Socio-Economic Impact on Building Energy Use

Gaurav Bhardwaj
.
Center for Urban Science & Progress
New York University
New York City, USA
gb1877@nyu.edu

***Abstract*— With the advent of the concept of green buildings, government has started a number of measures to make buildings more energy efficient. But the adaptation to the measures can be subjective and may vary across the city for various reasons such as demography, user literacy, median household income of the area and people's willingness to make an effort for the change. In this paper, I study what are the social or community impacts of buildings energy use and emissions. I have come up with a model that gives us the relationship between the energy use of building and other variables such as median household income and asthma rate that affect the community.**

Keywords—Energy Use Intensity, Asthma rate, Green Buildings, Public Health, Multi-family Residential Building

I. INTRODUCTION

With about 54% of world's population living in urban cities in 2016 [1], making cities more affordable and greener is a prime task for the city agencies. City Agencies have been trying to make building more energy efficient but they've had problem of coming up with ametric that would deal with all type of buildings such as residential, commercial, mixed use etc. and have a peer review matric that would compare the energy efficiency of buildings amongst their own type. There have been studies to improve the methods to measure and model energy performance foroffice buildings [2], but we're yet to explore other building types.

The building energy use depends greatly on what type of people are living in the complex, the kind of weather as the use changes from summers to winters and the amount of money people invest on maintaining the buildings and the median household income. During winters, there's a spike in GHG emissions because people use different kinds of fuel for heating and the fuels may not be environment friendly and may have high amount of pollutants. This increase of pollutants in the air leads to a number of air borne diseases and most common to New York City is asthma.

Asthma has been a common disease in New York City since 1999, so much so that 17% of children in New York City have experienced asthma-like symptoms at some point in their lives [3]. Majority of these children are from poor, African-American or Latino communities and these communities bear the burden of such diseases. The causes could be residential tobacco smoke, smoke from nearby industries, allergens such as molds and cockroaches are extremely common in low income areas. More often than not, the cuases for asthma are external factors such as GHG, particulate matter, hazardous air pollutants and poor housing quality. The emerging field of social epidimiology emphasizes that both physical and social characteristics of neighborhoods, such as poverty residential segregation, psychosocial stress, unemployment, nadequate transportation lack of affordable food stores, unsafe recreation spaces, high crime rates,baised policing, concentrated environmental hazards, and social metwork are important for understanding population distribution of disease and well being [4].

II. Literature Review

Increasingly, public health researchers have own that neighborhoods with low median household income are the burdened by the sir borne diseases such as Asthma. This is because of socio-economic divide between the society based on their financial condition. Oftenly, we would see a dumping lot concentrated in the such areas that may release hazardous fumes in the air, thereby causing risk of diseases. In one such study by Corburn et. al. ,Urban asthma and the neighborhood environment in New York City, seeks to assess the neighborhood effects on childhood asthma hospitalization rates New York City by analyzing the environmental characteristics f neighborhoods that may be ontributing to the onset and trigeering of the disease d comparing across different neighborhoods throughout the city [3]. For their study thet used GIScience tool to spatially analyse and clustered the areas with high level of asthma rate. Once that is achieved, they tag these neighborhoods as 'neighbrhood hotspots' [3]. In the later part they analysed the socioeconomic d physical characteristics of these neighborhoods focusing on housing and environmental condition.

Although contextual studies provides the notion hat neighborhood deprivation bad for health, Couburn's study shows the importance of geographic specification by proving how different neighborhoods exert strionger influence on health across low-income neighborhoods of New York City. While modelling, they found strong correlation between sthma hospitalization, ow median household income nd high percentage minority population, which is definitely not surprising. One can explain the relationship by examining the access of people from such neihborhoods to primary care physicians or health insurance. Along with this, substandard housing conditon can give rise to allergens and insects and may expose the residents to nitrogen dioxide from poorly performing combustion appliances.

In another such study by Abrahamse et. al. they examined the relative importance of socio-demographic variables and psychological variables in relation to household energy use and changes in energy use [5]. In general, the energy used is dependent on the socio-demographic variables as people with lower household income would rather buy something affordable than something expensive and environmental friendly. Another aspect of it could be the psychological variables for instance Brandon et. al. suggested that energy savings ere related to attitude and not on socio-demograhics [6]. They describe attitude as the degree to which person has a favorable or an unfavorable evaluation of behavior and depends on the weighing of various costs and benefits such as financial costs, effort, or time. Whereas, Behavior is determined by an individual's intention to perform it. In turn, behavioral intentions are assumed to be determined by attitude, perceived behavioral control, and subjective norm [5]. A person needs to be aware of the consequences of their own behavior for others or the environment and also needs to feel personally responsible for these behavioral consequences.

For their study, Abrahamse and team sampled a city in northern Netherlands with population of 180,000 and carried out the study for a course of five months. Households in control sample were asked to fill the questionnaire at three different instances, one before the start of the study and other two in between the study. The part of this study was to educate people on how energy can be conserved and how each participant can help make a big difference. The control group was given a target of 5% energy saving and it could be direct (gas, electricity etc.) or indirect (meat consumption; avoid throwing away food etc.). A regression analysis was performed where energy use and energy savings were dependent variables and the results for the study were explained in three steps: First, the explanatory power of attitude and perceived behavioral control (TPB) was examined, Second, the additional explanatory power of awareness of consequences, ascription of responsibility, and personal norm (NAM) was explored, and Third, socio-demographic variables were included [5]. As expected, the results obtained in this study indicate that household energy use appeared to be related to different variables than energy savings are. This suggests that constraints and opportunities strongly shape household energy consumption patterns.

III. Data And Methods

For my analysis I considered the following datasets:

- Local Law 84 Energy Benchmarking Data (LL84)
- Census Data
- Asthma Data from Department of Health, New York State
- Tract-ZipCode Relationship Data

LL84 data is a self-reported data which under the mandate, requires annual energy consumption reporting for large buildings. As per definition:

- building that exceeds 50,000 gross square feet
- two or more buildings on the same tax lot that together exceed 100,000 gross square feet, or
- two or more buildings held in the condominium form of ownership that are governed by the same board of managers and that together exceed 100,000 gross square feet [2]

Census data is collected by the US government every 10 years at block level, which consists of information about households at block level. For my analysis I extracted median household income from this dataset. Asthma data was collected from the Department of Health, New York State's website which was aggregated at zip code level. As the census data is at tract level, I used data from Office of PD&R, U.S. Department of Housing & Urban Development [7], to merge the two datasets and get the aggregated data at zip level.

For my analysis, I started with cleaning the LL84 da ta. As the majority of data was for Multifamily Hous ing, I considered only that data and did my analysis on it. In this dataset I was majorly concerned with W eather Normalized Site EUI (kBtu/ft²) and therefore I took the column and deleted all the records with nu ll values. Also, as the values were too large, I only c onsidered the values ranging between the two standa rd deviations of the mean.

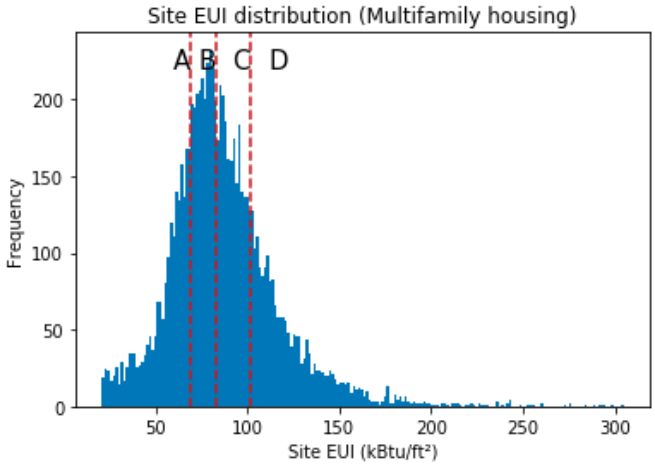


Fig 1

After filtering this data, I aggregated the data at zip code level and then merged the other datasets with it. I removed the outliers from each variables I considered based on the similar technique of consideing data between the two standard deviations. Post merge, I carried out univariate regression between the dpeendent variable, Discharge Rate from asthma data, and independent variable log of weather normalized Site EUI (kBtu/ft²).

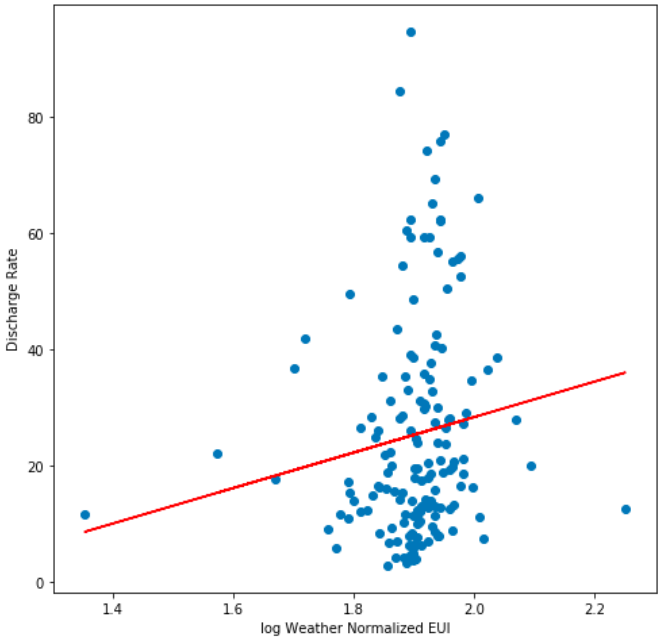


Fig 2

The above plot gives us the correlation between Discharge Rate and log of Normalized Site EUI.

For the second part of my analysis, I regressed the dependent variable log of weather normalized Site

EUI (kBtu/ft²) over independent variable, log of Median Household Income.

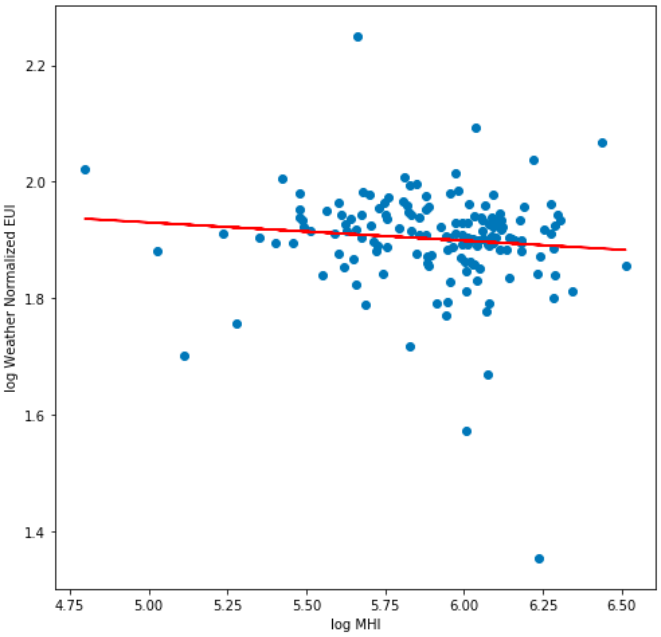


Fig 3

The ablve plot gives the relationship between log of weather normalized Site EUI and log of median household income.

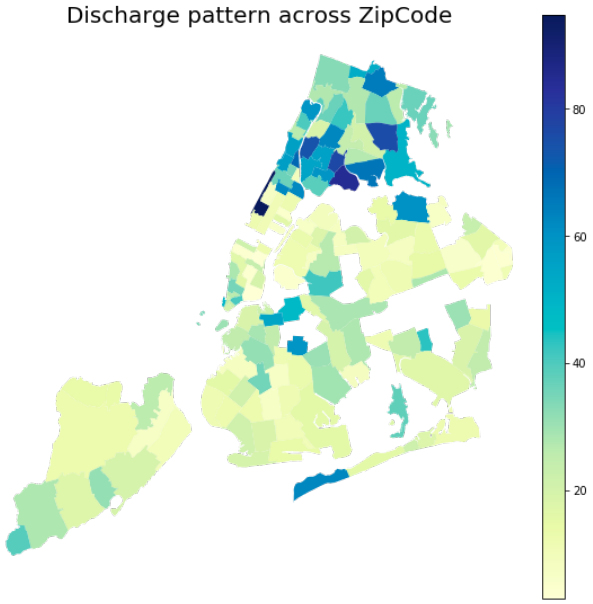
IV. Results

I carried out the study in two parts to understand the relationship between 3 different variables.

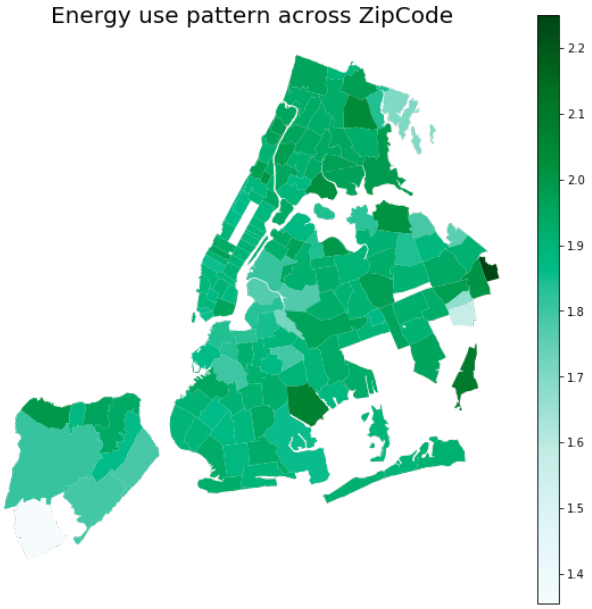
- For the first part, I analyzed the relationship between the dpeendent variable, Discharge Rate from asthma data, and independent variable log of weather normalized Site EUI (kBtu/ft²). From Fig 2, we can see that the regression shows positive correlation. This what we would expect as if the energy use increases, it would increase the number of pollutants in the air. The polluted air (other factors kept constant) would thereby cause asthma and which would further validate the increase in discharge rate of hispitals across the city.
- For second part of my analysis, I analyzed the relationship between log of weather normalized Site EUI and log of median household income. Here also from Fig 3, we can see that there is a negative correlation between the two variables. This confiems our hypothesis that with increase in median household income, energy use decreases. This is something that we can in general assume that the household with high median income can afford cleaner energy sources and use more energy efficient products.

V. Discussion & Conclusion

Energy use, as we have discussed depends on many factors, some are physical while some are behavioral. We can control the physical factors but it's really difficult to control the behavioral factors. For this study, I used univariate regression and assumed that all the other factors leading to discharge rate and EUI are kept constant. This helped in getting the one-to-one relationship between the variables. Further, to analyze the citywide effect, I used GeoPandas to plot the data on New York City's map.



This figure gives us the trend of discharge rate from hospital in different neighborhoods of the city. We can see that the maximum discharge rate is clustered in parts of Bronx and east Brooklyn which is validated by low the household income of house areas.



From this figure as well, we can infer that high energy use is clustered in certain parts of Bronx, Queens and Brooklyn where median household income is low.

Based on our analysis, we can conclude by saying that the asthma rate is positively correlated with energy use which in turn is negatively correlated with median household income. In order to decrease the growth rate of asthma in the city, we need to come up with solutions to make clean energy available for low income neighborhoods so that they don't have to bear the burden of such diseases in the future.

REFERENCES

[1] The United Nations Population Divisions World Urbanization Prospects, "Urban population (% of total)," 01 04 2017. [Online]. Available: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS. [Accessed 09 11 2017].

[2] C. E. Kontokosta, "A Market-Specific Methodology for a Commercial Building Energy Performance Index," 12 08 2014. [Online]. Available: https://link.springer.com/article/10.1007/s11146-014-9481-0. [Accessed 10 11 2017].

[3] J. Corburn, J. Osleeb and M. Porter , "Urban asthma and the neighbourhood environment in New York City," 21 01 2005. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S1353829204001029. [Accessed 10 11 2017].

[4] I. Kawachi and L. F. Berkam, "Neighborhoods & Health," Oxford University Press, 20 03 2003. [Online]. Available: https://books.google.com/books?hl=en&lr=&id=s1-FVY4IFU4C&oi=fnd&pg=PR9&dq=Neighbourhoods+and+Health+Kawachi,+L.F.+Berkman&ots=2MavDo3RO6&sig=s9eiPPTHklb431CNmWSOwqBko2g#v=onepage&q=Neighbourhoods%20and%20Health%20Kawachi%2C%20L.F.%20Berkman&f=false. [Accessed 10 11 2017].

[5] W. Abrahamse and L. Steg, "How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings?," 09 06 2009. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0167487009000579. [Accessed 11 11 2017].

[6] G. Brandon and A. Lewis, "REDUCING HOUSEHOLD ENERGY CONSUMPTION: A QUALITATIVE AND QUANTITATIVE FIELD STUDY," 05 01 1999. [Online]. Available: https://ac.els-cdn.com/S0272494498901050/1-s2.0-S0272494498901050-main.pdf?_tid=fae1a87e-c8e5-11e7-a23b-00000aacb35e&acdnat=1510627754_aea1e470b3131c769dc4f9ed3f0fdc21. [Accessed 11 11 2017].

[7] Office of Policy Development and Research (PD&R) U.S. Department of Housing and Urban Development, "HUD USPS ZIP CODE CROSSWALK FILES," Office of Policy Development and Research (PD&R) U.S. Department of Housing and Urban Development, 12 04 2017. [Online]. Available: https://www.huduser.gov/portal/datasets/usps_crosswalk.html. [Accessed 9 11 2017].