	[#]
CDDs	[#]
Function Space	[list Square Footage] [Included/Not Included]
Laundry Wash	[Included/Not Included]
Restaurant[s]	[Included/Not Included]
Swimming Pool	[Included/Not Included]
Spa	[Included/Not Included]
Fitness Center	[Included/Not Included]
Retail Outlets	[Included/Not Included]
Business Center	[Included/Not Included]

Boundaries		
Data Parameters	**Included**	**Not Included**
Data-as-boundary	All operated facilities' utility consumption	Construction/Renovation
2010 calendar year	All meeting space	Outsourced operations
Facility-level	Fuels Burned (stationary and mobile)	Treatment of wastewater
Self-reported	Fugitive Emissions	Water purification
No weather normalization	Purchased Electricity	Offsite IT servers
No chain scale normalization	Purchased Steam	Employee commutes/ travel
	RECs	Corporate or regional offices
	Carbon Offsets	Life cycles of materials and supplies
		Upstream or downstream impacts
		Guest travel or consumption offsite
Quantification Methods		
Source	**Emission Factor**	**Observation**
Refrigerants	WRI HFC and PFC Emissions Version 1.0	100-year GWP cycle
Natural Gas	WRI 4.0 Stationary Combustion	HHV, Global Factor, Site Energy
Propane	EPA Emissions from Stationary Combustion	HHV, Country Factor, Site Energy
LPG	WRI 4.0 Stationary Combustion	HHV, Global Factor, Site Energy
Fuel Oil	WRI 4.0 Stationary Combustion	HHV, Global Factor, Site Energy
Electricity	WRI 4.1 Stationary Combustion, EPA eGRID (USA)	HHV, Country Factor, Site Energy
Steam	EIA (USA)	Country Factor, Site Energy
Chilled Water	EIA (USA)	Country Factor, Site Energy

DIrect and indirect linkages to indicators developed through the measurement framework

Performance Indicator (Total, PRS, or PSF/PSM)	Description	Linkages							
		GRI 3.1	CDP 2011	ISO 26000	GSTC	Green Key	Green Seal GS-33 5th Ed.	LEED EB: O&M	AHLA Green Guidelines
GHGa	Scope 1 GHG emissions	EN16	8.2, 13.4	6.7.5.2, 6.5.5.2	D.2.1	Engineering & Maintenance 2		EA Credit 6	
GHGb	Scope 2 GHG emissions	EN16	8.3, 13.4	6.7.5.2, 6.5.5.2	D.2.1	Engineering & Maintenance 2		EA Credit 6	
GHGc	Gross carbon footprint	EN16	11.2, 13.4, SM4	6.7.5.2, 6.5.5.2	D.2.1	Engineering & Maintenance 2		EA Credit 6	
GHGd	Net carbon footprint	EN16, EN18	14.2a, SM4	6.7.5.2, 6.5.5.2	D.2.1	Engineering & Maintenance 2	3.8.4		
ENERGYa	Direct energy usage	EN3	12.2	6.5.3.2, 6.5.4.2, 6.7.5.2	D.1.3	Engineering & Maintenance 1, 60		EA Credit 3.2, 3.3	Guideline 2
ENERGYb	Indirect energy usage	EN4	12.2	6.5.3.2, 6.5.4.2, 6.7.5.2	D.1.3	Engineering & Maintenance 1, 60		EA Credit 3.2, 3.3	Guideline 2
ENERGYc	Total energy usage			6.5.3.2, 6.5.4.2, 6.7.5.2	D.1.3	Engineering & Maintenance 1, 60		EA Credit 3.2, 3.3	Guideline 2
WATERc	Total water usage	EN8	9.2 (Water)	6.5.3.2, 6.5.4.2, 6.7.5.2	D.1.4		3.8.7	WE Credit 1	Guideline 2

Sample of GHG emissions from air travel between selected cities

Lower left: ROUNDTRIP GHG EMISSIONS (kg); Upper right: ROUNDTRIP AIR DISTANCES (miles)

	Orlando	San Francisco	Dallas	Boston	Phoenix	San Diego	Amsterdam	Chicago	Dubai	London	Shanghai	New York	Las Vegas
Orlando		4,876	1,928	2,242	3,686	4,576	9,054	2,008	15,964	8,682	16,604	1,868	4,066
San Francisco	627		2,956	5,392	1,298	894	10,910	3,682	16,168	10,702	12,266	5,156	824
Dallas	326	394		3,102	1,764	2,366	9,806	1,602	16,370	9,466	15,222	2,758	2,140
Boston	356	694	391		4,590	5,160	6,888	1,728	13,332	6,508	17,658	374	4,748
Phoenix	397	213	296	594		604	11,588	2,876	18,326	10,512	13,564	4,296	510
San Diego	720	176	410	666	126		11,648	3,438	18,928	11,758	13,160	4,876	516
Amsterdam	1,168	1,280	936	771	1,433	1,397		8,210	6,416	460	11,064	7,262	11,788
Chicago	293	466	237	247	390	422	975		15,272	7,878	14,074	1,474	3,022
Dubai	2,163	1,640	1,687	1,365	2,422	2,555	615	2,096		6,824	8,010	13,660	17,112
London	967	1,028	1,099	776	1,472	1,257	120	870	589		11,474	6,882	11,366
Shanghai	2,085	1,410	1,804	2,104	1,623	1,586	1,671	1,748	783	1,112		14,746	13,090
New York	259	638	397	115	456	579	858	246	1,253	678	1,735		4,484
Las Vegas	650	167	309	611	149	155	1,452	392	1,924	1,211	1,577	533	

Notes: Calculated using TRX Air Emissions Calculator. http://carbon.trx.com

Assumptions

- Best performing airline used in each instance
- Economy class seating
- Statute miles
- Direct flights where routing available, comparable two-segment flight routes where direct flights not available
- Radiative forcing included (factor of 2.7)

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