Current Sustainable/Renewable Energy Reports (2018) 5:109–115
https://doi.org/10.1007/s40518-018-0105-9

END-USE EFFICIENCY (Y WANG, SECTION EDITOR)

Developments in Local Energy Efficiency Policy: a Review of Recent Progress and Research

David Ribeiro [1]

Published online: 24 February 2018

Abstract

Purpose of review This review analyzes trends in the increasing number of local energy efficiency activities through a study of the findings of the *2017 City Energy Efficiency Scorecard*. The review also examines recent literature to provide a greater understanding of select policies' potential effectiveness and outcomes, as well as possible policy improvements.

Recent Findings Within the last few years, municipalities have made more commitments to reduce energy use and have taken more action to achieve their goals. Cities have set energy savings goals, adopted building energy codes, collaborated with their utilities to deliver energy efficiency programs, and more. Some of the increased activity is due to a broader focus on reducing greenhouse gas emissions, but cities continue to use energy efficiency for achieving other priorities too, including lowering government expenditures and increasing economic development. A review of recent research also shows the importance of evaluating local energy efficiency efforts. Further research will provide better data on the energy savings potential of these activities and provide insight on potential improvements in policy planning and implementation.

Summary The results indicate that local policymakers have expanded their focus on building energy benchmarking and transparency as well as mode-shift strategies for transportation, though transportation policies are less of a focus than those aimed at energy use in buildings.

Keywords Local energy efficiency · Benchmarking · Building energy codes · Urban transportation · Smart cities · Urban climate governance

Introduction

Over the last several years, local leaders in large cities in the USA have ramped up their activities to reduce energy waste. Cities have set energy savings goals, adopted building energy codes, collaborated with their utilities to deliver energy efficiency programs, and more. In 2017, the federal government's planned withdrawal from the Paris Climate Agreement further galvanized US cities to take action to reduce greenhouse gas emissions. Approximately 250 mayors accompanied more than 2300 non-federal actors in joining America's Pledge [1]—a commitment to reduce their community's greenhouse gas emissions consistent with the goals of the Paris Climate Agreement.

By December 2017, more than 350 city leaders also joined the Climate Mayors Initiative to strengthen local efforts to reduce greenhouse gas emissions [2]. Furthermore, on December 2017, over 50 municipalities signed the Chicago Climate Charter [3]. Signatories pledged to achieve the Paris goals and set priorities their cities would use to achieve their goals. During the summit that accompanied the signing of the Charter, mayors around the USA acknowledged the role that energy efficiency has and will continue to have in reducing greenhouse gas emissions stemming from their communities [4].

Municipalities pursue energy efficiency for different reasons, whether due to mitigating climate change, reducing local government expenditures, promoting economic development, or some combination of factors. A sample of 110 global cities reported that combined, they are saving or planning to save $40 million each year from efficiency improvements in government operations [5]. For example, an energy retrofit in four

This article is part of the Topical Collection on *End-Use Efficiency*

✉ David Ribeiro
dribeiro@aceee.org

[1] ACEEE, 529 14th Street NW, Suite 600, Washington, DC 20045, USA

local government buildings in Philadelphia has saved the city $1.9 million in utility bills and helped it earn $500,000 in rebates between the start of construction in 2012 and the end of 2014 [6]. Energy efficiency also has clear benefits for city residents and businesses. A nonprofit started by the City of Portland to help facilitate energy efficiency improvements has created 470 jobs [7].

A tool for tracking the uptake of local energy efficiency policies is ACEEE's *City Energy Efficiency Scorecard*. The biennial report describes and compares actions that 51 large US cities[1] are taking to enable or improve their energy efficiency across five sectors, namely local government operations, community initiatives, buildings policies, transportation policies, and energy and water utilities [8••]. The findings of the *2017 City Energy Efficiency Scorecard* indicate that cities are increasingly embracing energy efficiency. Over 50% of the cities in the report improved their scores from the 2015 edition to the 2017 report, indicating that most municipalities are pursuing more activities and strengthening old initiatives.

The goal of this article is to review significant local energy efficiency policy developments and trends based on the findings of the *2017 City Scorecard*. We also examine recent literature on some policies to provide a greater understanding of their potential effectiveness and outcomes, as well as possible policy improvements. The research reviewed focuses on issues most directly affecting local energy efficiency policy, such as program effectiveness, program design, and the planning process. "The Buildings Policies" section focuses on developments in energy efficiency policies for private buildings. It discusses the increase in building energy benchmarking and transparency policies and research on benchmarking policies' effectiveness in reducing energy use. It also provides a brief overview of the importance of building energy codes and recent advances in local adoption. "The Transportation Policies" section focuses on transportation policies and gives significant attention to mode-shift strategies. Bike-sharing, in particular, has been a considerable area of attention for cities in recent years and is, therefore, one of the section's concentrations. It also discusses information and communications technology (ICT)—enabled energy efficiency as well as location efficiency initiatives. "The Local Energy Efficiency Policymaking and Policy Prioritization" section focuses on recent research's implications for the energy efficiency planning process. "The Conclusions" section wraps up with some concluding thoughts. The result is an article that provides an overview of trends in local energy efficiency policies while also giving a snapshot of critical literature related to those activities.

[1] The report focuses on the central cities of the 50 most populous US metro areas excluding San Juan. It also assesses Fort Worth and El Paso. Both cities were included in earlier editions of the scorecard that used a different methodology for selecting cities.

Buildings Policies

Local governments have several options for making their building stock more energy-efficient from adopting or advocating for stringent building energy codes for new construction to encouraging less energy waste in existing buildings. Boston has been one of the cities showing the most leadership in efforts to reduce energy use from buildings. The city has adopted the Massachusetts Stretch Energy code, has enacted green building requirements, and has passed benchmarking requirements. Los Angeles has also made strides recently. The city approved the Existing Building Energy and Water Efficiency (EBEWE) program in 2016. It includes energy audit, retrofit, and benchmarking requirements for commercial and residential buildings [9]. Other cities leading the way include Austin, New York, and Seattle []. While all these municipalities have lessons to offer, some trends exist when assessing buildings policies across cities.

Building Energy Benchmarking and Transparency Policies

The details of benchmarking policies differ from municipality to municipality, but each policy shares the same aim; each seeks to make better data available by requiring large building owners, typically commercial and increasingly multifamily, to benchmark the energy use in their buildings and make the data transparent in some way. Better data enables building owners and others to quantify and evaluate energy-saving opportunities throughout the building stock.

A significant trend in efficiency policies for existing buildings is the increase in the adoption of building energy benchmarking and transparency policies. While this policy type has existed for several years, the number of programs has grown significantly over the last 2 years. At least eight cities (Atlanta, Denver, Los, Angeles, Orlando, Portland, Saint Louis, Pittsburgh, and Kansas City, MO) adopted these policies or advanced the policies previously on the books between the data collection periods between the 2015 and 2017 scorecards. These cities join many other adopters, as shown in Fig. 1 [10].

Recent evaluations provide preliminary evidence that suggests benchmarking policies are leading to energy savings. These assessments are a positive development as few comprehensive evaluations have been available in the public realm. A past, extensively-cited EPA study found energy consumption decreased by 7% over 3 years in a pool of

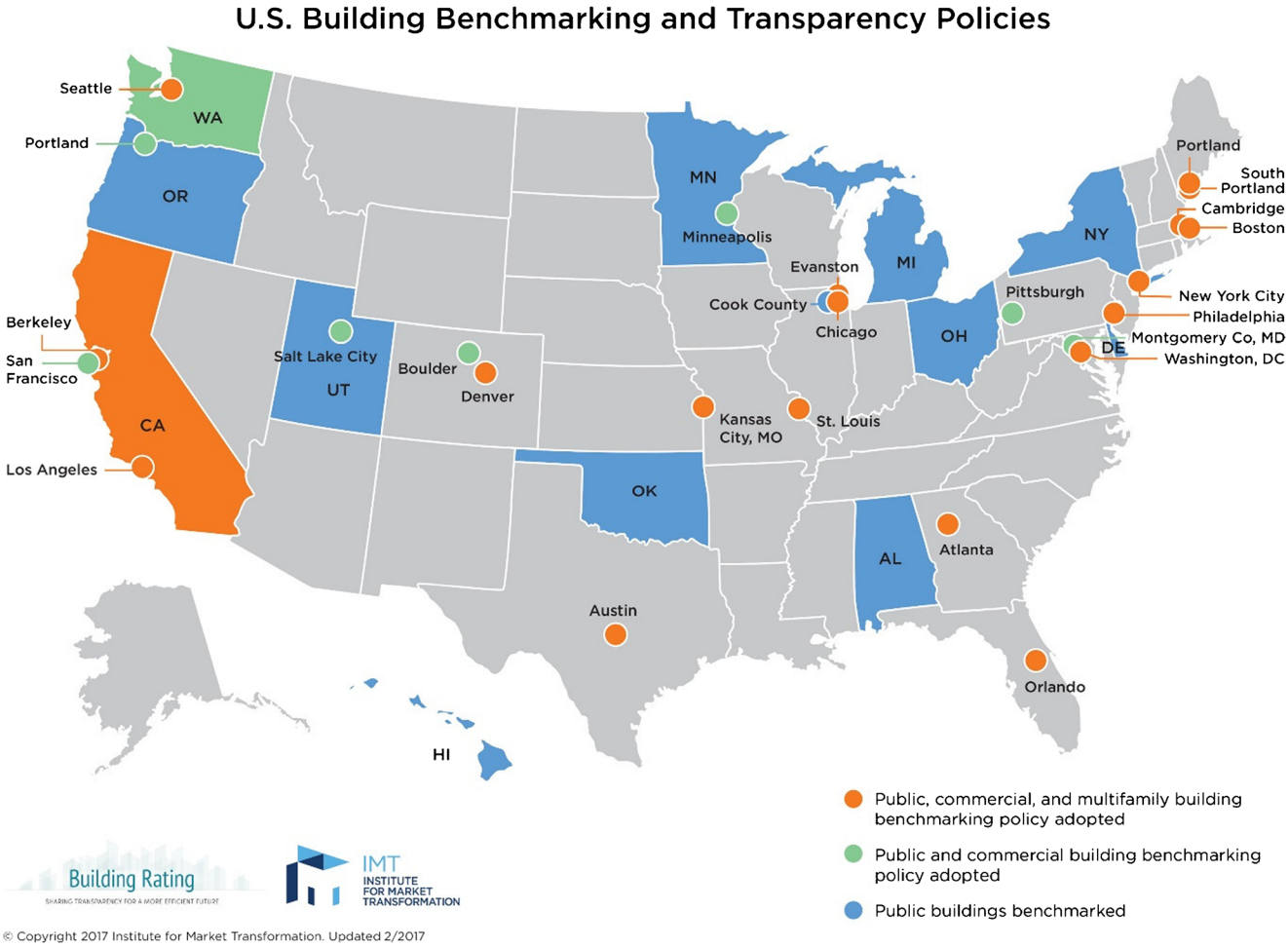

Fig. 1 Institute for Market Transformation. "Map: U.S. Building Benchmarking and Transparency Policies." Washington, DC: IMT. Accessed January 9, 2018. http://www.imt.org/resources/detail/map-u.s.-building-benchmarking-policies [10]

35,000 benchmarked buildings [11]. The recent research profiled below adds to this field of study.

Meng et al. (2017) evaluated the results of New York City's benchmarking program [12]. The benchmarking program is part of New York's Greener, Greater Better Buildings Plan to reduce energy use in large existing buildings. The authors found that the benchmarking policy saved building owners 6% of energy use 3 years after being implemented and 14% of energy after 4 years. Two takeaways are noteworthy from the study. The first is the energy savings, but the second is the time lag in seeing proven energy reductions. Energy reductions in the initial 2 years of the program were inconclusive. A study released by the City of Chicago found that property owners who disclosed energy use for three consecutive years (2014 to 2016) reduced energy use by 4% [13].

Mims et al. (2017) evaluated the impacts of 24 benchmarking and transparency policies adopted by cities and states [14••]. The review included the assessments of Meng et al. (2017) and City of Chicago (2017). The authors found that all but one of the policies achieved some reduction in energy use, energy costs, or energy intensity over a 2- to 4-year study period. Most of the studies indicate a 3 to 8% reduction in energy consumption or intensity over 2 to 4 years. However, they rightly note that all findings are preliminary due to a limited study period and inconsistencies in evaluation methods. Mims et al. (2017) echo the conclusions of Palmer and Walls (2016) that evaluators need to take a more systematic approach in evaluating these programs [15]. More research must be completed before making determinations on the extent to which benchmarking policies can potentially reduce community energy use.

Recent research also provides suggestions for improving benchmarking policies. Mims et al. (2017) provide recommendations for improving implementation and performance. The topics discussed include facilitating a faster transfer of data to market actors who can use energy use data, expanding evaluation to include a broader range of performance metrics, and providing a range of support services to building owners to help them comply with requirements. Samarippas et al. (2017) acknowledge some of the unique difficulties benchmarking may pose for multifamily building owners.

The research provides recommendations for designing and implementing these programs in ways to enhance compliance among owners of multifamily properties [15].

Building Energy Codes

Stringent building energy codes are an effective mechanism for reducing energy use in new or substantially renovated buildings. Building codes set minimum performance requirements for different aspects of buildings, including insulation and air sealing around windows. The International Code Council develops the model energy code for residential construction; the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) creates it for commercial buildings. As each is updated, the minimum performance requirements within them are typically enhanced to call for more energy savings than required by previous iterations of the codes. For the residential model code, energy use covered by it dropped by 32% between 2008 and 2012; for the commercial, it fell 37% between 2003 and 2013 [16•].

Authority for adopting energy codes sits with states or cities. Jurisdictions typically enact derivatives of these model codes, or in the case of some cities, develop their own. Over the past several years, many cities have adopted more stringent codes, or if they could not enact one, advocated for their states to do so. For example, Baltimore and Austin both put stricter building energy codes into force in the last 2 years, and Columbus and Cleveland advocated that the State of Ohio do the same. Cities are also taking proactive efforts to enforce them by having city staff dedicated to energy code enforcement, providing upfront support related to code compliance, or using other strategies [].

Transportation Policies

Local government strategies to reduce energy use in the transportation sector can take many different forms. Municipalities can increase mobility options aimed at reducing vehicle-miles traveled, encourage compact communities through location efficiency, invest in public transit, and incentivize vehicles that are more efficient. Over the last several years, some municipalities have pursued these strategies in attempts to reduce energy waste from the transportation sector. Los Angeles set goals to reduce city-wide vehicle-miles-traveled by 2025 and 2035 [17]. Drive Clean Chicago has programs that offer incentives for energy-efficient vehicles and electric vehicle charging stations [18]. Phoenix implemented a transit tax to raise funds for improving public transit. While individual cities have made progress and cities are doing more across the board on energy efficiency, a focus on transportation-related energy use may be lacking. Cities can do more to take advantage of the opportunities to save energy in the transportation sector [].

Mode Shift

Many cities are looking beyond single-occupancy vehicles and encouraging a move to more efficient modes of transportation. Over 663 municipalities across the USA have adopted complete streets policies [19•]. Cities have also widely pursued bike- and car-sharing programs. Most large US cities either operate a car-sharing program or support such a program. Car-sharing can reduce transportation-related energy use by reducing the number of cars on the road. According to the Transportation Research Board, each shared car can replace at least five private vehicles [20].

A particularly notable trend over the last several years has been a sharp increase in the number of bike-sharing programs. The overwhelming majority of cities in the *2017 City Scorecard* had a bike-sharing program in place, which is a change from previous scorecards. In fact, 25% more cities had these programs in 2017 as compared to 2015. Bike-sharing increases the ease of urban mobility, increases the use of public transit, and reduces overall energy use within a metropolitan area [21]. Current research indicates that bike-sharing has the potential to achieve modest energy savings over the next 30 years, but more evaluation and analysis of bike-sharing programs will allow for more informed projections in the future [22].

As was the case with benchmarking, the growth in bike-sharing programs has coincided with an increase in research on the topic. Two articles on Citi Bike in New York City look at the effect the bike-sharing program has had on other modes of transportation. Faghih-Imani et al. (2017) analyze bicycle competitiveness against taxis in urban areas regarding trip duration [23]. Their research shows that Citi Bike is faster or competitive with taxis during commuting periods for most trips under 3 km. Campbell et al. (2017) analyze the impact that Citi Bike has on bus ridership. The authors find that bike sharing reduces bus use by between approximately 1.5 and 2.5%, with potentially 50% of members substituting bus use for bike use. Both studies have implications for how planners may deploy bike-sharing systems and place bike docks for those systems. Furthermore, each demonstrates the need to continue evaluating bike-sharing programs, especially their effects on other modes of transportation. A better understanding of the impacts of these systems will inform planners who are considering the best ways to design multimodal transportation systems, optimizing opportunities for energy savings and access to multiple modes.

Caulfield et al. (2017) show that bike-sharing program can benefit not only large cities but smaller municipalities too [24]. Their research focuses on the bike-sharing program in Cork, Ireland. Their findings demonstrate that users in small

communities without a strong bicycling culture can take advantage of bike-sharing programs too. In fact, the results from Cork's program share some similarities with those in larger cities, including using the system for commutes as is common in Toronto and Chicago.

ICT-Enabled Energy Efficiency

Another area of growing interest is in greater leveraging the use of information and communications technologies (ICT) to reduce energy use in the transportation sector, aligning local government activities with tenets of the smart cities movement. The *2017 City Scorecard* captures some of these ICT-related initiatives. As discussed above, car and bike sharing are flourishing. Otherwise, few clear patterns emerge. Beyond Chicago, few cities have robust strategies for incentivizing electric-vehicle charging infrastructure, and fewer still employ Internet-based applications or services to help coordinate freight transportation. The opportunity for savings may be significant though. Vaidyanathan (2014) quantifies and discusses the energy savings from five ICT-based strategies for saving energy, including car sharing and vehicle-to-vehicle communications [25•]. If these activities are scaled up across communities, the study suggests an economy-wide savings potential of 13% by 2030. Chen et al. (2017) discuss ways in which the increased use of ICT in transportation uses can yield energy savings and provides an analytical framework for considering energy savings [26]. Contestabile et al. (2017) contribute research that argues for the balanced promotion of plug-in hybrid electric vehicles and battery electric vehicles (BEVs), rather than mostly incentivizing BEVs.

Location Efficiency

Location efficiency refers to different policy levers that local governments can use to encourage compact cities where residents live closer to their places of work and leisure. Location-efficient communities reduce the need to drive as residents are near public transit, job centers, and amenities [27]. The policy communities can use to encourage more compact cities include mixed use and transit-oriented zoning, urban growth boundaries, and reducing minimum parking requirements. Energy savings from increased location efficiency can take an extended amount of time to accrue due to the complexities involved in changing land-use patterns, but the potential savings are significant. By 2045, estimates show that a 10% reduction in transportation-related energy use is possible [22]. Some cities—like Portland, OR—have embraced location efficiency, but few municipalities appear to have pursued comprehensive location efficiency strategies over the last several years []. Improving location efficiency remains a critical opportunity to ramp up transportation-related energy savings.

Local Energy Efficiency Policymaking and Policy Prioritization

More large US cities are setting energy savings or climate-related goals for their communities. In the *2017 City Scorecard*, there was a 10% increase in the number of municipalities with targets, and three additional communities set goals related to energy use in their transportation sectors. New research may help local government staff prioritize the actions their cities can take to achieve savings goals.

The *2017City Scorecard* provides insights that may be helpful for policymakers looking to prioritizing specific sectors. The report finds that most cities do not perform well in the assessment of transportation policies. In scoring for transportation policies, most cities earned between 20 and 45% of the available points in the section. The concentration of scores between these levels is lower than those for the four other policy areas. The lower scores may mean that transportation strategies have been less of a priority for cities relative to other policy areas, or it may point to the complexity of transportation policy decisions since cities must work with regional actors to make many of these decisions. Regardless, cities should not overlook the importance of transportation policies when considering energy efficiency.

Trencher et al. (2016) analyzed strategies that ten cities in the C40 network[2] used and considered to be effective for increasing building energy efficiency [28]. The study categorized efforts into four mandatory policies and two voluntary initiatives. Each city began with a generic policy model, such as building benchmarking or an energy savings competition, and was able to adapt it successfully by engaging stakeholders and tailoring it to account for local government capacity and authority. By doing so, Trencher et al. (2016) show that through proper planning and consideration of stakeholder concern, municipalities can leverage and adapt already existing policy models for energy efficiency.

A growing number of research reports are also cataloging impactful programs within cities' energy efficiency portfolios; especially studies focused on international examples. Yoon et al. (2016) [29] provide assessments of municipalities in South Korea; Wu et al. (2017) [30] provide analysis related to cities in China, and Wang et al. (2016) [31] provide examples from 25 global cities.

[2] C40 is a network of populous global cities who have made commitments to mitigate the impacts of climate change.

Conclusions

Compared to only 2 years ago, municipalities have made more commitments to reduce energy use and have taken more action to achieve their goals. Detail descriptions of the activities of leading cities for energy efficiency, including Boston, New York City, and Seattle, would yield lessons from which peers can learn. Lessons are also evident from an analysis of trends in local energy efficiency policy and a review of recent, pertinent research, as was done in this article.

Municipalities are increasingly embracing benchmarking and transparency policies to reduce energy use in existing buildings. Communities continue to rely on building energy codes to reduce energy use in new or significantly renovated buildings. To reduce transportation-related energy consumption, cities are focusing on shifting residents toward more energy-efficient modes of transportation. Local governments have been focusing on bike-sharing programs in particular over the last several years. However, while cities have been pursuing mode shift strategies and ramping up energy efficiency activities generally, it still appears that efforts to reduce transportation-related energy use are lagging behind efforts in other sectors. A review of recent research also shows the importance of evaluating these policy efforts. Further research will provide better data on the energy savings potential of these activities and provide insight on potential improvements in policy planning and implementation. As such, additional evaluations of the policy efforts discussed in this article as well as other local policy initiatives will help to determine the policies that are most impactful across cities. Future editions of the city scorecard will remain to be key tools in compiling cities' energy efficiency efforts and assessing progress across cities in their pursuit of local energy efficiency.

Acknowledgements The author is grateful for the assistance of Heather DeLucia and Fernando Castro-Alvarez in gathering research for the literature review. He is also appreciative of Lauren Ross' thoughts on the original manuscript. Many thanks are also due to the co-authors of the *2017 City Energy Efficiency Scorecard*, whose research formed the basis of this article: Tyler Bailey, Ariel Drehobl, Stefen Samarripas, Mary Shoemaker, Shruti Vaidyanathan, Jen King, Weston Berg, and Fernando Castro-Alvarez.

Compliance with Ethical Standards

Conflict of Interest David Ribeiro reports that the Kresge and Surdna Foundation funded the 2017 City Scorecard. The Scorecard's research served as the foundation for this article.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. Igusky K, Calhoun K, Kennedy K, Ott C. America's pledge phase 1 report: states, cities, and businesses in the United States are stepping up on climate action. New York: Bloomberg Philanthropies; 2017. https://www.bbhub.io/dotorg/sites/28/2017/11/AmericasPledgePhaseOneReportWeb.pdf
2. Climate Mayors. "Members." Accessed 3 Jan 2018. http://climatemayors.org/about/members/
3. City of Chicago." Chicago Climate Charter." Accessed 9 Jan 2018. https://www.cityofchicago.org/content/dam/city/depts/mayor/Press%20Room/Press%20Releases/2017/December/ChicagoClimateCharter.pdf.
4. Ribeiro D. Mayors tout the importance of energy efficiency in meeting climate goals. ACEEE blog. December 14, 2017. http://aceee.org/blog/2017/12/mayors-tout-importance-energy.
5. Riffle C, Appleby K, Martin P. Wealthier, healthier cities: how climate change action is giving us wealthier, healthier cities. London: CDP; 2013. www.c40.org/researches/c40-cdp-2013-wealthier-healthier-cities-report
6. City of Philadelphia. Greenworks Philadelphia 2015 Progress report. Philadelphia: City of Philadelphia. 2015. beta.phila.gov/media/20160419140539/2015-greenworks-progress-report.pdf.
7. City of Portland. Climate Action Plan: Local Strategies to Address Climate Change. Portland: City of Portland. 2015. www.portlandoregon.gov/bps/article/531984.
8. •• Ribeiro D, Bailey T, Drehobl A, King J, Samarripas S, Shoemaker M, Vaidyanathan S, Berg W, Casto-Alvarez F. City Energy Efficiency Scorecard. Washington, DC: American Council for an Energy-Efficient Economy. 2017. https://aceee.org/research-report/u1705. **Study looking at the local energy efficiency efforts of 51 large US cities across five policy areas, namely local government operations, community initiatives, buildings policies, transportation policies, and energy and water utilities.**
9. City of Los Angeles. "Existing Buildings Energy and Water Efficiency Programs." Accessed 9 Jan 2018. https://www.ladbs.org/services/green-building-sustainability/existing-buildings-energy-water-efficiency-program.
10. Institute for Market Transformation. "Map: U.S. Building Benchmarking and Transparency Policies." Washington, DC: IMT. Accessed 9 Jan 2018. http://www.imt.org/resources/detail/map-u.s.-building-benchmarking-policies.
11. Energy Star. Energy Star® Portfolio Manager: Data Trends: Benchmarking and Energy Savings. Washington, DC: EPA (Environmental Protection Agency). 2012. www.energystar.gov/sites/default/files/buildings/tools/DataTrends_Savings_20121002.pdf.
12. Meng T, Hsu D, Han A. Estimating energy savings from benchmarking policies in New York City. Energy. 2017;133:415–23. https://doi.org/10.1016/j.energy.2017.05.148.
13. City of Chicago. City of Chicago Energy Benchmarking Report 2016. Chicago: City of Chicago. 2017. https://www.cityofchicago.org/content/dam/city/progs/env/EnergyBenchmark/2016_Chicago_Energy_Benchmarking_At-A-Glance.pdf.
14. •• Mims N, Schiller S, Stuart E, Schwartz L, Kramer C, Faesy R. Evaluation of U.S. Building Energy Benchmarking and Transparency Programs: Attributes, Impacts, and Best Practices. Berkley: Lawrence Berkley National Lab; 2017. https://emp.lbl.

gov/sites/default/files/lbnl_benchmarking_final_050417_0.pdf. **In-depth analysis of 24 benchmarking and transparency policies adopted across 24 states and municipalities**

15. Samarripas S, Bastian H. Benchmarking initiatives in the multifamily market. Washington, DC: ACEEE; 2017. Accessed 9 Jan 2018. http://aceee.org/sector/local-policy/toolkit/benefits-benchmarking
16.• Ungar L. Take a rise on the energy slide with building codes. ACEEE blog. February 12, 2016. http://aceee.org/blog/2016/02/take-ride-energy-slide-building-codes. **Brief article describing advances in residential and building energy codes in the US since the 1970s**.
17. City of Los Angeles. Sustainable City pLAn. Los Angeles: City of Los Angeles. 2015. http://plan.lamayor.org/wp-content/uploads/2017/03/the-plan.pdf.
18. Drive Clean Chicago. "Our Programs." Accessed 5 Jan 2018. http://www.drivecleanchicago.com/About/OurPrograms.aspx.
19.• National Complete Streets Coalition. The best complete streets policies of 2015. Washington, DC: National Complete Streets Coalition. Washington, DC: National Complete Streets Coalition. 2016. smartgrowthamerica.org/resources/best-complete-streets-policies-of-2015/. **Annual analysis of all complete streets policies that cities and states have adopted.**
20. Mason J, Fulton L, McDonald Z. A global high shift cycling scenario: the potential for dramatically increasing bicycle and E-bike use in cities around the world, with estimated energy, CO2, and cost impacts. Davis: Institute for Transportation and Development Policy and the University of California; 2015. www.itdp.org/wp-content/uploads/2015/11/A-Global-High-Shift-Cycling-Scenario-_-Nov-12-2015.pdf
21. Shaheen S, Martin E. Unraveling the modal impacts of Bikesharing. Access Mag. 2015;47(Fall):8–15. www.accessmagazine.org/wp-content/uploads/sites/7/2015/12/access47.shaheen.pdf
22. Vaidyanathan S. "Improving Evaluation Metrics for Buildings-Related Transportation Policies at the Local Level." In: Proceedings of the ACEEE 2014 Summer Study on energy efficiency in buildings. Washington, DC: ACEEE. https://aceee.org/files/proceedings/2014/data/papers/10-980.pdf.
23. Faghih-Imani A, Anowar S, Miller E, Eluru N. Hail a cab or ride a bike? A travel time comparison of taxi and bicycle-sharing systems in New York City. Transp Res A. 2017;101:11–21.
24. Caulfield B, O'Mahony M, Brazil W, Weldon P. Examining usage patterns of a bike-sharing scheme in a medium-sized city. Transp Res A. 2017;100:152–61.
25.• Vaidyanathan S. Energy Savings from Information and Communications Technologies in Personal Travel. Washington, DC: American Council for an Energy-Efficient Economy. 2014. http://aceee.org/research-report/t1401. **Report estimating energy savings from some ICT strategies in the transportation sector, including car and bike sharing, real-time transit information, in-vehicle ICT applications, vehicle-to-vehicle (V2V) communications, and workplace-based transportation demand management (TDM) programs.**
26. Chen Y, Ardilia-Gomez A, Frame G. Achieving energy savings by intelligent transportation systems investments in the context of smart cities. Transp Res D. 2017;54:381–96. https://doi.org/10.1016/j.trd.2017.06.008.
27. Jonathan Rose Companies. Location Efficiency and Housing Type: Boiling It Down to BTUs. Washington, DC: EPA. 2011. www.epa.gov/sites/production/files/2014-03/documents/location_efficiency_btu.pdf.
28. Trencher G, Broto VC, Takagi T, Sprigings Z, Nishida Y, Yarime M. Innovative policy practices to advance building energy efficiency and retrofitting. Approaches, impacts, and challenges in ten C40 cities. Environ Sci Pol. 2016;66:353–65. https://doi.org/10.1016/j.envsci.2016.06.021.
29. Yoon I, Lee Y, Yoon S. An empirical analysis of energy efficiency measures applicable to cities, regions, and local governments, based on the case of South Korea's local energy saving program. Mitig Adapt Strat Glob Chang. 2017;22(6):863–78. https://doi.org/10.1007/s11027-016-9702-3.
30. Wu J, Zuidema C, Gugerell K, de Roo G. Mind the gap! Barriers and implementation deficiencies of energy policies at the local scale in urban China. Energy Policy. 2017;106:201–11. https://doi.org/10.1016/j.enpol.2017.03.057.
31. Wang X, Li Z, Meng H, Wu J. Identification of key energy efficiency drivers through global city benchmarking: a data driven approach.