INT.1515 ENERGY EFFICIENCY BILL

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EXECUTIVE SUMMARY

New York City is famous for being a bright and bustling metropolitan that never sleeps; however, it remains heedless of the true expense of keeping the lights on. In an attempt to reduce excessive energy consumption in the city, Int. 1515 was recently introduced to promote energy efficiency measures in small businesses. The law allows small businesses to apply incurred civil penalties towards the implementation of sustainable appliances. This both reduces their financial burden and encourages participation in the city's initiatives for decreasing excessive energy consumption and emissions.

As the city's population continues to grow, energy consumption will remain a critical issue because of availability and infrastructure stress, as well as greenhouse gas (GHG) emissions from energy production. In New York City, nearly half of energy utilized comes from fossil fuels, which when burned produce potent GHGs that upon emission into the atmosphere cause global climate change. The impacts of climate change include sea level rise, flooding, and extreme weather events—all of which are threats to New York City.

Energy efficiency aims to address this environmental problem by using technological innovations that require less energy to perform the same functions as older hardware. These new technologies include changing to Light Emitting Diode (LED) bulbs and energy efficient certified appliances as well as installing double or triple pane windows and programmable thermostats. It is hoped that through the savings from Int. 1515, small businesses will be incentivized to undertake additional energy efficiency measures, therefore helping reduce the city's short-term energy consumption on the journey to finding long-term solutions.

While small in its scope, this bill allows small businesses to contribute to the city's overarching goal of energy and GHG emission reduction as laid out in New York's comprehensive energy strategy, REV 2030. This report offers a detailed analysis and evaluation of Int. 1515 as it currently stands, expounding on the various elements discussed above. We hope that policy makers will be able to utilize this report to determine the bill's next steps, moving forward to a more energy secure future for the ever-luminous New York City.

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1. Introduction

In New York City, buildings produce 79 percent of the city's total carbon emissions, compared with 40 percent nationwide.[i] According to the U.S. Environmental Protection Agency (EPA), as much as 30 percent of energy used in city buildings is lost to insufficient insulation, poor mechanical design, or bad consumer habits. Despite the city's aim to reduce emissions 80 percent by 2050, only a fraction of the city's small businesses have taken steps to make their operations more energy efficient. Small businesses across the five boroughs face a myriad of burdens including: high taxes, lack of qualified workers, shortage of space, and competition from larger stores. Moreover, they are confronted with increasingly high electricity costs which are significantly larger than anywhere else in the U.S.[ii]

Council Member Grodenchik introduced Int. 1515 in April 24, 2017 to the Committee on Small Business as part of a package of bills aimed at reducing civil code violation fines. Our research over the summer focused on establishing a scientific basis for Int. No. 1515. In particular, we reviewed the scientific challenges and opportunities that accompany energy efficiency measures in New York City. The goal of our work is to highlight the technical and scientific challenges of encouraging energy efficiency. We explore the science behind the environmental problems by discussing why inefficient energy consumption is a problem and how Int. 1515 is designed to address it.

We also consider the impediments to the implementation of the proposed bill, as well as explore the science behind energy losses and inefficiencies. The paper reviews several approaches to increasing energy efficiency, including energy audits, energy efficient appliances, and life cycle analysis. This augmented technical understanding provides a background for the issues and controversies associated with Int. 1515's

approach to the subject. Finally, the paper ends with suggestions for measuring the proposed program's success.

However, the results of this summer workshop do not offer specific solutions to many of the implementation and enforcement issues identified in the course of our research. In the fall semester, our team will build upon this scientific foundation in order to analyze these concerns and the policy implications of the bill.

2. The Problem of Energy Consumption

Figure 1 illustrates that New York City uses more energy than each of the other 26 megacities in the world, despite having a lower population than many of the cities listed.[iii] A significant contributor to energy consumption is commercial businesses. In 2011, the commercial sector contributed to 31% of the New York's energy consumption.[iv]

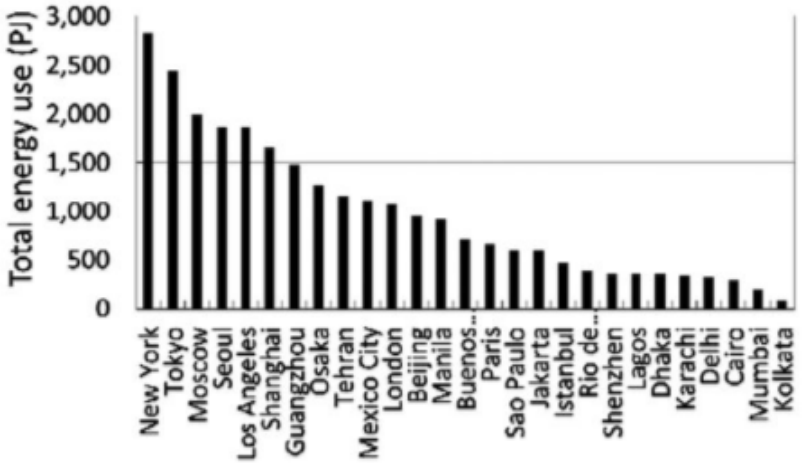

Figure 1. Chart showing total energy use by the world's 27 largest "megacities" - cities with metropolitan areas of more that 10 million residents. *Source: Kennedy, Christopher A. "Energy and material flow of megacities."*

GHG emissions from fossil fuel use in the city is a pressing issue when looking at how to reduce GHG emissions. Examining the use of fossil fuels of natural gas is particularly important as it accounts for 45% of New York City's electricity production[v]. The three primary problems with fossil fuels are: global climate change caused by GHG emissions, environmental and public health effects of emitted pollutants, and environmental and health effects of fuel extraction.

Our analysis focused on climate change, the consequences of which include sea level rise, drought, wildfires, flooding, severe weather events, altered food production, and coastal erosion.[vi] The greenhouse effect is a critical component in understanding climate change. When solar radiation enters our atmosphere, some of it stays in the atmosphere to regulate the earth's systems. GHGs assist this process, existing naturally in the atmosphere to prevent the escape of too much incoming radiation. As seen in Figure 2, activities such as natural gas production contribute to climate change by releasing methane and carbon dioxide, two of the most potent GHGs. Emissions above the naturally occurring levels cause more radiation to be trapped, warming the planet further[vii].

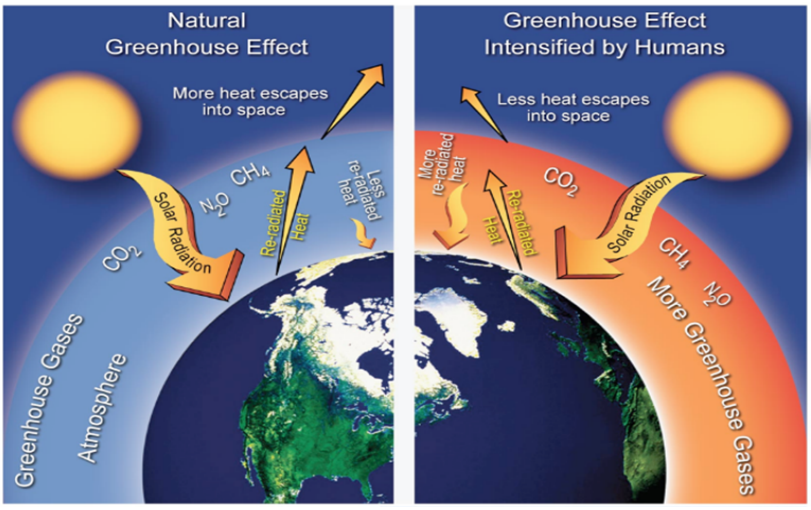

Figure 2. The greenhouse gas effect is a natural occurrence that has been intensified by human activity.

Source: U.S. Global Change Research Program. National Climate Assessment. Washington, DC, 2014.

Despite the abundance of scientific evidence, the Trump Administration (including the Secretary of the Interior, Ryan Zinke and the Secretary of Energy, Rick Perry) express skepticism towards climate change and energy efficiency regulation.[viii] Longstanding energy–related initiatives of the EPA, such as the Energy Star program that certifies energy efficient technology, are being rolled back at the federal level.[ix] Concerns are also voiced by certain conservative think tanks like the Heritage Foundation and the Competitive Enterprise Institute,[x] which oppose the regulation of energy efficiency as well as question the resulting cost savings claimed by the EPA and overall effect of these savings on energy consumption levels.[xi] Despite the federal government's antagonistic stand on energy efficiency regulation, the political agenda in New York State incorporated the promotion of energy efficiency in its agenda. The proposed initiatives culminated in the comprehensive state program REV 2030, which was introduced in 2015 by Governor Cuomo. The goals of REV 2030 are to curb CO_2 emissions, transition to renewable energy, and reduce energy consumption in buildings.[xii]

Government action is needed to give small business owners the final push to implement energy efficiency measures. The combination of rising electricity prices and a suboptimal economy has led small business owners in New York City to cite energy costs as their highest monetary concern.[xiii] Despite this financial pressure, few small businesses have taken advantage of state or private energy efficiency programs, suggesting the current approach to entice small business owners is unsatisfactory. The time and cost required to seek out, evaluate, and adopt efficiency measures has proven a deterrent to adoption. Int. 1515 brings energy efficiency options directly to the business owners once an appropriate penalty has been determined, thus lessening the

need for private initiative. Moreover, the nature of the bill necessitates government involvement to enforce penalties or alternatively, ensure compliance with this program.

3. Int. 1515: Overview

Int. No. 1515 intends to mitigate fines while incentivizing small businesses to adopt energy efficiency measures. This would allow business owners to reinvest a maximum of $3,000 in accumulated fines into their business in the form of energy efficiency. Small business owners can be overburdened with fines and regulations, preventing them from considering sustainable practices. As part of the city's remedial policies, which emphasize incentivizing correction over instituting punitive penalties, this bill would satisfy penalties without direct payment.[xiv] The program is voluntary because the bill is intended as a benefit, not another barrier.

The violations eligible for participation will be classified by the Departments of Sanitation (DSNY), Fire (FDNY), Health and Mental Hygiene (DOHMH), and Consumer Affairs (DCA), or by the Mayor's office or an agency designated by the Mayor. Specified violations in the bill are currently only given for the DSNY and the DCA. The DCA defines a violation as the failure to comply with any provision of the code or the rules of the city of New York with regard to creating or maintaining records, displaying prices, accuracy of scanners or signage postage. The DSNY stipulates violations of source separation, recycling of designated materials, and posting of signage.[xv]

Eligible energy efficiency measures will be determined by the Mayor or an office he designates. These options may include efficient appliances, programmable thermostats, or double or triple pane windows. For buildings smaller than 25,000 gross square feet in size, energy audits and retro-commissioning are additional options. If a business owner enters the program and does not implement the energy efficient

measure, the original penalty will be reinstated and doubled. This program would take effect 180 days after it becomes law.[xvi]

3.1 Impediments to Implementation

Despite the benefits for both New York City's efficiency and business operating costs, the proposed process of applying civil penalties to energy efficiency measures can be burdensome. For one, the city may face administrative challenges in implementing the law as the current monitoring workforce consists of only 35 people. This group is already involved with verifying consumer protection and licensing laws, which could hinder their effectiveness in monitoring energy efficiency. More resources will need to be made available for enforcement of the program. Given New York City's immensely diverse nature, language barriers may also pose as an impediment to the implementation of this bill. Thus, an emphasis on effective communication from the side of government is necessary. This could be in the form of translated support materials or multi-lingual enforcers.

Another issue concerns the three-step application process required for a business owner to participate. First, the Office of Administrative Trials and Hearings (OATH) would review testimonies and data to determine eligibility.[xvii] Then, the business owner must request, in person, to participate in the program. The final step is to receive approval for specific energy efficiency measures. The selected office must review the proposed measure and review the business' legal standing to ensure they are in compliance with other applicable laws and rules. The business owner may face further inspections as deemed necessary by the involved officers. This process may discourage smaller business owners from entering this program. As such, the program will likely appeal to businesses with larger, accumulated fines. If this bill becomes law, all of these

issues must be taken into serious consideration in order to ensure its most effective and efficient implementation.

4. The Science Behind the Problem

The U.S. Department of Energy (DOE) defines energy efficiency as "technology that requires less energy to perform the same function".[xviii] This simple definition belies the complex relationship between saving energy and mitigating climate change.

Fossil fuels are formed by organisms in the Earth's crust that have been subjected to pressure and heat over millions of years. Common types of fossil fuels used today include coal, petroleum, and natural gas. All fossil fuels require energy intensive processes to extract them from deep underground. Upon completion, they are processed to remove impurities and are prepared for heat extraction. They are then burned at high temperatures to create gas that is captured, processed, and used to power generators. The extraction and burning of fossil fuels emits harmful gases, such as methane and carbon dioxide, and the burning of coal is significantly less efficient than natural gas.[xix]

Energy from fossil fuels is difficult to store, and must be transmitted immediately or it will be lost.[xx] Transmission occurs through conductors that move high-voltage power over long distances.[xxi] Prior to being used, the voltage is reduced and distributed to the local residential electrical system. Multiple sources feed into this transmission network as part of the energy grid, which consists of the infrastructure required to move power from the suppliers to the utility companies to the customer.[xxii] In New York, most of this electricity is generated by natural gas, a substantial shift from traditional reliance on coal.[xxiii] The main component of natural gas is methane, and when released unburned into the atmosphere, it is 25 times more powerful than carbon dioxide.[xxiv] GHG

emissions, such as carbon dioxide and methane, come from direct emissions by businesses, and indirect emissions from leaking pipes and burning fossil fuels at power plants.[xxv]

4.1 Energy Audits

Energy audits analyze a building's energy use and determine areas for improvement. Three key techniques used during energy audits are blower door tests, infrared cameras, as well as appliance and lighting inspections.[xxvi] The blower door test measures airtightness within a building and can be used to detect air leakage.[xxvii] An infrared camera determines the location and magnitude of thermal leakage within a building, converting it into an electronic image and indicating holes within air sealing and poor insulation.[xxviii] Appliance and lighting inspection involves examining the state and type of appliances within a building and replacing older appliances with energy efficient models.

4.2 Energy Efficient Appliances

As seen in Figure 3 below, in Int. 1515 there are three specific energy efficient technologies suggested: triple pane windows, (LED) bulbs, and energy efficient appliances.

Figure 3. Energy Star alternatives: Light-emitting diode (LED) bulbs, energy efficient appliances, and a programmable Thermostat.

Triple pane windows have three panes of glass separated by two spacers, which reduces the amount of heat transfer between the outside and inside of a building. These

windows are commonly filled with argon gas due to its low heat conductivity. LED bulbs use two semiconductor layers created from a crystalline material. These layers are doped with other materials that have similar atomic structures but a differing number of valence electrons, thus creating an electron deficiency. This process is extremely energy efficient and allows the bulb to last up to 50,000 hours, which is 50 times longer than incandescent bulbs.[xxix] Smart thermostats connect boilers and thermostats, allowing the user to remotely control heating and cooling from their smart device. Some smart thermostats have learning abilities and can detect a user's daily schedule automatically.[xxx]

4.3 Life Cycle Analysis

Energy efficiency is only one portion of the environmental impact of a product or a service. To calculate the full impact, one must conduct a Life Cycle Analysis (LCA). LCA is a technique used to assess the environmental impact of a product, process, or service at all production and usage steps (i.e. from cradle to grave).[xxxi] When conducting a LCA, one can choose from different indicators or specific areas of impact, such as energy usage, water input, and conventional air pollutants like NO_x, PM, and VOCs.

To consider the environmental cost of replacing older appliances, we completed an analysis of the CO_2 emissions associated with the life cycles of four different commercial appliances. Recommended replacement ages for maximum CO_2 emissions reduction are given in Table 1 in Appendix B. For an older, non-Energy Star certified appliance, replacement ages are based on the age at which CO_2 emission reduction will be maximized. This is because there are emissions associated with creation and disposal of the both older appliance and newer appliance. All analysis used the Carnegie Mellon Economic Input-Output Life Cycle Assessment (EIO-LCA) tool, with average appliance

costs adjusted for 2002 inflation, energy savings based on the Savings Calculator for Energy Star Certified Appliances, and average appliance lifespans.

5. Issues and Controversies

Of the myriad strategies aimed at reducing GHGs in New York City, energy efficiency is the least controversial. Decision-makers and planners in every sector attempt to use their resources most efficiently, and the use of energy is no different. Yet, as seen in Figure 4, the issues associated with the anthropogenic climate change and natural gas extraction are still contested.

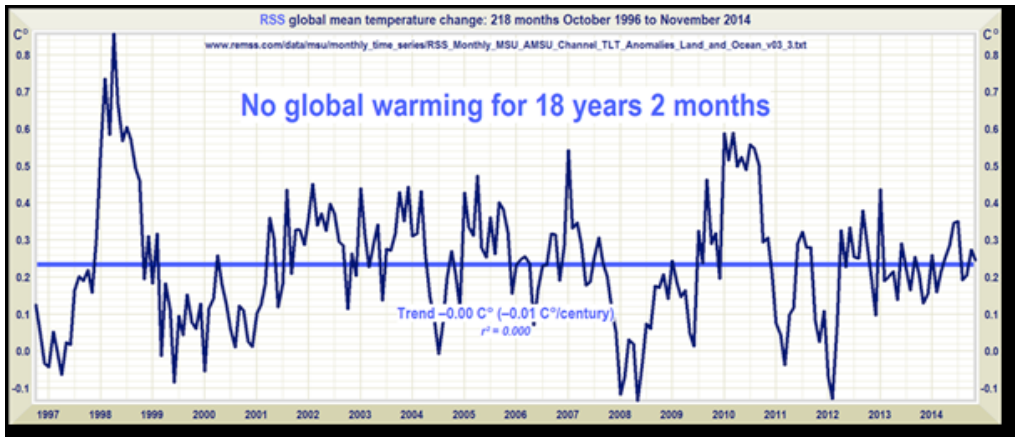

Figure 4. Selective data and time periods like the graph above are used to support claims that climate change is not happening. *Source: Monckton, Christopher. "Dueling Datasets: Satellite Temperatures Reveal the 'Global Warming Pause' Lengthens to 18 Years 2 Months." Climate Depot. N.p., 03 Jan. 2015. Web. 12 Aug. 2017*

The National Aeronautics and Space Administration (NASA) confirm 97 percent of actively publishing climate scientists agree that global warming and climate change are caused by human activities[xxxii]. Figure 5 shows the same data that is presented in

Figure 4 but over a much longer time period. It is by using selective data that climate deniers continue to validate their preferred narrative.

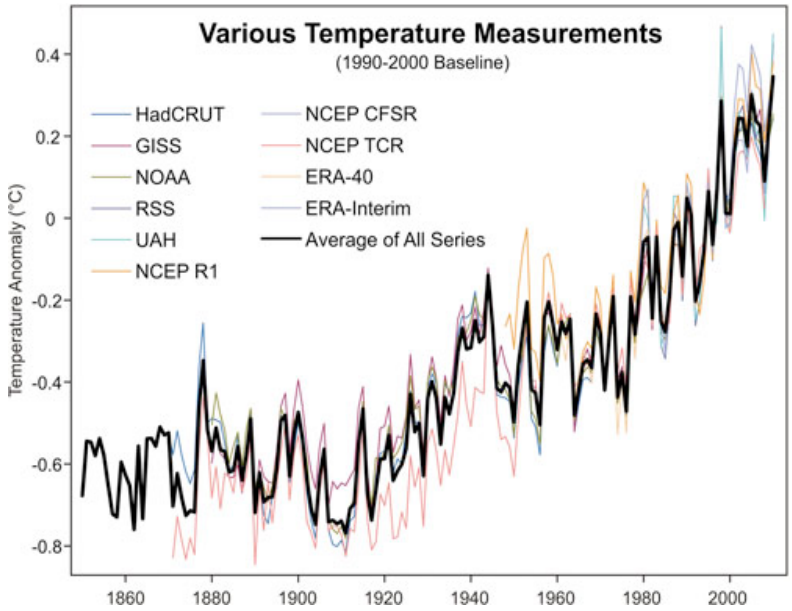

Figure 5. This graph was created from the same data that is used for Figure 4; however, it looks at the data over a much longer timespan. This has a significant impact on the trend line. *Source: "NOAA Temperature Record Updates and the 'hiatus'." RealClimate. N.p., n.d. Web. 12 Aug. 2017.*

Reducing GHG emissions can be achieved by greater energy efficiency or by increasing the use of energy sources that emit less carbon. While natural gas produces three quarters less CO_2 than coal, methane leaks during natural gas extraction and transportation can offset carbon emission savings.[xxxiii] Additionally, the environmental damage resulting from the process of hydraulic fracturing include groundwater contamination, methane leaks, and minor earthquakes.[xxxiv] While fracking does not occur in New York City, the environmental cost of using natural gas instead of coal remains a controversy.

Energy losses due to mis-installation may undermine this bill's efforts as well, reducing efficiency by roughly 30%, and raising utility bills for businesses[xxxv]. To prevent breakdowns and leaks, regular maintenance must occur regularly. This can present a significant time and labor barrier to businesses. A proper LCA consideration may not be made when deciding between continued maintenance and a new product, particularly for small businesses who may not have the resources or skills to conduct a LCA. Consequently, it could be argued that energy efficient appliances may not be the most important solution for small businesses. Additional education to business owners is likely needed to capture all expected benefits.

A final controversy is presented in the rebound effect, also known as Jevon's Paradox, which posits that demand for energy will actually increase if energy efficiency is implemented. Energy savings can lead a business to spend the avoided costs on growth, incurring greater energy use.[xxxvi] A study on rebound effect in Beijing's residential energy consumption revealed that long-term effects may be consequential, even if short-term effects are not.[xxxvii] Yet, despite the numerous controversies mentioned, we expect energy efficiency to remain a popular and viable method for reducing GHG emissions in New York City due to their net benefits.

6. Measuring the Program's Success

Int. 1515 does not currently prescribe how its performance will be measured. As such, we have developed a potential monitoring and evaluation strategy as seen in Table 2, Appendix B, based on best practices within the energy sector. Int. 1515 essentially aims to: improve energy efficiency in small businesses, raise awareness among businesses, and reduce GHG emissions. An appropriate methodology for measuring performance of the program would be an impact, or outcome-based,

evaluation framework.[xxxviii] It would identify intermediate outcomes required to achieve the objectives and set specific indicators to measure progress. A baseline for each business would be created,[xxxix] allowing program administrators to compare the energy participating businesses use relative to the status quo.[xl] This would help estimate the improvements in energy efficiency, reductions in greenhouse gas emissions, and the changes in energy efficiency awareness, attributable specifically to the program.[xli]

The proposed approach presents challenges however. First, the absolute energy data it not easily comparable across different businesses since energy demand is influenced by various variables such as weather, building size, and infrastructure type.[xlii] As a result, the framework also proposes to analyze each business in terms of its energy intensity—a measure of how much energy is required to make a unit of output.[xliii] However, collecting and analyzing this information for each participant and setting benchmarks would certainly be a costly and time-consuming process.

New York City currently measures energy efficiency through buildings, which represent the majority of it's energy use, and two-thirds of its GHG emissions.[xliv] The 2009 "Greener, Greater Buildings Plan" institutes a number of requirements such as periodic energy audits[xlv], public disclosure of building energy performance, and energy use benchmarking.[xlvi] However, it is still difficult to isolate the energy of small businesses using this data. If Int. 1515 becomes law, new techniques will be needed in order to measure energy efficiency among small businesses. The monitoring and evaluation framework as described in Table 2 would enable policymakers to monitor energy use patterns in small businesses and evaluate the effect of improvements. This would reveal whether or not the program is, in fact, achieving its objectives.

7. Final Reflections

New York City is often center stage in countless fields and issues, including policy. With its status as a global financial leader and one of the most populous megacities in the world, its legislative decisions are tracked, and often replicated, worldwide. If properly implemented, an effective strategy to address energy efficiency will set an example for other cities. If more cities adopt similar strategies, the effect will be compounded, significantly reducing the contribution of energy use to climate change.

The focus of Int. 1515 on the infrequently targeted sector of small businesses provides a unique initiative, that if implemented properly, could be replicated worldwide. It benefits both individual businesses owners by reducing costs, and the city as it looks to reduce energy consumption. With the realization of this bill, not only can New York City decrease its total energy expenditure from small businesses, but it will likely disseminate new knowledge to small business owners that will hopefully spread to others who can then pursue similar measures.

As with any law, policymakers must first address the numerous challenges associated with the policy before it can achieve a lasting impact. Some of the difficulties associated with enforcing this bill include training additional staff, the favorability of the program to small businesses with greater fines, and the language barriers between enforcers of the bill and small business owners. To address these hurdles, our group hopes policymakers will consider these suggestions and their scientific basis, and ultimately allow New York City to make considerable strides towards achieving its energy efficiency goals.

APPENDIX A

Defined Acronyms

CO_2— Carbon Dioxide

DCA—Department of Consumer Affairs

DOE—United States Department of Energy

DOHMH—Department of Health and Mental Hygiene

DSNY—Department of Sanitation, City of New York

EIA—United States Energy Information Administration

EPA—Environmental Protection Agency

FDNY—Fire Department, City of New York

LCA—Life Cycle Analysis

NO_x—Nitrous Oxide

OATH—Office of Administrative Trials and Hearings

PM—Particulate Matter

REV—Reforming the Energy Vision

VOC—Volatile Organic Compound

APPENDIX B

TABLES

TABLE 1. The recommended commercial appliance replacement age for maximum carbon dioxide emission reduction when replacing conventional commercial appliances with Energy Star appliances.

	CO_2 Savings (Tons/Lifetime)	CO_2 LCA Cost (Tons: Old + New)	Best Replacement Age (years)
Combination Oven	44.48	5.02	1.7+
Solid Door Fridge/Freezer	5.71	3.14	5.5+
Dishwasher – Cold Water	17.74	1.568	.88+
Dishwasher – Hot Water	21.92	1.568	.715+

APPENDIX B CONTINUED

TABLE 2. Performance Measurement Metrics for Int. No. 1515.

Impacts	Outcomes	Indicators of success	Monitoring strategies
Energy efficiency improvements	- Reduction in absolute energy consumption	- Reduction in kilowatt-hours (kWh)	- Self-reporting: total revenues - Self-reporting: baseline vs. post retrofit energy consumption - Benchmarking
	- Reduction in energy consumption intensity	- Reduction in kWh per unit of output	
Greenhouse emissions reductions	- Avoided emissions due to reduction of absolute energy consumption across all participating businesses	- Reduction of absolute energy consumption (kWh)	- Modeling tools such as AVERT used to estimate avoided emissions
		- Number of businesses participating and adopting energy efficiency measures	-Number of eligible businesses vs number of choosing to participate in the program -Compliance: installation of energy efficient equipment
Energy-efficiency awareness	- Increase in the number of businesses educated about energy efficiency (EE) measures	- Improvement in energy efficiency awareness survey score after participation in the program	-Pre-program survey: knowledge of EE measures - Post-program survey: knowledge of EE measures & willingness to continue making EE improvements - Participation rate over time

[i] Giles, David, and Jonathan Bowles. "Energizing New York's Small Businesses." *Center for an Urban Future* (2010): 3-17. Web.

[ii] Giles, David, and Jonathan Bowles. "Energizing New York's Small Businesses." *Center for an Urban Future* (2010): 3-17. Web.

[iii] Kennedy, Christopher A. "Energy and material flow of megacities." *Proceedings of the National Academy of Sciences of the United States of America,* vol. 112, no. 19, 2015, pp. 5985-5990. Web.

[iv] United States, "Profile Overview ." *Profile Overview* , EIA, 10 Aug. 2017. www.eia.gov/state/?sid=NY#tabs-2.

[v] Rueb, Emily S. "How New York City Gets Its Electricity." *The New York Times*. The New York Times, 10 Feb. 2017. Web. 18 July 2017.

[vi] *Climate Change 2014: Impacts,Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Barros, D.J. et al Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

[vii] "Natural Gas and the Environment." *Natural Gas and the Environment - Energy Explained, Your Guide To Understanding Energy - Energy Information Administration*. N.p., n.d. Web. 18 July 2017.

[viii] "*Climate Change and the Incoming Trump Government*", Coral Davenport, NY Times (Dec 19,2016)

[ix] "Killing Energy Star: A Popular Program Lands on the Trump Hit List." *Yale E360*. N.p., n.d. Web. 05 Aug. 2017.

[x] "Energy and Environment." *Competitive Enterprise Institute*. N.p., n.d. Web. 18 July 2017.

[xi] Owen, David. "The Efficiency Dilemma." *The New Yorker*. The New Yorker, 19 June 2017. Web. 05 Aug. 2017.

[xii] "Reforming the Energy Vision." Reforming the Energy Vision (REV). New York State, n.d. Web. 05 Aug. 2017.

[xiii] "Energizing New York's Small Businesses", David Giles and Jonathan Bowles, Center for an Urban Future, (February 2010)

[xiv] Testimony of Deputy Commissioner Amit S. Bagga, New York City Department of Consumer Affairs, New York City Council Committee on Small Business Cong., 1-7 (2017) (testimony of Amit S. Bagga). Print.

[xv] United States, New York, Int. No. 1515, Section 1. Title 22 Administrative Code. "*Chapter 10- Energy Efficiency Program for Businesses*", 2017.

[xvi] United States, New York, Int. No. 1515, Section 1. Title 22 Administrative Code. "*Chapter 10- Energy Efficiency Program for Businesses*", 2017

[xvii] Committee Report, pg. 4.

[xviii] United States Energy Information Agency. "Energy Efficiency and Conservation.' *United States Energy Information Energy*. Last updated December 15, 2016. Web. (accessed June 14, 2017)

[xix] United States Energy Information Agency. "Energy Efficiency and Conservation.' *United States Energy Information Energy*. Last updated December 15, 2016. Web. (accessed June 14, 2017).

[xx] Rueb, Emily S. "How New York Gets its Electricity." *The New York Times*. February 10, 2017. Web. 14 June 2017.(accessed June 14, 2017).

[xxi] United States Energy Information Agency. "Frequently Asked Questions." *United States Energy Information Agency*. Last updated February 16, 2017. Web. 14 June 2017.

[xxii] Office of Energy Efficiency and Renewable Energy. "Industrial Energy Efficiency Basics." *United States Department of Energy*. Web. 14 June 2017.

[xxiii] Rueb, Emily S. "How New York City Gets Its Electricity." The New York Times. The New York Times, 10 Feb. 2017. Web. 14 June 2017.

[xxiv] Howarth, Robert, Renee Santoro, and Anthony Ingraffea. "Methane and the Greenhouse-Gas Footprint of Natural Gas from Shale Formations." *Climatic Change* 13 Mar. 2011. https://shalegasespana.files.wordpress.com/2012/10/ingraffea-contaminaciocc81n-por-metano.pdf. Web. 14 June 2017.

[xxv] United States Environmental Protection Agency. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2015*. 430-P-17-001, 2017.

[xxvi] Romano, Adam. "Energy Audits." Speech, Association for Energy Affordability, Inc., Bronx, NY, February 10, 2017.

[xxvii] Department of Energy. "Blower Door Tests." Last modified 2017. Accessed July 11, 2017.

[xxviii] Systems, Inc. FLIR. "How Does an IR Camera Work?" *How Does an IR Camera Work?* | FLIR *Systems*. N.p.,n.d. Web. 10 July 2017

[xxix] "LED FAQs | LED Lighting." Bulbs.com. N.p., n.d. Web. 14 July 2017.

[xxx] "Smart Thermostats - What Are They and How Can They Help You?" USwitch. N.p., n.d. Web. 14 July 2017.

[xxxi] *Center for Life Cycle Analysis (CLCA) at Columbia University*. N.p., n.d. Web. 14 July 2017.

[xxxii] "Scientific Consensus: Earth's Climate Is Warming." *NASA*. NASA, 25 July 2017. Web. 18 July 2017.

[xxxiii] Tollefsen, J. "Air Sampling Reveals High Emissions from Gas Field." *Nature* 482.7384 (2012): n. pag. Macmillan Publishers Limited, 7 Feb. 2012. Web. 22 July 2017.

[xxxiv] Natural Gas and the Environment." U.S. Energy Information Administration, 12 July 2017. Web. 22 July 2017.

[xxxv] "Heat & Cool Efficiently." *Energy Star*. N.p., n.d. Web. 05 Aug. 2017.

[xxxvi] Greening, Lorna A., David L. Greene, and Carmen Difiglio. "Energy efficiency and consumption—the rebound effect—a survey." *Energy Policy,* vol. 28, 2000, pp.389-401.

[xxxvii] Wang, Zhaohua, Bai Han, and Milin Lu. "Measurement of energy rebound effect in households: Evidence from residential electricity consumption in Beijing, China." *Renewable Energy and Sustainable Reviews,* vol. 58, 2016, pp. 852-861.

[xxxviii] *Program Design & Customer Experience – Develop Evaluation Plans*. U.S. Department of Energy, 20 Jan. 2016. Web. 30 July 2017.

[xxxix] U.S. Department of Energy, 2016

[xl] Energy Savings = Base Year Energy Use – Post-Retrofit Energy Use ± Adjustments. Source: *International Performance Measurement & Verification Protocol: Concepts and Options for Determining Energy and Water Savings (Volume I)*. Publication no. DOE/GO-102002-1554. Efficiency Valuation Organization, Mar. 2002. Web. 30 July 2017.

[xli] *Energy Efficiency Program Impact Evaluation Guide: Evaluation, Measurement, and Verification Working Group*. Publication. State & Local Energy Efficiency Action Network, Dec. 2012. Web. 30 July 2017.

[xlii] Orvis, Robbie, et al. Metrics for Energy Efficiency: Options and Adjustment Mechanisms. April 2016.

[xliii] Energy Intensity = Energy/ GDP or Output. Source: "Energy Intensity Indicators: Efficiency vs. Intensity." U.S. Department of Energy, Office of Efficiency and Renewable Energy n.d. Web. 30 July 2017. <https://energy.gov/eere/analysis/energy-intensity-indicators-efficiency-vs-intensity>.

[xliv] Inventory of New York City Greenhouse Gas emission in 2014. Tech. New York City: Mayor's Office of Sustainability, 2016. Print.

[xlv] Urban Green Council. *New York City's Energy and Water Use 2013 Report*. Tech. N.p.: Mayor's Office of Sustainability, 2016. Print.

[xlvi] "Greener, Greater Buildings Plan." *NYC Mayor's Office of Sustainability: Greener Buildings and Energy Efficiency* . N.p., n.d. Web.

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