

MUNICIPAL BEHAVIOR WEDGE

DOE BEHAVIOR POTENTIAL WORKSHOP

SAN FRANCISCO, CA

JUNE 13, 2016

NAVIGANT

DISCLAIMER

Notice Regarding Presentation

This presentation was prepared by Navigant Consulting, Inc. (Navigant) for informational purposes only. Navigant makes no claim to any government data and other data obtained from public sources found in this publication (whether or not the owners of such data are noted in this publication).

Navigant does not make any express or implied warranty or representation concerning the information contained in this presentation, or as to merchantability or fitness for a particular purpose or function. This presentation is incomplete without reference to, and should be viewed solely in conjunction with the oral briefing provided by Navigant. No part of it may be circulated, quoted, or reproduced for distribution without prior written approval from Navigant.

DISCLAIMER

Copyright

This report is protected by copyright. Any copying, reproduction, publication, dissemination or transmittal in any form without the express written consent of the U.S. Department of Energy is prohibited.

Disclaimer

This report (“report”) was prepared for the U.S. Department of Energy on terms specifically limiting the liability of Navigant Consulting, Inc. (Navigant), and is not to be distributed without Navigant’s prior written consent. Navigant’s conclusions are the results of the exercise of its reasonable professional judgment. By the reader’s acceptance of this report, you hereby agree and acknowledge that (a) your use of the report will be limited solely for internal purpose, (b) you will not distribute a copy of this report to any third party without Navigant’s express prior written consent, and (c) you are bound by the disclaimers and/or limitations on liability otherwise set forth in the report. Navigant does not make any representations or warranties of any kind with respect to (i) the accuracy or completeness of the information contained in the report, (ii) the presence or absence of any errors or omissions contained in the report, (iii) any work performed by Navigant in connection with or using the report, or (iv) any conclusions reached by Navigant as a result of the report. Any use of or reliance on the report, or decisions to be made based on it, are the reader’s responsibility. Navigant accepts no duty of care or liability of any kind whatsoever to you, and all parties waive and release Navigant from all claims, liabilities and damages, if any, suffered as a result of decisions made, or not made, or actions taken, or not taken, based on this report.

Confidentiality

This report contains confidential and proprietary information. Any person acquiring this report agrees and understands that the information contained in this report is confidential and, except as required by law, will take all reasonable measures available to it by instruction, agreement or otherwise to maintain the confidentiality of the information. Such person agrees not to release, disclose, publish, copy, or communicate this confidential information or make it available to any third party, including, but not limited to, consultants, financial advisors, or rating agencies, other than employees, agents and contractors of such person and its affiliates and subsidiaries who reasonably need to know it in connection with the exercise or the performance of such person’s business. The terms of the client engagement letter or contract usually provide that the Client is the owner of the copyrighted report, but in some contracts, Navigant retains ownership of the copyright.

MUNICIPAL BEHAVIOR WEDGE: FOCUS



Estimates

Achievable, household energy savings potential.

Scale

Estimates have been generated at the city-level for 5 U.S. cities

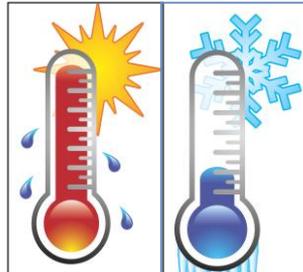
As currently configured, could produce estimates at the following scales:

- utility district
- state
- regional
- national levels



MUNICIPAL BEHAVIOR WEDGE: BEHAVIORS

Heating
(7 behaviors)



Cooling
(8 behaviors)

Appliances
(7 behaviors)



Plug Load &
Electronics
(3 behaviors)

Lighting
(3 behaviors)



Pools & Spas
(4 behaviors)

MUNICIPAL BEHAVIOR WEDGE: BEHAVIORS

Ehrhardt-Martinez, 2015: Achievable = 7.5-11% of Res. Demand

Heating & Cooling	Appliances	Electronics, Plug Load & Lighting	Other	
Accelerate equip. replacement (x2)	Unplug 2 nd fridge/freezer	CFLs, LEDs & EE bulbs	Install and/or use pool pump timers	
Equip. maintenance (x2)	Water heater settings	Turn off unused indoor light	Install and/or use pool covers	
Thermostat setbacks (x2)	Water heater insulation	Turn off outdoor light	Accel. adoption of EE pool pumps	
Smart thermostats (x2)	Purchase of EE Washer	Laptops & EE computers	Install and/or use hot tub timers	
Weatherization (x2)	Cold water wash	Vampire load mgmt.		
Manage temp in unused spaces (x2)	Reduce laundry loads	Plug load mgmt.		
Window insulation or blinds (x2)	Air dry laundry			
Ceiling fan use				
			TOTAL BEHAVIORS	34
			Res. EE Investments	6
			Res. Non-Investments	28
			Transportation	0
			Embedded	0

MUNICIPAL BEHAVIOR WEDGE: DATA



Data Sources and Inputs for the Residential Municipal Behavior Wedge Model

1 CENSUS DATA

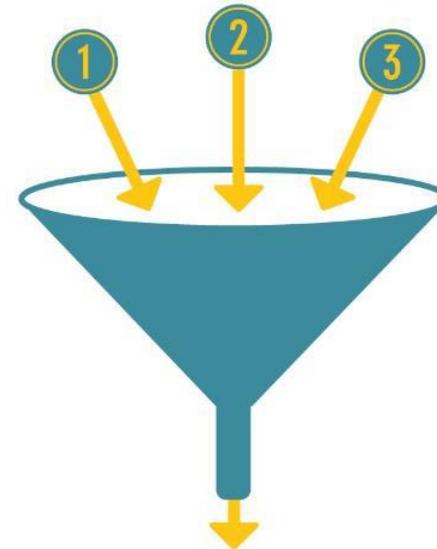
- Population & demographic information
- Housing stock characteristics
- Economic & poverty measures

2 RECS DATA (Residential Energy Consumption Survey)

- Technology saturation & housing characteristics
- Technology use patterns
- Energy consumption data

3 EXPERT INSIGHTS & LITERATURE REVIEW

- Household participation rates
- Energy savings estimates
- Compliance rates



ESTIMATES OF ACHIEVABLE SAVINGS
for Behavioral Programs



The Step by Step Process

1. Identify existing data sources (RECS, Census)
2. Identify laundry list of potential behaviors
3. Narrow the list (based on likely savings and data availability)
4. Develop algorithms to estimate *achievable* savings
5. Weight state-level energy data to reflect city-level housing stock characteristics and household characteristics
6. Consult literature and experts to estimate participation rates
7. Run algorithms to develop estimates for each behavior

MUNICIPAL BEHAVIOR WEDGE: METHOD



4 Sets of Algorithms across 32 Behaviors

		Savings Period	
		Short-Term	Medium-Term
Housing Type	Single-Family (SF)	(Number of Homes) x (% single family) x (% SF eligibility) x (likely short-term SF participation) x (current SF energy use) x (estimated savings rate per HH)	(Number of Homes) x (% single family) x (% SF eligibility) x (likely medium-term SF participation) x (current SF energy use) x (estimated savings per HH)
	Multi-Family (MF)	(Number of Homes) x (% multi family) x (% MF eligibility) x (likely short-term MF participation) x (current MF energy use) x (estimated savings per HH)	(Number of Homes) x (% multi family) x (% MF eligibility) x (likely medium-term MF participation) x (current MF energy use) x (estimated savings per HH)



4 Sets of Algorithms across 32 Behaviors

cooling conservation actions	<p>ELIGIBILITY = [(# of homes) x (% of homes with central AC) x (% of homes in which bedrooms > (HH occupants-1))].</p> <p>TOTAL SAVINGS = For Elig HHs, [\sum[(number of excess bedrooms {# of bedrooms - (HH occupants - 1)}) x (120 sqft)] / (home size)] x (Cooling BTUs) x (Particip. Rate).</p> <p>AVG SAVINGS = Total Savings / ((# Elig. HHs) x (Particip. Rate)).</p>
------------------------------------	--

* Example is for short-term savings for cooling conservation action in SF homes only.

**Data for all variables other than participation rate are drawn from RECS. Participation rates associated with particular actions are drawn from a combination of program literature and expert insights.

MUNICIPAL BEHAVIOR WEDGE: OUTPUTS



EXECUTIVE SUMMARY

Baltimore's opportunity to reduce residential energy consumption by 7.7% using behavior change programs is predominantly in the single-family market.

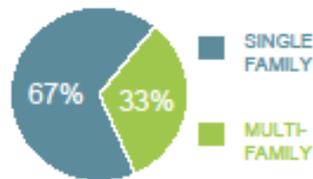
**6.3%
REDUCTION**

in Baltimore's residential energy use can be achieved through single-family behavior initiatives over an 8-year timeframe.

**1,775 bBtus
IN SAVINGS**

would be realized from the 6.3% reduction in energy use. Add equivalency.

BUILDING STOCK RATIO



**1.4%
REDUCTION**

in Baltimore's residential energy use can be achieved through multi-family behavior initiatives over an 8-year timeframe.

**390 bBtus
IN SAVINGS**

would be realized from the 1.4% reduction in energy use. Add equivalency.

SINGLE-FAMILY SAVING OPPORTUNITIES

		% OF (SF) OPPORTUNITY	bBtu SAVINGS
HEATING		52.7%	936
COOLING		8.6%	153
APPLIANCES		19.4%	344
ELECTRONICS		3.9%	69
LIGHTING		6.6%	117
POOLS & SPAS		8.9%	157
		100%	1,776

Short-term Savings (1-4yrs)
 Medium-term Savings (5-8yrs)

MULTI-FAMILY SAVING OPPORTUNITIES

		% OF (MF) OPPORTUNITY	bBtu SAVINGS
HEATING		64.8%	253
COOLING		14.9%	58
APPLIANCES		8.0%	31
ELECTRONICS		6.6%	26
LIGHTING		5.7%	22
POOLS & SPAS		-	-
		100%	390

Short-term Savings (1-4yrs)
 Medium-term Savings (5-8yrs)

MUNICIPAL BEHAVIOR WEDGE: OUTPUTS

Baltimore's Top 10 Residential Behaviors



TOP 10 ENERGY SAVING BEHAVIORS

Opportunities represent combined single and multi-family savings in the medium-term.

1,630 bBtus
OF SAVINGS
Can be achieved through these 10 behaviors

5.8%
REDUCTION
in Baltimore's residential energy use can be achieved through these 10 behaviors

1	2	3	4	5
<p>HEATING & COOLING Home Weatherization</p> <p>The large number of old and drafty homes in Baltimore mean that caulking, weather stripping and duct sealing can save a lot of heat.</p> <p>15.9% OF TOTAL OPPORTUNITY 345 bBtus OF ENERGY SAVINGS</p>	<p>HEATING Conservation Actions</p> <p>By closing doors and ducts and reducing heat in unused rooms, households can reduce energy waste.</p> <p>10.8% OF TOTAL OPPORTUNITY 235 bBtus OF ENERGY SAVINGS</p>	<p>HEATING Thermostat Settings & Setbacks</p> <p>Thermostats should be set at or near EPA recommended temperatures and set back further at night and when no one is home.</p> <p>10.2% OF TOTAL OPPORTUNITY 221 bBtus OF ENERGY SAVINGS</p>	<p>HEATING Accelerated Heating Equip. Replacement</p> <p>Programs that encourage people to replace inefficient heating equipment before it breaks down can save a lot of energy.</p> <p>9.7% OF TOTAL OPPORTUNITY 210 bBtus OF ENERGY SAVINGS</p>	<p>APPLIANCES Unplug 2nd Refrigerator</p> <p>An estimated 37% of single-family households in Baltimore have a second (generally inefficient) refrigerator. Recycled it could save a lot of energy.</p> <p>8.3% OF TOTAL OPPORTUNITY 181 bBtus OF ENERGY SAVINGS</p>
<p>6</p> <p>HEATING Equipment Maintenance</p> <p>Annual maintenance of heating equipment and replacement of filters ensures greater efficiency.</p> <p>4.8% OF TOTAL OPPORTUNITY 103 bBtus OF ENERGY SAVINGS</p>	<p>7</p> <p>HEATING Window Insulation</p> <p>An estimated 40% of Baltimore's homes have single pane windows. Using storm windows, window film and thermal window coverings could reduce heat loss.</p> <p>4.3% OF TOTAL OPPORTUNITY 94 bBtus OF ENERGY SAVINGS</p>	<p>8</p> <p>LIGHTING Install Energy Efficient Bulbs</p> <p>CFL saturation in Baltimore is estimated at 15%. Installing more CFLs (and other efficient bulbs) can still have a big impact.</p> <p>4.2% OF TOTAL OPPORTUNITY 91 bBtus OF ENERGY SAVINGS</p>	<p>9</p> <p>POOLS Increase Use of Pool Pump Timers</p> <p>Most households with pools, either don't have a pump timer or fail to set it properly. Timers can reduce the hours of pump running time.</p> <p>3.6% OF TOTAL OPPORTUNITY 77 bBtus OF ENERGY SAVINGS</p>	<p>10</p> <p>APPLIANCES Clothes Washer Conservation</p> <p>An estimated 50% of Baltimore's households wash primarily in cold water. Cold water wash and load consolidation can reduce hot water use.</p> <p>3.4% OF TOTAL OPPORTUNITY 73 bBtus OF ENERGY SAVINGS</p>

MUNICIPAL BEHAVIOR WEDGE: OUTPUTS

Baltimore's City Profile



Every city is different. Multiple factors were considered when developing the achievable energy savings estimates for Baltimore.

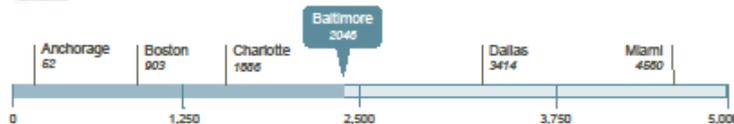
CLIMATE



HEATING DEGREE DAYS | per year on average



COOLING DEGREE DAYS | per year on average



TECHNOLOGY SATURATION

Percentages represent the proportion of Baltimore's households (both single and multi-family) with the following characteristics.

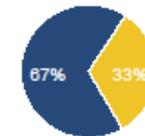
- 32% Heating systems over 15 years old
- 44% Fail to perform regular heating system maintenance
- 22% Programmable Thermostat
- 40% Single pane windows
- 50% Two or more ceiling fans
- 25% Second fridge
- 27% Top Load Washer
- 51% Wash in Cold Water
- 5% Swimming Pools

BUILDING STOCK

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

BUILDING STOCK RATIO

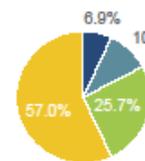
of the 296,056 housing units in Baltimore



- SINGLE-FAMILY
31.7% Rent | 68.2% Own
- MULTI-FAMILY
90.4% Rent | 9.6% Own

BUILDING STOCK AGE

Combined single & multi-family data



- <1950
- 1950-1969
- 1970-1989
- 1990-2009



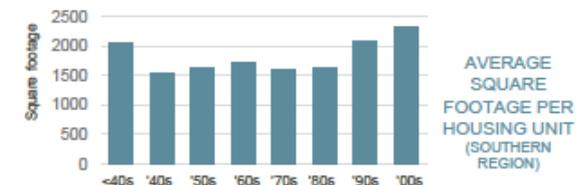
2,233sf

Average single-family home size



924sf

Average multi-family housing unit size

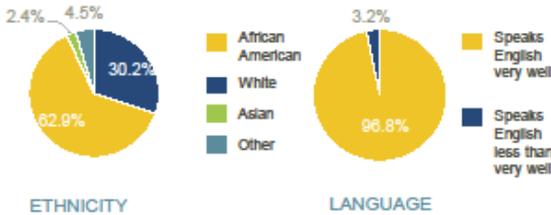


MUNICIPAL BEHAVIOR WEDGE: OUTPUTS

Baltimore's City Profile

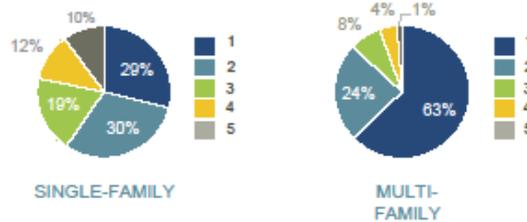
DEMOGRAPHICS

622,104
PEOPLE
are living in Baltimore



PEOPLE PER HOUSEHOLD

2.48
PEOPLE
living per home on average in Baltimore

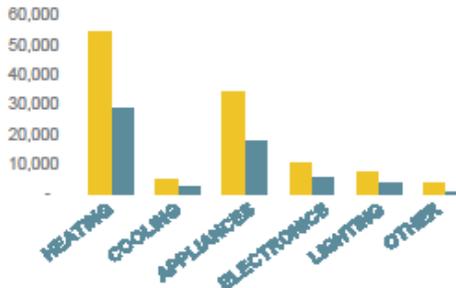


CURRENT USAGE PATTERN

Single-family homes use roughly twice as much energy a year compared to multi-family units

113,165 tBtus
Average annual energy use
SINGLE-FAMILY

57,548 tBtus
Average annual energy use
MULTI-FAMILY



HOUSEHOLD INCOME

Median household income in Baltimore is \$40,803, however median income among renters (\$26,861) is less than half the median income of owners (\$59,923). Nearly a quarter of Baltimore's adult residents (23.4%) live below the poverty line.



HOUSEHOLD COMPOSITION

Single-family homes are more likely to have youth, teens and older adults living in them. Young adults and elderly residents are equally likely to be found in single-family or multi-family homes.

FAMILY HOUSEHOLDS		
• HHs w/children under 18 years old	22.2%	
• Married couples	24.0%	
• Married couples w/children	8.1%	
• Female headed household	23.4%	
• Female headed household w/children	12.0%	
• Male headed household	5.0%	
• Male headed household w/children	2.0%	

NON-FAMILY HOUSEHOLDS		
• Living alone	39.2%	
• 65+ years	11.2%	

EDUCATION LEVEL

18.4% < HIGH SCHOOL
25.9% HIGH SCHOOL
26.3% SOME COLLEGE
29.3% COLLEGE DEGREE OR MORE

MUNICIPAL BEHAVIOR WEDGE: OUTPUTS

End Use findings for **Cooling**-related Behaviors



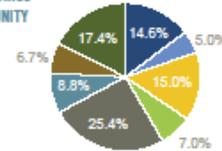
COOLING

Single-family energy saving opportunities

17%
SAVINGS

in current cooling demand is achievable through the identified behaviors. Single-family homes in Baltimore are currently using an estimated 899 bBtus annually.

% OF SAVINGS OPPORTUNITY



153 bBtus

could be saved through these behaviors alone.

A B C D E F G H

Left hand Bar= Estimated Annual Savings by end of Year 4.

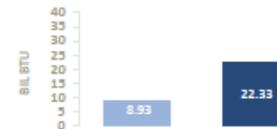
Right hand Bar= Estimated Annual Savings by end of Year 8.



A Ceiling Fan Installation & Use

Target: Home Owners & Renters
Increase the prevalence and frequency of use of fans and reduce AC use.

25.4% % OF COOLING OPPORTUNITY
47% HOUSEHOLDS ELIGIBLE*
Up to **25%** ANNUAL HOUSEHOLD SAVINGS**



D Accelerated Cooling Equipment Replacement

Target: Home Owners
Increase efficiency through accelerated replacement of inefficient AC equipment (10+ years old) before it breaks down.

14.6% % OF COOLING OPPORTUNITY
28% HOUSEHOLDS ELIGIBLE*
Up to **33%** ANNUAL HOUSEHOLD SAVINGS**



B Window Film & Window Coverings

Target: Home Owners and Renters
Reduce solar heat gain and energy loss through the use of reflective film and window coverings.

17.4% % OF COOLING OPPORTUNITY
57% HOUSEHOLDS ELIGIBLE*
Up to **13.2%** ANNUAL HOUSEHOLD SAVINGS**



E Weatherization

Target: Primarily Home Owners
Minimize the loss of cool air through caulking, weather stripping and duct sealing.

8.8% % OF COOLING OPPORTUNITY
11% HOUSEHOLDS ELIGIBLE*
Up to **30%** ANNUAL HOUSEHOLD SAVINGS**



C Thermostat Settings & Setbacks

Target: Home Owners and Renters
Set thermostats at EPA recommended temps (82 at night, 88 away, 78 during the day when someone is home).

15.0% % OF COOLING OPPORTUNITY
39% HOUSEHOLDS ELIGIBLE*
Up to **15.6%** ANNUAL HOUSEHOLD SAVINGS**



F Wall Unit AC Settings

Target: Primarily Renters
Set thermostats at EPA recommended temperatures and turn off when no one is at home.

7.0% % OF COOLING OPPORTUNITY
36% HOUSEHOLDS ELIGIBLE*
Up to **11.4%** ANNUAL HOUSEHOLD SAVINGS**

*Household eligibility is determined independently for each behavior. More information is available in the methodology report.

**Estimates of annual households savings are for participating households.

MUNICIPAL BEHAVIOR WEDGE: OUTPUTS

End Use findings
for **Cooling**-related
Behaviors



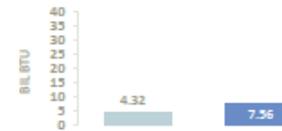
COOLING

Single-family energy
saving opportunities

...Continued

Left hand Bar= Estimated Annual Savings by end of Year 4.

Right hand Bar= Estimated Annual Savings by end of Year 6.



G Conservation

Target: Home Owners and Renters
Reducing energy waste by closing doors and ducts
and reducing heat in unused rooms.

6.7% % OF COOLING OPPORTUNITY
46% HOUSEHOLDS ELIGIBLE*
6.1% ANNUAL HOUSEHOLD SAVINGS**

H Cooling Equipment Maintenance

Target: Home Owners and Renters
Increase performance of cooling equipment with
regular cleaning/service and changing of filters.

5.0% % OF COOLING OPPORTUNITY
32% HOUSEHOLDS ELIGIBLE*
Up to 8% ANNUAL HOUSEHOLD SAVINGS**

MUNICIPAL BEHAVIOR WEDGE: OUTPUTS

Top Ten Residential Behaviors across Cities

Baltimore	Boston	Charlotte	Miami	Park City
Home Weatherization	Heating Home Weatherization	Heating Thermostat Settings	Ceiling Fans	Heating Thermostat Settings
Heating Conservation	Heating Equipment Replaceme	Heating Conservation	Cooling Window Film	Heating Weatherization
Heating Thermostat Settings	Heating Conservation	Ceiling Fans	Cooling Thermostat Settings	Heating Equipment Replaceme
Heating Equipment Replaceme	Heating Thermostat Settings	2nd Refrigerator	Cooling Equipment Replaceme	Heating Equipment Maintenance
2nd Refrigerator	Heating Equipment Maintenance	Energy Efficient Light Bulbs	Cooling Equipment Maintenance	Heating Conservation
Heating Equipment Maintenance	Heating Window Insulation	Heating Equipment Maintenance	Energy Efficient Light Bulbs	2nd Refrigerator
Heating Window Insulation	2nd Refrigerator	Heating Weatherization	2nd Refrigerator	Energy Efficient Lighting
Energy Efficient Light Bulbs	Energy Efficient Light Bulbs	Cooling Window Film	Cooling Conservation	Water Heater Settings & Ins.
Pool Timers	Water Heater Settings & Ins.	Clothes Washer Conservation	Energy Efficient pool Pumps	Heating Window Ins.
Clothes Washer Conservation	Home Entertainment Plug Load	Pool Timers	Pool Timers	Air Dry Laundry

MUNICIPAL BEHAVIOR WEDGE: OUTPUTS

Top Ten Residential Behaviors

	BEHAVIOR	
5	2nd Refrigerator	
5	Energy Efficient Light Bulbs	
4	Heating Home Weatherization	
4	Heating Conservation	
4	Heating Thermostat Settings	
4	Heating Equipment Maintenance	
3	Heating Window Insulation	
3	Pool Timers	
3	Heating Equipment Replacement	
2	Cooling Window Film	Charlotte and Miami
2	Ceiling Fans	Charlotte and Miami
2	Clothes Washer Conservation	Baltimore & Charlotte
2	Water Heater Settings & Ins.	Boston & Park City
1	Home Entertainment Plug Load	Boston
1	Cooling Thermostat Settings	Miami
1	Cooling Equipment Replacement	Miami
1	Cooling Equipment Maintenance	Miami
1	Cooling Conservation	Miami
1	Energy Efficient pool Pumps	Miami
1	Air Dry Laundry	Park City

MUNICIPAL BEHAVIOR WEDGE: OUTPUTS

Savings from Non-investment Behaviors

	Baltimore	Boston	Charlotte	Miami	Park City
Savings from Every Day Energy Practices	21%	13%	32%	54%	24%
Savings from Energy Stocktaking	63%	66%	55%	33%	61%
Saving from Behavioural Practices	84%	78%	87%	87%	85%

MUNICIPAL BEHAVIOR WEDGE: CLOSING THOUGHTS

Benefits

- Scalable
- Uses reliable and rigorous data inputs
- Low-cost
- Able to estimate potential energy savings from 32 household behaviors

Opportunities to Modify

- Run at the state, regional or national level
- Add additional behaviors
- Supplement or triangulate using utility data
- Use regressions to develop a set of city-specific household profiles

Access

- Most data inputs are publically available
- Underlying model would require additional work to make it broadly accessible

MUNICIPAL BEHAVIOR WEDGE: SUMMARY

Municipal Behavior Wedge Profile

Geographic Coverage: City-level estimates (could be state, regional, national)

Behaviors: 32 (6 investment behaviors)

Methodology: **Existing Data Resources as Model Inputs**

Focus	Savings as % of National Energy Consumption	Savings as % of Res. Energy Consumption	Range of Behaviors
Achievable Energy Savings	1.5-2.4%	7-11%	Res. actions + EE investment

References:

Ehrhardt-Martinez, Karen, et al. (2013). Behavior Wedge Profile: Model Development and Documentation, Garrison Institute Climate, Mind and Behavior Program.

Ehrhardt-Martinez, Karen. (2015). Municipal Behavior Wedge Profile: Methodology Report, Garrison Institute.

Ehrhardt-Martinez, Karen. (2015). Behavior Wedge Profiles for Cities: Estimating Achievable Savings and Critical Behaviors, eceee Summer Study.

CONTACTS

KAREN EHRHARDT-MARTINEZ

Associate Director

303.942.1094

Karen.Ehrhardt.Martinez@Navigant.com