Office Building Energy Benchmarking Comparison:
Sydney and New York

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ABSTRACT: In recent years several national and municipal governments have begun requiring building owners to disclose the actual annual operational energy and water performance of their properties. These mandates promise not only to be effective in encouraging building operators to be more energy efficient, but also instrumental in improving energy benchmarking practices through the creation of large databases that building owners, occupants, and researchers can access to evaluate the energy performance of certain properties in relation to the performance of a vast inventory of similar buildings using consistent metrics. In 2012 pilot results from energy performance disclosure programs in Australia and New York began trickling in to their supervising entities, and subsequently some Energy Use Intensity (EUI) and Green House Gas (GHG) data have become accessible to the public. This paper presents the preliminary results of a study that examined how effectively this data can be used to compare representative top, middle, and bottom commercial office building energy performers in central business districts of Sydney, Australia and New York, United States of America.
Keywords: building energy performance, energy metrics, energy performance disclosure, commercial office energy performance, architecture and energy consumption, energy benchmarking

TRODUCTION

ilding energy consumption depends on a myriad of riables that simplistically can be reduced down to four :tors: (1) building type, (2) site characteristics, (3) ilding design and (4) operations. As primarily velopers dictate the building type through their brief, inners determine many site characteristics through :ir zoning regulations, architects and engineers define : building design through their drawings and ecifications, and occupants and facility managers ving operations through their daily habits, and as all s often happens with little or no collaboration, it is no nder that some buildings squander energy. storically the movement to counter this wastage has ught to advance design and construction practices by :ating more stringent building energy codes, which couraged the development of both better buildings stems and better tools to design buildings. However, re recently, in order to meet green house gas (GHG) issions targets, city officials have recognized that :y must contend with the challenge of retrofitting eable stocks of existing buildings, and the focus has fted from improving methods in predicting building ergy performance of new construction to improving :thods in reporting the real building energy rformance of existing buildings.

Within the span of the last five years several national d municipal governments have enacted regulations encourage building owners to improve the ener performance of their building portfolios. For sor programs, an additional aim is that researchers may able to use these registers with large inventories annual operational energy data to reveal new insigl about operational energy management. These databas are not an entirely new creation. The U.S. Ener Information Administration has been collecting data commercial building operational energy through Commercial Building Energy Consumption Surve (CBECS) since 1979. These data have been used create several successful benchmarking tools such as t Energy Portfolio Manager and Target Find Nevertheless the voluntary nature of these ener disclosure surveys for energy did not assist in garneri an extensive response rate. Therefore these n programs with mandated requirements will expand t numbers of buildings included in these existi databases exponentially as well as create new database

Studies using these data are just beginning, a results already are unmasking interesting patterns urban building energy consumption. Undoubtedly the databases will continue to prove extremely useful illustrating trends in energy performance specific to locality. This paper in attempting to perform a simp preliminary comparative analysis of commercial off energy performance for two well known metropolises opposite sides of the globe, New York City and Sydn imately prove useful in suggesting techniques for proving efficiency.

(C AND SYDNEY ENERGY DISCLOSURE

of May 2013, ten municipalities in the United States ve instituted programs requiring building owners to omit energy and water consumption data. In 2007 the w York City government set the goal of reducing eenhouse gas emission by more than 30% by the year 30, and then two years later with the passing of Local w 84 established the country's most ambitious energy sclosure program in terms of building area covering ore square footage than all the other US programs mbined. New York City's five boroughs contain more in one million structures, but city officials somewhat rprisingly determined that a disclosure program dressing only the biggest 2%, or those properties over ,000 square feet (4,645 square meters), would cover lf of the city's built area. They identified proximately 15,000 properties as being responsible 45% of New York City's green house gas emissions |.

On the opposite side of the globe, the government of istralia followed a similar trajectory by enacted the ilding Energy Efficiency Disclosure Act 2010 and inching its compulsory commercial building energy sclosure program in 2010, using as a basis its luntary National Australian Built Environment Rating stem (NABERS), first administered by the state of w South Wales (NSW), and an outgrowth of the istralian Green Building Rating (AGBR) first veloped in 1999 [2].

While both programs encourage the owners and erators of larger commercial properties to track, to sess using certified assessors and to disclose annual erall energy consumption, energy use intensity (EUI) d water use intensity data as well as provide a lculation of their green house gas (GHG) emissions to sist in their city's or nation's GHG inventories, they fer in some important respects. Firstly, Australia's mmercial Building Disclosure (CBD) program does t require all commercial building owners to submit an nual report directly. Rather, it stipulates each seller or sor of an office space of 2000 square meters or more ovide their prospective buyers or tenants with a ilding Energy Efficiency Certificate (BEEC). Only 3D accredited assessors on behalf of the seller or sor can apply for a BEEC, achievement of which is sed on fulfilment of criteria set out by the NABERS ogram. One of the NABERS criteria requires annual porting of energy and water data to be maintained. It the NABERS organisation that issues the BEEC and accredited assessors to submit annual energy and wa using the Energy Star's Portfolio Manager on-line to This tool initially was developed in the year 2000 as p of United States government's Energy Star program, r by Environmental Protection Agency (EPA).

Australia's NABERS program provides star ratin with the highest rating of 6 stars signifying mark leading performance. The lowest rating of 1 s indicates poor performance. The Energy Star rati system ranks buildings on a scale of 1-99, with ranking of 99 indicating that the building has ener performance in the top 1% of its category. An Ener Star ranking of 1 indicating that the building falls in t lowest 1% of all reported buildings of its category. Or buildings that perform in the top 25%, or having Energy Star rating of 75, earn an Energy Star certifica However, New York's Local Law 84 does not requ that property owners achieve this Energystar certifica It only requires that the assessor obtain an Energys rating using the EPA's on-line tool [4].

Administrators of Local Law 84, as part of N York's Green Greater Buildings Plan, compiled t submitted data into an on-line publically accessil database on-line. In addition the City of New York h sponsored a number of studies to analyse the da collected and have published these findings in informative report [3]. At this point the regis maintained by the administrators of Australia's CE program contains the names and addresses of t buildings that have obtained NABERS rating, but it do not list any performance data such as annual ener consumption or energy use intensity. In order to obta this information, the public can search register a download from the website copies of individual BEEC

Australia's CBD and NYC's Local Law 84 a stipulate different metrics. In the case of energy da provided in Australia's CPD, the BEEC provides t NABERS star rating, the rating period, the rating sco (Base or Full Building), the rated area (m^2), annu emissions (kg CO2-e per year), annual emissio intensity (kg CO2-e/ m^2 per year) and annual ener consumption in MJ per year. Meanwhile the NYC downloadable database identifies properties not name, but by the cities tax office's Borough Block L (BBL) numbering system, and it holds addresses oft different from those by which the building is commo known. In terms of energy data, it provides the metr used by Energystar: Site EUI, Weather Normalized E in the imperial units of kBtu per square foot, calculated Energystar Score, and GHG emissions (M CO2e)

Lastly a most significant difference between sclosure programs that most be noted is the disparity building stock impacted. During the first year of full sclosure for Australia's program, nearly the rformance of 900 buildings was assessed, but this cluded buildings all across the country. By contrast, 'C's Green Greater Building Plan released data on ore than 4000 buildings at the end of its first year.

ETHODOLOGY

order to make the most solid comparison between the st-year of results of disclosure data, it was decided it a focus on commercial office building performance ould yield the best results as it represents the largest ctor. New York's full database covers 28 different ilding sectors, but over one quarter of the listings 145) were for office buildings. An even greater rcentage of Australia's CBD entries pertained to fice buildings with reportedly 65% of national office rket space (17.4 million square meters) rated as of ne 2012 [e-mail correspondence, Dale Harkess, NSW vernment].

The sample sizes were further reduced to concentrate the primary commercial business districts of the ernational cities of Sydney and New York where the ghest density of office space occurs. While some may gue that New York City's primary business district is fined by a square kilometre or two in Manhattan's dtown with the lower island financial district being its condary center, all of the borough of Manhattan was cluded in this study. Sydney's business district cluded all properties that shared the postcode 2000. ice incomplete entries and suspect office building tings, which included either extreme data such as 0 or 0 Energy Star scores, were eliminated from the nple, the number of Manhattan commercial office ildings assessed was 744. There were 151 buildings cluded in the study from the Sydney CBD.

In order to establish whether there were any obvious nding relations, data for each city was first sorted in a mber of ways including building size versus EUI, star ing versus EUI, GHG emission versus EUI and cation versus EUI. Smaller samples representational top third performance, middle third performance, and ttom third performance were then selected on basis of JI, NABER or Energystar Ratings, and GHG nissions. A preliminary review of enclosure design d construction systems was then conducted for all ildings included in these samples. The performance ta for six of these representational buildings is cluded in the table below.

REPRESENTATIONAL PERFORMANCE

Table 1: Representational performance for Sydney's and N York's top, middle, and bottom third in 2012 commercial of energy performance public disclosure samples.

		Name	Floors	Year		NABERS or Energystar* Rating	AREA (sqm)	EUI (MJ / sqm)	G (k
SYDNEY	Top	ATO Centre (Latitude East)	12	2007		5.5	22,684	293	
	Mid	59 Goulburn Street	25	1975		3.5	15,705	523	
	Bottom	NRMA House	15	1965		1.5	14,846	902	
NEW YORK	Top	National Association Building	20	1920		95*	33,470	702	
	Mid	Canada House	27	1957		73*	21,386	956	
	Bottom	Seagram Buildiing	38	1958		3*	73,875	2518	

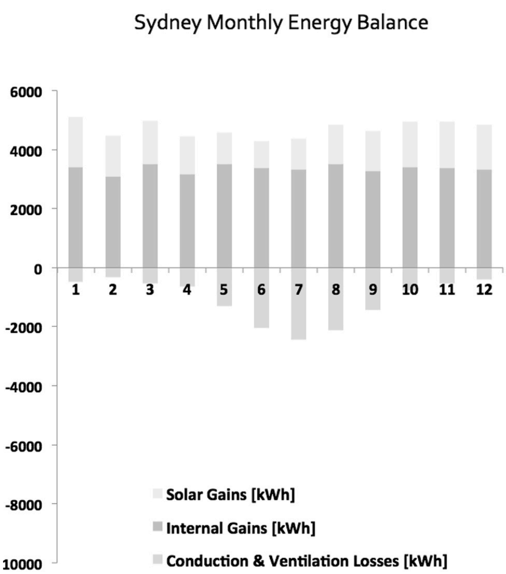
As one expect energy consumption as measured by E (megajoule/square metre) runs inversely to NABE and Energy Star Ratings. In Australia's CBD progra a Sydney commercial office building that rated in t top third averaged 5.5 NABERS stars. A mid-ran building in the sample was assessed with 3.5 NABE stars, and an average building in the bottom third wo have 1.5 NABERS stars. Likewise buildings from t NYC sample are included in table reflect high, mediu and low Energy Star ratings. The average Energy S rating for all New York City buildings is in the 60s, a this rating is even higher for Manhattan office building

The authors of PlanNYC: New York Local Law Benchmarking Report highlight that the bottom 5% office buildings in New York have on average an E about 450% greater than the average EUI of the top 5 [3]. Consistent with these results, the table above sho that a bottom tier performer out consumes a top t performer by about 307% and 359% in Sydney and N York City. However, the alignment between E numbers between the top, middle, and bottom cities do not correlate so nicely suggesting that differences each disclosure program's EUI computatio methodologies makes a comparative analysis of E impossible.

FACTOR 2: SITE & CLIMATIC DIFFERENCES

As discussed introduction, differences in site conditio also have significant implications. For any comparati analysis of building energy performances, disparities both regional climate conditions and local microclim conditions should be assessed. According the Kopp classification system, Sydney has the characteristics o Mediterranean climate with typically a hot summ mild winter and a dry spring. Meanwhile New Yo

/ season, and a much cooler winter. While typical nter days in New York City often hover around the ezing point, cold snaps often occur for at least a week two each winter where temperatures fall into the gative double digits centigrade. By contrast in dney, a typical winter day has a temperature of nearly °C, and it rarely drops below 8°C. In terms of heating gree days (HDD 10 C) New York has 1101 degree ys, and Sydney has only 3 reflecting the fact that New ›rk commercial buildings require heating systems, ile their importance in Sydney is reduced. Although th cities' summertime maximum design temperatures : comparable, Sydney requires significantly more oling year round with typically 2936 cooling degree ys (CDD 10C) typically. New York requires ;nificant air conditioning during summer months and ›ically has 1779 CDD each year. Sunny days and solar liation also differ significantly in Sydney and New ›rk. In Sydney the radiation is not only more intense, t the sunny days are more numerous. Sydney records average 107 sunny days and 121 partly sunny days a ar. New York has sun 58% of the time. The two arts below illustrate the differences in monthly energy lances for Sydney and New York typical office aces. Internal gains and solar gains are not radically ferent, but New York's energy losses due to nduction and ventilation during the colder months en offset those gains.



;ure 1: For a typical Sydney commercial office building ar gains and internal gains exceed conduction and ıtilation losses necessitating cooling year round.

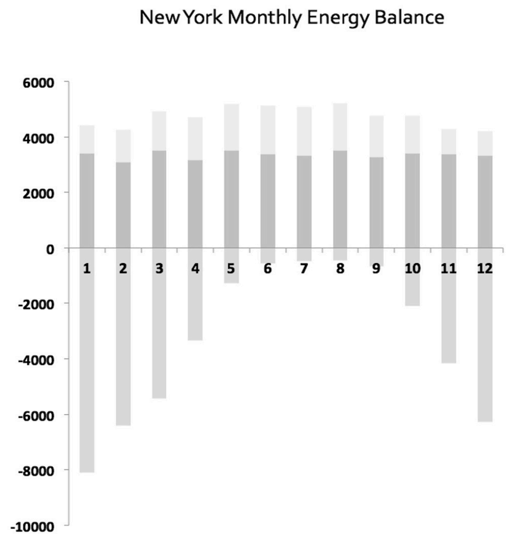


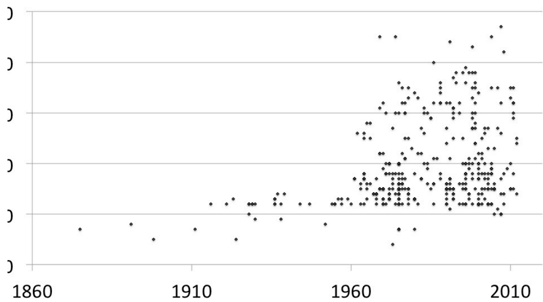
Figure 2: For a typical New York commercial office build conduction and ventilation losses can exceed solar c internal gaining necessitating heating in winter months.

Solar radiation gains in the two cities also vary d to differences in their latitudes. Sydney has a latitude 33.5°S has summer days almost an hour shorter th New York does at its 40.5° N latitude. Therefore t sun is already a bit higher in the sky when the sumn workday begins in New York. In wintertime t opposite occurs, and the days in NYC are almost an hc shorter requiring that all office turn on lights in the l afternoon even if they have good day-lighting schem In Sydney dusk conditions impact much less of norn winter workday.

As both New York and Sydney are harbour cit their microclimates bear some similarities with t bodies of water moderating temperatures and providi frequent breezes. Wind speeds are marginally higher New York, but the built density of its downtown aı can create more severe microclimate condition. T orientation of Manhattan's urban grid favours bet solar control than Sydney's, but its historic allowar for greater building heights counters the shading bene providing by street layout. While Sydney has 9 buildings over 35m and 154 buildings over 100m, N York has 5,845 buildings over 35m and 700 buildir over 100m. For New York City, a plot of EUI vers zip codes did indicate some differences neighbourhood performance. While it is likely tl social, economic, and zoning factors are accountab geometric factors may play a role. The actual relati impacts of climate and microclimate on each of : representational buildings require additional study

ACTOR 3: BUILDING DESIGN

1e of the most striking differences between Sydney's d New York's commercial building stocks that was vealed by this study was the divergent trends when mparing building age and EUI performance. As gure 3 below indicates, Sydney's building boom took f in early 1960s when height restrictions were lifted d as result a large percentage of energy intensive ildings, representative of that era, were constructed ring the 1960s and 1970s.



gure 3: Sydney Building Stock: number of floors versus year nstructed

In contrast New York's building boom began 70 ars earlier, and a significant percentage of the anhattan buildings included in the survey were nstructed before 1930 before lighter weight curtain ll systems had made an appearance. Their enclosures re comprised of heavy masonry and punched ndows rather than vast expanses of conductive glass. ot surprisingly these older buildings of New York en demonstrate good energy performance. In fact, all l of the buildings that figured as typical top rformers in terms of EUI the New York selective nple happened to be constructed between 1891 and 32. In comparison, Sydney, the best performing ildings in Sydney are those most recently constructed accordance with increasingly stringent building code gulations. When Sydney's building boom began in the 60s, there were no energy codes with which designers d builders had to abide.

The study of the representative sample of New York tter performers also suggests that some other factors ty be at play. The majority of these early century ildings have between seven and twenty-five floor vels with the median being about twelve floor levels. ch buildings are nestled between other buildings on anhattan's narrower streets opposed to wider avenues. ith party walls on two sides, a much smaller building velope is exposed to the elements. Moreover the areas these buildings are usually much smaller than those

not to say that the all of New York's older buildings h exemplary performance. Indeed in the review of the 7 buildings, several older buildings fell in the bottom th as well as the middle tier. Nevertheless there was positive correlation between age and performance in t New York sample with only a few recent buildin breaking into the top tier and none at the very t despite the advancement in building codes and ener efficient technologies. Even models of mode environmental design such as Four Times Squa received only a moderately decent Energy Star score 73 despite its state-of-the-art mechanical systems.

FACTOR 4: OCCUPANT BEHAVIOR

Occupant behaviour is often considered the great wildcard in energy performance assessment [8], and it beyond the scope of this preliminary study to offer a suggestions on how energy performance disclosu programs might be modified to provide more accura data in this field. Already studies have shown th occupant density in buildings can fluctuate over t years and often is not consistent with what is modell or assumed in energy calculations [9]. As the publish data currently does not include these indicators, comparative analysis can yet be conducted. Likewi factors that vary regionally such air conditioning points do affect energy use, and requirements to inclu information on them by the certified assessors cou quickly become too cumbersome making the disclosu process ineffective.

CONCLUSION

This paper has sought not only to provide a br overview of two important energy disclosure progran but also to show the potential that comparative analys of their results may bring as programs develo Currently the methods for calculating ener consumption in Australia's CPD and NYC's Local La are not aligned and thus a proper comparative stu between EUI values cannot be conducted. At this po in time GHG intensity figures seem to be mo appropriate for comparison between regions international protocols for universal GHG emissio reporting are more developed and more consisten applied. Globalizing the metrics used for commerc building performance programs can only increase t positive influence of benchmarking.

As it stands, a review of GHG emissions intens data supplied by the Australia's and New York City benchmarking programs demonstrate similar wi variations in energy performance in both Sydney a New York City. In New York City, the older buildi alyses of more disclosure databases would help cipher the intricacies of how the four factors (building pe, site, design, and operations) impact energy nsumption. For decades now energy-modelling ograms have been able to predict the influence of mate on building energy consumption. However, it ll be the analysis of extensive data on actual building ergy consumption that will be able to verify the gorithms these programs use, and extend their pabilities by highlighting trends on a neighbourhood d microclimatic scale. Already each city can use GIS ethods in combination with their disclosure databases surmise how site geometry and solar access are pacting energy consumption. The designs of istralia's and New York's commercial building sclosure programs as of yet offer little additional formation on occupant or operator behaviour, but imately a systematic examination of how a building's rformance change annually allow occupants and cility managers to improve their understanding of how eir behaviour affects energy consumption.

The simple analyses done in this preliminary study nfirmed some of the basics that architects and gineers are taught in university. Better energy codes ve led to better performing buildings, and the average ergy performance of tall office towers has gotten tter each decade. Nevertheless, glassy buildings with htweight walls typically tend consume more energy in those with smaller windows and more massive nstruction systems, although exceptions can exist. views of energy disclosure data highlight these ceptions. In summary, even a basic comparative alysis between Sydney's and New York City's sclosed commercial office building energy rformance data helps reveal and verify patterns and nds of urban energy use. This bodes well for the ure. As disclosure programs become more widespread d more developed in the coming, the potential to alyse massive amounts of performance data from ound the world will exist thereby advancing both our obal and local knowledge of building and architecture.

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