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Behavior Wedge Profile: Model Development and Documentation

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Use of this Report

Dr. Karen Ehrhardt-Martinez, the Director of The Garrison Institute's Climate, Mind and Behavior (CMB) Program, prepared this report for the Urban Sustainability Directors Network (USDN) – a project of the Global Philanthropy Partnership – with funding from the Mertz-Gilmore Foundation.

This report was produced for use by USDN member cities. USDN member cities are invited and encouraged to contact the Garrison Institute or Dr. Ehrhardt-Martinez to learn more about this project and to explore opportunities for applying the model and methodologies encompassed in this report. We also encourage other interested parties (individuals, companies and organizations) to contact us to learn more about this work and to explore opportunities for collaboration in the development of city and state-level solutions to energy, climate, and environmental sustainability challenges.

Acknowledgements

This effort, entitled the "GreeNYC Replication Project," grew out of a desire to assess the availability of a low-cost approach for replicating the findings from New York City's seminal GreeNYC study on the behavioral opportunities for carbon savings in New York City.

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About the Garrison Institute and the Climate, Mind and Behavior Program

The Garrison Institute is a not-for-profit, non-sectarian organization exploring the intersection of contemplation and engaged action in the world. Our program initiatives – Contemplative Teaching and Learning, Transforming Trauma and Climate, Mind and Behavior - create rigorous, innovative, contemplative-based tools and approaches to help teachers, caregivers, human service providers, environmentalists and others on the front lines of social and environmental engagement succeed. The Garrison Institute nurtures the development of professional fields to discuss and disseminate these approaches, breaking silos and opening up dialogues between frontline professionals, scientists, and contemplatives. The organization tests these approaches in innovative pilot programs in settings from domestic violence shelters to classrooms to multi-family affordable housing buildings; refining, replicating and adapting them to new settings and larger scales, and track results.

The Climate, Mind and Behavior (CMB) Program builds on the work of sociologists, anthropologists, psychologists, cognitive scientists and others to identify effective, durable, and scalable approaches to environmental sustainability that engage and empower people, organizations, communities and cities. This work is science based and deeply rooted in an informed understanding of social systems, organizational behavior, cultural values and beliefs, cognitive biases and decision-making, among other relevant fields of research. Using social and behavioral research insights, CMB seeks to develop and implement effective approaches for achieving large-scale, people-centered solutions to climate and energy problems. To do so we work collaboratively with a diverse set of existing networks to address energy and climate issues throughout the real-estate sector, the nation's cities, and at the policy level.

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Substance and Disease Registry's (ATSDR) Petition Program. During a hiatus from university, Adam received his International Ground Source Heat Pump Association (IGSHPA) certification in residential geothermal system design and installation while working for Eastern Energy Systems in NY. At Stony Brook, he received a grant to study the impact of NYC's Greenmarkets on groups of underserved populations' and immigrants' patterns of food acquisition. He also co-designed the curriculum for the Sustainability Studies capstone course, worked as a teaching assistant, served as a Senator on the student government, was a founding member of the conservation collective and served as a campus coordinator for the Energy Action Coalition's 2011 Powershift conference.

John A. "Skip" Laitner is a resource economist who leads a team of consultants with his own group, Economic and Human Dimensions Research Associates based in Tucson, Arizona. He served nearly 10 years as a senior economist for technology policy at the U.S. Environmental Protection Agency. He won EPA's Gold Medal award for his contributions to economic policy analysis for that agency. More recently he led the Economic and Social Analysis Program for the American Council for an Energy-Efficient Economy (ACEEE), a well-known think tank based in Washington, DC. As an author of nearly 300 reports, journal articles, and book chapters, Laitner has 42 years of involvement in the environmental, energy and economic policy arenas. His expertise includes benefit-cost assessments, behavioral assessments, resource costs and constraints, and the macroeconomic impacts of energy and climate policy scenarios. Among his latest publications is a book he co-edited with colleague Karen Ehrhardt-Martinez, *People-Centered Initiatives for Increasing Energy Savings*. Washington, DC: American Council for an Energy-Efficient Economy. See, www.aceee.org/node/9275. His clients have ranged from the United Nations and the United Nations Foundation to the Appalachian Regional Commission, the Semiconductor Industry Association, Argonne National Laboratory, and the Nebraska Public Power District. He has served as an adjunct faculty member for the Virginia Polytechnic Institute and State University and the University of Oregon, teaching graduate courses on the Economics of Technology. He has a master's degree in Resource Economics from Antioch University in Yellow Springs, OH.

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Executive Summary

A growing body of research has determined that the everyday practices, decisions, and lifestyles of individuals, households, organizations, and businesses in the United States both determine current energy use patterns and existing levels of greenhouse gas emissions and also offer the potential means for large-scale, short-term and low-cost approaches for reducing our collective carbon and energy footprint. Such research suggests that behavior-related energy and carbon savings from the residential and personal transportation sectors alone amount to roughly 7-14 percent of current U.S. emissions and 9 percent of U.S. energy consumption (Gardner and Stern 2008; Dietz et al. 2009; Laitner et al 2009; NRDC and Garrison Institute 2010).

This growing body of research has inspired urban sustainability directors around the country to address the human dimensions of energy and carbon as part of a comprehensive approach to address city-level sustainability challenges. Despite mounting interest, however, these efforts have been thwarted by the lack of affordable, city-level assessments of behavior-based savings opportunities. While city-specific survey-based approaches do offer a means of collecting much needed information about existing conditions and practices, they are often expensive and time-consuming to implement. On the other hand, the existing set of national-level assessments provide an affordable alternative source of data but lack the ability to account for important sources of regional and city-level variation whether in climate conditions, building stock, technology saturation, technology use practices, attitudes or other factors that influence how energy is used locally and which types of behaviors are likely to yield the most promising savings. This report documents a third alternative that provides a low-cost means for developing city-specific assessments of behavior-based energy and carbon reduction opportunities. The product of this approach is a city-specific Behavior Wedge Profile that highlights local opportunities and targets that can guide behavior-based strategies.

What is the Behavior Wedge Profile and How was It Developed?

A behavior wedge profile is a document that summarizes the scope and characteristics of city-specific opportunities for reducing energy consumption and/or carbon emissions through the application of projects aimed at shifting existing energy use patterns, practices, and decisions. The profile is based on a city-specific estimation technique to assess both the volume of potential savings opportunities and identifying the particular sets of behaviors that are likely to yield the most sizeable savings. While the sample behavior-wedge profile (developed as part of this project) is focused on residential sector energy consumption, a fully developed profile could contain assessments for any (or all) of the following: 1) residential sector energy/carbon, 2) commercial sector energy/carbon, 3) transportation sector energy/carbon, 4) food sector energy/carbon, 5) water-related energy/carbon, 6) waste and recycling, and 7)the underlying attitudes and opinions that shape resource use practices.

The estimates contained in behavior wedge profiles rely on an estimation model that draws from several existing data sources as well methodologies used in national level behavior wedge assessments and the insights of subject-matter experts. The resulting estimates represent a set of reasonably *achievable*

savings as opposed to the full range of behavior-based savings opportunities. In order to arrive at these estimates, the model takes into account the following factors: household eligibility, the range of likely savings associated with a particular behavior, and the likely participation rate in whatever actions are required to reduce the energy footprint of a particular behavior. For example, when considering the *achievable* savings associated with air drying laundry, we start with the proportion of households that currently have clothes driers (either gas or electric), account for current use patterns and climatic conditions, assess likely household participation rates, and apply relevant savings estimates. The results provide a conservative estimate of reasonably *achievable* savings. Such estimates are calculated given the particular characteristics of the local population, their living conditions and energy use practices as indicated by existing data sources. Similar estimates are developed for a set of 23 types of behaviors and savings are calculated for both the short term (<4 years) and the medium term (<8 years). Medium-term savings were calculating by reassessing household eligibility given changes in product saturation and/or shifts in behaviors needed to achieve short-term savings. The process begins by assessing short-term savings opportunities (1-4 years), followed by an assessment of medium-term savings opportunities (years 5-8). These savings estimates are then added together to determine the cumulative savings opportunities in the medium term (within the first 8 years). Once the full set of estimates has been developed, they are tallied to determine the overall size of the local behavior-based savings opportunity and then rank ordered to identify those opportunities that represent the largest savings opportunities.

How can Behavior Wedge Profile Assessments be Provided at a Low Cost to Cities?

Behavior Wedge Profile Assessments can be provided in a relatively inexpensive manner through the use of existing data sources and through a collective, one-time investment in the development of the underlying model. The use of existing data sources from the Energy Information Administration, the U.S. Bureau of the Census (among other sources) eliminates the need for developing, fielding and analyzing unique, city-specific surveys as a means of data collection and assessment. While the full development of the estimation model for all seven sectors is likely to be expensive, it represents a one-time investment with potential application in an unlimited number of cities.

Is the Information Rigorous, Valid and Reliable?

A variety of factors suggest that the approach described in this report represents a rigorous, valid and reliable means of creating city-specific measures. First, the assessments are based on high-quality data collected by reputable government agencies including the U.S. Energy Information Administration and the U.S. Census Bureau[1]. The use of such high quality data sources provides confidence in the reliability and validity of the source data used in the development of the behavior wedge profiles. Second, the behavior wedge framework is modeled on methodologies used to develop national-level estimates which have been scrutinized by way of several peer-review processes. As noted earlier in this report, these methodologies draw from the work of Dietz et al. (2009) – as published in the Journal of the National Academies of Science – as well as Laitner et al. (2009) – as published in the proceedings of the

[1] The Energy Information Administration administers it Residential Energy Consumption Survey every four years and the micro data are released incrementally at later dates. The limited frequency of EIA's data collection efforts may be considered a limitation associated with the use of these data.

ECEEE summer study (an international conference attended by many of the most prominent energy experts from around the world) among other sources.

Finally, while the sample behavior wedge profile (developed as part of this project for the city of Baltimore) represents a *preliminary* application of the model described in this report, a fully developed model offers the opportunity for rigorous and reliable estimates of behavior savings opportunities if fully developed as recommended. Currently, the greatest limitation of the behavior wedge model lies in its estimates of likely participation rates. Estimated participation rates are typically drawn from evidence from past programs and may also rely on the expertise of researchers and program implementers. These estimates can be enhanced through the use of Monte Carlo simulation techniques (as performed by Laitner et al). and other methodologies that assess multiple scenarios and a range of outcomes. In order to maximize the validity of estimates, the full development of the model would ideally involve a rigorous peer-review process that would draw on the expertise of a set of energy experts from relevant organizations and agencies and potentially include some scenario assessments for those estimates with the highest levels of uncertainty. This type of approach would ensure that behavior wedge profile estimates are both consistent and valid measures of the *achievable* behavior-related savings opportunities.

How Does This Approach Compare to the Use of City-Specific Surveys?[2]

As summarized in the table provided below, an overall assessment of the advantages and disadvantages of the behavior wedge model versus a city-specific data collection effort reveals large economic advantages and time savings for city employees associated with the development and application of the behavior wedge model while the principle advantages of a city-specific data collection effort are its ability to ask questions not addressed in existing data sources and to use the primary survey data to perform population segmentation analysis. While primary data collection is required in order to perform population segmentation analysis, it is important to note that many cities may not choose to engage in this effort regardless of how the initial estimates are made. In addition, Section 8 of this report outlines a low-cost alternative approach to segmentation analysis should cities opt for the development of a behavior wedge profile. As discussed in Section 8, this approach recommends the use of targeted surveys and suggests the development of a set of survey modules to provide a low-cost means for data collection.

Point of Comparison	Behavior Wedge Profile	Primary Survey Data Collection
Cost per city	Low Cost	High cost
Effort required of cities	Low	High
Level of Rigor, Validity and Reliability[3]	Med. to High	Med. to High
Ease of (optional) Segmentation Analysis	Requires targeted but small-scale follow-up survey	Can be performed using original survey data

[2] A more detailed explanation, providing further clarification concerning the reliability, validity, and rigor of the conclusions drawn, is supplied in the Conclusions section of this report.

[3] Because the methodologies associated with primary survey data and those used to create the BWP are dramatically different, only a rough comparison or rigor, validity and reliability can be made. For these reasons we present our overall estimates as a likely range.

Estimates of behavior-related savings opportunities (regardless of whether the estimates come from the implementation of the behavior wedge model or primary data collection) may be supplemented with utility data. However, two important notes should be made here concerning the availability and scope of utility data. First, most utilities have not been willing to share energy use data with cities or other entities, effectively barring the ability to use this source of information in the analysis of local patterns and trends. Second, even when utility data are made available, they typically only provide information about energy consumption patterns at the building or community level but cannot provide information about technology saturation or use within buildings. Thus, even when utility data are available, the level of insights that they can provide about behavior-related savings opportunities is much more limited when compared with either the information provided by a behavior wedge profile or city-specific, primary data collection efforts.

How Can the Behavior Wedge Profile be Utilized by Cities and/or Regional Governments and Organizations?

Cities have expressed an interest in using the information provided in behavior wedge profiles to help them:

1) Document the scale of savings opportunities associated with behavior-related approaches,
2) Identify specific behavioral opportunities that offer the most promise of resource savings,
3) Evaluate the relative importance of behavioral initiatives as part of a larger, city-wide sustainability, climate, and/or energy initiative,
4) Prioritize investments in different types of projects and programs and focus limited resources on a more precise and promising set of interventions,
5) Write more effective funding proposals,
6) Make the case for pursuing behavior-based opportunities with team members, supervisors, partner organizations, city councils, and others,
7) Validate decisions to pursue a particular project focus or project design,
8) Develop more targeted marketing and communications efforts, and
9) Make better work plan decisions for personnel.

How Can the Behavior Wedge Assessment Model be Utilized by Cities?

Cities have several options for how they might want to use the information contained in this report: 1) creating an in-house assessment, 2) working collaboratively with the Garrison Institute to develop an assessment, or 3) contract with the Garrison Institute to develop the assessment as part of a multi-city collaborative. First, cities can use the information provided in this report to develop their own estimates by collecting the relevant data from the secondary data sources identified herein, refining and applying the appropriate set of algorithms, analyzing the data, and creating their own profile report. Second, cities can work collaboratively with the Garrison Institute through a consulting-type relationship in which the Garrison Institute would provide assistance on an as-needed, hourly basis.[4] Third, cities can join a multi-city collaborative that is currently working together to establish a common funding pool and

[4] The information contained in this report represents the intellectual property of Dr. Karen Ehrhardt-Martinez and the Garrison Institute and has been provided for the use of the employees of USDN member cities, however the sharing and use of this information with and by others is expressly prohibited.

a contract with the Garrison Institute to refine the Residential Sector Assessment model and profile, to develop a Commercial Sector Assessment model and profile, and to develop a set of city-specific profiles for those cities involved in the collaborative. Finally, once the Behavior Wedge Assessment model has been fully developed, cities will have the option of simply purchasing a Behavior Wedge Profile from the Garrison Institute. The cost of such profiles will simply reflect the labor required to isolate the relevant data, run the model and develop the profile. We anticipate that the cost of this process will be $2,000-$5,000.

What are the Next Steps in Developing and Applying the Model?

The Garrison Institute is working with a set of USDN member cities to develop and refine the Behavior Wedge Assessment Model and Profile Reports to assess behavioral opportunities for reducing energy consumption and carbon emissions in the residential and commercial building sectors. For more information, please contact Dr. Karen Ehrhardt-Martinez (KarenE@GarrisonInstitute.org) or Adam Meier (AdamM@GarrisonInstitute.org).

1. Introduction

A growing number of cities across the United States have recognized the importance of engaging with urban residents in an effort to move away from wasteful energy use practices, reduce energy consumption and lower carbon emissions. And an expanding body of peer-reviewed research supports this interest. As documented in several recent studies, when compared to more traditional technology-focused efforts, people-centered initiatives can achieve faster reductions with much smaller investments – all while achieving meaningful contributions toward sustainability goals. Such studies have provided clear evidence of national-level savings opportunities, but they have been much less successful at identifying city-specific opportunities that take into consideration the unique factors that define local conditions such as local climatic conditions, the age and other characteristics of the local building stock, technology saturation, technology use patterns, and the lifestyles, attitudes, and preferences of local populations.

The successful development of effective interventions at the city level requires that city sustainability managers are able to gain access to much needed city-specific information about behavioral opportunities that recognize local conditions and enhance the likelihood of effectively engaging city residents. Not surprisingly, however, this type of information has not been readily available and is expensive to develop when cities are required to independently engage in their own primary data collection efforts.

To begin to address these barriers, a collaborative effort was initiated in December of 2011 involving the Garrison Institute's Climate, Mind and Behavior Program, the Urban Sustainability Director's Network, and a core group of urban sustainability leaders. The goal of this collaboration was to explore opportunities to develop a low cost model for identifying and prioritizing behavioral targets for energy/climate programs; one that would be informed by the GreeNYC behavior change prioritization process but could be applied to cities of various sizes across the country.

The collaboration resulted in the development of a model that uses a variety of *secondary* data sources in the creation of city-specific characterizations of behavior opportunities for energy and carbon savings. The model was applied to create a proto-type report or sample behavior wedge profile for the city of Baltimore. The purpose of this report is to document the development of the low cost model and how it was applied to create the sample behavior wedge profile for the residential sector.

Following this introduction, Sections 2, 3 and 4 of the report provide a more detailed description of the project context, a review of some of the important patterns of regional variation, and a review of potentially useful secondary data sources. Section 5 presents a summary of national-level research studies and their findings regarding behavior-based opportunities for energy and carbon savings in the residential and personal transportation sectors. Sections 6 and 7 are focused on the characteristics of the sample residential sector behavior wedge profile and the model that was used to create it. These sections provide a detailed description of the information contained in the profile as well as the methodology employed by the model to assess the specific savings opportunities associated of

particular sets of energy use practices. Section 8 provides a description of other approaches that might be used to provide additional information about local conditions and allow for further targeting of efforts by means of population segmentation. Finally, Section 9 provides some reflections concerning both the value of the proposed approach as well as its limitations, discusses issues of reliability and validity, and suggests several potential means of supplementing the information provided in a profile. (Table of Contents)

2. Context

The insights presented in this report were developed through a collaborative effort involving the Garrison Institute's Climate, Mind and Behavior Program, the Urban Sustainability Director's Network and a core group of urban sustainability leaders in response to their interest in "replicating" the innovative, behaviorally-focused work being done through the GreeNYC initiative (part of New York City's larger sustainability efforts). In 2011, GreeNYC – the public outreach arm of PlaNYC – undertook a comprehensive analysis of the relative environmental impacts of sustainability actions, as well as the barriers to their adoption (City of New York 2013). The analysis found that individual and household actions offered significant opportunities for carbon reduction in New York City. In fact, the cumulative impact of the set of priority sustainability actions, identified in the aforementioned assessment, show the opportunity to achieve an 7.5 percent reduction in New York City's overall greenhouse gas emissions through public education.

In response to the launch of this unique effort in NYC, USDN joined with the Garrison institute and a small group of sustainability leaders to explore opportunities for developing a low-cost model for replicating the NYC initiative in both large and small cities around the country. We refer to this joint effort as the "GreeNYC Replication Project. As part of this effort, a planning grant was secured to 1) assess the methodologies employed in the NYC program, review the NYC findings and assess their relevance for other U.S. cities (especially given distinct characteristics of local populations, climates and built environment), 2) explore multi-city and regional approaches to program design, and 3) explore alternative models and approaches to a people-centered initiative.

Assessment of NYC Program: The findings from the initial CMB review of the GreeNYC research concluded that the findings from the NYC study would be of limited value to other cities due to the unique characteristics of NYC's built environment, housing stock, transportation patterns, saturation of technologies in NYC's households, and characteristics of the NYC population and their specific attitudes and opinions. In addition, the questions asked in the NYC study were designed based on the assumption that subsequent programs would rely on the use of a set of large scale media strategies as a core component of their efforts for generating a change in behaviors. This important underlying assumption was inconsistent with the approaches that other cities indicated they were likely to employ. The fact that most cities were unlikely to pursue broad, large-scale media campaigns suggests that the wholesale replication of New York City's approach would add unnecessary costs to the data collection efforts of most cities and should therefore be avoided if the goal the development of a *low-cost* model for informing behavior-oriented programs. Finally, another important consideration was the fact that the NYC research included a broader array of potential sustainability strategies than other cities considered as likely program targets. For example, the NYC study inquired about general consumption practices and patterns, while most of the cities who were interested in replication were primarily concerned with energy efficiency and conservation in residential and commercial buildings, followed by food systems, transportation, waste/recycling and water consumption.

Exploration of Alternative Models: Given that the NYC research results were not suitable as a means of informing programs in other cities, the task turned to identifying important strengths and weaknesses of the model and the identification of an alternative model that could be replicated in other cities. Two of the most important strengths of the model were: a) its rigorous collection of information concerning existing practices and local demographics, and b) the application of that information to determine the sets of behaviors that offered the promise of the greatest savings and to identify the population segments that were most likely to adopt new behaviors. Three of the biggest potential drawbacks of replicating the study in other cities are: a) its cost, b) it reliance on self-reported data (questionable validity), and c) that it didn't explore the potential of behavior-based energy savings in commercial buildings[5].

In order to keep costs low, the focus turned to identifying existing data sources that could be used to develop a low-cost, *alternative* means of helping cities to determine the most promising behavior-based opportunities for achieving city sustainability goals. This effort resulted in the identification of numerous data sets that span several categories of sustainable behavior from energy use in residential and commercial buildings to transportation and waste/recycling. The review of existing data sources documented the strengths and weaknesses of each data set, whether the amount of regional variation in each was significant, and how the information compared with measures from the GreeNYC survey. This effort showed notable variability in residential energy end-use consumption and demographic characteristics across and within regions.

Subsequent effort was spent exploring in more depth the data available through the 2009 Residential Energy Consumption Survey (RECS) and the development of a sample behavior wedge profile with the goal of illustrating how the data could be used to create a rigorous, meaningful, and easy-to-use source of information for city sustainability managers. The resulting *Residential Sector Behavior Wedge Profile* was developed for the city of Baltimore as a "proof of concept". This report documents the model that was used to create the sample *Residential Sector Behavior Wedge Profile.*
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3. Patterns of Regional Variation

As stated earlier, one of the primary goals of the GreeNYC Replication project was to determine whether and to what extent the findings from the GreeNYC behavioral research were likely to be generalizable to populations in other cities and regions given potentially important city-to-city differences in demographic characteristics, climatic conditions, characteristics of the built environment, technology saturation and technology use patterns. Our assessment of regional variation was primarily focused on measures associated with residential energy given that the GreeNYC research was similarly focused on understanding individual and household level behaviors and had collected a large amount of data on energy-related measures. The first step of our assessment was the identification of a set of indicator variables that are closely associated with residential energy demand. The second step of the assessment involved the documentation and evaluation of the scope of regional variation across the chosen indicator variables. For any given variable, low levels of variation across regions would indicate a greater likelihood that findings from the GreeNYC research would have applicability to other cities in other areas of the country. High levels of variation across regions indicate a lower likelihood of applicability of GreeNYC findings. In other words, there is an inverse relationship between the level of variability and

[5] Commercial buildings were not in the scope of the NYC study because the study was conducted to inform the work of GreeNYC which exclusively focuses on residential behavior change.

the generalizability of the findings. One additional consideration is the number of variables for which there is considerable levels of variation. High levels of variation in a *large number* of variables is a strong indication that GreeNYC findings are likely measuring many unique characteristics of living conditions and practices associated with New York City, suggesting the GreeNYC findings should not be used to identify opportunities in other cities and regions.

Assessing Variability:
In order to assess variability, we used the micro-data from the Energy Information Administration's 2009 Residential Energy Consumption Survey (RECS). The RECS data set is comprised of household-level data for more than 12,000 households across the United States. Data collection involved mixed methods including survey research and home visits to ensure the validity and reliability of the information collected. Households were selected using a stratified random sampling method. Statistical weights were developed to ensure that the resulting data are representative of populations at both the national level, as well as regionally, and (in some cases) by state. Data from the 2009 RECS have been tabulated for each of the four major Census regions, the nine Census divisions, and 16 States and are considered to be representative of the 113.6 million housing units that are occupied as primary residences. RECS data include a broad set of household-level measures of regional climate measures, building characteristics, technology saturation, technology use patterns, and demographic measures.

* Additional information about the RECS data are provided in Section 4 of this report entitled "***Existing Data Sources Across Sectors***".

Data Organization to Assess Variation:
Our preliminary assessment of variability compared national, regional and state-specific measures (averages, medians, and proportions) for a set of household level indicator variables. In order to make the comparisons, we created a set of tables that provided National measures as well as measures for each of the four Census regions and five specific states (or state clusters) including: New York, Colorado, California, North and South Carolina, and the four state area of Washington DC+ Delaware+ West Virginia + Maryland. These 5 state-level selections were chosen to reflect the areas and interests of the USDN representatives involved in the GreeNYC replication project.

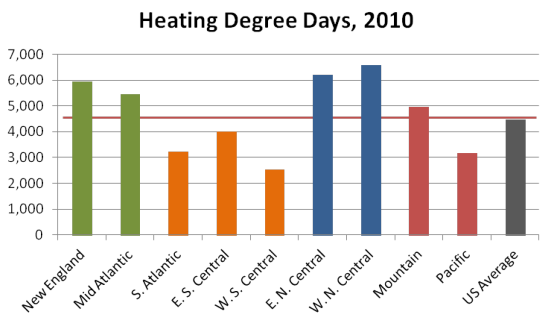
A set of 63 indicator variables was identified to represent those factors that play significant roles in determining total household energy use in different parts of the country. Among the variables chosen, many were selected because they were also included in the GreeNYC data set and therefore would serve as a point of comparison with GreeNYC research findings. The choice of indicator variables also sought to consciously include those variables that were among the best measures of individual and household practices, technology use patterns, and the availability of alternative choices – regardless of whether similar measures were included in the GreeNYC survey. These variables were selected due to their relevance to the development of behaviorally-focused energy reduction programs and would also allow for comparisons across regions and states. The selection of variables relied on expert-level knowledge of residential energy demand and information from a selection of EIA reports on residential energy consumption.

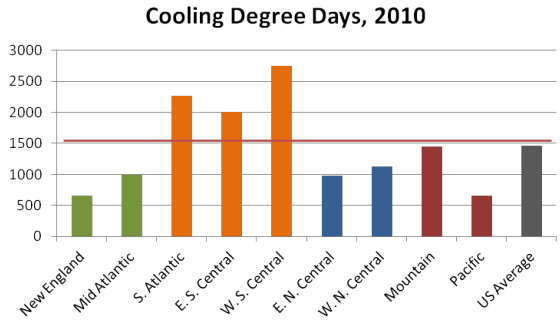
The indicator variables were organized into six categories: demographic measures, infrastructure measures, measures associated with heating and cooling, appliances-related measures, electronics-related measures, and housing characteristics. Some examples from the assessment are described in the following section.

Note: Additional information about the data organization, measures of regional variation, and the variables used to assess variability are contained in Appendix 2.

Regional Variation Assessment Findings:
The assessment of variation (across four Census regions and five state-level areas) revealed significant variation in nearly all categories of indicator variables. We assessed variables in categories such as: climactic, infrastructural, housing characteristics, demography, existing appliance technology and its use patterns, existing electronic technology saturation and its use patterns, electricity consumption, and relevant GreeNYC variables. Below are examples of variation in several areas that are important to determining potential interventions, particularly in the residential sector. For additional detail on variability please see the appended presentation on the topic.

Climactic Variation:
Not surprisingly, comparisons across regions revealed significant variation in heating and cooling degree-days (HDD, CDD) by region. This range of variation has a significant impact on both current energy use patterns and in determining the achievable savings opportunities associated with particular energy end uses – especially those associated with heating and cooling related behaviors. As noted in each of the charts provided below, heating degree days in the north central regions of the U.S. are more than twice as high as they are in the pacific, south Atlantic or west central regions. While the average number of heating degree days is just over 4500, the coldest regions of the country exceed regional averages over 6000. Variation in cooling degree days is even more dramatic with some southern regions experiencing nearly *5 times* the number of cooling degree days as compared to New England and Pacific states.





Residential Housing – Infrastructure Characteristics:
The infrastructural makeup of a city is influenced by many factors, among them; when a city was established and grew, geographic limitations on development, and economic drivers. From the age of housing stock to the type of fuel used for heating, infrastructural variables such as these influence potential savings opportunities and the development of programs designed to decrease energy and resource consumption. Our assessment of the RECS data on infrastructural variables revealed the following highlights:

- ***Northeast*** tends to be more urban (86.5 percent) with older homes and fewer single family detached homes. The housing stock relies heavily on natural gas and fuel oil for heating.

- ***Midwest*** is less urban (76.8 percent) than NE and West and there are a lot of single-family detached homes. Slightly more than 1/5th of Midwest homes were built since 1990 and most homes are heated by natural gas.
- ***South*** is the least urban (67.9 percent) (with exceptions). There are large numbers of single-family detached homes and lots of newer homes - most of which are heated by electricity.
- ***West*** is highly urban (86.7 percent) but single-family detached homes predominate (62 percent). There are lots of newer homes (28 percent) and natural gas (55 percent) and electric heat (28 percent) make up the majority of heating fuel types.

Existing Heating/Cooling and Appliance Technology Saturation and Use:
[Additional information can be found in Appendix 2, Section 2B, slides 17-20]
Household heating and cooling equipment, appliance technologies and electronic technologies make up a majority of residential energy consumption. Understanding the regional patterns of technology saturation and technology and its variation across regions is important considering that many factors influence the rate of technology adoption and availability. There were many variables in RECS that pertained to household appliances and electronic technologies. In our assessment of the regional variation we considered technologies that presented achievable savings based on the behavior change requirements, potential savings, and the likelihood of adoption.

*The figures below represent several examples of the indicator variables that were assessed for household appliance technology. In addition to those described below we assessed; type of central AC, window/wall AC units and number of units, main heating fuel and equipment, programmable thermostat saturation for heating and cooling equipment, second refrigerators, clothes washers and type of clothes washer as an indicator of efficiency, dishwasher use, and clothes dryer use.

Household Heating/Cooling Technology:

- **Central Air Conditioning:** Use of central AC is highest in the South (82 percent) and Midwest (66 percent) and is lowest in the West (44 percent) and Northeast (35 percent) and very low in New York (21 percent).
    - **Central A/C Usage:** Of households with AC, there was significant variation in the proportions of households that report using their AC all summer. The South was highest (67 percent) while other Census regions were between 35-38 percent. New York was significantly lower (20 percent) than the Northeast average.
- **Ceiling Fans:** The proportion of households with one or more ceiling fans was highest in the South (84 percent), average in the Midwest (75 percent) and low in the Northeast (60 percent) and the West (63 percent). New York was ten percentage points lower than the Northeast with a saturation level at 50 percent of households.
    - **Ceiling Fan Usage:** Regular ceiling fan use for households with fans varies from 66 percent in the Northwest to 72 percent in the South to a low of 59 percent in the Northeast. Regular fan use in New York is at 57 percent. Therefore, the data show that households in the Northeast have fewer fans and are less likely to use them.

Household Appliances Technology:

- **Dishwasher:** The saturation of households that use a dishwasher is highest in the South and the West (62 percent) and lowest in the Northeast and Midwest (55 and 57 percent respectively). Variation between states is higher than the variation between Census Regions. The proportion

of New York households use dishwashers is 44 percent, in Colorado 79 percent, and in California 53 percent of households use dishwashers.

- **Dishwasher Use:** Between 30-34 percent of households use their dishwasher between 2-3 times a week. Most households use their dishwasher four or more times per week. Frequent use of a dishwasher is highest in the Midwest (40 percent) and lowest in the South (33 percent). 40 percent of households in Colorado use their dishwasher more than 4 times per week while only 27 percent of households in North and South Carolina use their dishwashers at the same rate.

Household Electronic Technology:
RECS contains many variables that were not included in our assessment of electronic technology adoption and use for the same reasons described earlier; potential savings, likelihood of adoption, behavior change requirements. The survey also includes more nuanced information about some of the variables that are included. As mentioned, the RECS codebook is included as Appendix 4.

Interestingly, the variation of electronic technology was relatively low among the areas of residential energy consumption that we assessed. The relatively equal access to fairly cheap technology differs little across regions. Variation is more likely to occur between socio-demographic and socio-economic variables than broad geographic variables.

In addition to the variables presented below on household electronic technology and use, the following were also included in our assessment; number of computers and use of most-used computer, number of rechargeable electronic devices, device power management, TV display type and hours used per week/weekend, and saturation of peripherals connected to TV.

- **Computers:** Households with one of more computers ranged between 74-80 percent across regions. Households in the West are least likely to be without a computer and more likely to have two or more computers and laptops.
  - **Computer Use:** there was little variation in computer use as well.
    - 35-40 percent of households with computers report using their computers for 1-3 hours per day.
    - 56-61 percent of households report turning off their computers when they're not in use.
- **Device Power Management:** We did find significant variation in household's reported power management of their electronic devices.
  - 23-34 percent of households report always having chargers plugged into the wall. This behavior is lowest in the Northeast (23 percent) and highest in the South (34 percent). The Midwest and West fall in between at 30 and 29 percent respectively.

**Additional information can be found in Appendix 2, Section 2B, slides 17-20]

Variability between GreeNYC findings and RECS:
[Additional information can be found in Appendix 2, Section 3, slides 25-28]
In addition to assessing nationwide patterns of regional variation, the study also sought to assess the degree to which GreeNYC data (for New York City) was consistent with RECS data for New York State and urban areas of New York State as well as with other data for New York City. To do so, comparisons were made across a set of indicator variables to ascertain the degree to which GreeNYC data might "represent" the experiences of state residents in other New York cities and in the state as a whole.

Finally, observational data from a market survey of New York City residents was used as a rudimentary and partial test of the validity of the GreeNYC survey data.

GreeNYC's innovative efforts to collect and assess a broad set of critical data concerning current household practices, intentions, and attitudes along with its plans to use this information to actually realize the behavior-based opportunities for reducing energy consumption and carbon emissions, has earned the City recognition as a leader and innovator among cities. A core part of the GreeNYC effort entailed the fielding of a unique survey of New York City residents to obtain much needed information about the city's diverse population. Data were collected from 2149 city residents and then weighted to reflect certain population characteristics of New York City (New York City 2013). This information was then used to populate a set of carbon estimation calculations, allowing for the evaluation of various emissions reduction strategies.

While the data collected by the GreeNYC study was uniquely focused on New York City residents, the EIA's Residential Energy Consumption Survey collected information for a more diverse sample of residents across the state. RECS data for New York State are based on information from 839 households collected through multiple research methods. The comparisons made below contrast 1) state-level measures (RECS), 2) state-level measures for urban New York (RECS), and 3) New York City-specific measures (GreeNYC and a CFL Market Study).[6]

In this section we limit our reporting to three survey topics (programmable thermostats, energy audits, and energy efficient lighting) that highlight areas of notable variation. The assessment of these variables reveals notable variability between the GreeNYC findings and those of RECS. Some of this variation is likely associated with geographical differences in technology saturation and use. However, the comparison of New York City-specific lighting data also suggests that respondent to the GreeNYC survey may have over-reported participation in certain practices.

- **Programmable Thermostats:**
    - Fifty percent of GreeNYC respondents reported having programmable thermostats in their homes compared with just 32 percent of NY state residents (RECS) and 31 percent of urban NY state residents (RECS).
    - The GreeNYC data suggest that NYC households are roughly 56 percent more likely to have programmable thermostats than RECS data suggest for households in other NY cities.
    - These differences suggest that there may be a higher prevalence of programmable thermostats in New York City households compared to households in other NY cities and/or that there may be some over-reporting of programmable thermostats in the GreeNYC survey.

- **Energy Audits:**
    - Fourteen percent of GreeNYC respondents reported having an energy audit compared with 4.2 percent of NY state households (RECS) and 4.4 percent of *urban* NY state households (RECS).
    - The GreeNYC data suggest that NYC households are more than three times as likely to have programmable thermostats as RECS data suggest for households in other NY cities.

[6] It is important to note that each of the surveys (RECS and GreeNYC) relied on their own set of survey questions and that the ordering and wording of survey questions can affect the reliability and validity of the responses.

- **Energy Efficient Lighting:**
    - According to GreeNYC data, 85 percent of NYC households use energy-efficient light bulbs in at least 20 percent of their light fixtures.
    - A slightly different question from the REC Survey indicates that just over half (51%) of NY state households use energy-efficient light bulbs in *any* fixtures while only 44 percent of households in urban areas of New York State use energy-efficient light bulbs in any fixtures.
    - A comparison of GreeNYC and RECS results suggests that households in NY City are nearly twice as likely to use energy-efficient light bulbs as households in urban areas of the state overall.
    - Importantly, findings from a separate CFL market study based on observational data (Bickel et al. 2010) found that the percentage of New York City households with CFLs in at least 25 percent of their light fixtures was roughly 22 percent.
    - The findings from Bickel et. Al (2010) are consistent with the RECs data for urban New York but suggest that the GreeNYC data may be over-reporting CFL use in households.
    - A comparison of NY State data (RECS) with regional measures for the NE region (RECS) suggests that the proportion of NY households using energy efficient lighting is similar to that of households in the larger Northeast region but lower than every other geographical region. The highest percentage of HHs using CFLs is the West at 66 percent. The regional RECS data is consistent with the CFL study which indicates that the highest saturation of CFLs is in CA.

How does Regional Variability Influence the Applicability of GreeNYC Findings, Savings Opportunities, and the Design of Behavior-Based Strategies in Cities?

As suspected, regional comparisons revealed a great deal of variation in climate, building stock characteristics, technology saturation and technology use. Based on these findings, we can conclude that the information obtained by the GreeNYC study is not representative of household practices in other parts of the country. These findings support the notion that additional research is needed to inform the efforts of cities around the United States to develop behavior-based interventions.
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4. Existing data sources across sectors

Upon examining data from RECS in combination with the findings from GreeNYC it was determined that the variability across and between regions was significant enough to impact whether and how the findings from GreeNYC could be applied broadly. In order to provide cities with relevant data and information to guide the development of people-centered sustainability initiatives it was important to assess the types and range of publically available data for different sectors. Described below are data sources that we've identified and assessed for residential energy, commercial energy, transportation, demographics/attitude/opinions, water use, and waste and recycling. For the residential energy, commercial energy and transportation sectors there are large publically available data sources that can be used to profile a targeted region. These data can be combined with more local supplemental data, allowing a profile to more accurately reflect a targeted city or region. Sectors such as water and waste and recycling would increasingly rely on data collected at the municipal data

Residential Energy Sector:

RECS:

The primary data source used for the residential energy sector was the Energy Information Administration's (EIA) 2009 Residential Energy Consumption Survey (RECS).

The 2009 survey collected data from 12,083 households in housing units statistically selected to represent the 113.6 million housing units that are occupied as a primary residence. Data from the 2009 RECS are tabulated for the four Census regions, the nine Census divisions, and 16 States. The 2009 RECS contains detailed data from 12 more states than in past EIA residential energy surveys.

The 16 states detailed in the 2009 RECS account for 63 percent of all primary residence homes and 64 percent of the US population. A threefold increase in the number of households included in the 2009 RECS offers more accuracy and coverage for understanding energy usage for all estimated States, Regions and Divisions.

Specially trained interviewers who collect energy characteristics on the housing unit, usage patterns, and household demographics conduct RECS. This information is combined with data from energy suppliers to these homes to estimate energy costs and usage for heating, cooling, appliances and other end uses. First conducted in 1978, the 2009 version represents the 13th iteration of the RECS program.

The results of each RECS initiative include data tables, a micro-data file, and a series of reports. Micro-data provides detailed results from all survey respondents on each variable that was asked. The micro-data also include the sample weight of each respondent; a value that indicates the number of households each respondent represents. The 2009 codebook for RECS is provided as Appendix 4, which details all survey questions and the codes used for the micro-data. The micro-data are available formatted in Excel and SAS datasets, allowing for a variety of statistical analysis.

RECS provide a large, reliable sample size with individual household level variables such as ownership of a second refrigerator. However, like any national-level survey, the more you focus in on a particular variable for a particular subset of the population the more the data coverage will be an issue. Supplemental data such as the US Census or local utility data can increase the specificity of data to a targeted location.

RECS data provide an inventory of a range of types of variables that includes housing structure characteristics, demographic information about occupants, technologies in the home, and the use of technologies. Below are several examples of specific variables within each of these categories. These represent a small fraction of the variables contained but are helpful in providing examples of the type of data contained in RECS.

- **Infrastructural and Housing Characteristics:** urban and rural; housing unit type (single family detached/attached, mobile home, etc.); year of construction; adequacy of insulation; total square footage of heated/cooled space; insulation added by current household; home is too drafty during the winter; unusually high ceilings; energy efficient light bulbs used.
- **Demographic Information**: number of household members; race of householder; age composition of household; 2009 annual household income; income relative to poverty line; received housing assistance; at home behavior: someone home all day.
- **Technologies in the Home:**

- Appliances: type of air conditioning equipment used; main heating fuel and equipment; programmable thermostat; number of ceiling fans used; second refrigerator; clothes washer; dishwasher; clothes dryer.
- Electronics: number of computers; computer type; number of rechargeable electronic devices; number of televisions; television display type; number of peripherals connected to TV.

- **Use of Technologies:**
  - Appliances: use space heating equipment; perform routine service or maintenance; heating equipment programmable thermostat set to reduce temperature during day/during sleeping hours; use patterns of central AC equipment; use patterns of central AC programmable thermostat; frequency of most-used ceiling fan use; number of months second refrigerator is turned on; clothes washer use; frequency of dishwasher use.
  - Electronics: most-used computer hours used per day; power management strategies; charging pattern for rechargeable electronics; chargers always plugged into wall; hours most-used TV is used per weekday/weekend day.

RECS: http://www.eia.gov/consumption/residential/

Supplemental Residential Sector Data:
US Census:
In the development of the Sample Behavioral Wedge Profile for Baltimore data on housing characteristics and demographics from the US Census was compared to RECS data. Specific Census data for Baltimore on housing characteristics such as the division between single-family and multi-family households and averages of household square footage were used to refine the RECS data which was representative of a four state region; Delaware, District of Columbia, Maryland and West Virginia. Demographic data such as the percent below the poverty line, proportion of renters versus owners, and population levels also allowed us to refine the values that were used in the City Profile Model. We were able to get a sense of what the Baltimore demographics and housing characteristics look like and determine if RECS data should be weighted and how much.

Census: http://www.census.gov/

US DOE Energy Star CFL Market Profile Report:
This 2010 report was prepared for the US Department of Energy. It evaluates a number of characteristics of the CFL market including market characteristics, general saturation characteristics, household characteristics, household use and placement, satisfaction, and an assessment of the future market for CFLs.

Much of the conclusions and data in the report are aggregated nationally, therefore presenting mostly averages and totals. Information that is broken out regionally includes regional CFL program spending in 2010, CFL savings as a percent of total demand-side management savings, net-to-gross values for CFL programs, regional CFL saturation (percent of sockets and number per resident), proportion of homes with low socket saturation, and consumer satisfaction with CFLs.

Energy Star Report: http://www.energystar.gov/ia/products/downloads/CFL_Market_Profile_2010.pdf

Commercial Energy Sector:

CBECS:

The primary source of data for the commercial energy sector is the EIA's 2003 Commercial Building Energy Consumption Survey (CBECS).

The Commercial Buildings Energy Consumption Survey (CBECS) is a national sample survey that collects information on the stock of US commercial buildings, their energy-related building characteristics, and their energy consumption and expenditures. Commercial buildings include all buildings in which at least half of the floorspace is used for a purpose that is not residential, industrial, or agricultural, so they include building types that might not traditionally be considered "commercial," such as schools, correctional institutions, and buildings used for religious worship. The CBECS was first conducted in 1979; the eighth, and most recent survey, was conducted in 2003.

The EIA announced in April of 2011 that the 2007 Commercial Buildings Energy Consumption Survey (CBECS) has not yielded valid statistical estimates of building counts, energy characteristics, consumption, and expenditures. Because the data do not meet EIA standards for quality, credible energy information, neither data tables nor a public use file will be released. The good news is that the EIA plans to administer CBECS in 2013 with public data to be released in the years following.

Like RECS, CBECS is administered to a nationally representative sample size and distribution. The results of each CBECS include data tables, a micro-data file, and a series of reports. Appendix 6 provides the 2003 CBECS codebook and Appendix 7 and 8 provide the 2003 and 2012 questionnaires for CBECS, respectively, which detail the codes used for the micro-data and all survey questions respectively. The micro-data for 2003 CBECS are available formatted in Excel and SAS, allowing for a variety of statistical analysis.

CBECS are designed to assess a wide spectrum of variables related to energy consumption in the commercial sector. The data are organized by building characteristics, end-use consumption variables, and consumption and expenditures by fuel source. Below we've provided examples of some core variables that are included in the building characteristics and consumption and expenditures sections of CBECS. We have not yet assessed CBECS to determine specific variables that would be used in a profile because the Behavior Wedge Profile for the residential sector was prioritized and therefore do not present detailed examples of end-use consumption variables.

- **Building Characteristics:** location; size and building age; principle building activity; employment and occupancy; energy sources and end use; heated and cooled floorspace; end-use equipment.
- **End-Use Consumption:** space heating; cooling; ventilation; water heating; lighting; cooking; refrigeration; office equipment; computers.
- **Consumption and Expenditures:** major fuels: natural gas, electricity, fuel oil, district heat, etc.

The use of additional, supplemental data would be especially useful for cities that consider the commercial sector a priority and anticipate the development of programs prior to the release of the 2013 CBECS data. Supplemental local data sources can characterize the data to reflect a given region more accurately.

CBECS: http://www.eia.gov/consumption/commercial/

Transportation Sector:

US Energy Information Agency and Department of Transportation Data:

In the transportation sector, EIA's core consumption survey was the Residential Transportation Energy Consumption Survey. RTECS belongs to the consumption group because it collects information directly from the consumer, the household. For roughly a decade, EIA fielded the RTECS--data were first collected in 1983. This survey, fielded for the last time in 1994, was a triennial survey of energy use and expenditures, vehicle miles-traveled (VMT), and vehicle characteristics for household vehicles. For the 1994 survey, a national sample of more than 3,000 households that own or use some 5,500 vehicles provided data.

With the discontinuation of the RTECS after 1994, EIA no longer had a survey of energy consumption for any part of the transportation sector. To fill the gap in household vehicle energy data, EIA partnered with the US Department of Transportation to fill this gap in energy-related transportation statistics, using the latest National Household Travel Survey (NHTS), conducted in 2001/2002. The National Household Travel Survey [formerly known as the Nationwide Personal Transportation Survey (NPTS) and the American Travel Survey (ATS)] are household-based travel surveys conducted every five years by the US Department of Transportation (US DOT) and the Federal Highway Administration (FHA) to collect data on both long-distance and local travel by the American public.

Survey data are collected from a sample of US households and expanded to provide national estimates of trips and miles by travel mode, purpose, and a host of other characteristics. The survey collects information on daily, local trips and on long-distance travel in the United States. Because the survey included direct collection of odometer-based vehicle miles traveled, EIA was able to derive energy consumption and expenditures information for the vehicles in the sample households. In that way, EIA was able to create a data set essentially comparable to the data available from RTECS.

Data tables and the micro-data from the 2001 initiative are available on EIA's website:
http://www.eia.gov/emeu/rtecs/contents.html
The data can be broken out by Census divisions and regions and state/city-level data are available for: Baltimore, MD, Des Moines, IA, Oahu, HI, Lancaster, PA, New York, Hawaii, Texas, and Wisconsin.

EIA is currently investigating the possibility of producing commercial highway vehicle energy consumption and expenditures estimates based on the 2002 Vehicle Inventory and Use Survey, sponsored by the Department of Transportation and conducted by the Census Bureau.

The EIA also provides a number of links US Government Agencies and Departments on items related to consumption and efficiency on their webpage: http://www.eia.gov/emeu/rtecs/links/federal.html

Bureau of Transportation Statistics (BTS):

The Bureau of Transportation Statistics' Research and Innovation Technology Administration (RITA) provides national transportation statistics on the US transportation system, including its physical components, safety record, economic performance, the human and natural environment, and national security. This is a large online document comprising more than 260 data tables plus data source and accuracy statements, glossary and a list of acronyms and initials. Of particular interest for a Behavior Wedge Profile is their Chapter on transportation, energy and the environment. BTS legislation specifically targets data on the volumes and patterns of passenger transportation.

Data is collected from 2012 and is updated quarterly. The BTS research includes metropolitan statistical areas for the variables; congestion, air pollution, and air quality. The data is collected from 100 US urban sites and includes some of the following characteristics:

- **Transportation sector data:** energy consumption; energy consumption by mode of transportation; energy intensity and fuel efficiency; air pollution; water pollution; noise and solid waste.

BTS: http://www.bts.gov/publications/national_transportation_statistics/

Water Use:

USGS Water Use in the US:

The US Geological Survey's National Water-Use Information Program is responsible for compiling and disseminating the nation's water-use data. The USGS works in cooperation with local, State, and Federal environmental agencies to collect water-use information. USGS compiles these data to produce water-use information aggregated at the county, state, and national levels. Every five years, data at the county level are compiled into a national water-use data system and state-level data are published in a national circular.

The goals of the National Water-Use Information Program are to:

- Analyze the source, use, and disposition of water resources at local, state, and national levels
- Reply to water-use information requests from the public
- Document trends in water use in the United States
- Cooperate with state and local agencies on projects of special interest
- Develop water-use data bases
- Publish local, state, and national water-use data reports

The USGS gathers water-data information from a large site inventory – over 1.5 million sites. The most recent publically available data – aggregated for counties and downloadable by state – is available from 2005. They expect to release a compilation report and data for the report "Estimated Use of Water in the United States in 2010" to be released in 2014. Below we've provided a summary of what the 2005 USGS report contains/does not contain.

2005 USGS Estimated Use of Water in the US:

- All States provided estimates for public supply, domestic, irrigation, livestock, aquaculture, industrial, mining, and thermoelectric power water use. All States also provided estimates of public supply deliveries for domestic use.
- All States have estimates of the total population served by public supply. States optionally estimated public supply population served by groundwater and surface water.
- All States have estimates of total irrigation. States optionally estimated subtotals for crop irrigation and golf-course irrigation.
- No consumptive-use data were collected nationally for any of the categories for 2005.
- No commercial water-use data were collected nationally for 2005.
- No wastewater release data were collected nationally for 2005.
- No hydroelectric power instream use data were collected nationally for 2005.

- Public-supply deliveries for commercial, industrial, and thermoelectric power were not collected nationally for 2005.

USGS: http://water.usgs.gov/watuse/data/

Waste and Recycling:

EPA Municipal Waste in the US:

The Environmental Protection Agency published a 2010 report entitled "Municipal Solid Waste (MSW) in the United States: Facts and Figures." The MSW Characterization fact sheet and data tables provide the most recent available data on annual US waste generation, recycling, and disposal, as well as the benefits of recycling. The majority of the data is aggregated at the national level. The 2010 report breaks out a limited amount of data by US Census Regions (NE, S, MW, W). Tables in the report that are broken out by region include; number and population served by curbside recyclables collection services, material recovery facilities, municipal waste-to-energy projects, and landfill facilities.
The EPA report also sourced some of the data used in their 2010 report from BioCycle's report, the "State of Garbage in the US"

The full report from 2010, which is released every two years, contains data on:

- Municipal Solid Waste (MSW) generation, recovery, and disposal from 1960 to 2009;
- Per capita generation and discard rates;
- Source reduction (waste prevention);
- Materials and products that are in the waste stream;
- Aggregate data on the infrastructure for MSW management, including estimates of the number of curbside recycling programs, composting programs, and landfills in the US; and
- Trends in MSW management from 1960 to 2009, including source reduction, recycling and composting, and disposal via combustion and landfilling.

EPA MSW: http://www.epa.gov/epawaste/nonhaz/municipal/msw99.htm

Biocycle and Columbia University's Earth Engineering Center: The State of Garbage in the US:

Published since 1960, *BioCycle* is the foremost magazine on composting, organics recycling, anaerobic digestion and renewable energy. Columbia University's Earth Engineering Center's (EEC) mission is to identify and help develop the most suitable means for managing various solid wastes research, and disseminate this information by means of publications, the web, and technical meetings.

BioCycle and EEC collaborate to conduct a bi-annual survey of waste generation and disposition in the US. This Survey, called State of Garbage in America (SOG) is based on information provided to EEC by the waste management departments of the fifty states in the U.S. The results of this Survey are used by U.S.EPA in computing the GHG effects of MSW management in the U.S.

The 2010 report supplies the following data by state:

- Estimated tonnage of MSW reported, recycled, composted, combusted via waste-to-energy, and landfilled.
- Quantity of materials recycled per state in 2008, per category (single stream commingled recyclables, PMG containers, paper fiber, iron/steel scrap, plastics, glass, aluminum, other metals, tires, and other.

- Number of municipal solid waste landfills and WTE plants, average tip fees, and landfill capacity for 2008.
- Waste imports and exports for 2008.
- Materials banned from landfills (yard trimmings, containers, paper, whole tires, used oil, lead-acid batteries, white goods, electronics, C&D, and other.

BioCycle and Columbia U.: http://www.biocycle.net/images/art/1010/bc101016_s.pdf

Supplemental and Local Data Sources:
State Departments of Environmental Protection/Conservation are a possible source of localized waste and recycling data for target regions and urban areas.
Example: Connecticut's Department of Energy an Environmental Protection collects and publically provides solid waste and recycling data:
http://www.ct.gov/dep/cwp/view.asp?a=2714&q=453366&depNav_GID=1645
The BioCycle website provides links to State Agencies that are responsible for waste and recycling management: http://www.biocycle.net/resources/other-resources/

Attitudes and Opinions:

Yale Project on Climate Change Communication (YPCCC):
The Yale Project on Climate Change Communication grew out of a 2005 conference on "Americans and Climate Change" convened by Yale's School of Forestry and Environmental Studies. The Project's mission is to:

1. Conduct original research on public climate change awareness, attitudes, risk perceptions, policy support, and behavior;
2. Design and tests new strategies to engage the public in climate science and solutions;
3. Empower educators and communicators with the knowledge and tools to more effectively engage their audiences.

The YPCCC has released a number of publications on American's and climate change, however of particular interest to the development of a behavior wedge profile are reports that present state and/or regional data on American's perceptions, attitudes, and opinions of climate and energy related subjects. The series of reports entitled "Global Warming's Six Americas" begins to get at these topics, however the data contained in the reports is based nationally and state-level data is not available if in fact it has been collected. The "Six Americas" study identified six population segmentations among Americans, which can help establish a baseline understanding of the diversity of American's perceptions and some patterns in their beliefs. However, the particular segmentations may not accurately characterize a target city.

YPCCC: http://environment.yale.edu/climate/publications/

Shelton Group: Energy Pulse 2012 Survey:
The Shelton Group is a marketing communications agency entirely focused on the energy-efficiency and sustainability sphere. The firm studies American on an ongoing basis and tracks their shifting attitudes and motivations around efficiency and sustainability. Their annual Energy Pulse survey examines consumers' energy efficiency attitudes and behaviors. The data is broken out by the U.S. Census Regions (NE, MW, S, W).

The 2012 Energy Pulse survey was conducted using an online questionnaire that contained fixed-response alternative, open-response and Likert scale questions.
For the 2012 Energy Pulse study, the Shelton Group surveyed a total of 1,003 Americans utilizing SSI's three million member online community. Based on the total population of U.S. households (114,567,419), results from this study would be comparable to an RDD phone sample of the U.S. population with a 95% confidence level and a confidence interval of +/- 3.09% (margin of error).

The 2012 study analyzes consumer attitudes and motivations to identify continuing trends and emerging issues on energy efficiency products and services. Some of the reports' content and conclusions include:

- How renewable energy is heating up. A look at consumers' likelihood to embrace solar energy, its potential for explosive growth and the need to position programs and products for full engagement.
- Why energy messaging isn't moving consumers from apathy and inaction – and the real key to driving energy efficiency behavior change.
- The need for EE program overhauls and a faster rollout of smart metering. One-off rewards and rebates aren't getting the job done. The report also discusses how smart metering can be part of a holistic, long-term EE program and positive customer experience.

Energy Pulse: http://sheltongrp.com/what-we-do/intelligence-and-insights/pulse-studies/energy-pulse/

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5. Review of National Behavior Wedge Assessments

The work presented in this report builds on several recent studies that have used a variety of distinct although similar approaches to estimate the amount of carbon and energy savings that could be achieved at the national level in the United States by addressing the everyday practices and choices of the nation's more than 300 million citizens (Gardner and Stern 2008, Laitner et al. 2009, Dietz et al. 2009, and NRDC and Garrison Institute 2010). This section of the report provides a brief review and comparison of these national-level assessments to provide an important foundation for understanding the development of the municipal-level behavior wedge profile framework and the sample behavior wedge profile that was developed for the city of Baltimore. In general, these studies suggest that current levels of energy consumption and carbon emissions from the household and personal transportation sectors could be reduced by an estimated 20-30% in the short to medium-term (<10 years) through efforts that sought to influence the everyday practices and purchasing decisions of households. Such savings could reduce national level carbon emissions by 7.5 to 14 percent and reduce energy consumption by an estimated 9 percent.

In 2008 Gardner and Stern presented a compelling assessment of the potential carbon emissions savings that could come from moderate shifts in the energy use practices of U.S. households resulting in reductions in home energy use and personal transportation. According to these well-regarded researchers, the strategic engagement of U.S. households in energy conservation and energy efficiency has the potential of reducing U.S. carbon emissions by as much as 11% without the need for the development of any new technologies, making any major economic sacrifices, or reducing their sense of well-being.

According to the study, U.S. households currently account for about 38 percent of national carbon emissions – just through their direct actions alone. Notably, this amount of emissions is large - "greater

than that of any entire country except China and larger than the entire U.S. industrial sector." The potential savings are also large. Gardner and Stern's research suggests that by changing the selection and use of household and motor vehicle technologies, emissions from households and personal transportation sources could be reduced by nearly 30 percent.

This savings opportunity is not new but it has remained unrealized for several important reasons. Foremost among these, households lack accurate, accessible, and actionable information on how best to achieve potential savings through their own steps. Overcoming this barrier requires that households know not only what they can do but which actions will produce the most benefits. Gardner and Stern's study points to evidence that although many householders are motivated, they lack the necessary knowledge to act and often make choices based on mistaken notions about which actions are most beneficial.

According to the authors:

> *When strategies are proposed for households, they often appear in laundry list format, giving little or no priority to effectiveness. It is easy for households that want to cope with rising gasoline prices and heating and cooling bills to respond by taking small actions under the impression they are saving energy, while they are actually making a negligible dent in their personal energy consumption.*

Similarly, estimates of potential savings made by householders often diverge dramatically from similar estimates made by energy experts (sometimes by a factor of four). In general, householders emphasize highly visible actions that can reduce energy use if repeated regularly, such as lowering winter thermostat settings and turning off lights, and they overestimate the potential energy savings from these actions. Meanwhile the savings from many actions with higher energy-saving potential but low visibility (such as installing storm windows) were underestimated.

Gardner and Stern conclude that "the public needs more direct and coherent advice concerning household and individual actions." And the demand for such advice is becoming increasingly apparent. People are increasingly asking, 'What can I do?' Unfortunately, however, Gardner and Stern found that the advice found in most books and articles is unlikely to lead to effective action because such advice takes the form of long and unranked lists of recommended actions.

> *When people are faced with a laundry list of advice, they may feel confused and overwhelmed, and consequently take no action, or they may carry out one or two actions—probably the easiest to remember and perform. However, the behaviors that are easiest to remember and perform, for example, turning out lights when leaving rooms, tend to have minimal impact on climate change. Thus, long and unranked lists of behaviors are likely to be ineffective at best and may even be counterproductive, if they lead people to feel satisfied that they have done their part after accomplishing very little.*

The solution? According to decades of research, the authors suggest: "it is much more effective to focus campaigns on a very small number of specific actions that can make a real difference and disseminate the message repeatedly through multiple media outlets, using sources that are credible to target audiences." Timing is also important. When possible, information should be provided when audience members are poised to make choices about the issue the message addresses (for example, in public health, in the doctor's office or at the cigarette counter). *A necessary first step is to identify which*

actions are the most effective. By identifying the most promising opportunities, programs can be more targeted and have a greater impact.

Gardner and Stern's assessment is based on an evaluation of 27 specific actions in the household and personal transportation sectors. They categorize 13 of the actions as curtailment behaviors in which people are required to cut back on certain activities. The remaining 14 actions are categorized as *efficiency* behaviors which they characterize as "investing in home equipment that lowers energy costs without sacrificing desired energy services." The following table summarizes the most impactful savings opportunities as identified by Gardner and Stern's study.

	Action Type	**Estimated Savings (% of sector emissions)**
Invest.	Buy a more fuel efficient vehicle	13.5%
Low cost	Install and upgrade attic insulation and ventilation	Up to 7%
Beh.	Car pool to work with one other person	4.2%
Beh.	Replace 85% of all incandescent bulbs with cfls	4.0%
Beh.	Get frequent tune ups and air filter changes	3.9%
Beh.	Turn HH temperature down (heating) or up (cooling)	3.4%
Beh.	Alter driving practices (no jack rabbit starts, etc)	3.2%
Invest.	Install more efficient heating unit	2.9%
Invest.	Replace poor windows with high efficiency windows	2.8%
Beh.	Combine trips to ½ current mileage	2.7%
Beh.	Cut highway speed from 70 to 60 mph	2.4%
Invest.	Install more efficient AC unit	2.2%
	13 Other Actions	6.6%
	TOTAL potential savings (unadjusted)	58.8%
	TOTAL potential carbon savings (adjusted for HH eligibility and double counting of savings)	30%

*Results assume that equipment is only replaced at the end of old equipment's useful life.
Source: adapted from Gardner and Stern (2008)

Several subsequent studies (Laitner et al. 2009, Dietz et al. 2009, and NRDC and Garrison Institute 2010) have performed similar assessments of the energy and carbon emissions savings opportunities associated with household energy use and personal transportation decisions. These studies have come to similar conclusions. For example, in 2009 Laitner et al. assessed the amount of *energy* (as opposed to carbon) that could be saved by households. This study explored a list of roughly 120 behaviors associated with household energy use and personal transportation practices. Similar to Gardiner and Stern, Laitner and his team of researchers concluded that current levels of energy use in the residential and personal transportation sectors could be reduced by an estimated 20-25 percent in the short-term (5-8 years), representing a reduction of 9% in total U.S. energy consumption. The estimates were formulated to reflect the "realistically achievable savings" as opposed to the entire savings opportunity assuming a best case scenario. According to the study's estimates, the largest reductions in energy consumption appear to be associated with energy end uses such as refrigeration, air conditioning, lighting, space heating and personal transportation, while more moderate savings opportunities were associated with hot water heating, consumer appliances and other miscellaneous end uses. Notably, 57 percent of the estimated savings resulted from low-cost and no-cost types of behaviors while 43 percent

were associated with household investments in insulation, appliances and HVAC equipment. Monte Carlo simulations were used to account for likely variation in: household eligibility, household participation rates, and the range of energy savings that might result from specified actions.

During the same year, Dietz et al. (2009) considered the potential *carbon* savings from a list of just 33 actions representing 17 household action types in 5 behaviorally distinct categories. Their estimates used a similar methodology as Laitner et al. (2009) with the goal of estimating the "reasonably achievable emissions reductions (RAER)." Their findings suggest achievable *carbon* savings of 20% in the household sector within 10 years if the most effective non-regulatory interventions are used. As shown in the following table, this study suggests that the largest savings are likely to be associated with ten household action types – half of these are associated with investment-type activities while the other half are strictly associated with choices and practices.

	Action Type	**Estimated Savings**
Invest.	Fuel Efficient Vehicles	5.02%
Beh.	Weatherization	3.39%
Invest.	Appliances	1.87%
Invest.	HVAC Equipment	1.72%
Beh.	Driving Behavior	1.23%
Invest.	Low Resistance Tires	1.05%
Beh.	Car Pooling	1.02%
Invest.	Energy Efficient Water Heater	0.86%
Beh.	Thermostat Settings	0.71%
Beh.	Routine Auto Maintenance	0.66%
	7 Other Actions Types	2.47%
	Total	20%

Source: adapted from Dietz et al. 2009

A final study by the Natural Resources Defense Council and the Garrison Institute (2010) also considered the potential *carbon* savings that could be achieved by U.S. households. This study found that roughly $1/7^{th}$ (14.2%) of total U.S. greenhouse gas emissions could be saved if "Americans adopted a series of simple and inexpensive emissions-reducing measures in the areas of transportation, household energy consumption, diet and waste over the next 10 years." This sum is roughly equivalent to the total greenhouse gas emissions of Germany, the largest polluter in Western Europe. The study looked at 32 potential actions and found that 38 percent of the estimated savings would come from household energy use, 29 percent from personal transportation, 17 percent from dietary shifts and reductions in food waste, and 16 percent from recycling and responsible consumption practices. Some notable differences associated with this study are that 1) it assumes action on the part of *all* eligible participants (not just a particular proportion of eligible participants), 2) it looks beyond household energy consumption and personal transportation and also considers the impact of dietary practices as well as recycling and consumption, and 3) it is predominantly focused on actions that involve little in the way of investments. The following table shows the estimated GHG savings (in carbon equivalents) from the 12 most impactful actions. These 12 actions represent nearly 70% of the estimated carbon savings that could be achieved through the 32 actions identified in the study.

	Action Type	Abatement (MMtCO2e)
Beh.	Increase recycling by 50%	106
Low cost	Address building leaks and attic insulation	84
Beh.	Car pool 2 days per week or telecommute 1 day per week	73
Beh.	Switch from red meat to poultry 2 days per week	72
Beh.	Reduce food waste by 25%	65
Beh.	Take one fewer domestic flights per year	56
Beh.	Use programmable thermostat settings	47
Beh.	Reduce idling by 50%	43
Invest.	Upgrade to an Energy Star refrigerator	39
Beh.	Hang dry clothes in summer	35
Beh.	Drop dairy 2 days per week	35
Low cost	Insulate water heater, install low flow shower heads and faucet aerators	34
	20 Other actions	311
	TOTAL	1000

Source: adapted from NRDC and Garrison Institute (2009)

These studies have done an excellent job of laying the groundwork needed to recognize the savings opportunities associated with our everyday choices and practices and the impact that they could have on energy consumption and carbon emissions at the national level. They also provide an effective framework for assessing the scale of the behavioral opportunities that abound in our nation. Where they fall short, however, is in their ability to account for important sources of variation across regions, states and cities. Because national level assessments look at aggregate savings opportunities, they do not account for area-to-area variation in climate, building infrastructure, technology saturation and technology use patterns and therefore cannot provide the information needed for the effective development and justification of behaviorally-focused policies and programs at city and state levels. (Table of Contents)

6. Description/Discussion of the Sample Behavior Wedge Profile Report

The Sample Behavior Wedge Profile (BWP) Report that was produced for the City of Baltimore serves as a proof of concept, demonstrating the feasibility of a BWP Report as a means of informing behavior-based sustainability strategies and programs. The profile is not meant to be an exhaustive report documenting all potential savings opportunities; rather its primary purpose is to provide a focused summary and rank ordering of *achievable* savings opportunities for a particular city. A great deal of additional information is available through RECS and other data sources, but it was consciously omitted from the report in order to keep the profile as simple and easy to use as possible. With that objective in mind, the BWP report focuses on identifying and characterizing existing behavioral opportunities rather than the myriad data points involved in establishing those estimates or other related (and often interesting and relevant) information.

The sample BWP report is organized so as to present aggregate-level savings opportunities first, followed by several sections that provide more detailed assessments of savings associated with specific energy end uses. It begins with an overview of all potential savings opportunities in both the short-term (<4 years) and medium-term (<8 years) by end use and by type of residence (single-family or multi-family). The presentation of aggregate-level savings is followed by two top-ten lists; the first specifying

the top ten sets of behaviors for generating savings in single-family homes and the second specifying the top ten sets of behaviors for generating savings in multi-family homes. Both lists reflect the rank ordering of behaviors based on the estimated *achievable* savings and are ordered from largest to smallest savings potential.

The *achievable* savings for each end use is estimated using algorithms that take into account a range of variables including number of households, number of households with particular end-use technologies, current practices and other measures of eligibility. More detail on the methodology used to calculate estimates for Baltimore is provided in the description of the model in Section 7 of this report.

Our goal for the BWP is to provide a useable and meaningful tool for city sustainability professionals to aid them in the development of behavior-based energy and resource savings interventions. Below is a discussion on the decision to limit the content of the profile to achievable savings opportunities, the profile's layout and framework, and the potential ways in which city sustainability officers may find the profile useful.

Achievable savings opportunities versus the universe of potential savings:
Similar to prior, national-level behavior wedge studies, the Sample Behavior Wedge Profile Report developed as part of this project represents a conservative estimate of the true range of potential energy/carbon savings that could be achieved through shifts in behaviors, lifestyles and practices. The estimate is considered to be conservative for at least two reasons: 1) the estimation methodology is focused on a subset of the long list of practices that could result in energy savings, and 2) estimates of gross savings opportunities are moderated by estimates of household eligibility and likelihood of participation. A subset of the most promising behaviors is used to simplify the assessment and the presentation of results. As described in Section 5 of this report, there are over 200 behaviors associated with residential energy consumption, each of which represents a potential savings opportunity. A profile encompassing all of these potential behaviors would be overwhelming to a city-sustainability professional designing behavioral interventions. Moreover, the benefit of identifying behaviors with very small savings opportunities is of limited value. The development of the BWP report was therefore strategically constructed with a focus on a limited range of behavior-based savings opportunities. The identification of the most relevant behavioral opportunities was informed by previous research and information pertaining to the *size of potential* savings, household eligibility, and the likelihood of adoption. **As a result, while t**he estimated energy savings presented in the Behavior Wedge Profile Report represent only a slice of the larger universe of potential behavior-related energy savings, they are likely to result in the greatest savings. Second, the Behavior Wedge Profile Report provides estimates of *achievable* energy savings. Achievable savings estimates are more realistic assessments of likely savings because they take into account likely household participation rates.

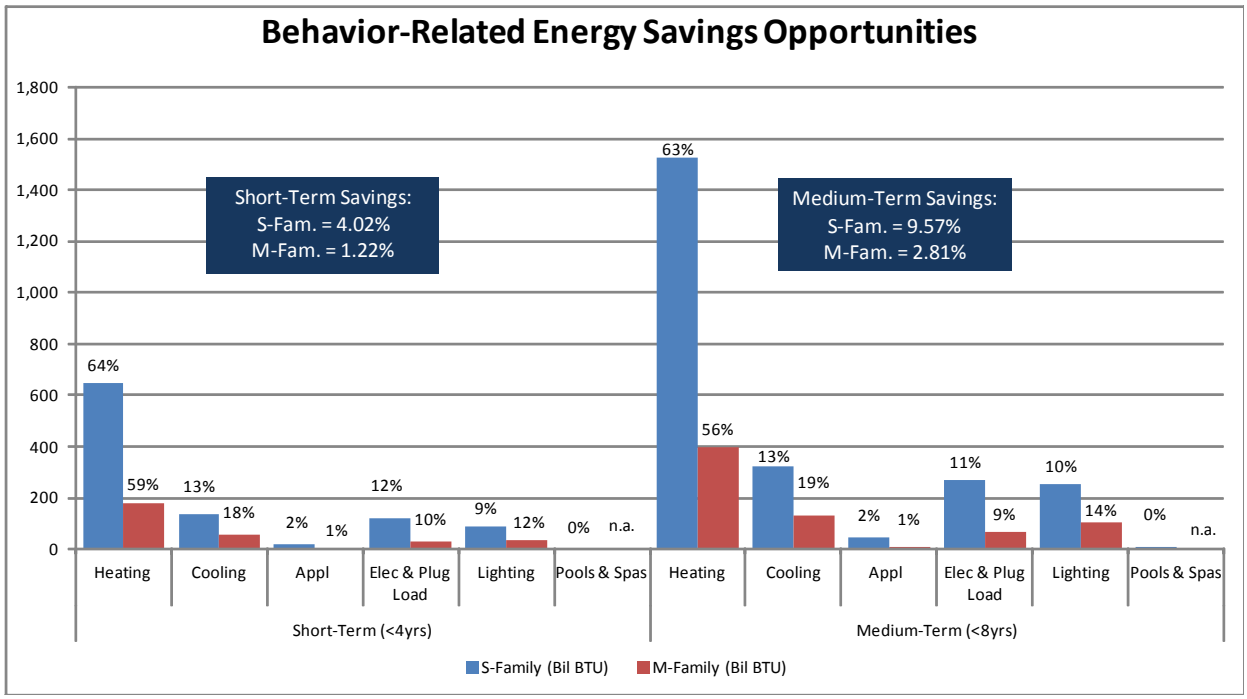
- Core methodological considerations associated with the development of achievable energy savings estimates are summarized below. Additional details concerning the estimation methodology can be found in our discussion of the City Profile Model and the National Behavior Wedge Assessment.
    - Following a review of RECS data and other data on energy use patterns and practices, we determined which specific set of energy end uses promised the largest potential savings. This process began during our assessment of sources of regional variability. At this stage we identified a smaller set of core variables relating to behavior change. This variable set was further refined and reassessed during the data organization and development for the Behavior Wedge Profile Assessment.

- Using RECS and Census data we identified the percent of the population that is eligible to shift their practices in a particular way (i.e. getting rid of or downsizing their 2nd refrigerator) through an assessment of measures of current technology saturation and technology use practices.
- Using data from earlier research (discussed in Section 5 of this report), we developed preliminary estimates of likely short-term and medium-term participation rates.

Behavior Wedge Profile - contents and layout:

The Behavior Wedge Profile is adaptable and could be used to present information about any range of geographic regions, states, and/or cities. Similarly, while the sample report is focused on potential savings from the residential sector, it could also provide savings estimates for other sectors such as commercial buildings, transportation, and food. While profiles for sectors other than residential energy consumption have not yet been created, they would likely follow a similar logic and presentation. In general, the Sample BWP report was developed with the purpose of providing potential users with a glimpse of the potential utility and value of such a tool. The Sample Behavior Wedge Profile created for Baltimore presents a tangible example of what a profile may look like for other cities and/or regions. The profile begins with an overview of achievable savings by household type (single and multi-family) and energy end use categories, which is followed by highlights of savings opportunities and the top ten savings opportunities by housing type. The profile then presents behavior related savings insights by end use categories and specified target behaviors. Following this section the profile presents backdrop information such as housing characteristics, infrastructural information, and population demographics of the targeted region.

Overview of Achievable Savings by Housing Type and Energy End Use:



The BWP begins with a chart presenting an overview of achievable savings by housing type and energy end use. The chart is also broken out to reflect savings over the short (<4 year) term and medium (<8 year) term. End use categories include: heating, cooling, appliances, electronics & plug loads, lighting and pools & spas. Each bar indicates shows the aggregate amount of achievable savings across households in billion Btus. The percentage above each bar indicates the proportion of short- and/or medium-term savings that will come from a particular end-use. The dark blue text boxes show the aggregate savings opportunity for single-family and multi-family households in the short and medium-term. Medium-term savings are cumulative. According to the chart, short-term savings of roughly 5.25% are achievable with roughly three-quarters of those savings coming from single-family households. (This is in part a reflection of the much larger energy footprint of single-family homes as well as the higher amounts of energy waste in single-family homes.) Achievable savings in the medium term are estimated at roughly 12.4 percent.

In the BWP report, the savings opportunity overview is followed by a series of savings opportunity highlights from the report. These highlights are described in more detail within the report; however presenting them initially provides city sustainability workers with a quick glimpse into some of the largest opportunities.

The Residential Sector BWP consistently presents data and savings opportunities by housing type whether single family or multi-family. Estimates are broken out by housing type to facilitate the design of innovative intervention strategies that take into account variations in barriers and opportunities that are determined by housing type. For example, strategies focused on multi-family homes need to consider the potential opportunities and barriers associated with centralized metering, high-levels of resident interaction, availability of property managers, and differences in technology saturation such as dishwashers and central AC. Alternatively, strategies focused on single-family homes are more likely to benefit from a focus on efforts to reduce heating and cooling in unused rooms.

Top Ten Energy Saving Strategies by Housing Type:
The subsequent section presents two top ten lists: the first rank orders savings opportunities for reducing energy consumption in single-family homes while the second rank-order the same opportunities for multi-family homes. These tables specify the end use category, the targeted behavior, the savings opportunity as a percent of total residential energy consumption, and the total achievable savings. Information on the calculation of savings opportunities and the necessary assumptions can be found in the Section 7 of this report.

Achievable Savings by End Use and Target Behaviors:
More detailed information about specific end use categories is presented in the remainder of the report using a format similar to the initial overview section. A chart – following a similar format as the one described earlier – presents the savings opportunities (in BTUs) associated with specific behaviors over the short term and medium term, broken out by single and multi-family homes. The percent savings in these charts represents the total percent from that target end use category (i.e. heating). Below each chart, the report highlights notable trends and opportunities associated with each end use category

The sample behavior wedge profile for Baltimore's residential sector includes the following end use categories and target behaviors:

- **Heating**: equipment replacement, maintenance, adjustment of settings and setbacks, weatherization, and waste reduction.

- **Cooling**: equipment replacement, maintenance, adjustment of settings and setbacks, weatherization, and supplemental cooling strategies (ceiling fans, window film, etc.)
- **Appliances**: eliminate or downsize second refrigerator or freezer, replace old washing machine with energy efficient model, change settings and use frequency, and air-dry laundry.
- **Plug Load and Electronics**: vampire load management with smart strips, plug load management with settings and conservation strategies, and replacing desktops with laptops.
- **Lighting (and Pools and Spas)**: light bulb replacement with CFL or LED, turning off unnecessary lighting, enhanced day-lighting, and using more efficient pool pumps, settings and solar covers.

City-Specific Demographics and Characteristics:
This section provides important background information concerning city-specific demographic patterns, building stock, and other factors that are likely to play a role in shaping engagement strategies. This information may be drawn from RECS data as well as the Census Bureau and other reliable sources. For example, the Sample BWP Report for Baltimore highlights a variety of variables concerning the age of the city's housing stock as well as average home size and other information that really set the City of Baltimore apart from most U.S. cities and which should be kept in mind as city officials consider the adoption of practices and strategies employed by other cities. Population demographics are key to developing intervention strategies and are included in this section of the profile. Information on home ownership/renting, the number of people per household, persons below poverty level and other information reveal possible strategies for programs and highlights potential opportunities to address issues.

How city sustainability officers can use the sample residential sector profile:

Many USDN **c**ities have expressed a growing interest in implementing behavioral strategies for reducing energy consumption and carbon emissions. Compared with technology-focused efforts, behaviorally-focused initiatives can achieve faster reductions with much lower investments – and they can make a meaningful impact toward achieving sustainability goals. Recent national level estimates suggest that behavioral strategies could reduce energy consumption and carbon emissions by 20-30% in the residential and personal transportation sectors alone. At the national level, the savings from such interventions would reduce total U.S. energy consumption by roughly 9% and carbon emissions by 7.4% (Dietz et al 2009, Laitner et al 2009). While cities recognize the importance of unlocking these savings opportunities, they lack an affordable means of determining where best to focus their efforts. Although national level research has provided some insights into where the largest opportunities lie, they cannot account for important sources of variation between cities that are shaped by difference in climate, building characteristics, building age, technology saturation, technology use patterns, lifestyles and preferences. The goal of this project is to redirect assessments of behavior wedge savings opportunities to the city level to provide city-specific assessments of savings opportunities in ways that are both affordable and easily replicated.

Cities can use the information provided in the behavior wedge profiles to:

1) Document the scale of savings opportunities associated with behavior-related approaches,
2) Identify specific behavioral opportunities that offer the most promise of resource savings,

3) Evaluate the relative importance of behavioral initiatives as part of a larger, city-wide sustainability, climate, and/or energy initiative,
4) Prioritize investments in different types of projects and programs and focus limited resources on a more precise and promising set of interventions,
5) Write more effective funding proposals,
6) Make the case for pursuing behavior-based opportunities with team members, supervisors, partner organizations, and others,
7) Validate decisions to pursue a particular project focus or project design,
8) Develop more targeted marketing and communications efforts, and
9) Make better work plan decisions for personnel.

The Behavior Wedge Profile Report provides cities with the means of identifying which target behaviors offer the greatest achievable savings potential given the specific characteristics of their city's climate, infrastructure and population.
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7. Residential Sector Behavior Wedge Profile Model: A Proof of Concept

The behavior wedge profile model involves the use of existing data sources (primarily RECS data) and the development and use of a set of algorithms to create estimates of energy saving opportunities. The model development involved 5 components. First, a subset of RECS data providing information about regional housing characteristics, technology saturation and technology use, was created for the regional district that includes the state of Maryland. Second, some additional variables were calculated (using RECS data) to create the complete set of data inputs to be used in the model. Third, Census data were used to determine how best to weight the RECS data so that they would more accurately reflect the specific housing characteristics of Baltimore – primarily in terms of the size and age of the existing housing stock. Fourth, a set of algorithms was created to calculate the amount of energy that could be saved from each of a variety of different behaviors associated with six particular energy end uses. Finally, the algorithms were applied to RECS data for Maryland to calculate the energy saving opportunities for discrete sets of behaviors and end uses. The results were subsequently summarized through charts, tables, and text in the resulting Residential Sector *Behavior Wedge Profile for the City of Baltimore.*

Data selection and Variable Development: This section describes the subset of RECS data used to specify housing characteristics, technology saturation, and technology use and also indicates which variables we calculated ourselves and how.

Variables relating to infrastructure, housing characteristics, technology saturation and technology use were previously identified during our assessment of regional variability. At that point the data was broken out by region, but in order to develop a Profile that presents savings opportunities for Baltimore we determined an alternative method of data organization that could readily inform the workbook-based model for Baltimore and be useful to a city-sustainability officer developing behavior-based interventions for the residential sector. This method breaks the RECS variables out into geographic variables like the state-subset, urban households, single and multi-family households, and others.

The entire spreadsheet is available as an appended data file named "*CMB_USDN_Baltimore_Residential_Profile.*" The spreadsheet contains the entire list of RECS variables that were used to inform the profile model. Descriptions of each variable can be found in Column 1 of

the spreadsheet. Columns R, S, and T of the spreadsheet identify the RECS variable name, variable description, and response codes and labels (found in the 2009 RECS codebook – Appendix 4) that were used to create each variable. An example is provided below

The RECS subset spreadsheet for Baltimore was broken out to assess the variables at the following geographic levels:

- **Columns B&C:** urban households at the national level,
- **Columns D&E:** targeted state/multi-state subset,
- **Columns F&G:** urban households of the state-subset,
- **Columns H&I:** urban single-family households of the state-subset,
- **Columns J&K** urban multi-family households of the state-subset,
- **Columns L&M:** single family households of the state subset,
- **Columns N&O:** multi-family households at the sub-state level.

*The RECS "Variable Name" and selected response codes and labels for each of these geographic spaces can be found in the appended spreadsheet in Row 1.
**"State-subset" refers to RECS survey respondents from the region that includes Maryland as well as the District of Columbia, Delaware, and West Virginia.

For each of those geographic spaces, the spreadsheet includes both the number of households that fell into the response category and the percentage of households that represents. The base number of households upon which percentages are dependent varies according to the particular variable being represented.

To illustrate the structure of the RECS subset, the table below provides several heating-related variables (RECS includes other heating-related variables that were not included). The first column provides a description of the variable. The rows following "Have Central Heating Equipment" are indented to indicate that the percentages are dependent upon whether households have central heating equipment. For example, 50.4 percent of urban single-family households **with** central heating equipment have a furnace and 44.5 percent of households report conducting a high level of routine maintenance.
*See "*CMB_USDN_Baltimore_Residential_Profile*" for the complete list of selected variables and geographic/infrastructural divisions used in the BWP.

Heating Equipment for Urban Households within Selected State-Subset

Heating	Urban Single-Family Households		Urban Multi-Family Households	
Have Central Heating Equipment	2,050,020	100.0%	692,022	100.0%
Furnace (Central or Floor/Wall Pipeless)	1,032,564	50.4%	255,585	36.9%
Boiler	245,992	12.0%	205,106	29.6%
Space Heater (Electric or Kerosene)	33,022	1.6%	0	0.0%
Routine Maintenance Level (High)	912,175	44.5%	195,028	28.2%
Age of heating equipment (15-19)	229,393	11.2%	77,324	11.2%
Age of heating equipment (20+)	568,012	27.7%	175,478	25.4%

The RECS subset spreadsheet documents the specific RECS variable, its description and the response codes and labels used to organize the selected variable – they can be found found in columns R, S, and T in our spreadsheet. The "Response Codes and Labels" column identifies the selected response codes required for a specific variable A list of all RECS variables can be found in the 2009 RECS codebook, which is also attached as Appendix 4.

Heating Equipment RECS Variable Details

Heating	RECS Variable	Variable Description	Response Codes and Labels (Used)
Have Central Heating Equipment	**HEATHOME**	Space heating equipment used	1 = Yes
Furnace (Central or Floor/Wall Pipeless)	**EQUIPM**	Type of main space heating equipment used	3 = Central Warm-Air Furnace, 6 = Floor or Wall Pipeless Furnace
Boiler	**EQUIPM**	Type of main space heating equipment used	2 = Steam or Hot Water System
Space Heater (Electric or Kerosene)	**EQUIPM**	Type of main space heating equipment used	10 = Portable Electric Heaters, 11 = Portable Kerosene Heaters
Age of heating equipment (15-19)	**EQUIPAGE**	Age of main space heating equipment	42 = 15 to 19 years old
Age of heating equipment (20+)	**EQUIPAGE**	Age of main space heating equipment	5 = 20 years or older

The results from the RECS subset inform the development of the city profile model by identifying current infrastructural conditions, housing characteristics, technology saturation, and technology use patterns for the sub-state region that includes Baltimore, Maryland. Once weighted using Census data to accurately reflect Baltimore these values can then be used in the model as baseline statistics. To understand the achievable savings opportunities of a heating related behavior like replacement of central heating equipment it's important to know the current proportion of households that have a furnace, a boiler, or a space heater, and knowing the age of that equipment can help determine the likelihood of adoption as well as a broad understanding of the likely efficiency levels of existing technology (and therefore the potential efficiency gains).

Integrating Census Data to Reflect the Baltimore's Housing Characteristics: This section describes the use of Census data to determine appropriate means of weighting RECS data with the goal of more accurately reflecting the specific housing characteristics of Baltimore.

Given that RECS does not provide data for particular cities, we determined that one of the best ways to ensure that our behavior wedge profile estimates are sensitive to the specific (and somewhat unique) characteristics of Baltimore was to use Census data for Baltimore to assess the degree to which the Baltimore's housing characteristics and demographics align with housing characteristics for urban areas within the state of Maryland or not. Doing this type of assessment provided us with important insights

and allowed us to weight our estimates based on the specific characteristics of the Baltimore housing stock.

We were particularly interested in the comparative age and size of the housing stock for Baltimore compared with urban Maryland more generally. The comparison revealed important distinctions. As can be seen in the following table, the housing stock in Baltimore tends to be older and smaller than that for urban areas in Maryland as a whole. Census data indicate that while roughly 29% of urban Maryland homes were built before 1950, the comparable proportion of homes in Baltimore is 55.4%. And, whereas urban roughly 33% of homes in urban Maryland were built between 1980 and 2000, the comparable number for Baltimore was only roughly 8%. Given these differences in the average age of the housing stock, it isn't surprising that the average home size in Baltimore is smaller than the average urban home within the state. As shown in the following table, the average home in Baltimore is roughly 1280 square feet compared to the average home size in urban Maryland of roughly 1650 square feet. As described later in this document, these differences where used in the behavior wedge profile model to create a more accurate estimate of energy saving opportunities in Baltimore.

Housing Characteristics: Urban Maryland and Baltimore

Age of Residence	Avg. Home Size (SqFt)	Urban MD Single-Family	Urban MD Multi-Family	SF + MF Total	Baltimore
2000-2009	2465	4.7%	17.1%	7.8%	3.4%
1990-1999	2200	16.8%	11.1%	15.4%	3.3%
1980-1989	1770	20.5%	10.5%	17.9%	4.6%
1970-1979	1685	7.6%	13.2%	9.0%	6.5%
1950-1969	1350	22.1%	17.9%	21.0%	26.9%
Older than 1950	1020	28.3%	30.2%	28.8%	55.4%
Average/Total	1650	100.0%	100.0%	100.0%	100.0%
Estimated Avg. Home Size Baltimore (SqFt)		1697	842		1276
% of HH Reporting Adequate insulation		77.3%	80.7%	78.4%	

Notes: Average home size in the US has been increasing over the past 60 years. Most of Baltimore's housing stock is from 1970 or earlier and is smaller than overall national averages or even state averages.

RECS data were also adjusted to account for differences in demographic measures. The following table provides critical information concerning the number of housing units in Baltimore as well as differences in the distribution of housing units across single-family and multi-family housing sectors. As documented in the following table, Baltimore represents roughly 11% of Maryland's population and roughly 12% of Maryland's housing stock. Nevertheless home ownership rates in Baltimore are much lower than for Maryland as a whole (roughly 50% in Baltimore compared with 72% in Maryland. Not surprisingly, a larger proportion of Baltimore's homes (33%) can be considered multi-family units compared with just 26% for Maryland as a whole. In addition, it is valuable to note that the median value of owner occupied

housing in Baltimore is roughly half that of the larger state and that while the number of people per household is roughly the same in Baltimore (compared with the larger state), the median household income in Baltimore is only 56% of the median income for the state. One final point of interest is that the poverty rate in Baltimore is much higher than for the state overall, such that more than 1 in 5 residents of Baltimore live in poverty while less than 1 in 10 Maryland residents do. These measures provide important insights into the housing conditions of Baltimore residents as well as their likely propensity to engage in particular energy saving behaviors and including investments in energy efficient technologies.

Given these Census data, we would expect that there the proportion of Baltimore residents who are renters is much higher than the rest of the state, and that much of the housing stock in Baltimore was built without energy efficiency in mind. In addition, the relatively low income levels and high rates of poverty in Baltimore diminish the likelihood that residents can afford to finance investments in more energy efficient technologies. These insights suggest that cash-strapped residents of Baltimore may be more interested in reducing their energy consumption and more likely to do so using a variety of non-investment approaches. Such insights are incorporated into the model estimates as described later in this document.

Population Demographics: Maryland and Baltimore

	Baltimore	Balt/MD	Maryland
Population	619,493	11%	5,828,289
Housing Units	296,450	12%	2,391,350
Home Ownership Rate	49.80%	72%	69%
Housing Units in MF Structures	33.10%	129%	25.70%
Median value of owner-occupied Housing	160	49%	329
Persons per Household	2.52	96%	2.62
Median Household Income	$ 39,386	56%	$ 70,647
Persons below Poverty	21.3%	248%	8.6%

Source: Census Bureau 2011

Algorithm Development and Assumptions: This section describes the set of algorithms that were created to calculate the amount of city-level energy savings that could be achieved from six particular energy end uses in the residential sector. The assessment started by identifying a set of 23 residential behaviors with the greatest savings opportunities. While this list could be expanded in the future, the combined energy expertise of the authors was used to create a list that was both manageable in size and that also represented the largest savings opportunities. The following set of actions was used as the basis of model estimates:

> Heating equipment replacement, heating equipment maintenance, setback of heating thermostat, use of a programmable thermostat, heat-related weatherization, heat conservation actions (closing doors and vents), cooling equipment replacement, cooling equipment maintenance, setback of cooling thermostat, use of programmable thermostat for AC, cooling-

related weatherization, cooling conservation actions (use of ceiling fans, blinds and shades), discarding a second refrigerator, purchasing an energy efficient clothes washer, using cold water and efficient settings on washers, air drying clothes, replacing desktop computers with laptops, managing vampire loads, managing plug loads, installing CFLs, turning off lights, increased use of daylighting, using best practices for pools and spas (pump settings, covers and pump replacement).

For each of these actions, an algorithm was developed to calculate the potential savings associated with single-family homes and with multi-family homes. In addition, for each of the two categories of homes, achievable energy savings were estimated for both the short-term (less than 4 years) and the medium-term (4-8 years). Medium-term savings were calculating by reassessing household eligibility given changes in product saturation and/or shifts in behaviors needed to achieve short-term savings. The process begins by assessing short-term savings opportunities (1-4 years), followed by an assessment of medium-term savings opportunities (years 5-8). These savings estimates are then added together to determine the cumulative savings opportunities in the medium term (within the first 8 years). In other words, for each of the 23 actions noted above, a set of four estimates was developed taking into account both the savings period and the housing type – as indicated in the following table.

		Savings Period	
Housing Type		Short-Term	Medium-Term
	Single Family	(Number of Balt. Homes) x (% single family) x (eligibility) x (likely short-term participation) x (estimated savings per HH)	(Number of Balt. Homes) x (% single family) x (eligibility) x (likely medium-term participation) x (estimated savings per HH)
	Multi-Family	Number of Balt. Homes) x (% multi family) x (eligibility) x (likely short-term participation) x (estimated savings per HH)	Number of Balt. Homes) x (% multi family) x (eligibility) x (likely medium-term participation) x (estimated savings per HH)

Measures of the number and types of homes relied on census data for the city of Baltimore. Eligibility represents the proportion of households of each type that are eligible to partake in a particular activity. Most of these measures relied on data from RECS. For example in order to determine the proportion of households that were eligible to unplug or dispose of a second refrigerator, the model draws from RECS data that measure the proportion of households with 2 or more refrigerators. Likely short-term and long-term participation was drawn from an assessment of historical program participation rates (see Laitner et al. 2009). Estimated savings per household for each of the actions was estimated using expert advice from a small group of energy experts and published DOE data sources.

Energy Savings Estimation Algorithms

To obtain a copy of the Behavior Wedge Profile Model Algorithms, which provides a detailed list of formulas used to estimate likely energy savings from each of the 23 behaviors, please contact Dr. Karen Ehrhardt-Martinez, 6380 Bluebird Court, Niwot, CO 80503, 303-530-2056, KarenE@GarrisonInstitute.org

Model Specifications: This section describes the ways in which the algorithms and RECS data were used to calculate the energy saving opportunities for discrete sets of behaviors and end uses.

In order to develop the *Sample Behavior Wedge Profile for the City of Baltimore* (i.e. proof-of-concept document), we chose to use an Excel workbook for our estimation calculations. The workbook contained 24 worksheets – one for each behavior plus a summary worksheet. The worksheets are organized by energy end-use, beginning with all of the heating-related behaviors, following by cooling-related behaviors, etc. Each of the worksheets begins with information about current energy consumption patterns for the energy end-use under consideration. Current energy use information is broken out by housing type and is shown as both *average* household consumption and *total* consumption (in BTUs). The following chart provides an example of what these reference tables look like for heating-related end uses.

	Households	Avg. Energy Use for *Heating* per HH (mmBTU)	Total Energy Use per HH (mmBTU)	Residential Energy Use for *Heating* – Baltimore (mmBTU)	Residential Energy Use Baltimore (mmBTU)
Total	296,000			16,241,520	25,285,800
Single-family	67%	68.8	103.1	13,237,120	19,836,440
Multi-family	33%	29.0	52.6	3,004,400	5,449,360

In order to assess the potential savings, the algorithms were applied to the reference case using data from RECS for Maryland. As mentioned earlier in this report, the model uses the reference case, information about technology saturation, information about current use practices, and information about likely participation in order to determine eligibility, participation rates and what we refer to as *achievable* savings estimates. Such estimates were created for each of the two household types (single-family and multi-family) and for both the short- and long-terms. As such, an assessment of the achievable energy savings associated with each of the 23 behaviors results in a table similar to the following which documents the estimated achievable savings associated with the replacement of heating equipment.

Achievable Savings from the replacement of Heating Equipment

	Aggregate Energy Savings across HHs (mmBTU)			**Savings as a % of Total Energy Use**		
	Single-family	Multi-family	Total	Single-family	Multi-family	Total
Short-term	42,328	18,234	60,562	0.32%	0.61%	0.37%
Medium-term	89,947	38,746	128,693	0.68%	1.29%	0.79%
Short + Medium	132,275	56,980	189,255	1.00%	1.90%	1.20%

While data from the RECS data set were used to provide values for each of the variables needed to create the estimates in energy savings, there were cases in which informed assumptions were made. The following discussion documents any assumptions underlying the estimates for each of the energy end uses and behaviors.

Heating

Heating equipment replacement

Eligibility: homes with furnaces that are 15 or more years old

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	10%	25%
Multi-family	10%	25%

Heating equipment maintenance

Eligibility: homes with furnaces that aren't regularly maintained

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	25%	33%
Multi-family	33%	50%

Setback of heating thermostat

Eligibility: homes with settings higher than EPA recommendations

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	15%	30%
Multi-family	15%	30%

Use of a programmable thermostat (for night time and periods away)

Eligibility: homes with programmable thermostats that don't use them

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	15%	30%
Multi-family	15%	30%

Heat-related weatherization

Eligibility: homes that haven't weatherized in the past 5 years

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	10%	25%
Multi-family	10%	25%

Heat conservation actions (closing doors and vents)

Eligibility: single family homes with spare bedrooms

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	35%	50%
Multi-family	0%	0%

Cooling

Cooling equipment replacement

Eligibility: homes with AC units that are 10 or more years old

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	10%	25%
Multi-family	10%	25%

Cooling equipment maintenance

Eligibility: homes with AC units that aren't regularly maintained

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	25%	33%
Multi-family	33%	50%

Setback of cooling thermostat

Eligibility: homes with settings lower than EPA recommendations

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	15%	30%
Multi-family	15%	30%

Use of programmable thermostat for AC

Eligibility: homes with programmable thermostats that don't use them

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	15%	30%
Multi-family	15%	30%

Cooling-related weatherization

Eligibility: homes that haven't weatherized in the past 5 years

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	10%	25%
Multi-family	10%	25%

Cooling conservation actions (use of ceiling fans, blinds and shades and closing vents in unused rooms)

Eligibility: homes with fans, all homes and single family homes with spare bedrooms

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	30%	40%
Multi-family	30%	40%

Appliances

Discarding or unplugging second refrigerator

Eligibility: single-family homes with second refrigerators

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	35%	50%
Multi-family	0%	0%

Purchasing an energy efficient clothes washer

Eligibility: homes with clothes washer older than 10 years

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	30%	50%
Multi-family	30%	50%

Using cold water and efficient settings on washers

Eligibility: homes with clothes washers washing in hot and warm water

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	30%	50%
Multi-family	30%	50%

Air drying clothes

Eligibility: homes with clothes dryers

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	5%	10%
Multi-family	5%	10%

Electronics and Plug-load

Replacing desktop computers with laptops

Eligibility: homes with desktop computers

Participation Rate (among eligible households):

	Short-term	Medium-term

Single-family	25%	65%
Multi-family	25%	65%

Managing vampire loads (smart strips for large plug loads)

Eligibility: All homes

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	35%	50%
Multi-family	35%	50%

Managing plug loads (timers and unplugging)

Eligibility: all homes

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	35%	50%
Multi-family	35%	50%

Lighting

Installing CFLs

Eligibility: homes with CFL saturation below 60 percent

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	35%	65%
Multi-family	35%	65%

Turning off lights

Eligibility: all homes

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	20%	25%
Multi-family	20%	25%

Pools and Spas

Use of best practices for pools and spas (pump settings, covers and pump replacement).

Eligibility: all homes

Participation Rate (among eligible households):

	Short-term	Medium-term
Single-family	10%	25%
Multi-family	0%	0%

Model Results: The results of the assessment were compiled in a summary table which show the short-term and medium-term savings opportunities for each of the behaviors that were assessed. Estimates of achievable savings are given for both single-family and multi-family homes. These results were then used as inputs for the graphs and charts in the sample behavior wedge profile report.

Estimated SHORT-TERM* Achievable Savings Opportunities for the Residential Energy Sector in Baltimore

		Single-Family Homes		Multi-Family Homes		Total Resident. Savings	
	Actions	BTU	% of total energy consump.	BTU	% of total energy consump.	BTU	% of total energy consump.
1	Heating Equip. Replacement	42,328	0.17%	18,234	0.07%	60,562	0.24%
2	Heating Equip. Maintenance	211,640	0.84%	86,333	0.34%	297,973	1.18%
3	Heating Settings Setback	66,186	0.26%	15,022	0.06%	81,208	0.32%
4	Heating (Program. Therm.)	105,897	0.42%	24,035	0.10%	129,932	0.51%
5	Weatherization	74,128	0.29%	29,443	0.12%	103,571	0.41%
6	Close Rooms-Doors-Vents	148,256	0.59%	8,412	0.03%	156,668	0.62%
7	Cooling Equip. Replacement	13,187	0.05%	3,550	0.01%	16,737	0.07%
8	Cooling Equip. Maintenance	48,840	0.19%	23,908	0.09%	72,748	0.29%
9	Cooling Settings Setback	15,103	0.06%	4,558	0.02%	19,662	0.08%
10	Cooling (Program. Therm.)	24,165	0.10%	7,293	0.03%	31,459	0.12%
11	Cooling Weatherization	16,916	0.07%	8,934	0.04%	25,850	0.10%
12	Cooling Supplemental	16,916	0.07%	8,934	0.04%	25,850	0.10%
13	2nd Fridge-Freezer Removal	7,677	0.03%	435	0.00%	8,112	0.03%
14	Energy Efficient Washer	6,317	0.02%	3,282	0.01%	9,599	0.04%
15	Appliance Settings	3,000	0.01%	488	0.00%	3,488	0.01%
16	Air Drying Laundry	2,455	0.01%	399	0.00%	2,854	0.01%
17	Computer Replacement	26,201	0.10%	13,493	0.05%	39,694	0.16%
18	Vampire Load Mgmt.	65,616	0.26%	11,930	0.05%	77,546	0.31%
19	Plug Load Mgmt & Conserv.	28,121	0.11%	5,113	0.02%	33,234	0.13%
20	CFL Bulb Replacement	61,998	0.25%	31,094	0.12%	93,091	0.37%
21	Turn off Lighting	13,419	0.05%	3,109	0.01%	16,529	0.07%
22	Increased Daylighting	13,419	0.05%	1,555	0.01%	14,974	0.06%
23	Pools-Spas	3,636	0.01%	0	0.00%	3,636	0.01%
	TOTAL	**1,015,421**	**4.02%**	**309,556**	**1.22%**	**1,324,977**	**5.24%**

*Short-term is defined as <4 years.

Estimated MEDIUM-TERM* Achievable Savings Opportunities for the Residential Energy Sector in Baltimore (cumulative)

		Single-Family Homes		Multi-Family Homes		Total Resident. Savings	
	Actions	BTU	% of total energy consump.	BTU	% of total energy consump.	BTU	% of total energy consump.
1	Heating Equip. Replacement	132,275	0.52%	56,980	0.23%	189,255	0.75%
2	Heating Equip. Maintenance	365,079	1.44%	136,694	0.54%	501,773	1.98%
3	Heating Settings Setback	198,557	0.79%	45,066	0.18%	243,623	0.96%
4	Heating (Program. Therm.)	317,691	1.26%	72,106	0.29%	389,796	1.54%
5	Weatherization	170,494	0.67%	67,719	0.27%	238,213	0.94%
6	Close Rooms-Doors-Vents	340,988	1.35%	19,348	0.08%	360,337	1.43%
7	Cooling Equip. Replacement	39,560	0.16%	10,651	0.04%	50,211	0.20%
8	Cooling Equip. Maintenance	85,282	0.34%	45,976	0.18%	131,258	0.52%
9	Cooling Settings Setback	45,310	0.18%	13,675	0.05%	58,985	0.23%
10	Cooling (Program. Therm.)	72,496	0.29%	21,880	0.09%	94,377	0.37%
11	Cooling Weatherization	38,906	0.15%	20,549	0.08%	59,456	0.24%
12	Cooling Supplemental	38,906	0.15%	20,549	0.08%	59,456	0.24%
13	2nd Fridge-Freezer Removal	17,657	0.07%	1,001	0.00%	18,657	0.07%
14	Energy Efficient Washer	14,213	0.06%	7,385	0.03%	21,598	0.09%
15	Appliance Settings	6,900	0.03%	1,123	0.00%	8,023	0.03%
16	Air Drying Laundry	5,645	0.02%	919	0.00%	6,564	0.03%
17	Computer Replacement	52,402	0.21%	26,986	0.11%	79,389	0.31%
18	Vampire Load Management	150,917	0.60%	27,438	0.11%	178,355	0.71%
19	Plug Load Mgmt. & Conserv.	64,679	0.26%	11,759	0.05%	76,438	0.30%
20	CFL Bulb Replacement	177,136	0.70%	88,839	0.35%	265,975	1.05%
21	Turn off Lighting	38,341	0.15%	8,884	0.04%	47,225	0.19%
22	Increased Daylighting	38,341	0.15%	4,442	0.02%	42,783	0.17%
23	Pools-Spas	8,364	0.03%	0	0.00%	8,364	0.03%
	TOTAL	**2,688,139**	**10.63%**	**776,153**	**3.07%**	**3,464,292**	**13.70%**

*Medium term is defined as <8 years.

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8. Description of Other opportunities

While the development of city-specific behavioral profiles provides a low-cost means for cities to identify the scope of behavior-related opportunities for saving energy and reducing carbon emissions as well as the specific sets of behaviors that offer the largest local savings opportunities, these profiles do not provide the means of identifying the most receptive population segments that cities may want to target as part of an initiative to bring about behavioral change. Nevertheless, additional opportunities exist that would allow for a low-cost approach in this area of inquiry as well. Among the potential strategies, we recommend a two-part approach: 1) the development of a library of survey modules that pertain to different sustainability topic areas that USDN cities could draw from to develop a customized population segmentation survey focused on a given city's particular topic(s) of interest, and 2) the development of multi-city collaborations around the fielding of surveys on topics of interest.

Library of Survey Modules:

The development of a pre-established set of survey modules across relevant sustainability topics would provide USDN-member cities (and others?) with readily accessible sets of questions for collecting valid and reliable measures of existing practices, technology saturation, attitudes, and intentions to change behaviors. While cities would still need to pay to have the data analyzed, the creation of sets of sustainability survey modules would reduce the cost of doing segmentation analysis by 1) reducing staff time associated with researching prior surveys and identifying appropriate survey questions, and 2) reducing labor associated with the development and/or refinement of survey questions. A variety of other benefits would also be achieved, including 1) the application of a relatively uniform set of questions across cities that would allow for subsequent comparisons and data analysis between and across cities, and 2) increasing the validity and reliability of survey results attained by most cities. The development of the library would benefit from a concerted effort to fund and realize its development with initial efforts focused on the development of modules around topics that represent the greatest level of interest across USDN-member cities.

We have included five sample survey modules below in order to provide a general idea of what sample survey modules might look like. These sample modules and the questions that they contain have not been assessed for quality since the purpose here is simply to provide an example of the form that modules might take.

Sample Survey Module #1: Thermostats (City of New York 2013)

Survey Question	Response Choices
Does your home currently have a programmable thermostat?	1. Yes, I have a programmable thermostat. 2. I have a thermostat, but it's not programmable. 3. I don't have a thermostat. 4. DK/NA
What are the 2 most important reasons why your home currently has a programmable thermostat?	1. It is good for the environment behavior it helps save energy 2. People I trust are doing this (friends, family, colleagues, neighbors, etc) 3. It helps me save money 4. I feel good about doing this 5. It make adjusting the temperature in my house easier 6. It existed in my home when I moved in 7. Other (please specify) 8. DK/NA
Which of the following, if any, would most motivate you or someone in your household to install a programmable thermostat?	1. Doing so benefits the environment by reducing your HH's energy usage 20% 2. You could significantly reduce your average monthly electric bill 3. Programmable thermostats are available at most hardware stores 4. Installing a programmable thermostat is easy to do 5. People you trust are using programmable thermostats 6. Nothing will motivate me to purchase a programmable thermostat 7. Other (please specify) 8. DK/NA
How likely would you (or someone in your household) be to install a programmable thermostat?	1. Not at all likely (0 – 19 %) 2. 20% - 39% 3. 40% - 59% 4. 60% - 79% 5. Very likely (80% - 100%)
How often do you (or someone in your HH) manually adjust the temperature to conserve energy (i.e., turn it up or down depending on the season, when you leave the house, or before you go to bed)?	1. Never (0 – 19 %) 2. 20% - 39% 3. 40% - 59% 4. 60% - 79% 5. As much as possible (80% - 100%) 6. I cannot manually adjust the temperature in my home
What are the 2 most important reasons why you (or someone in your household) manually adjust the temperature to conserve energy?	1. It is good for the environment behavior it helps save energy 2. People I trust are doing this (friends, family, colleagues, neighbors, etc) 3. It helps me save money 4. I feel good about doing this 5. It make adjusting the temperature in my house easier 6. It existed in my home when I moved in 7. Other (please specify) 8. DK/NA
Would most motivate you to manually adjust the temperature in your home to conserve energy (i.e turn it up or down depending on the season when you leave the house or before you go to bed)?	1. Doing so could reduce your HH energy usage and benefit the environment 2. People you trust are doing this (friends, family, colleagues, etc.) 3. You could reduce your monthly electric bill by 15% 4. Nothing will motivate me to manually adjust my temperature 5. Other (please specify) 6. DK/NA
How often would you manually adjust the temperature in your home to conserve energy?	1. Never (0 – 19 %) 2. 20% - 39% 3. 40% - 59% 4. 60% - 79% 5. As much as possible (80% - 100%)

Sample Survey Module #2: Household Laundry (Action Research 2013)

Survey Question	Response Choices
Are you the person responsible for doing the laundry within your household?	1. Yes 2. No (End)
Do you live in a single-family home, mobile home, apartment complex, condominium or townhome?	1. Single-family home or mobile home 2. Apartment complex, condominium or town home (employ skip pattern)
Do you have a washer and dryer within your home?	1. Yes 2. No (End)
Do you use the washer and dryer within your home, or do you go to a Laundromat to wash and dry your clothes?	1. Yes, I use washer/dryer within my home (employ skip pattern) 2. No, I go to Laundromat (End)
If you live in an Apartment Complex, Condominium or townhome, is your washer and dryer within your home or within your building?	1. Within the home (employ skip pattern) 2. Within the building (employ skip pattern)
If your washer/dryer is within your building. Do you use the washer and dryer within your building, or do you go to a Laundromat to wash and dry your clothes?	1. Yes 2. No, I go to Laundromat (End)
Do you pay your own utility bills, or are the bills shared with other households within your building, or are they paid by the landlord?	1. Pay own utility bills (employ skip pattern) 2. Share with other households 3. Paid by the landlord (End)
With how many other households do you share laundry facilities?	1. Less than 3 2. More than 3 (End)
Are the washers and dryers coin operated?	1. Yes 2. No
Do you wash your laundry in cold water only, in warm or hot water only, or in a combination of temperatures?	1. Cold water only (End) 2. Warm or hot water only 3. Combination of temperatures
Do you dry your clothes in a dryer, on a clothes line, or a combination of dryer and clothes line?	1. Dryer only 2. Clothes line only (End) 3. Combination of dryer and clothes line
On average, how many loads of laundry do you do per week?	____ loads per week
How often do you use an automatic dryer for your laundry?	1. All of the time 2. Some of the time 3. None of the time

Sample Survey Module #3: Lighting (City of New York 2013)

Survey Question	Response Choices
What percentage of the light fixtures in your home use energy efficient light bulbs?	1. None (0 – 19 %) 2. 20% - 39% 3. 40% - 59% 4. 60% - 79% 5. All (80% - 100%)
What are the two most important reasons why you use energy efficient light bulbs in your home	1. Doing so conserves energy and is good for the environment. 2. I see other people doing this 3. It helps me save money 4. It is easy and convenient to do. 5. People I trust use them (friends, family, colleagues, etc) 6. Other (please specify) 7. DK/NA
Which of the following, if any, would motivate you to use more energy efficient light bulbs in your home?	1. Energy efficient light bulbs benefit the environment by using 75% less energy than traditional light bulb. 2. Other people are using them. 3. Energy efficient light bulbs are available in a variety of styles (dimmable, globes, flood, etc.) and soft white colors. 4. Energy efficient light bulbs are comparable in price to traditional light bulbs. 5. You could reduce your monthly electric bill by 15%. 6. People you trust use them (friends, family, colleagues, etc.) 7. Nothing will motivate me to purchase more. 8. Other (please specify) 9. DK/NA
You indicated that the percentage of light fixtures in your home that use energy efficient light bulbs is:	1. None (0 – 19 %) 2. 20% - 39% 3. 40% - 59% 4. 60% - 79% 5. All (80% - 100%)

Sample Survey Module #4: Sustainability Attitudes and Opinions (New York City 2013)

Please indicate to what extent you agree or disagree with each of the following statements.

Response choices for all questions (response choice order may be randomized):

1. Strongly agree, 2. Somewhat agree, 3. Neither agree or disagree, 4. Somewhat disagree, 5. Strongly disagree, 6. Don't know

Survey Question
I prefer to repair something when it is broken rather than buying a replacement.
I am willing to consume less to sustain the quality of the environment for future generations.
I am willing to pay more for energy efficient and environmentally friendly products.
I am currently going all I can to reduce my own impact on the environment.
Recently, I have been paying more attention to news stories about the environment.
Being environmentally friendly is just too expensive.
I always remember to carry a durable and reusable shopping bag when I go to a grocery store so that I do not use plastic bags.
I expect "green" products to have all the benefits of regular "non-green" products.
In my home everything that can be recycled gets recycled.
Being "green" or environmentally friendly requires too much effort.
I prefer to donate my old clothing and household products (furniture, electronics, etc) to a charity instead of throwing them away.
In the next year, I am planning to take one less vacation that would require air travel, in order to help reduce my environmental impact.

Sample Survey Module #5: Demographics (US Department of Energy 2012 Questionnaire)

Survey Question	**Response Choices**
Please indicate your gender:	1. Male 2. Female 3. DK/NA
Please indicate which of the following age groups represents your current age:	1. Under 18 2. 18-24 3. 25-34 4. 35-44 5. 45-54 6. 55-64 7. 65+
What is the highest level of education you have completed?	1. Below high school 2. High school graduate 3. College diploma 4. Bachelor's degree 5. Master's degree or PhD 6. Other (please specify) 7. DK/NA
Which of the following best describes your total household	1. Less than $50,000 2. $50,000 - $74,000

income in ____ before taxes?	3. $75,000 - $99,999 4. $100,000 - $149,999 5. $150,000+ 6. Prefer not to answer
Which of the following best describes your marital status?	1. Married 2. Single, never married 3. Divorced / separated 4. Widower 5. Other (please specify) 6. Living with Partner 7. Prefer not to answer
Are you a parent?	1. Yes 2. No
Race:	1. Hispanic or Latino 2. White/Caucasian 3. Black/African-American 4. Asian/Asian-American/Pacific Islander 5. Other
Were you born in the United States?	1. Yes 2. No
What is your political affiliation?	1. Democrat 2. Republican 3. Independent 4. None 5. Other (please specify) 6. Prefer not to answer
Which of the following describes your current employment status?	1. Full-time 2. Part-time 3. Retired 4. Not employed 5. Student 6. Self-employed 7. Other (please specify) 8. Refused
What type of dwelling do you live in?	1. Single family home 2. Multi-family building (2-4 units) 3. Large multi-family building (5 or more units) 4. DK/NA
Do you own or rent?	1. Rent 2. Own 3. Other (please specify) 4. DK/NA
How long have you lived in your current home?	1. Less than 1 year 2. 1 – 5 years 3. 6 – 10 years 4. 11 – 20 years 5. More than 20 years

Multi-city Collaborations in the Fielding of Surveys:
In addition to the development of sustainability survey modules, cities could reduce the cost of survey research through collaboration in the fielding of surveys. The application of this approach would require that cities to work together to identify a set of cities interested in the same (or similar) sets of topics. The group of cities could work together with a survey research firm or university to design and field a collaborative survey effort that would benefit from various efficiencies. Since most survey firms use either online surveys or computer assisted telephone interviewing methods that require detailed computer programming, the costs of these efforts to individual cities could be lowered when the same survey firm is able to develop a single program to collect data for multiple cities.
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9. Conclusions

The goal of the GreeNYC Replication Project collaboration was to explore the potential development of a low cost model that could both assess the scale and characteristics of behavior-based opportunities for saving carbon and energy and prioritize or rank those sets of behaviors according to their savings potential in particular cities.

The collaboration resulted in the development of a "behavior wedge assessment" model that uses a variety of high-quality *secondary* data sources in the creation of city-specific characterizations of behavior opportunities for energy and carbon savings. As part of this project, the model was applied to create a prototype report or sample behavior wedge profile for the city of Baltimore. In this report, we have documented the development of the low cost model and how it was applied to create a sample behavior wedge profile for the residential energy sector in Baltimore.

Given the success of this effort, we can conclude that a low-cost means of providing cities with such estimates does exist. Moreover, a variety of factors suggest that the approach described in this report represents a rigorous, valid and reliable means of creating city-specific measures. First, the assessments are based on high-quality data collected by reputable government agencies including the U.S. Energy Information Administration and the U.S. Census Bureau. The use of such high quality data sources provides confidence in the reliability and validity of the source data used in the development of the behavior wedge profiles. Second, the behavior wedge framework is modeled on methodologies used to develop national-level estimates which have been scrutinized by way of several peer-review processes. As noted earlier in this report, these methodologies draw from the work of Dietz et al. (2009) – as published in the Journal of the National Academies of Science – as well as Laitner et al. (2009) – as published in the proceedings of the ECEEE summer study (an international conference attended by many of the most prominent energy experts from around the world) among other sources.

Finally, while the sample behavior wedge profile (developed as part of this project for the city of Baltimore) represents a *preliminary* application of the model described in this report, a fully developed model offers the opportunity for rigorous and reliable estimates of behavior savings opportunities if fully developed as recommended. Currently, the greatest limitation of the behavior wedge model lies in

its estimates of likely participation rates. Estimated participation rates are typically drawn from evidence from past programs and may also rely on the expertise of researchers and program implementers. These estimates can be enhanced through the use of Monte Carlo simulation techniques (as performed by Laitner et al. and other methodologies that assess multiple scenarios and a range of outcomes. In order to maximize the validity of estimates, the full development of the model would ideally involve a rigorous peer-review process that would draw on the expertise of a set of energy experts from relevant organizations and agencies and potentially include some scenario assessments for those estimates with the highest levels of uncertainty. This type of approach would ensure that behavior wedge profile estimates are both consistent and valid measures of the *achievable* behavior-related savings opportunities.

If developed as suggested here, the model could be used to generate city-specific behavior wedge profiles for the residential and personal transportation sectors in which the rigor, reliability and validity compare closely to the levels that can be achieved through much costlier approaches that rely on the collection of primary data through the fielding of city-specific surveys. As an added benefit, the planned development of the behavior wedge model will also identify behavioral opportunities associated with energy use in the *commercial* buildings sector – estimates that were not included in the GreeNYC research project.[7]

As summarized in the table provided below, a rough comparison of the advantages and disadvantages of the behavior wedge model versus a city-specific data collection effort reveals large economic advantages and time savings for city employees associated with the development and application of the behavior wedge model while the principle advantages of a city-specific data collection effort are its ability to freely determine which questions to ask and its ability to use the same survey data to perform population segmentation analysis. While primary data collection is required in order to perform population segmentation analysis, it is important to note that many cities may not choose to engage in this effort regardless of how the initial estimates are made. In addition, Section 8 of this report outlines a low-cost alternative approach to segmentation analysis should cities opt for the development of a behavior wedge profile. As discussed in Section 8, this approach recommends the use of targeted surveys and suggests the development of a set of survey modules to provide a low-cost means for data collection.

Point of Comparison	**Behavior Wedge Profile**	**Primary Survey Data Collection**
Cost per city	Low Cost	High cost
Effort required of cities	Low	High
Level of Rigor, Validity and Reliability[8]	Med. to High	Med. to High
Ease of (optional) Segmentation Analysis	Requires targeted but small-scale follow-up survey	Can be performed using original survey data

[7] Commercial buildings were not in the scope of the NYC study because the study was conducted to inform the work of GreeNYC, which exclusively focuses on residential behavior change.

[8] Because the methodologies associated with primary survey data and those used to create the BWP are dramatically different, only a rough comparison or rigor, validity and reliability can be made. For these reasons we present our overall estimates as a likely range

It is important to note that the comparisons made above are based on the best judgment of the authors of this report and are not founded on any type of quantitative measurement. None of the estimates provided in the table represent conclusions drawn from precise measures. In particular, the estimated levels of reliability, validity, and rigor must take into account many factors associated with the characteristics of the methodologies employed. As such, any attempt to provide a precise comparison would be misleading. More specifically, the reliability and validity of survey-based information is a function question wording, question ordering, the size of the sample, its ability to represent the larger population, and a variety of other factors that will vary from survey to survey. Because the methodologies employed to collect primary survey data and those used to create the Behavior Wedge Profile Report are dramatically different, only a rough comparison of these two methodologies can be made. For these reasons we present our overall estimate of rigor, validity and reliability as a likely range. More information about the factors used to evaluate these methodologies is also provided in the following text box.

Comparison of the validity, reliability, and rigor of the two methodologies

GreeNYC survey methodology and carbon assessment: This methodology uses primary survey data collection methodologies to collect information from New York City residents and then uses that information in combination with a series of algorithms to calculate city-level savings opportunities. The primary benefit of this approach is that it uses city-specific information to assess current practices, attitudes and intentions to change. The primary weakness of this approach is that the survey methodology is less rigorous than the more comprehensive set of data collection methodologies (including observational data) employed through RECS. The implication is that GreeNYC data are likely to be somewhat less valid and potentially less reliable given a variety of reporting biases that are not controlled for by the methodology employed. Some of these biases were revealed in the assessment of the GreeNYC approach which showed over-reporting of energy efficient lighting.

Behavior Wedge Model methodology: This methodology uses data from the EIA's Residential Energy Consumption Survey (for urban areas in states and state clusters) and the Census Bureau (for cities) to estimate city-level savings opportunities. The primary benefit of this approach is that it is based on some of the highest quality data collected through highly rigorous and proven data collection techniques. (The standard of quality of the RECS and Census data exceed that of the GreeNYC survey.) The primary weakness of this approach is that the RECS data are not city-specific. In order to arrive at city specific estimates, the methodology uses data for urban areas only and then weights those data according to the characteristics of the city in question. This estimation approach presents a different set of constraints that also limit the reliability and validity of these measures.

Estimates of behavior-related savings opportunities (regardless of whether the estimates come from the implementation of the behavior wedge model or primary data collection) may be supplemented with utility data. However, two important notes should be made here concerning the availability and scope of utility data. First, most utilities have not been willing to share energy use data with cities or other entities, effectively barring the ability to use this source of information in the analysis of local patterns and trends. Second, even when utility data are made available, they typically only provide information about energy consumption patterns at the building or community level but cannot provide information about technology saturation or use within buildings. Thus, even when utility data are available, the level of insights that they can provide about behavior-related savings opportunities is much more limited when compared with either the information provided by a behavior wedge profile or city-specific, primary data collection efforts.

Overall, the results of this assessment have confirmed that the energy and carbon savings opportunities associated with behavior-based approaches could result in significant reductions in energy use and carbon emissions. The assessment also documents some of the important sources of variation that exist across different areas of the country which confirm the need for city-specific assessments of behavioral opportunities. According to the set of recent, national-level assessments reviewed in Section 5 of this report, potential savings from the residential sector and personal transportation alone have been estimated at between 20 and 30 percent of current levels of energy consumption and carbon emissions. Importantly, the extension of these assessments to the commercial buildings sector is likely to reveal additional savings opportunities. Similar to the national-level assessments, the sample behavior wedge profile created for the city of Baltimore (described herein) resulted in an estimated potential energy savings in Baltimore's residential sector alone of roughly 14 percent. While the scale of national-level savings opportunities has become increasingly well documented, the assessment provided in this report provides new and compelling information that regional and sub-regional differences in climate, building stock, technology saturation, technology use, and public attitudes provide important sources of city-to-city variation and determine which types of behaviors that offer the greatest savings opportunities in particular cities. This variation suggests the value in developing city-specific assessments of the most promising behavioral opportunities for energy and carbon savings.

Finally, this assessment has not only identified a potential, low-cost means of replicating the information gathered by the GreeNYC initiative but has actually laid the groundwork for the full development of such a model. In response to the expressed interest of USDN members involved in this project, the Garrison Institute developed a preliminary model that draws from existing data sources and past research to create city-specific estimates of the *achievable* behavior-based savings and to identify specific sets of behaviors that offer the greatest savings opportunities (see Section 7 of this report). Moreover, the model was subsequently applied to develop a prototype report – or "Behavior Wedge Profile" – for the city of Baltimore as discussed in Section 6. (A copy of the Sample Behavior Wedge Profile is also included in the Appendices of this report.) The results provide clear evidence that of a low-cost model is available to provide rigorous, reliable and much needed data to cities and that this information can provide the means for better programs and enhanced energy and carbon savings. (Table of Contents)

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11. Appendices

1. Sample Behavior Wedge Profile – Baltimore
2. Regional Variation Slide Presentation
3. RECS Subset - Baltimore Residential Profile Spreadsheet
4. 2009 RECS Codebook
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5. 2009 RECS Questionnaire
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6. 2003 CBECS Codebook
    a. http://www.eia.gov/emeu/cbecs/cbecs2003/public_use_2003/layouts&formats.pdf
7. 2003 CBECS Questionnaire
    a. http://www.eia.gov/emeu/cbecs/cbecs03ques.pdf
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    a. http://www.eia.gov/survey/form/eia_871/2012/2012%20CBECS%20Form%20871A%20Building%20Questionnaire.pdf

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