THE ENERGY EFFICIENCY PRIZE: SIMPLE DESIGN TO OVERCOME COMPLEX BARRIERS

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ABSTRACT: Due to the almost 40% share they have of all energy produced and 70% of all electricity produced and 38% share of all greenhouse gas emissions, the existing building stock needs immediate attention. Several studies identify the complexity and variability of conditions that cause the behavioral, financial and informational barriers preventing owners and occupants from adopting one-size-fits-all energy efficiency approaches despite the fact that these measures have cost-saving potential. Hirst and Brown coined the term "energy efficiency gap" and noted the failure of households, businesses, manufacturers and government agencies to take full advantage of cost-effective energy-conserving opportunities.

The Georgetown University Energy Prize (GUEP) was launched in 2014 and challenged cities and counties of populations ranging from 5,000 to 250,000 to reduce their energy use during a two-year competition period (2015-2016). The focus of the competition is on the reduction of municipal and residential building energy use by increasing energy efficiency. This makes it one of the largest national efforts to focus attention on closing the energy efficiency gap. The design strength of the competition is that it allows communities to create the approaches that best fit their needs in order to address one or more of these barriers.

This paper surveys public sources of information to identify the efforts that have been undertaken by the 50 semi-finalist cities. It further categorizes these efforts into three major typologies and several sub-typologies of energy-efficiency efforts. These typologies are sorted according to the hierarchy of rankings based on the GUEP dashboard providing a cluster visualization of impactful efforts.

The paper concludes with a discussion of typology combinations that appear to have the greatest utility in this preliminary study and outlines further research directions based on future data submitted by the actively participating cities.

KEYWORDS: Energy-efficiency, energy-efficiency gap, Energy Prize, GUEP

INTRODUCTION

As compared to other uses such as transportation and industrial sectors, residential and commercial buildings together add up to almost 40% of energy use (U. S. Energy Information Administration "Energy Consumption by Sector," 2016). Over the lifetime of buildings 80-90% of this energy use is in operations (heating, cooling, lighting, devices) whereas only 10-20% is in embodied energy (manufacturing, demolition) (Ramesh et al 2010). As a result, investments in reduction of operational energy use of buildings or their energy efficiency can have a large impact on reducing building energy use. Per Raman (2009), 70% of the existing building stock will still be functional in 2050. Seto et al (2014) projected that urban areas are responsible for 67%-76% of global energy use and 75% of carbon emissions. Per Creutzig, Baiocchi, Bierkandt, Pichler, and Seto (2015), urban interventions have the potential to reduce global energy use by 26%. These conditions present an opportunity for impacting global energy use and carbon emissions by acting at the city scale on energy-efficiency.

Per Molina (2014), energy efficiency is the cheapest method to provide Americans with electricity. Though energy efficiency is a much-needed and necessary strategy to reduce energy use, the *energy efficiency gap* needs to be addressed. Despite the fact that energy-saving measures have cost-saving potential, several studies identify barriers preventing owners and occupants from pursuing them. Hirst and Brown (1990) coined the term "energy efficiency gap." They identified behavioral barriers under the control of occupants, including attitudes towards energy efficiency, the perceived risk of energy-efficiency investments, and barriers that were not under the control of the occupants such as information gaps, and misplaced incentives.

Gillingham and Palmer (2013) outline and discuss three primary approaches to addressing energy efficiency: information

strategies, economic incentives, and energy efficiency standards. Information strategies include low- or no-cost energy audits for households; product labels such as Energy Guide or Energy Star certification for buildings and the Energy Star label for products; and public disclosure of buildings' energy use. Abrahamse et al. (2005), Stern (1985), and Stern and Aronson (1984) have found that by themselves, information programs identifying energy saving investments and behavior changes have limited effects on energy consumption. Schultz, Khazian, and Zaleski (2008) have shown that combining energy-use reduction information combined with comparison information produces results. This social and informational comparison approach works on energy consumers (Ayres, Raseman, and Shih, 2013).
Financial incentives in the form of rebates, tax incentives, and low-cost loans are used to encourage energy-efficient purchase and use behavior. Documented concerns about the effectiveness of such approaches in reducing energy use include the requirements for funding sources; and a rebound effect which reduces energy savings (Joskow & Marron 1992). Studies report mixed cost-effectiveness of such programs (Arimura, Li, Newell, & Palmer, 2012; Auffhammer, Blumstein, & Fowlie 2008; Rivers & Jaccard 2011). In the United States, building energy codes and standards have been used to achieve energy efficiency. Studies cited by Gillingham & Palmer (2013) show that the effectiveness of building efficiency standards have shown mixed results. According to Gillingham & Palmer, Jaffe & Stavins (1995) conclude that "building codes have no significant effect on energy demand," but Aroonruengsawat, Auffhammer, and Sanstad (2012) report that "building codes decreased per capita residential electricity consumption by 3 to 5 percent, and Jacobsen and Kotchen (2012) find electricity savings of about 4 percent."

In summary, research shows that the causes of the energy efficiency gap are difficult to explain and pinpoint, and consistent results on energy-efficiency programs' effectiveness are elusive. It is becoming increasingly clear that heterogeneity of needs and conditions of consumers might be the ultimate cause of difficulties in measuring and addressing the energy efficiency gap (Srivastava 2017). Different issues are relevant to different consumer groups making one-size-fits-all efforts effective only to a limited audience and less effective to other audiences. According to Gillingham and Palmer (2013), heterogeneity presents researchers with both an opportunity and a challenge.

1.0 GEORGETOWN UNIVERSITY ENERGY PRIZE

The Georgetown University Energy Prize (GUEP) conceived in 2012 by Francis Slakey, PhD, a physics professor at Georgetown University whose work in the area of energy policy indicated the tremendous potential for energy efficiency, but showed how underutilized efficiency strategies were among mid-sized American cities and counties. The team at Georgetown developed the GUEP to incentivize and inspire cities and counties across the U.S.to develop and begin implementing plans for innovative, replicable, scalable and continual reductions in the energy-per-residential-account consumed from local natural gas and electric utilities.

The GUEP was formally opened in April 2014 to any U.S. city or county with a population between 5,000 and 250,000. The competition garnered significant interest from communities throughout the country, and by December 2014, 50 communities had submitted comprehensive energy plans and had been selected to compete for the prize. These communities came from 26 states and included every geographic, demographic, and political region of the country.

The GUEP structure was based on historical incentive prizes that have spurred innovative solutions to problems for centuries, dating back as far as the Longitude Prize in 1714. Sobel 1995. In the modern era, incentive prizes have been deployed on a wide range of problems from computer algorithms to developing commercial spacecraft. A 2009 McKinsey & Company Report, "And the winner is...Capturing the Promise of Philanthropic Prizes," described the ways in which prize competitions were being deployed and how public institutions could utilize this methodology to spur innovation. A 2014 report from Deloitte University Press, "The Craft of Incentive Prize Design," showed the growth of prizes as an innovation tool, stating, that "In the last five years, incentive prizes have transformed from an exotic open innovation tool to a proven innovation strategy for the public, private, and philanthropic sectors." Vine and Jones (2016) assessed the energy savings potential of energy efficiency competitions, studying twenty competitions in the United States from 2006 to present. Three of the competitions that they studied were national competitions: the Campus Conservation Nationals (limited to University campuses); OPower, a social media based competition; and EPA's Energy Star Building Competition. They concluded that for competitions to be effective, there needs to be long-term and appropriate commitment of resources for design, implementation and rigorous evaluation from policy makers at the federal, regional, state and local levels.

The GUEP, currently in its first implementation, has been a key part of the growing landscape of incentive prizes, and is an example of what the McKinsey & Company report described as a "participation prize," designed not only to identify end-solutions, but to create substantial benefits through increasing the engagement of the competitors in advancing a field. Prizes have a number of advantages over other innovation approaches, but one key advantage is that innovation prizes function by defining an ambitious goal without needing to predict which methodology will be most successful.

The GUEP established the core goal of reducing community-wide residential and municipal electricity and natural gas consumption, but left it up to each individual community how best to accomplish this goal. Moreover, the final evaluation and awarding of the Prize will be based not only on the amount of energy reduction, but on whether the participating community has developed innovative, sustainable, replicable, and scalable approaches to ensure the solutions were applicable to others, but did not dictate the specific elements of a given approach. This structure has lead to a great diversity of participating communities with many different approaches worthy of deeper analysis.

2.0. PROCESS

2.1. Data collection and ranking methodology for GUEP

To participate in the GUEP, each community was required to submit letters of commitment from the following three entities: (1) the municipal government, (2) all of the electric and natural gas utilities that service the municipal and residential buildings within the geographic boundaries of the community, and (3) local non-profits or other community groups representing the residents of the community. The competition guidelines[1] stipulated that any one of these entities may take the leadership role in managing the community's participation in the GUEP, however, all three entities must be committed to participating and supplying data as requested by Georgetown University.

During the competition performance phase, from January 1, 2015 through December 31, 2016, each community submitted quarterly reports of their energy consumption to the GUEP administration team[2]. These reports included monthly aggregate electric and natural gas energy consumption for the residential and municipal sectors, plus the total number of residential bills issued for electric and natural gas service. Communities also submitted baseline energy reports for 2013 and 2014, which were compared to the quarterly reports submitted throughout the competition period to assess overall savings. While communities were competing against their peers, their energy data was only compared to themselves and how much energy they saved in 2015 and 2016 over the baseline years. Performance in the competition, and the energy performance rankings are based on the 24-month average of the normalized energy performance per residential energy customer using the simple formula:

Overall Energy Score = 100 x (Competition Average - Baseline Average) / Baseline Average

Competition data was normalized for weather, population, and to account for the "source energy" required in to produce the energy in the "full-fuel-cycle". Weather normalization and source-energy conversion was handled by the U.S. Environmental Protection Agency's Energy Star Portfolio Manager[3], a free and web application. To normalize each community for its relative size, GUEP divided the total normalized energy consumption by the number of residential bills issued each month. Residential energy bills were used as a standardized way of comparing energy use of two different sized communities by calculating the average energy consumption per residential customer. It is important to note that the final evaluation of the Prize will be based on the additional qualitative criteria described above, but the monthly performance ranking was based solely on performance.

2.2. Data collection and categorization

Since the final GUEP performance data will not be available till Fall 2017, extensive keyword searches of online public sources including published articles and community websites were the primary data source of this study. This was done in order to identify categories of major activities and efforts that the various cities were utilizing to reduce their energy use. The three common categories that emerged from this extensive search of online materials and subsequent categorization exercise were Engagement, Financial investments and Assessments.

2.2.1 Engagement:

E1 - Gaming & Competitions

Games are typically categorized as individual efforts at homes and businesses to make buildings more efficient. Competitions were dependent on team efforts or individual efforts that contributed to teams for homeowners and neighborhoods. Games and competitions were available to their communities most often in digital formats as web-interfaces or apps. Physical games like Energy Bingo or the Fargo K-12 Energy Challenge were implemented as well. For example, *Walla Walla, Washington* implemented Walla Walla Power Play, where residents track energy-saving actions on a bingo card. *Fremont, California* had the Green Challenge awards points which ranks participants for energy-efficient actions. *Fargo, North Dakota* designed, coded and implemented two games, a web-based digital platform for community members to reduce energy in homes, and the K-12 Energy Challenge for teachers, students and administrators to reduce energy in their schools.

E2 - Community Education, Engagement

This category includes sustainability workshops, community education and outreach and all such approaches to raising community awareness about sustainability. For example, *Sunnyvale, California* had monthly Compost Workshops teach residents how to reduce food waste and create their own fertilizer free of charge.

E3 - Messaging / Branding

Cities invested in creating awareness and energy messaging around branding efforts for businesses and homes. These were typically acknowledgements of efforts and results that people or organizations made in order to become more energy efficient. For example, *Bend, Oregon* had the Do Just One Thing campaign aims to highlight how small actions can have a large impact over time; the Bend Energy Challenge also refers to all participants as “Energy Heroes.”

E4 - Prizes

Prizes, in-kind or financial prizes were often used as rewards for participation by various communities. These prizes were typically not associated with competitions and other engagement programs. For example, *Takoma Park, Maryland's* Neighborhood Energy Challenge used branding efforts to incentivize energy efficiency, and offered a $2,000 prize to neighborhoods that are working on reducing energy.

E5 - Misc

These were unique efforts that Includes affordable, high-efficiency passive houses project, energy reduction house parties, alternate transportation fair, community action/empowerment workshops, community gardens, monthly sustainability themes, and building benchmarking. For example, *Madison, Wisconsin's* Green Madison encourages residents to host Energy House Parties, where a “local energy expert” teaches guests about energy efficiency within the home. Or Fargo, North Dakota created a partnership with the architecture program at the University and local non-profits to design and build affordable, Passive Houses for low-income families.

2.2.2 Financial:

F1 - Incentives

This category includes financial programs to incentivize energy reduction but not tied to particular action items. Often these programs might be paired with with upgrades, retrofits and rebates. For example, *Park City-Summit County, Utah's* Summit Community Power Works connects residents to state incentives, including the Utah Solar Incentive Program.

F2 - Upgrades, Retrofits, Rebates

Programs to pay for physical improvements to homes and replacement to more efficient appliances. For example, *Aspen, Colorado's* Energy Smart Colorado hosts an application for Home Rebates to connect homeowners to programs that make energy-saving upgrades more affordable.

F3 - Weatherization

Improvements to increase the efficiency of homes; several programs specifically offer free weatherization for low-income renters and homeowners. For example, in *Champaign, Illinois*, the County Regional Planning Commission funds a weatherization program that prioritizes low- and moderate-income, elderly, and disabled applicants.

F4 - Renewables

Renewable energy including solar and wind power, is often purchased in co-ops or other community-based groups. For example, *the City of Palo Alto, California* is setting an example for its residents by installing solar energy for municipal buildings, creating the necessary infrastructure for solar long-term, and offering incentives for residents to install solar for electricity and water heating.

F5 - Loans, Financing

Financing programs to make weatherization, upgrades and renewable energy accessible to lower-income residents. For example, *City of San Mateo, California* offers financing options to those looking to install solar panels.

2.2.3 Assessments:

A1 - Assessments

Online and in-person assessments of home energy efficiency. For example, *Anacortes, Washington's*, Anacortes Community Energy provides both an online dashboard for tracking home energy use and referrals to professional energy assessors.

A2 - Customized Advice, Energy Coaching, Plans

Individualized plans and advice for improving the energy efficiency of homes. For example, *Bellingham, Washington's* Bellingham Energy Prize offers an online assessment dashboard complete with individualized plans to improve energy efficiency in the home.

Once the activities were categorized, the cities were ordered by their current GUEP rankings and all activity categories that the cities pursued were recorded (Figure 1 & 2).

City	#	Activity Type												# of activities
		E					F					A		
		1	2	3	4	5	1	2	3	4	5	1	2	
South Burlington, VT	1									X		X		2
Aspen, Co	2		X					X		X		X	X	5
Park City- Summit	3						X	X	X	X				4
Claremont, CA	4			X				X		X		X		4
Sunnyvale, CA	5	X	X		X			X				X	X	6
Montpelier, VT	6					X			X	X				3
Palo Alto, CA	7		X					X		X				3
Anacortes, WA	8						X	X		X	X	X		5
Knoxville, TN	9							X				X		2
San Mateo, CA	10							X		X	X			3
Fort Collins, CO	11	X					X	X						3
Bellingham, WA	12	X		X				X		X		X	X	6
Waterbury-Duxbury, VT	13									X				1
Bellevue, WA	14		X				X				X			3
Walla Walla, WA	15	X			X									2
Charlottesville, VA	16	X										X	X	3
Huntsville, AL	17											X	X	2
Columbia, MO	18							X	X			X		3
Arlington County, VA	19			X						X		X		3
Calhoun County, AR	20										X	X		2
# of ranked cities using the activity type		5	4	3	2	1	4	11	3	11	4	12	5	

Figure 1: Ranked cities with current datasets, ranked according to performance

This preliminary analysis only includes the twenty cities that have current completed and verified data sets. The early conclusions of this work are drawn from this limited dataset. The energy use data of the thirty cities (Figure 2) is currently under review pending audits for incomplete information or anomalies. In addition, the cities are in the process of submitting an activities and investments report which will be more comprehensive and indicative of all the work undertaken by the various cities. Future analysis will benefit significantly from the final community rankings and by gaining access to the qualitative reports from the communities. This will be made available following the close of the competition in Fall 2017.

From the data currently available, of all the activity categories found for both ranked and unranked cities following are some of the preliminary findings. Generally, the top ten cities focussed more heavily on the financial and assessment categories rather than engagement type activities.

Of all the activity categories, home-efficiency assessments (A1) were most frequently utilized. 12 of the ranked twenty cities and 17 of the unranked thirty cities utilized home-efficiency assessments (A1). Following closely behind were Upgrades, Retrofits & Rebates (F2) and renewables (F4) among the ranked cities. In the unranked cities group, home-efficiency assessments (A1) were followed closely by renewables (F4) and Community education programs (E2) which were followed closely by Gaming and Competitions (E1), Weatherization (F3), Upgrades, Retrofits & Rebates (F2). In the top ten ranked cities, every city had an Upgrades, Retrofits & Rebates (F2) or renewables (F4) program and six of the ten cities had both programs.

City	#	Activity Type												# of activities
		E					F					A		
		1	2	3	4	5	1	2	3	4	5	1	2	
Davis, CA		X		X			X	X				X		5
Fremont, CA		X												1
Brighton, CO		X				X								2
Winter Park, FL			X					X						2
Dubuque, IA			X									X		2
Urbana, IL		X					X		X	X	X			5
Monroe CO, IN									X			X		2
Cambridge, MA			X						X	X	X	X		5
Takoma Park, MD		X		X	X		X	X		X		X	X	8
Farmington Hills/ Farmingt		.			X		X			X		X		4
Holland, MI		X	X		X			X	X			X	X	7
Houghton Co, MI														0
Duluth, MN								X	X			X	X	4
Bates County, MO														0
Fargo		X	X		X	X		X	X	X		X		8
Atlantic City, NJ											X			1
Athens Co, OH		X							X	X		X		4
Oberlin, OH			X	X						X				3
Bend, OR				X						X		X	X	4
Corvallis, OR		X	X	X			X							4
Providence, RI			X									X		2
Chattanooga, TN			X			X							X	3
Blacksburg, VA								X	X	X		X	X	5
San Juan County, WA			X				X						X	3
Madison, WI		X				X						X		3
# of cities using the activity type		10	11	7	4	5	6	8	9	11	3	17	7	

Figure 2: Unranked cities with datasets being verified, not ranked

Of all activity categories, Prizes (E4) were the *least frequently* utilized in ranked cities and the second-least frequently used activity in the unranked cities. Messaging/branding (E3) was the other least frequently used engagement activity among the ranked cities. Interestingly, among the ranked cities within the financial category Weatherization (F3) programs were least frequently used but upgrades, retrofits and rebate (F2) programs that included weatherization as part of a list of other efficiency-related upgrades was very frequent. Loans & Financing (F5) was the second least frequently used program within the financial category for both ranked and unranked cities. General incentive (F1) programs that are offered by entities other than the municipality could include federal or state incentives, were not as frequently emphasized in ranked cities or unranked cities as the local upgrades, retrofits and rebate programs that connected people to programs that pay for physical improvements.

Since these preliminary findings are based on a limited data set they are likely to adjust when the complete dataset is available. Although we have noted some general trends in the current data, there does not seem to be any clear and emphatic correlation between the number of activities or the types of activities that a city implemented and the GUEP rankings. When final data and activity reports are available, a correlation analysis will be conducted.

4.0. LIMITATIONS & CHALLENGES

Communities voluntarily participated in the Georgetown University Energy Prize (GUEP), and were therefore responsible for self-reporting on energy consumption and programs. This meant that the timelines and completeness of reports were subject to shifting priorities and resources in each community and would sometimes lag for weeks or months beyond required deadlines. This created inconsistencies across any given reporting period and lead to GUEP being able to update data and rankings less often than desired.

In addition, the analysis in this paper was based on the best data available while the competition was still in progress. Because of this, thirty of the fifty communities had not submitted their complete and error-free energy consumption data, and therefore may receive revised rankings once their data is updated and completed. Moreover the activity analysis was based on publicly available reports because communities had not yet submitted their complete report on program activities.

5.0 FUTURE DIRECTIONS

Once the competition is complete, this extensive data set of community energy-use, activities and efforts and existing conditions can provide the grounds of multiple future research directions. Valuable research could be conducted in determining the most impactful activities or combinations of activities to achieve maximum energy-use reductions, carbon emissions reductions and financial savings correlated to independent variables such as community conditions. Community conditions could include issues such as political spectrum (congregational delegation distribution among the Democratic, Republican and Independent parties), economic markers (poverty, household income, income per capita), demographic make-up (race, gender, age, ethnicity, household size) and community agency due to housing types (owned, rented, single family, multi-family, age of housing stock). Additional information currently being gathered and organized for every city includes political spectrum history, income information, housing types and demographics. Future descriptive and inferential analysis to discover any correlations between activity type modifying variables, community conditions independent variables and the GUEP performance dependent variables will be conducted.

A future adjustment to the design of the Georgetown University Energy Prize or other such efforts would include additional periodic incentives or other similar mechanisms to ensure more timely and up-to-date data submittals to the program administrators. While some of the variability is to be expected given the broad and distributed nature of an innovation program like the GUEP, future programs need to address the difficulties that the communities are encountering in data collection and transmittal.

CONCLUSION

This preliminary overview demonstrates that there is significant opportunity for further analysis once the complete rankings and full programmatic data is available which should lead to useful assessments of what approaches lead to successful outcomes in different conditions. This analysis would reveal successful activity category combinations correlated to community conditions. This will provide immensely valuable information for the more than 8,000 small- and medium-sized cities and counties in the U.S. that are considering future programs. Any community-wide approach to a problem is necessarily complex, and needs to accommodate the varied conditions and needs of these communities.

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REFERENCES

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology* 25 (2005), 273–29.

Arimura, T., Li, S., Newell, R., & Palmer, K. (2012). Cost-effectiveness of electricity energy efficiency programs. *The Energy Journal* 0(2). Retrieved from: http://www.nber.org/papers/w17556

Aroonruengsawat, A., Auffhammer, M., & Sanstad, A. (2012). The impacts of state level building codes on residential electricity consumption. *Energy Journal* 33(1), 31-52.

Auffhammer, M., Blumstein, C., & Fowlie, M. (2008). Demand-side management and energy efficiency revisited. *The Energy Journal* 29(3), 91-104.

Ayres, I., Raseman, S., & Shih, A. (2013). Evidence from two large field experiments that peer comparison feedback can reduce residential energy usage. *Journal of Law, Economics, and Organization* 29(5), 992–1022.

Creutzig, F., Baiocchi, G., Bierkandt, R., Pichler, P.-P., & Seto, K. (2015). Global typology of urban energy use and potentials for an urbanization mitigation wedge. *Proceedings of the National Academy of Sciences* 112(20), 6283-6288. doi: 10.1073/pnas.1315545112

Gillingham, K. & Palmer, K., 2013. Bridging the energy efficiency gap: Policy insights from economic theory and empirical evidence. *Environmental Economics and Policy* 8(1), 18-38. doi:10.1093/reep/ret021

Hirst, E., & Brown, M. (1990). Closing the efficiency gap: Barriers to the efficient use of energy. *Resources, Conservation and Recycling*, 3(4), 267-281.

Jacobsen, G., & Kotchen, M. (2013). Are building codes effective at saving energy? Evidence from residential billing data in Florida. *The Review of Economics and Statistics* 95(1), 34-49.

Jaffe, A., & Stavins, R. (1995). Dynamic incentives of environmental regulations: The effects of alternative policy instruments on technology diffusion. *Journal of Environmental Economics and Management* 29(3), S43-S63. doi: 10.1006/jeem.1995.1060

Joskow, P., & Marron, D. B. (1992). What does a megawatt really cost? Evidence from utility conservation programs. *The Energy Journal* 13(4), 41-74.

Molina, M. (2014). *The best value for America's energy dollar: A national review of the cost of utility energy efficiency programs*. Retrieved from http://aceee.org/sites/default/files/publications/researchreports/u1402.pdf

Raman, M. (2009). Mitigating climate change: What America's building industry must do. *Design Intelligence* July 7, 2009. Retrieved from http://www.di.net/articles/mitigating-climate-change-what-americas-building-industry-must-do/

Rivers, N., & Jaccard, M. (2011). Electric utility demand side management in Canada. *The Energy Journal* 32(4), 3-116.

Schultz, P. W., Khazian, A. M., & Zaleski, A. C. (2008). Using normative social influence to promote conservation among hotel guests. *Social Influence* 3(1), 4-23.

Seto K., Dhakal, S., Bigio, A., Blanco, H., Delgado, G., Dewar, D., Huang, L., Inaba, A., Kansal, A., Lwasa, S., McMahon, J., Müller, D., Murakami, J., Nagendra, H., & Ramaswami, A. (2014). Human settlements, infrastructure and spatial planning. In O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel & J. Minx (Eds.), *Climate change 2014: Mitigation of climate change* (pp. 923-1000). Cambridge (UK): Cambridge University Press.

Sobel, Deva. (1995). Longitude: *The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time.* New York: Bloomsbury USA.

Srivastava, M., (2017) Unpublished dissertation proposal, Carnegie Mellon University, DPP program.

Stern, P. C. & Aronson, E. (Eds). (1984). Energy use: *The human dimension.* New York: W. H. Freeman & Co.

Stern, P. C. (1985). *Energy efficiency in buildings: Behavioral issues*. Washington, DC: The National Academies Press. doi: 10.17226/10463

T. Ramesh., Ravi Prakash., K.K.Shukla., (2010). Life cycle energy analysis of buildings: An overview. *Energy & Buildings* 42, 1592-1600.

Vine, E.L., Jones, C.M. (2016). Competition, carbon, and conservation: Assessing the energy savings potential of energy efficiency competitions. *Energy Research & Social Science*. 19(2016) 158-176.

ENDNOTES

1 See the official Competition Guidelines at https://guep.org/about-the-prize/ for complete details on the competition structure, community eligibility, definitions, data reporting, calculations, and evaluation criteria.

2 See https://www.guep.org/energydata/ for energy data reporting templates and instructions.

3 See https://portfoliomanager.energystar.gov for more information about how Portfolio Manager performs calculations, including weather normalization, and their conversion factors for "site" to "source" energy.