New York City Office Building Energy Analysis

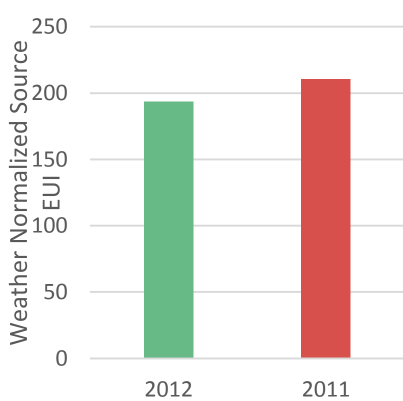
1. Instruction

New York City Local Law 84 (LL84), part of the Greener, Greater Buildings Plan (GGBP), requires all privately-owned properties with individual buildings more than 50,000 square feet (sq ft) and properties with multiple buildings with a combined gross floor area more than 100,000 sq ft to annually measure and submit their energy and water use data to the City.[1] In this analysis, the City's 2012 and 2011 Energy and Water Data Disclosure for Local Law 84 are merged with information from the Primary Land Use Tax Lot Output (hereafter PLUTO) data file, to provide a brief description of the energy consumption and carbon emission of trackable office buildings, explore the determinations and identify building performance fluctuations through the reporting years of 2012 and 2011, and thus produces helpful discussions and proposals on the reduction of energy consumption and carbon emission in New York City.

2. Data Description and Background

Initially, the City's 2012 and 2011 Energy and Water Data Disclosure for Local Law 84 contained 14112 and 4081 observations separately. However, substantial cleaning was made to remove errors and omissions. After combining the data on the office buildings having the same address, merged with information from PLUTO, and removing the top and bottom two percent (one percent for each year), there are 784 observations available.

The figures below provide a brief descriptive analysis of the 784 trackable office buildings of the reporting year 2012 and 2011.



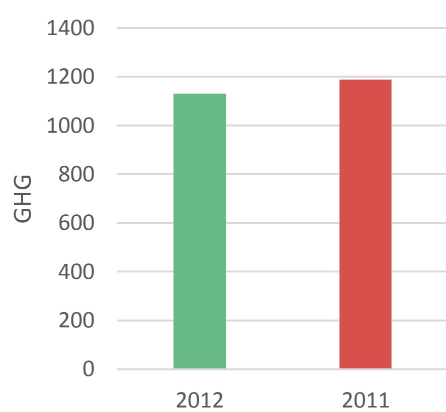


Figure 2.1: Average Weather Normalized Source EUI and GHG of the Year 2012 and 2011

There's a decrease in Weather Normalized Source EUI and GHG in 2012.

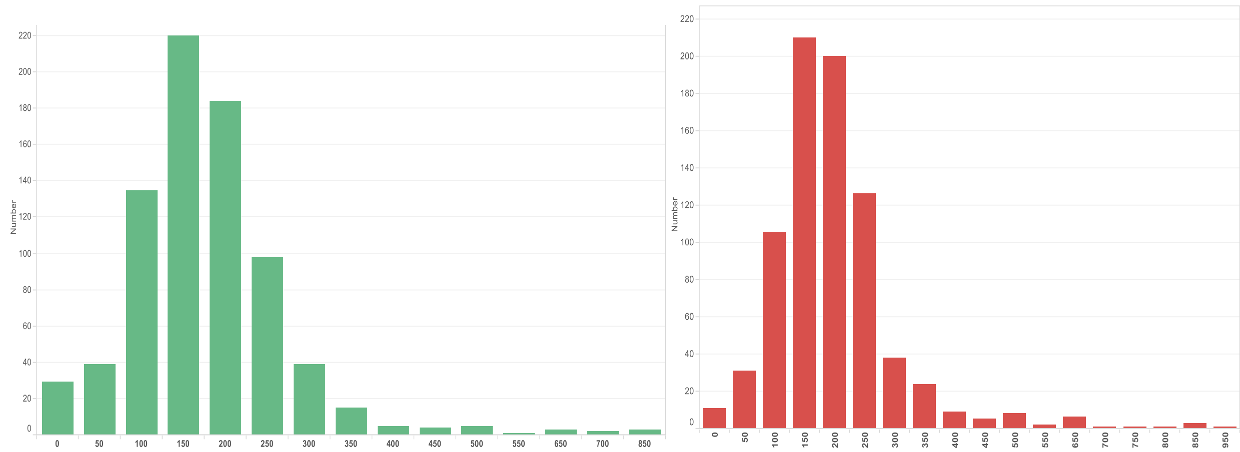


Figure 2.2: Histogram of Weather Normalized Source EUI of the Year 2012 and 2011

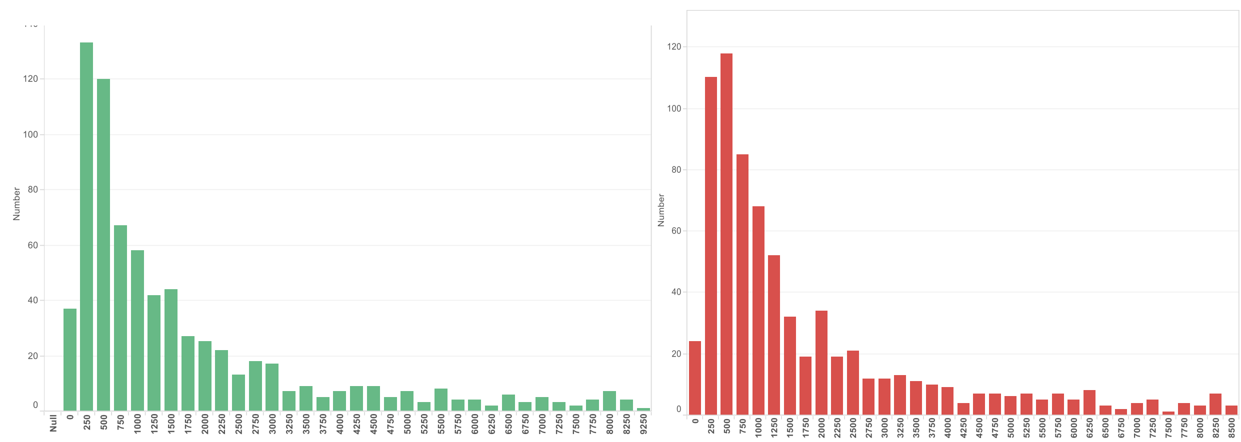


Figure 2.3: Histogram of GHG of the Year 2012 and 2011

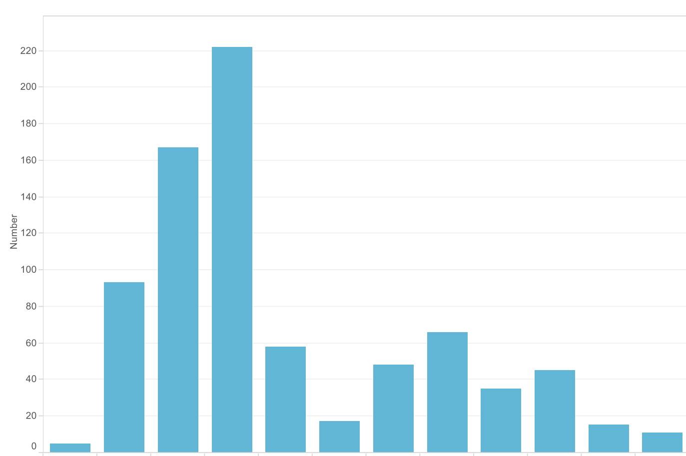


Figure 2.4: Histogram of Building Year of Trackable Office Buildings

Figure 2.5: Median Weather Normalized Source EUI and GHG of Year 2012 and 2011by Building Year

It’s observed that the office buildings built in 1970s seem to have both higher Weather Normalized Source EUI (hereafter Source EUI) and GHG, but the buildings built in 1990s seem to have higher Weather Normalized Source EUI but lower GHG.

3. Regression Model of the Year 2012

Using linear regression models, this section presents the factors that might influence building energy efficiency and carbon emission. Source EUI and GHG are dependent variables, potential independent variables including building square footage, building age, FAR, lot coverage, building depth, building width, number of floors. Stepwise regression method is adopted to choose predicitive vaviables from the independent variables above. The models with the largest R^2 are listed as following:

Source EUI,

Building age and depth entered the Source EUI function, R^2 is 0.113, and P is 0.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	（Constant）	248.01	14.192		17.48	0.000		
	Age	-0.974	0.130	-0.261	-7.522	0.000	0.944	1.059
	Depth	0.225	0.049	0.160	4.621	0.000	0.944	1.059

Table 3.1: Coefficients

The age of building is negatively correlated with Source EUI, and building depth is positively correlated with EUI. However, collinearity diagnosis shows that there's a collinearity between building age and the constant.

GHG,

Building square footage, building age, FAR, number of floors entered the GHG function, R^2 is 0.877, and P is 0.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
1 （Constant）	401.36	178.51		2.299	0.022		
Square Footage	0.009	0.000	0.898	48.65	0.000	0.464	2.155
Age	-5.322	1.726	-0.043	-3.083	0.002	0.803	1.246
FAR	-61.703	11.638	-0.128	-5.302	0.000	0.271	3.691
Number of floors	33.745	8.562	0.118	3.941	0.000	0.176	5.669

Table 3.2: Coefficients

The age and FAR of building are negatively correlated with GHG, and building square footage and number of floors are positively correlated with GHG. Collinearity diagnosis shows that there're collinearity between FAR and the number of floors, and also between the constant and building age. Actually, the R^2 of the function with only building square footage as independent variable is as high as 0.870.

The building information used for these models is from PLUTO which was reported in February to March 2013, and only 784 observations in the year of 2012 are utilized, so more observations and specific yearly building information might be needed to develop more reliable models and thus make more solid conclusions.

4. Comparative Analysis of the Year 2012 and 2011

Through the year-to-year analysis, the office buildings have the largest increase and decrease in Source EUI and GHG from 2011 to 2012 can be identified.

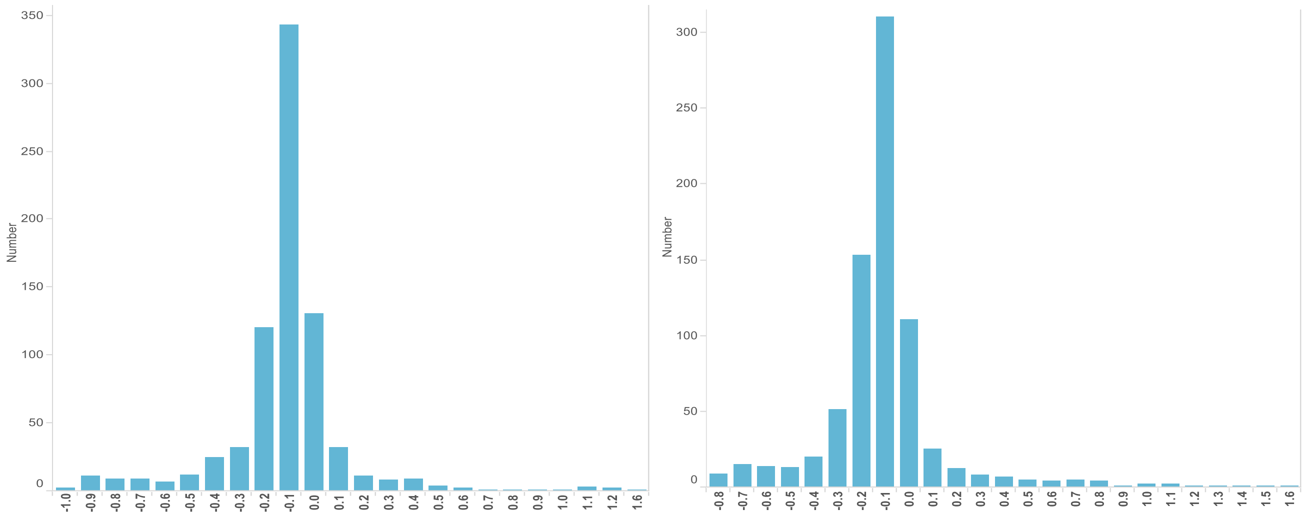


Figure 4.1: Source EUI and GHG increase percentage compared to the year of 2011

Split the top and bottom 78 office buildings into zip codes according to the change percentage.

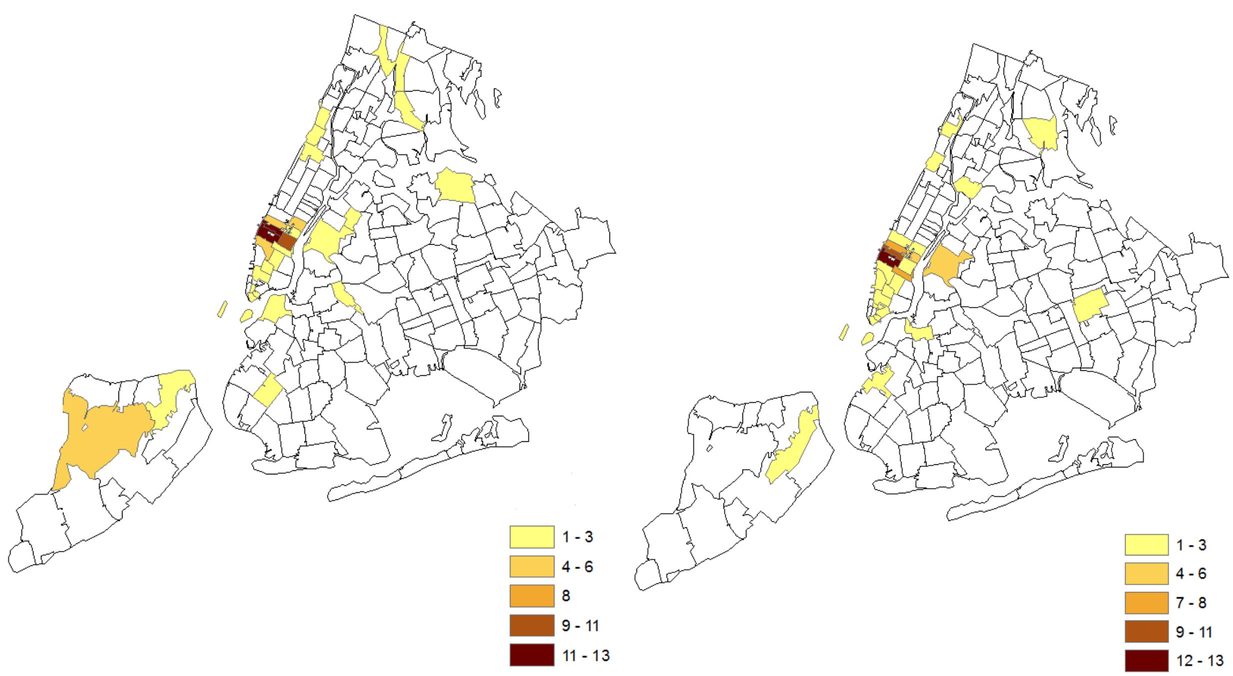


Figure 4.2: Spatial distribution of the bottom and top 10 percent buildings based on Source EUI increase (from left to right is bottom and top)

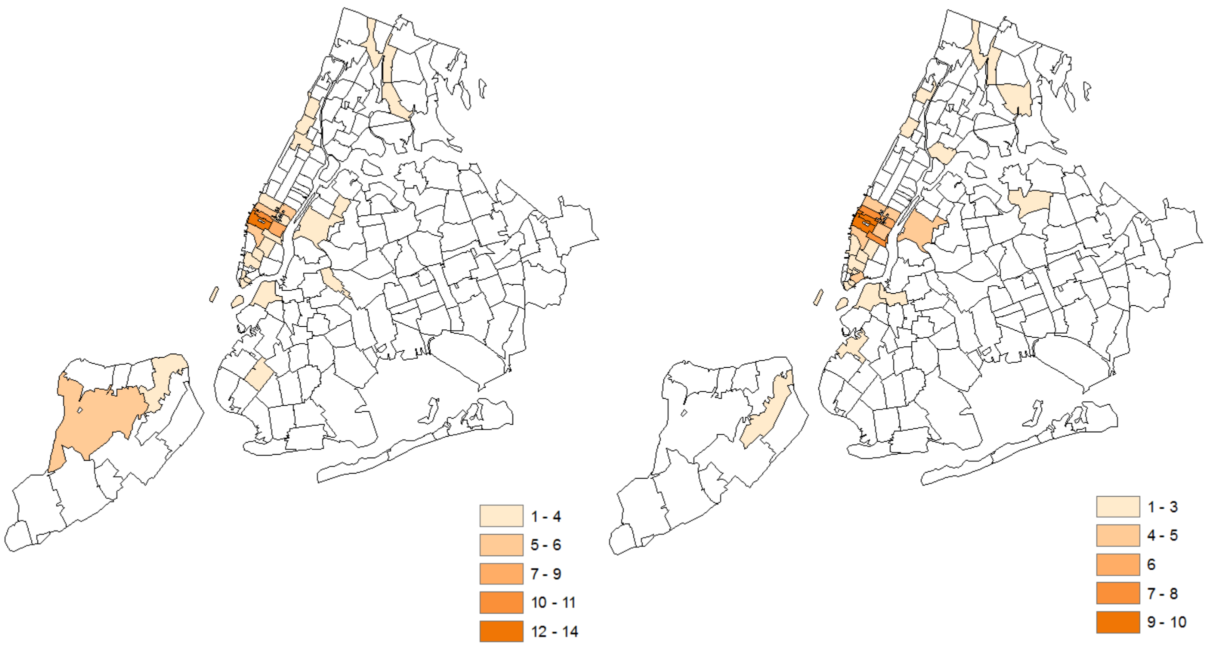


Figure 4.3: Spatial distribution of the bottom and top 10 percent buildings based on GHG increase (from left to right is bottom and top)

Top buildings are the ones have large increases in Source EUI or GHG, bottom buildings are the ones have large decreases in Source EUI or GHG. The spatial distribution of top or bottom buildings of Source EUI is almost the same as that of GHG. Zip code 10001 collects nearly 50 of these top and bottom buildings.

5. Discussion and Proposal

Although the number of observations seems quite large in the initial, the ones available are limited. There're so many errors and omissions in the database, like no value provided, duplicate entries, and incorrect locations. And also, the compliance is only about 75%[1]. More qualified data should be collected to facilitate future energy analysis. To improve the reporting quality of energy data, more detailed instructions on how to report must be given, and with more experience, the quality would be increased. Easy-to-use tools, like an app, might be helpful to arise reporting enthusiasm. On the other hand, a more reliable or automatic way to collect and publish the data is essential to improve the quality of data.

Based on the current data of 784 trackable office buildings, a few findings are made: decreases in Source EUI and GHG in the reporting year of 2012; the different performing patterns in Source

EUI and GHG in terms of building year; building depth is positively correlated with Source EUI, and building square footage is negatively correlated with GHG, etc. However, further analyses are indispensable to figuring out the real factors behind these data. For example, the different performing patterns brought by building year, might be explained by different materials, construction structures or energy sources preferred in different years.

Through confirming and publishing the top and bottom 10 percent performance improved or declined buildings in Source EUI and GHG, the city agents could further promote the energy saving consciousness in New York City, encourage building owners to fulfill their social responsibilities and share their experience in energy improvement or emission reduction. A further case-to-case study on building scale or zip code scale, especially the greatly performance improved or declined buildings or the 10001 zip code in Manhattan, is badly needed. More architectural and construction information about buildings is essential to making more profound findings. Only thing to note here is that, since each building has its own specific context, anything learned must be carefully investigated before widespread practiced.

Reference

[1] New York City Local Law 84 Benchmarking Report September 2013.
http://www.nyc.gov/html/gbee/html/plan/ll84_scores.shtml