THE BEST LOCAL RESPONSE TO CLIMATE CHANGE IS A COMPREHENSIVE EFFICIENCY PLAN

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EXECUTIVE SUMMARY

The City of Philadelphia has committed to reducing its carbon emissions by 80% by 2050. But achieving this goal largely depends on developing a carbon-neutral regional electricity grid, requiring both state and federal support. For this reason, the most effective response may be to first focus on local energy efficiency.

Following the signing of the Paris Climate Agreement in 2016, and subsequent withdrawal by the United States—a key player in the negotiations—many cities around the world committed to upholding the target of achieving an 80% reduction in greenhouse gas emissions by 2050.

Philadelphia, for example, committed to an "80 by 50" plan in 2016. However, Philadelphia has limited power to influence the rate of grid decarbonization or the electricity costs that may result from this decarbonization. The city simply represents too small a portion of the relevant energy market.

Without a clean electricity grid—powered entirely by zero-carbon energy sources such as solar, wind, hydropower, nuclear, and fossil fuel combustion coupled with carbon capture technology—cities cannot feasibly fully decarbonize their energy demand. Cities can, however, reduce their demand for grid electricity and fossil fuels by improving building efficiency, influencing traffic and mobility patterns, utilizing waste heat, generating electricity through distributed sources, and by encouraging behavior change.

It may, therefore, be in the city's best interest to increase efforts to reduce local energy use rather than focus so heavily on the goal of electrifying demand with the hope of eventually being a part of a larger carbon-neutral grid. Improving Philadelphia's energy efficiency would not only reduce emissions regardless of grid mix, it would also reduce energy costs for low-income communities, improve the city's standard of living, insulate the city from future energy cost fluctuations and grid reliability

issues, and make the eventual transition to clean energy easier by reducing seasonal fluctuations in demand.

Using example initiatives from some of the world's most energy efficient cities. this report argues that an effective citywide efficiency plan can be designed around three pillars—or policy strategies—each designed to support an organic transition to a sustainable local energy system:

- **Guide Through Investment**
  - *Upgrade or retrofit municipal assets with systems that are more energy efficient*
  - *Offer cost-sharing programs to homeowners and businesses for implementing greener infrastructure*
  - *Direct investment in public spaces with efficiency in mind*
  - *Provide free inspections and consultations to homeowners and businesses*
- **Enforce Through Regulation**
  - *Reconsider existing regulations on traffic, parking, and building standards and determine if they are still supportive of 21st century goals*
  - *Introduce penalties and ensure strict enforcement*
  - *Direct funds from penalty systems toward achieving the targeted goal*
- **Encourage Through Education**
  - *Invest in community education and foster community initiatives, competition, and engagement so that residents and businesses understand the co-benefits of efficiency improvements*
  - *Use surveys and community feedback to develop an in-depth understanding of residents' primary concerns and priorities and their willingness for investment and behavior change*
  - *Provide clear and detailed goals, objectives, and measures of success based on the information and preferences revealed through community engagement*

INTRODUCTION

Following the signing of the Paris Climate Agreement in 2016, and subsequent withdrawal by the United States—a key player in the negotiations—many cities around the world committed to upholding the target of achieving an 80% reduction in greenhouse gas emissions by 2050. Philadelphia, for example, committed to an "80 by 50" plan in 2016. In September 2018, Philadelphia followed up on this commitment by releasing a clean energy vision that outlined how the city was planning to achieve its ambitious emissions targets (City of Philadelphia 2018).

This comprehensive plan is structured around five broad strategies:

1. Establishing a Clean Electricity Supply
2. Installing Rooftop Solar Throughout the City
3. Improving Building Efficiency
4. Decarbonizing Heating
5. Building a Low-Carbon Economy

In Philadelphia's vision, each of these strategies is supported by detailed policy action. Together these strategies have the potential to sufficiently reduce local emissions to achieve the city's goals. However, the findings of our recent exploration of decarbonization strategies for Philadelphia Gas Works (PGW) and heating demand within the PJM footprint, would suggest that the City of Philadelphia would have more success achieving its emissions goals and protecting the economic wellbeing of Philadelphia's residents by placing a greater emphasis on local energy efficiency improvements.

The existing clean energy vision relies heavily on securing a clean electricity supply. Many of the policies included in strategies three, four, and five of the City's plan are designed around electrification of existing fossil fuel demand—a strategy that does, in many cases, directly improve efficiency but also only delivers its full emissions reduction potential if that new electricity demand is met with renewably-generated electricity.

However, our recent research has found that meeting new electricity demand with 100% clean energy is extremely costly to homeowners and businesses, is difficult to manage, and runs up against land use and technological constraints once seasonal load management is taken into account (Serpell et al. 2020).

Furthermore, Philadelphia has limited power to influence the rate of grid decarbonization or the electricity costs that may result from this decarbonization. The city simply represents too small a portion of the relevant energy market. While Power Purchase Agreements and Customer Choice Aggregation offer a market solution for "decarbonizing" the city's electricity supply, there is a limit to how far these strategies can take us. When Philadelphia or its residents agree to purchase clean energy, they are simply paying for those clean energy resources to be distributed throughout the whole electricity grid. The customer is receiving the same supply of electricity as everyone else.

Purchase agreements are a great way for early actors to effectively decarbonize their energy use by diluting everyone's carbon intensive electricity, but there will come a point when grid operators, and consequently the customers buying the renewable electricity, will have

to deal with the load-balancing challenges of a heavily decarbonized grid and absorb the associated costs.

Possible solutions to this load-balancing challenge are to store the energy until it is needed (batteries, pumped hydro, electrolysis), change the patterns of demand for electricity through demand response, or move the electricity to where it is needed via long-distance transmission. Power purchase agreements are absolutely worthwhile, but only as long as there is appetite by developers and customers to build renewable generation without any compensation for load-balancing costs. Even before this critical level of renewable deployment is reached, relying on customer choice to deliver local emissions reductions puts additional burden on consumers and assumes a level of community willingness to pay that may not be a reality.

Beyond these purchase agreements, there is very little action Philadelphia can take at the state or federal level beyond advocacy. The Office of Sustainability's vision outlines a number of state and federal initiatives that would help decarbonize the grid, including maintaining existing nuclear capacity, reinstating the Clean Power Plan, joining the Regional Greenhouse Gas Initiative (RGGI), and strengthening Pennsylvania's Alternative Energy Portfolio standards. But the city is limited in its ability to take any direct action or implement policies that will ensure that these state and federal goals are achieved (NRDC 2017; RGGI; PA PUC).

For these reasons, it may be in the city's best interest to increase efforts to reduce local energy use through efficiency improvements, distributed generation investments, and behavior change, rather than focus so heavily on the goal of electrifying demand with the hope of eventually being a part of a larger carbon-neutral grid.

Improving Philadelphia's energy efficiency would not only reduce emissions regardless of grid mix, it would also reduce energy costs for low-income communities, improve the city's standard of living, insulate the city from future energy cost fluctuations and grid reliability issues, and make the eventual transition to clean energy easier by reducing seasonal fluctuations in demand.

In the aftermath of the COVID-19 pandemic, many of these urban lifestyle factors will have increased importance. Reducing the burden of energy costs can be an essential tool on the road to economic recovery from the global disaster, and incentivizing low-risk and high efficiency modes of transportation like walking and biking can help promote physical health and ensure that residents are protected from future disease outbreaks.

However, the COVID pandemic has also introduced a number of new barriers to increased urban efficiency of which cities and residents should be cognizant. Public transportation systems, for example, have long been a unique and effective urban service to promote low-cost and high-efficiency movement of people. Now they represent a source of increased viral transmission risk. Ridership of public transit systems in many cities has dropped by over 90% over the last several months and many transit agencies will continue to suffer financial hardship during the recovery process (Pachon, 2020).

As cities begin to recover from this lockdown, people may prefer to drive cars and avoid public transit, leading to increased carbon emissions, congestion, and air pollution. Furthermore, city budgets are experiencing their worst deficits in decades, making energy-efficiency investment programs an even more considerable undertaking (Zarroli 2020).

In reading through this framework for a comprehensive efficiency plan for the City of Philadelphia, please remain aware of the uncertainties cities face at this time and recognize that depending on the lasting effects of the COVID pandemic, both economic and social, some of the strategies discussed in this digest may be more feasible than others over the next several years.

Fortunately, there are dozens of strategies available to Philadelphia for how to reduce local energy demand, not all of which require direct investment in infrastructure. This means that an effective efficiency plan should be possible even with severe economic or epidemiological constraints experienced as a result of COVID-19.

Improving building efficiency, both in new construction and by retrofitting the existing building stock, is perhaps the most impactful method of achieving citywide efficiency improvements and is the only strategy that is specifically called for in the City's September 2018 *Powering our Future* report. However, for Philadelphia to

have the greatest impact on its emissions and improve the overall livability of the city, it would be beneficial to adopt a much broader concept of energy efficiency.

Increasing local energy efficiency is no easy task. Energy efficiency is a feature of the urban landscape influenced by individual behavior, aging housing and infrastructure, and dynamic economic activity. However, this report argues that an effective citywide efficiency plan can be designed around three pillars—or policy strategies—each designed to support an organic transition to a sustainable local energy system:

1. **Guide Through Investment**: By investing in public spaces and infrastructure, cities can influence the way residents and businesses engage with the city, thereby reducing energy use and improving livability. Further, by offering loans and cost-sharing opportunities to property owners, cities can guide residents and businesses to think long-term about their energy costs.
2. **Enforce Through Regulation:** Efficiency standards, fees, and regulations can effectively limit wasteful energy practices and ensure that all members of the community are contributing their fair share of effort to Philadelphia's vision. These regulations will only be effective if they are well enforced, if members of the community believe they are well enforced, and if members feel that the city is investing resources to help them meet these regulations.
3. **Encourage Through Education:** Community-based education and initiatives can help catalyze purposeful behavior change and community buy-in. They are just as necessary as investments in infrastructure and stringent regulations because without community buy-in, other initiatives will fail to deliver optimal results. This effort must work to inform the public of what steps the city is taking, and how voluntary steps by the public can benefit residents and businesses (cost savings, livability of the city, transportation efficiency, and public health).

Improving building efficiency, both in new construction and by retrofitting the existing building stock, is perhaps the most impactful method of achieving citywide efficiency improvements.

The goal of this report is to illustrate how Philadelphia could approach developing and implementing a comprehensive efficiency plan. We first outline the steps Philadelphia is already taking in each of these three policy areas, and then use several initiatives that have been successfully demonstrated in cities around the world as examples of what Philadelphia should strive for.

All of the example cities discussed in this report (Boston, London, Seoul, and Singapore) have demonstrated a considerable commitment to local efficiency and are ideal role models for Philadelphia.

Boston was ranked #1 on the ACEEE's 2019 scorecard of U.S. cities and has pledged to continue tackling local emissions via building regulations, transportation mode shifts, and increased connectivity (Ribeiro et al. 2019). London has a high capacity for local governance as the UK's capital and largest city and has been an efficiency pioneer for years through its use of congestion pricing of low-efficiency vehicles. Seoul has been driven to pursue ambitious energy efficiency measures, partly in response to fears over energy dependence on foreign imports and aging nuclear power plants. Singapore offers unique insights into the possibilities of local action thanks to its status as a city–state and has been a pioneer in urban livability and building efficiency.

GUIDE THROUGH INVESTMENT

Change the urban landscape to improve efficiency and livability.

Currently the City of Philadelphia offers a number of incentives for energy efficient buildings. Buildings that achieve a LEED Gold or higher rating may be granted a density bonus by Philadelphia, and the city's EnergyWorks program provides loans ranging from $100,000 to $2.5 million with 3.5% interest to a wide variety of businesses and nonprofits, to go toward efficiency upgrades in buildings (EnergyWorks). Perhaps partially as a result of these programs, the number of buildings that have met LEED or Energy Star label criteria have increased by 53% since 2013 (Jaramillo 2019).

While these programs have undoubtedly helped improve overall building efficiency, one must always be aware of the tradeoffs. Density bonuses, for example, are an excellent incentive for efficiency but, if overused, could begin to negatively impact livability. Additionally, starting in 2019, the city adopted the Property Assessed Clean Energy Program (C-PACE) Financing Program (Davis & Johnston 2019; PA Dept. of Environmental Protection). This program provides low-interest, long-term loans for clean energy and water projects for commercial property owners throughout Pennsylvania, which are repaid as property taxes to benefit the community.

In some instances, up to 100% of total project costs can be funded through C-PACE (Pennsylvania C-PACE). In Philadelphia, property owners submit projects for city approval, and then private lenders involved with C-PACE provide financing to the building owners for these projects, relieving the city of any financial risk and giving building owners access to necessary capital (Commercial PACE LLC). Owners of new or existing commercial, industrial, and/or agriculture properties are eligible. Funded projects include building insulation, heating and cooling, and smart building systems. The improved efficiency ultimately lowers utility costs and can be transferred to future property owners.

In one Pennsylvania case-study project, a lighting upgrade that cost $134,000 (entirely financed by C-PACE), resulted in an annual energy savings of 242,389kWh, and lifetime energy cost savings of $285,820. In a larger project, 35-year-old chillers and inefficient lighting were replaced at a cost of $1,304,352 (entirely financed by C-PACE), for an annual energy savings of 1,548,086kWh and a lifetime energy cost savings of $3,660,000 (Pennsylvania C-PACE).

Even though only certain projects may qualify for C-PACE funding, it is clear that the lifetime energy cost savings from C-PACE projects are significantly greater than the costs of the projects themselves. This suggests that even partial funding from C-PACE could result in net energy and cost savings for the variety of businesses that utilize it. Since the program was only recently implemented in Philadelphia, it remains to be seen how effective the program will be locally, but these early case studies are promising.

Philadelphia is taking several steps to invest in improving the energy efficiency and climate impacts of municipally-owned property. For example, since 2009, the city has reduced its vehicle fleet by 500 and plans to add an additional 20 electric vehicles to the fleet (bringing the total to 50) by the end of 2020 (City of Philadelphia

2019). There are also plans for the city to install solar-powered charging stations for these EVs.

Philadelphia is also investing in municipally-managed public spaces. Last year the city announced plans to retrofit all 100,000 public streetlights with high-efficiency smart LED bulbs, a considerable expansion of previous policy to only replace broken or non-functioning streetlights (Maykuth 2019). Also last year, Philadelphia announced a 10-year "urban forest" plan to increase tree canopy, an extension of the 30% increase in tree cover proposed in the city's Greenworks initiative (Kummer 2019).

These programs are broadly representative of the many initiatives Philadelphia has already undertaken to guide local efficiency through investment in municipal assets, private property, and public spaces. The following section explores several examples from other cities and uses them to suggest additional steps Philadelphia could take in order to develop a more comprehensive, resilient, and effective energy efficiency plan.

FURTHER INVESTMENT OPPORTUNITIES

Boston is a city that faces many of the same energy transition challenges as Philadelphia; namely wintertime heating demand, old building stock, vehicle congestion, flooding and increased precipitation from climate change, and a poverty rate that far exceeds the national average. For these reasons, policies that have been successful at delivering efficiency improvements to the city of Boston have the potential to be easily adapted for Philadelphia.

Go Boston 2030 is Boston's plan to increase efficiency in the transportation sector (City of Boston). It is a broad initiative aimed at eliminating emissions from passenger vehicles, expanding public transportation infrastructure, and encouraging cycling and walking. One indicator for transportation efficiency is a city's walkability score. Boston is ranked the third most walkable city by the 2019 Walk Score report with a score of 82 out of 100, while Philadelphia is ranked 4th with a score of 79 (Walk Score). Additionally, Boston is ranked #6 in the list of bike friendly cities, while Philadelphia fails to enter the top ten. To continuously increase bike ridership, Go Boston 2030 outlines specific goals such as encouraging a fourfold increase in cycling trips and installing bike share stations within a 10-minute walk of 100% of homes (an increase from the current rate of 85%).

Boston has also released a 2030 housing plan that seeks to provide 69,000 new housing units including 16,000 that are income-restricted (Walsh 2014). This initiative will help Boston meet its housing needs, while also dramatically reducing its per capita energy consumption by ensuring that all of these new housing units are carbon neutral and constructed according to the guidelines of Transit Oriented Development (TOD). Sixty-four percent of the units built as part of the 2030 housing construction effort are located within a 5-minute walk from a major transit hub, as compared to 37% of existing housing stock.

Philadelphia is already a very walkable city, but Boston's efforts demonstrate that even dense urban centers can dramatically improve connectivity and ease of movement. Doing so not only improves the mobility of cities (reducing congestion, improving safety, and reducing travel times) but also can have a dramatic impact on a city's energy efficiency.

Transportation accounts for 17% of Philadelphia's carbon footprint, so every opportunity to allow commuters to cycle, walk or take public transportation over driving is an opportunity to reduce the city's energy demand (City of Philadelphia 2018). Incentivizing non-automobile modes of transportation could be even more impactful when electric vehicles make up a sizable proportion of the Philadelphia vehicle fleet. Fewer cars on the road helps reduce the load balancing and infrastructure strain of daily EV charging.

The potential for energy savings through efficiency improvements in the mobility sector, however, pales in comparison to the potential impact of residential and commercial building improvements. London has recently introduced a number of incentive-based programs to improve the efficiency of new and existing buildings (Green World Building Council).

In London, 78% of CO_2 emissions come from homes and workplaces, and 80% of existing building stock is still likely to be in place by 2050 (The City of London). To work with existing buildings, London has implemented the Retrofit Accelerator Homes program and Workplaces program A key feature is providing boroughs, housing associations, and workplaces with free technical expertise and consulting to begin a wide range of retrofitting projects. Another goal is to create a new market for low carbon goods and services sectors, and to make homes warmer and more affordable while tackling fuel poverty.

The Homes program aims to get started on 1,600 whole-house retrofits over the next three years, and the Workplaces program has already supported over 220 organizations. The London Mayor's office has also allocated funds for the Energy Leap project, which is a trial project for net-zero retrofitting homes (The City of London). Providing a network of expertise and service providers could be a tool to help Philadelphia facilitate the process of individuals and businesses improving efficiency in their homes.

This network could specifically help when individuals and businesses are unaware of feasible energy improvements or need additional encouragement to follow-through with identified projects. This may be an opportunity for the city to build upon the C-PACE program, in addition to expanding to a variety of buildings other than the businesses and nonprofits that are currently eligible.

Investment incentive programs can also help cities achieve urban greening goals, like Philadelphia's "urban forest" plan. Singapore's Skyrise Greenery Incentive, for example, offers a 50% cost share on both vertical and horizontal green building projects for both residential and nonresidential construction with the goal of replacing any green space that is lost on the ground with greenspace on "another layer of space" (Kolczak 2017).

In a land constrained country like Singapore, high urban density is unavoidable, but through this and other programs, Singapore is working to ensure that this density offers opportunity, variety, and convenience. This greening program also has the effect of reducing the urban heat island effect and improving local air quality.

Singapore is located in the heart of the tropics where temperatures and humidity remain relatively high year-round, but the urban heat island effect has an even greater impact on local energy efficiency in more temperate cities like Philadelphia and the other three cities included in our analysis (Manoli et al. 2019).

Urban green space allows for greater capture and evapotranspiration of moisture and helps to reduce local temperatures on hot days. In addition, tree cover can provide shade, further reducing local temperatures and the need for energy intensive cooling. Trees can even help moderate temperatures in the winter by reducing wind speeds at ground level. Tall buildings can create wind tunnels in dense urban environments, but trees help to buffer against harsh winter weather.

Urban greening efforts should be looked at as a key element of any urban efficiency initiative, but many cities including Boston are pursuing an ambitious urban greening effort primarily for the purposes of climate adaptation. As part of its Climate Action Plan, Boston has made growing and improving its green and open spaces a key priority to tackling the many effects of climate change that the city expects to experience in the years to come (Walsh 2019).

Urban greening is just one of many urban design principles that can be used to simultaneously aid in the effort to mitigate local emissions through efficiency improvements and to help cities prepare for the effects of climate change by providing water management and safe and comfortable recreational space.

A major part of a city's investment strategy ought to be focused on improving the livability and utility of public spaces. As a large and densely populated city that experiences both cold and hot weather conditions, Philadelphia has an enormous amount to gain by greening public spaces, a cost-conscious strategy that has proven effective at reducing the heat island effect, buffering winter weather, lowering local emissions levels, and promoting outdoor recreation (Roxon et al. 2020).

ENFORCE THROUGH REGULATION

Institute responsible standards, fees, and requirements to fight wasteful energy use.

In Philadelphia, 72% of the city's carbon footprint comes from its buildings, with the biggest contributors being large college and university buildings, offices, and multifamily residential structures. Starting in 2012, buildings over 50,000 square feet in Philadelphia are required to benchmark and publicly disclose their energy and water usage (Sasko 2019). Between 2013 and 2018, there was a 12% reduction in GHG emissions and a 5% reduction in overall energy use from the buildings involved in this reporting.

The number of buildings that have met LEED or Energy Star label criteria also increased by 53% in that time. Two primary metrics of energy demand used in calculating Energy Star scores are site and source energy use intensity (EUI). The *site EUI* includes heat and electricity consumed by buildings as reflected in utility bills (such as electricity, steam, natural gas, and fuel oil), while the *source EUI* is equal to the total amount of energy used to operate the building, including all transmission, delivery, and production losses (Energy Star).

Thus, source EUI is the most comprehensive unit of evaluation, and ultimately the more important metric when it comes to evaluating environmental sustainability. A building with an EnergyStar score of X means that the building is more efficient than X% of buildings in the U.S. with similar size and function. Therefore, a lower EUI will result in a higher EnergyStar score.

Figure 1a illustrates the median Energy Star score for all of the reported buildings in Philadelphia's benchmarking program demonstrating that Philadelphia is performing better than the national median. Figure 1b illustrates changes in source EUI of different building types.

A key finding of the 2019 Benchmarking Report is that while some sectors have significantly improved in energy use, others are trending in the opposite direction (Philadelphia OOS 2019). Furthermore, as of 2018, only ~85% of the buildings over 50,000 square feet were compliant in reporting their energy and water use as part of the benchmarking program.

In Figure 2, we provide a comparison of the EUI of the reported buildings from 2013 to 2018, in an effort to provide additional insight into the effectiveness of Philadelphia's benchmarking regulation.

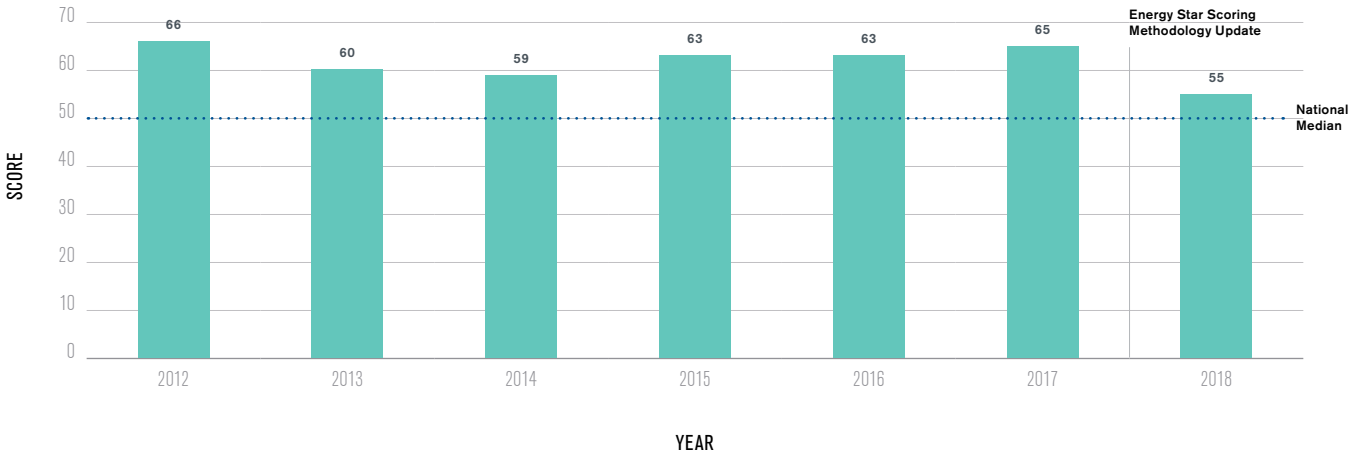
Figure 2 contains two groups of data from the benchmarking reports from 2013 to 2018, from the Office of Sustainability: the number of buildings that reported each year varied between 1000 to 1500 (all submitted), with 462 buildings reporting each of those six years (6yeargroup). In addition to the source and site EUI, Figure 2 also contains electricity use EUI, which we calculated as the site EUI from only electricity use.

Both groups show a decrease in source EUI, but only the "All submitted" group shows a decrease in site EUI. It is possible that the overall reduction in site EUI may simply be a result of new buildings reporting that already had lower energy use, though we note that this is not the only possible explanation for this reduction.

Additionally, the lack of significant change of electricity EUI in both sets of data suggests that there hasn't been significant electrification of end use demand. The fact that source EUI for both groups dropped faster than site

FIGURE 1

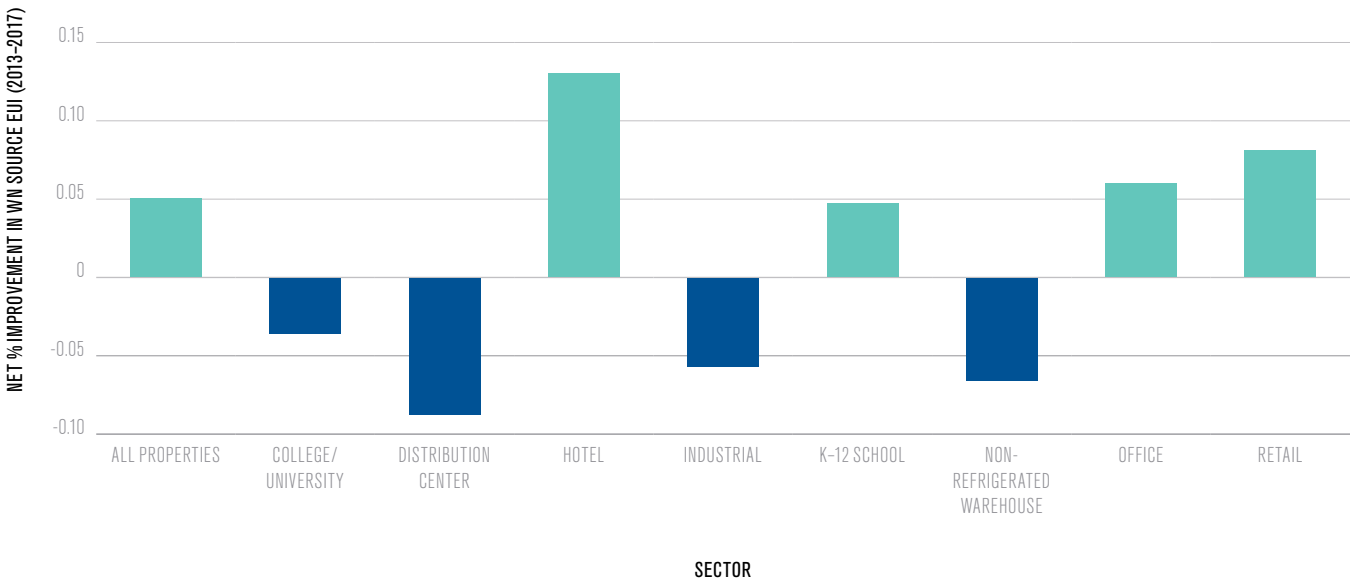
a) Median Energy Star Score from 2012–2018 in Philadelphia



The Scoring methodology was updated between 2017 and 2018.

Source: Philadelphia 2019 Benchmarking Report

b) Change in Source EUI of Different Sectors in Philadelphia from 2013–2017



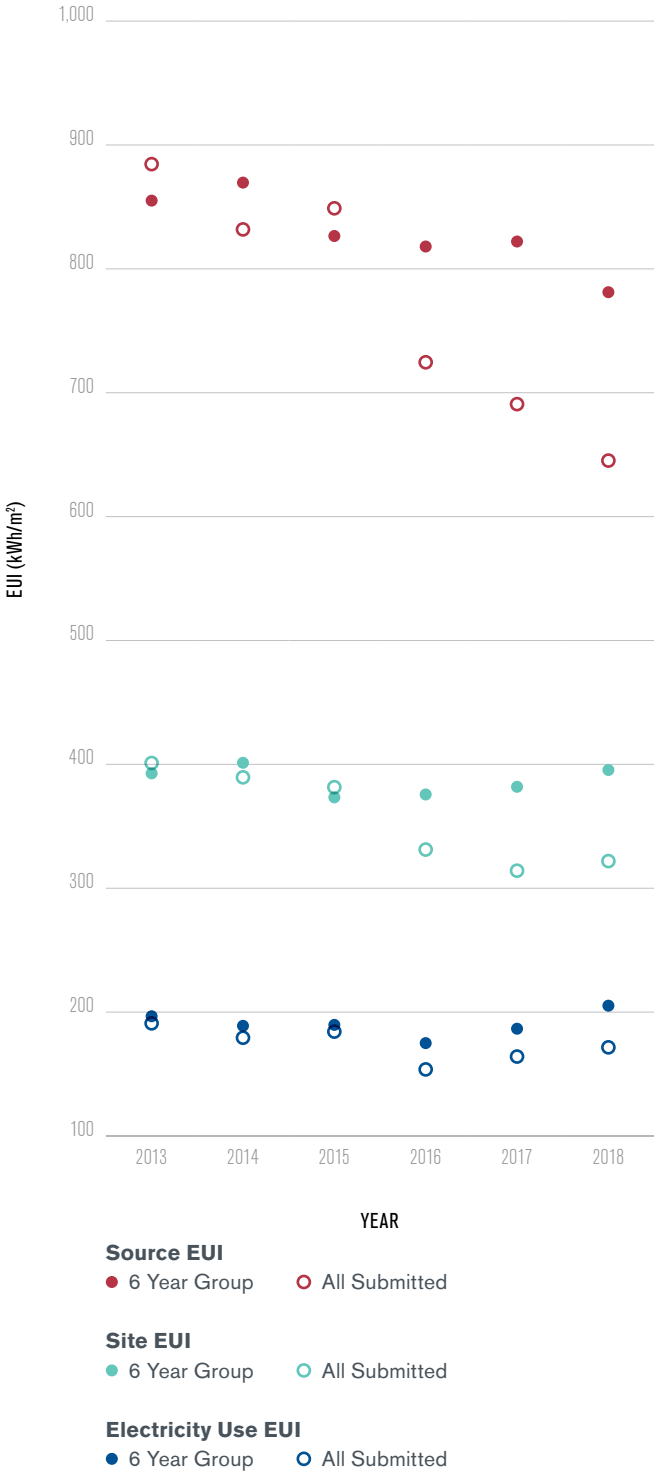
Source: Philadelphia 2019 Benchmarking Report

EUI, indicates that much of the efficiency improvement may have come from supply side improvements such as grid generation or fuel transportation. Little improvement in site EUI and electricity use may be a result of the program's design, which lacks a penalty for noncompliance.

Fortunately, a more restrictive bill was passed by the city in December 2019 to improve the benchmarking program. As part of this new law, large buildings must submit a certificate of high energy performance to Philadelphia's office of sustainability or improve their building and energy systems until they are "up to a state of good repair" (Jaramillo 2019).

Buildings must earn an Energy Star score of 75—meaning more efficient than 75% of U.S. buildings

FIGURE 2: CALCULATED SOURCE, SITE, AND ELECTRICITY USE EUI USING DATA FROM THE PHILADELPHIA 2013–2018 BENCHMARKING REPORTS



Only properties that reported values for Source EUI, Site EUI, and Electricity use were included in these data.

Source: Philadelphia 2013–2018 Benchmarking Reports

of similar size and function—to be considered highly efficient. Tune-up reports for buildings that don't meet this score need to be submitted every five years to the office of sustainability. Building owners can be fined up to $2,000 for violating the law, and an additional $500 for each day they fail to file the report or take action to achieve the required efficiency standard.

This plan is expected to reduce carbon emissions by 200,000 metric tons annually after implementation (equivalent to 40,000 cars) (EPA). Building owners are also estimated to save up to three times what they spend on the assessment, which costs approximately five to eight cents per square foot. Based on the median Energy Star score of 55 in 2018, this new target of 75 is ambitious; however, penalties and evidence of overall cost savings are likely to significantly improve reporting and compliance. The law is a great step by the city to reduce overall energy use by large buildings and is an example of how Philadelphia is using regulation to demand that residents and businesses take energy efficiency seriously.

FURTHER REGULATORY OPPORTUNITIES

Expansion of Philadelphia's regulatory efforts into a wider range of local sectors will shift the responsibilities of tracking and reducing emissions onto consumers. Both London and Singapore offer insights into the future regulatory opportunities Philadelphia could pursue. These cities show that when implementation of penalties is coupled with incentive programs and governmental support, well-crafted regulations have the potential to influence an overall behavioral change to increase citywide efficiencies.

The Singapore Building Control Act was announced in 2013. This program is not considerably different in nature to Philadelphia's benchmarking program in that building owners are required to meet minimum environmental sustainability standards set by the GreenMark scheme, participate in energy audits on cooling systems, and submit building energy consumption data annually (C40 2015). However, unlike

Philadelphia's benchmarking program, Singapore exhibited a remarkable 99% compliance rate in its first year, and compliance rates of 100% in recent years (Singapore BCA 2018).

A key distinction between this program and Philadelphia's is the high fines for non-compliance which can be up to $10,000. The status of buildings in Singapore has improved from <0.1% "green" buildings in 2005, to 34% "green" buildings in 2017. Though success of any program is rarely attributed to a single factor, this example from Singapore is encouraging in that it suggests the recent improvements to Philadelphia's benchmarking law may be effective at raising compliance.

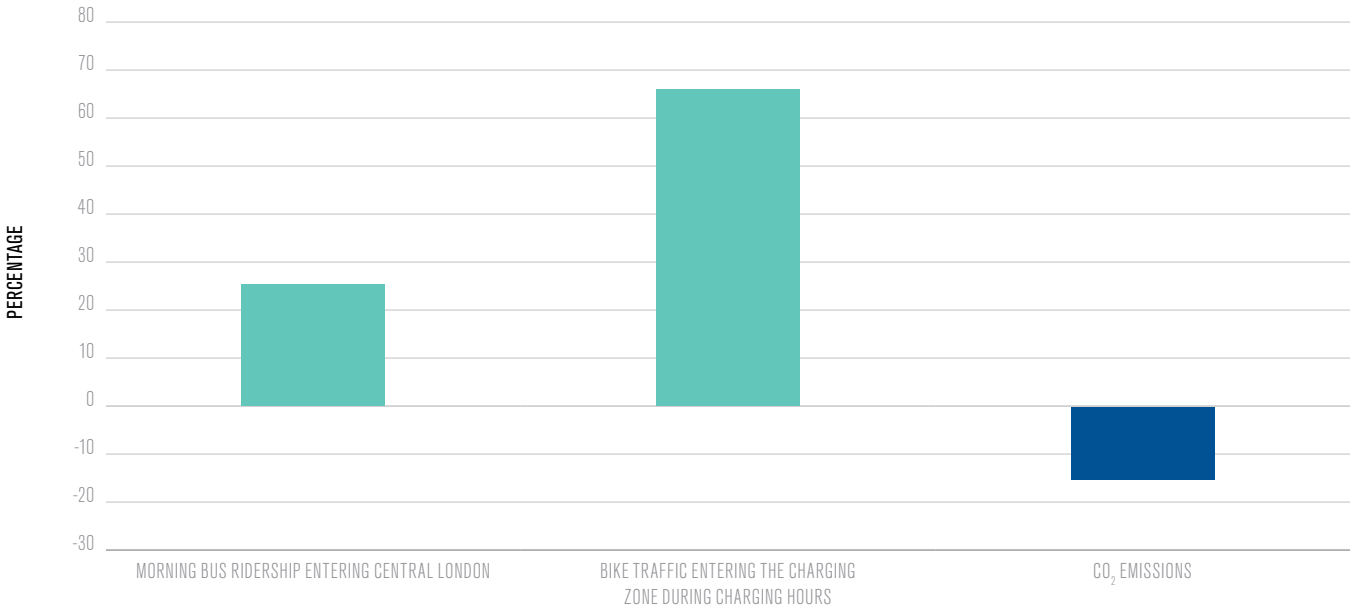
Citywide regulations need not be limited to building efficiency, and in many ways the regulation of public spaces is much more straight-forward for local governments. London, for example, has used its ability to impose traffic restrictions to reduce inner-city congestion, incentivize the use of public transportation, and help to fund the maintenance of the city's public infrastructure.

Congestion charges were first introduced in London in 2003 to ease traffic in central London. The charges are based on vehicle efficiencies and CO_2 emissions, which discourages older and less efficient vehicles from traveling into the city. This regulation was followed by a 26% increase in bus ridership during morning peak hours into central London, and a 66% increase in bike traffic into the charging zone by 2007 (Transport for London 2008).

These mode shifts resulted in a 16% reduction in CO_2 emissions, equivalent to 30,000 tons of CO_2 annually, in the congestion pricing zone compared to 2002 levels. London is actively upgrading and expanding public transportation infrastructure, enabled by the £122 million surplus revenue created by congestion charges, to support residents that have adopted transportation mode changes (C40 2011).

London parking maximums were introduced in the early 2000s as part of a London Parking Reform initiative (Guo 2016). Parking maximum rules limit the number of parking spaces that residential and commercial buildings may have within the development. Prior to the Parking Reform Initiative, London instead had parking *minimums*, regulations that required developments to guarantee a minimum number of parking spaces for developments.

FIGURE 3: THE EFFECTS OF THE CONGESTION CHARGING SCHEME IN LONDON



The effects of the London congestion charging scheme in percentage change of 2007 compared to 2002. Morning bus ridership only counts for peak hours (7 AM to 10 AM). Charging hours are 7 AM to 6 PM. All data excludes the expanded charging zone introduced in 2007.

Theoretically, decreasing the number of available parking spaces can reduce urban emissions by discouraging ownership of private vehicles and increasing urban density by freeing up land for more efficient purposes. An NYU study on parking in London during 2001 to 2011 found a 49% reduction in new residential parking supply and strong evidence of decreased car ownership per household caused by the parking reform in inner London (Li & Gao 2014).

Historically, Philadelphia also had regulations on parking minimums. However, this was eliminated from the zoning code in 2012 for some developments. Unfortunately, mid- and high-rise mixed-use buildings, which are predominantly located where traffic is most dense, are still subjected to parking minimums (Blumgart 2018). This is an example of a regulation that may no longer be contributing to the larger goals of the city and should possibly be reversed as was done in London.

These examples show encouraging trends in urban efficiency through imposing regulations and penalties on wasteful energy practices. Importantly, these regulations are frequently supported by additional programs that provide incentives for compliance or improvement to public amenities. Without these additional supportive policies, regulations on consumers could negatively affect low- and middle-income communities and struggling businesses and could disincentivize investment in the region. Furthermore, supportive policies are often an essential piece of regulatory legislation as they can increase public support, as was initially the case with the controversial London congestion charge.

Without these additional supportive policies, regulations on consumers could negatively affect low- and middle-income communities and struggling businesses and could disincentivize investment in the region.

ENCOURAGE THROUGH EDUCATION

Teach residents about energy efficiency, the steps they can take, and the lifestyle and economic benefits it can mean for them.

Community outreach and education has not been a major focal point of Philadelphia's Clean Energy Vision or Greenworks initiative. There are, however, a handful of efforts outlined within the goals of these reports. Philadelphia has, for example, a multi-family outreach program that seeks to deliver tailored reports of energy use patterns to multi-family building owners, but it is unclear what supporting context is given to these building owners or the building tenants regarding the changes that could be made to improve energy use.

The Philadelphia Energy Authority (PEA) also runs the Philadelphia Energy Campaign, which adopts a community-centric approach to expanding clean energy and improving energy efficiency. This $1 billion campaign aims to create clean energy jobs and support job training; help low- and middle-income homes, businesses, and schools to address deferred maintenance and reduce energy costs and consumption by over 20%; improve public health by improving indoor conditions; and reduce outdoor pollutants (Philadelphia Energy Authority).

While the PEA campaign is strongly focused on community improvement, there is little in its most recent progress report to indicate that community engagement, education and public buy-in is a predominant feature of the campaign. Instead, the emphasis is on investment within communities. This is of course a valuable undertaking, well-aligned with our first pillar (outlined above) but alone, it will not necessarily create the long-term and sustainable momentum within communities to pursue retrofits and the efficient use of energy.

Although not specifically related to energy efficiency, Philadelphia is demonstrating its ability to engage and educate residents without the need for large scale investment through its Solarize Philly program, also managed by the Philadelphia Energy Authority. This program streamlines the application and installation process for Philadelphia homeowners to install rooftop solar on their homes. The program has also negotiated lower costs from equipment suppliers on behalf of residents.

By September 2017, over 2000 homes in Philadelphia had expressed interest in participating in the Solarize Philly program and by December 2019, 6,000 homes had signed up for a free installation evaluation. Despite this, only 640 homeowners took the next step of signing a contract—a dishearteningly low percentage (Baylis 2020). This program is closer to a community engagement initiative since it is not dependent on massive funding by the city in order to thrive. There is still opportunity, however, to expand the community outreach and education efforts for this program and a comprehensive efficiency improvement plan.

FURTHER EDUCATIONAL OPPORTUNITIES

As discussed at the beginning of this report, improving energy efficiency in Philadelphia has a wide range of local benefits beyond just the improvements to regional emissions profiles. Energy efficiency, retrofits, urban greening, traffic and parking regulations, and strong standards can reduce energy costs for homeowners and businesses, improve public health, and make the city more enjoyable and livable. These benefits can be experienced by all Philadelphians and it is essential that the city works hard to make these widespread benefits known to Philadelphia residents, especially those living in low- or middle-income households.

By demonstrating the individual benefits that can be experienced by a comprehensive energy efficiency plan, Philadelphia would be able to motivate community action and buy-in for these initiatives. For example, few cities have demonstrated greater success at motivating their populace to tackle urban efficiency than Seoul. Since 2012, Seoul has been promoting the "One Less Nuclear Power Plant" initiative across two phases (Seoul Metropolitan Government 2013).

The goal of this program, as made clear by the name, is to reduce Seoul's grid electricity demand by the equivalent of a nuclear power plant. Phase two of the initiative has extended this goal to making Seoul an energy self-reliant city. Both phases of this initiative have focused heavily on energy efficiency as a tool with which to reduce citywide energy demand.

Seoul's efficiency program has received a high level of public buy-in because it was framed around solving related energy issues that the citizens of Seoul cared about: reliability and safety. Philadelphia can learn from this success and work to frame a local efficiency effort around related public concerns such as building safety, disrepair, congestion, public health, and energy affordability, especially following its own energy-related disaster in last year's refinery explosion.

By demonstrating the individual benefits that can be experienced by a comprehensive energy efficiency plan, Philadelphia would be able to motivate community action and buy-in for these initiatives.

In 2011, Seoul was only 3% self-reliant on energy and had a reserve margin of just 5.5% (Seoul Metropolitan Government 2014). A major blackout in the region in September helped catalyze the "One less nuclear power plant" energy policy. Public opposition to nuclear power following the Fukushima incident also helped set the priorities for Seoul's energy policy.

In addition to building retrofits, investments in public infrastructure, and creation of a low-carbon energy industry, one of the key pillars of Seoul's energy plan is the "creation of a civic culture promoting energy conservation."

The first step to transforming the local culture in this way was to come up with 23 clear policy tasks and 71 programs that encompass the city's energy efficiency plan. The city government signed over 60 MOU's with local businesses and civic groups and held over 100 public contests. By 2014, Seoul recorded an electricity reduction of 2.04 million tonnes of oil equivalent (TOE), of which 1.78 million TOE was from energy savings and efficient use practices. Close to one million TOE was saved just through citizens' active participation—monitoring their own indoor temperature control, transportation, and waste production.

Despite significant electrification, Seoul's electricity demand has dropped by more than 1% a year. Phase two of the Seoul program builds on the success of phase one. By 2020, the goal is to have reduced Seoul's electricity demand from 50,000 GWh (under a baseline case scenario) to 41,000 GWh. In addition to that, Seoul plans to provide over 8,000 GWh (20% of demand) using thermal cogeneration and renewable energy (PV and fuel cells). This plan will reduce Seoul's carbon emissions from 49 million tonnes of CO_2e to 39 million tonnes, even with no change in the grid mix.

Clear and detailed goal setting and policy tasks were invaluable for Seoul and ought to be replicated by any city looking to galvanize public support around urban transformation. In Seoul's case, the highly structured plan provided easy progress reporting to residents, which meant that they could see exactly how they were helping the city achieve its goals.

As part of this goal setting, the city could also outline clear but voluntary energy use targets for individuals, and work with utilities to provide customers with regular updates of their progress toward those targets. Having a granular and detailed plan is more work up front, but it makes an efficiency plan much more resilient and achievable in the long run and allows the public to track the city's progress leading to community engagement and public accountability.

Another tool that Philadelphia could deploy to improve local energy efficiency is the use of public surveys. A 2017 study in Singapore concluded that the consensus among various stakeholders (from consumers to industrial entities) was that cost-effectiveness was the community's highest priority, with sustainability considered a secondary, non-prioritized factor (Siva et al. 2017). Consumers also preferred well-established technologies that required no new knowledge to operate. This suggests that the most effective strategies to improve building efficiency may be those that have the greatest cost benefit to consumers and do not disrupt any of their current behaviors.

The study also concluded that the key barriers to implementation were the inflexible habits and mindsets of end users, ineffective collaboration between different parties involved, and the fact that the main push for green buildings was coming predominantly from the government. If non-governmental entities were more aggressive in their push for energy efficiency strategies, this may also lead Philadelphians to accept behavioral changes.

Philadelphia could take the findings from this Singapore survey and use them to inform the design of a Philadelphia efficiency program or, even better, Philadelphia to write and distribute its own survey to gauge residents priorities and concerns and use this to tailor the framing and policy tasks of an efficiency plan to best meet these local priorities.

NEXT STEPS

In many respects, Philadelphia has already demonstrated itself to be a leader in tackling city-wide carbon emissions and embracing regional sustainability. The City is also well positioned to become a leader on urban energy efficiency.

Adequately reducing regional carbon emissions will require bold and clear policy goals and market action at the federal and state level. Without a clean electricity grid—powered entirely by zero-carbon energy sources such as solar, wind, hydropower, and nuclear—cities cannot feasibly fully decarbonize their energy demand. Cities can, however, reduce their demand for grid electricity and fossil fuels by improving building efficiency, influencing traffic and mobility patterns, utilizing waste heat, generating electricity through distributed sources, and by encouraging behavior change.

In this report, we outlined three "policy pillars" for improving efficiency measures and offer several examples that illustrate the kinds of programs Philadelphia could adopt.

- **Guide Through Investment**
  - *Upgrade or retrofit municipal assets with systems that are more energy efficient*
  - *Offer cost-sharing programs to home-owners and businesses for implementing greener infrastructure*
  - *Direct investment in public spaces with efficiency in mind*
  - *Provide free inspections and consultations to home-owners and businesses*
- **Enforce Through Regulation**
  - *Reconsider existing regulations on traffic, parking, and building standards and determine if they are still supportive of 21st century goals*
  - *Introduce penalties and ensure strict enforcement*
  - *Direct funds from penalty systems toward achieving the targeted goal*

- **Encourage Through Education**
  - *Invest in community education and foster community initiatives, competition, and engagement so that residents and businesses understand the co-benefits of efficiency improvements*
  - *Use surveys and community feedback to develop an in-depth understanding of residents' primary concerns and priorities and their willingness for investment and behavior change*
  - *Provide clear and detailed goals, objectives, and measures of success based on the information and preferences revealed through community engagement*

Together, these policies can encompass an effective local energy efficiency plan that reduces the city's carbon footprint, and also reduces energy costs for residents, improves urban public spaces, reduces congestion, encourages healthy decisions by residents, reduces indoor and outdoor air pollution, and engages communities.

The ability of Philadelphia, or any city for that matter, to implement some or all of the many efficiency strategies outlined in the report is dependent on the near-term economic and social impacts of the global coronavirus pandemic. There is still an enormous amount of uncertainty at the time of writing as to how negatively city budgets, transit agencies, and local businesses will have been impacted by this pandemic and what that will mean for the near-term capacity of cities to tackle the issues of energy affordability, carbon emissions, and public health. That said, the diverse strategies presented in this digest offer a menu of options for taking those steps forward.

BIBLIOGRAPHY

Baylis, Shalon. 2020. "Philly homeowners are interested in solar energy. So why aren't more installing panels?" *Green Philly*. Accessed 06/08/20: https://www.thegreencities.com/energy/solarize-philly-homeowners-solar-panels/

Blumgart, Jake. 2018. "City Council tweaks bill requiring developers to provide more parking in Philly neighborhoods." *WHYY*. Accessed 06/08/20: https://whyy.org/segments/city-council-tweaks-bill-requiring-developers-to-provide-more-parking-in-philly-neighborhoods/

C40 Cities. 2011. *Case Study: London's Congestion Charge Cuts CO_2 Emissions by 16%*. Accessed 06/08/20: https://www.c40.org/case_studies/londons-congestion-charge-cuts-co2-emissions-by-16

C40 Cities Climate Leadership Group. 2015. Urban Efficiency: A Global Survey of Building Energy Efficiency Policies in Cities. Accessed 06/08/20: https://www.c40.org/researches/urbanefficiency_i

Commercial PACE Finance LLC. 2018. *Pennsylvania Approves PACE Financing*. Accessed 06/05/20: https://commercialpacellc.com/pa-pace-financing/

Energy Star. The Difference Between Site and Source Energy. Accessed 06/08/20: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/difference

EnergyWorks. *Commercial: Energy Saving is Good Business*. Accessed 06/05/20: http://www.energyworksnow.com/commercial/

Environmental Protection Agency. *Greenhouse Gas Emissions from a Typical Passenger Vehicle*. Accessed 06/08/20: https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle#:~:text=A%20typical%20passenger%20vehicle%20emits%20about%204.6%20metric%20tons%20of,around%20-11%2C500%20miles%20per%20year

Davis, Timothy, and William Johnston. 2019. "Philadelphia Enacts Commercial Property Assessed Clean Energy (C-PACE) Program." *White and Williams LLP*. Accessed 06/05/20: https://www.jdsupra.com/legalnews/philadelphia-enacts-commercial-property-47181/

Green World Building Council. *Advancing to Zero: London, UK*. Accessed 06/05/20: https://www.worldgbc.org/sites/default/files/NZCB%20Commitment_Signatory%20Profile_City_London.pdf

Guo, Zhan. 2016. "From Parking Minimums to Parking Maximums in London." *Access Magazine*. Accessed 06/08/20: http://www.accessmagazine.org/wp-content/uploads/sites/7/2016/11/access49-web-from-parking-minimums.pdf

Jaramillo, Catalina. 2019. "Philadelphia Mayor Signs Law Requiring Energy Efficiency Tune-ups for City's Biggest Buildings." *State Impact Pennsylvania*. Accessed 06/05/20: https://stateimpact.npr.org/pennsylvania/2019/12/11/philadelphia-mayor-signs-law-requiring-energy-efficiency-tune-ups-for-citys-biggest-buildings/

Kolczak, Amy. 2017. "This City Aims to be The World's Greenest." *National Geographic*. Accessed 06/08/20: https://www.nationalgeographic.com/environment/urban-expeditions/green-buildings/green-urban-landscape-cities-Singapore/

Kummer, Frank. 2019. "Philadelphia launching 10-year 'urban forest' plan after startling tree decline." *The Philadelphia Inquirer*. Accessed 06/05/20: https://www.inquirer.com/science/climate/philadelphia-climate-change-forest-trees-canopy-heat-island-20191205.html

Li, Fei, and Zhan Guo. 2014. "Do parking standards matter? Evaluating the London parking reform with a matched-pair approach." *Transportation Research Part A: Policy and Practice*, Vol. 67, p. 352–365

Manoli, G. et al. 2019. "Magnitude of urban heat islands largely explained by climate and population". *Nature*. Accessed 06/08/20: https://www.nature.com/articles/s41586-019-1512-9

Maykuth, Andrew. 2019. "Philly to switch all 100,000 streetlights to 'smart' LEDs; expect some debate." *The Philadelphia Inquirer*. Accessed 06/05/20: https://www.inquirer.com/business/philadelphia-streetlight-conversion-smart-led-savings-20190822.html

Natural Resources Defense Council. 2017. *What is the Clean Power Plan*? Accessed 06/05/20: https://www.nrdc.org/stories/how-clean-power-plan-works-and-why-it-matters

Pachon, Angela. 2020. "A Shaky Future for U.S. Transit Systems… and Why We Need to Save Them". *The Kleinman Center for Energy Policy*. Accessed 06/11/20: https://kleinmanenergy.upenn.edu/blog/2020/05/06/shaky-future-us-transit-systems…-and-why-we-need-save-them

Pennsylvania C-PACE. *Pennsylvania C-PACE*. Accessed 06/05/20: https://pennsylvaniacpace.org

Pennsylvania Department of Environmental Protection. *C-PACE: Improving Communities by Financing Clean Energy Projects for Businesses*. Accessed 06/05/20: https://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/FinancialOptions/Pages/C-PACE.aspx

Pennsylvania Public Utility Commission. Pennsylvania Alternative Energy Credit Program. Accessed 06/05/20: https://www.pennaeps.com/aboutaeps/

Philadelphia Energy Authority. The Philadelphia Energy Campaign. Accessed 06/08/20: https://philaenergy.org/programs-initiatives/the-philadelphia-energy-campaign/

Ribeiro, Mark et al. 2019. "The 2019 City Clean Energy Scorecard." *American Council for an Energy-Efficient Economy*. Accessed 06/05/20: https://www.aceee.org/research-report/u1904

Roxon, J., F.-J. Ulm, and R.J.-M Pellenq. 2020. "Urban heat island impact on state residential energy cost and CO_2 emissions in the United States." *Urban Climate Vol 31*. Accessed 06/08/2020: https://www.sciencedirect.com/science/article/pii/S2212095518303560

Sasko, Claire. 2019. "Philly Just Took a Big Step Toward Making Big Buildings More Energy Efficient." *City Life*. Accessed 06/08/20: https://www.phillymag.com/news/2019/12/10/bill-buildings-energy-efficient/

Seoul Metropolitan Government. 2013. *One Less Nuclear Power Plant Brochure*. Accessed 06/08/20: https://www.ieac.info/IMG/pdf/201305smg-one_less_nuclear_power_plant.pdf

Seoul Metropolitan Government. 2014. *One Less Nuclear Power Plant, Phase 2: Seoul Sustainable Energy Action Plan*. Accessed 06/08/20: https://www.ieac.info/IMG/pdf/20140914olnpp2-lr.pdf

Serpell, O., A. Chu, B. Paren, and G. Sankar. 2020. "Feasibility of Seasonal Storage for a Fully electrified Economy." *The Kleinman Center for Energy Policy*. Accessed 06/05/20: https://kleinmanenergy.upenn.edu/policy-digests/feasibility-seasonal-storage-fully-electrified-economy

Singapore Building and Construction Authority. 2018. *Building Energy Benchmarking Report*. Accessed 06/08/20: https://www.bca.gov.sg/GreenMark/others/BCA_BEBR_Abridged_FA_2018.pdf

Siva, Vidushini, Thomas Hoppe, & Mansi Jain. 2017. "Green Buildings in Singapore; Analyzing a Frontrunner's Sectoral Innovation System." *Sustainability 9*(6), 919. Accessed 06/11/20: https://www.mdpi.com/2071-1050/9/6/919

The City of Boston. *Go Boston 2030*. Accessed 06/05/20: https://www.boston.gov/departments/transportation/go-boston-2030

The City of London. *Energy in Buildings*. Accessed 06/05/20: https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings

The City of London. *Energy Leap Project Pilots*. Accessed 06/08/20: https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings/energy-leap-project-pilots

The City of London. *Retrofit Accelerator—Homes*. Accessed 06/05/20: https://www.london.gov.uk/what-we-do/environment/energy/retrofit-accelerator-homes

The City of London. *Retrofit Accelerator—Workplaces*. Accessed 06/05/20: https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings/retrofit-accelerator-workplaces

The City of Philadelphia. 2019. *City Announces Participation in EV Purchasing Collaborative*. Accessed 06/05/20: https://www.phila.gov/2019-06-28-city-announces-participation-in-ev-purchasing-collaborative/

The City of Philadelphia's Office of Sustainability. 2018. *Powering our Future: A Clean Energy Vision for Philadelphia*. Accessed 06/05/20: https://www.phila.gov/media/20180821150658/Powering-Our-Future-Full-Report.pdf

The City of Philadelphia's Office of Sustainability. 2019. *Philadelphia Building Energy Benchmarking: 2019 Report*. Accessed 06/05/20: https://www.phila.gov/media/20191210091804/2019-Municipal-Energy-Benchmarking-Report.pdf

The Regional Greenhouse Gas Initiative. *Elements of RGGI*. Accessed 06/05/20: https://www.rggi.org/program-overview-and-design/elements

Transport for London. 2008. Central London Congestion Charging Impacts Monitoring Sixth Annual Report. Accessed 06/08/20: http://content.tfl.gov.uk/central-london-congestion-charging-impacts-monitoring-sixth-annual-report.pdf

Walk Score. 2020. *2020 City and Neighborhood Rankings*. Accessed 06/05/20: https://www.walkscore.com/cities-and-neighborhoods/

Walsh, Martin. 2014. *Housing a Changing City: Boston 2030*. Accessed 06/05/20: https://www.boston.gov/sites/default/files/embed/h/housing_a_changing_city-boston_2030_full_plan.pdf

Walsh, Martin. 2019. *City of Boston Climate Action Plan: 2019 Update*. Accessed 06/08/20: https://www.boston.gov/sites/default/files/embed/file/2019-10/city_of_boston_2019_climate_action_plan_update_4.pdf

Zarroli, Jim. 2020. "Cities Have Never Seen a Downturn Like This, and Things Will Only Get Worse" *National Public Radio*. Accessed 06/05/20: https://www.npr.org/2020/05/20/859713720/american-cities-and-towns-face-financial-challenges-during-the-pandemic

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