Behavior Wedge Profiles for Cities:

Estimating Achievable Savings and Critical Behaviors

Residential Buildings

Commercial Buildings

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eceee Summer Study
June 5, 2015

Contents

1. The Challenge for Cities (and the goal)
2. Estimation Model
3. Achievable Savings Estimates for Cities
4. Conclusions

The Challenge for Cities

National Studies for USA: 38% of emissions under direct control of households

	Dietz et al. (2009)	Laitner & Ehrhardt-Martinez (2009)	Gardner & Stern (2008)
Focus:	Carbon Emissions Savings	Energy Savings Opportunities	Energy Savings Opportunities
Scope:	17 Household Actions	110 HH Actions (Roughly)	27 HH Actions (Roughly)
Potential Savings: Residential Sector	20% (of HH Direct Emissions)	22%	30%
Potential Savings: National	7.4% (of National Emissions)	9%	11%
Period to Achieve Max. Annual Savings	10 years	5 to 8 years	N/A

Conservative estimates for Residential and Personal Transport only.

USDN

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The Urban Sustainability Directors Network (USDN) is a peer-to-peer network of local government professionals from cities across the United States and Canada dedicated to creating a healthier environment, economic prosperity, and increased social equity. Our dynamic network enables sustainability directors and staff to share best practices and accelerate the application of good ideas across North America.

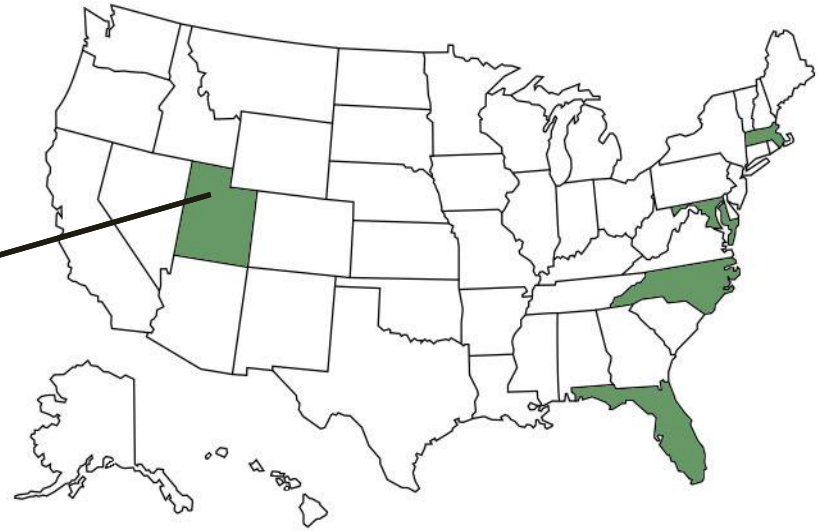
The Challenge for Cities

Goal

- Identify the scale of savings opportunities from behavior at the city level.
- Determine the behaviors that offer the largest savings opportunities.

Challenge

- Utility data was not available.
- Primary data collection was too expensive.



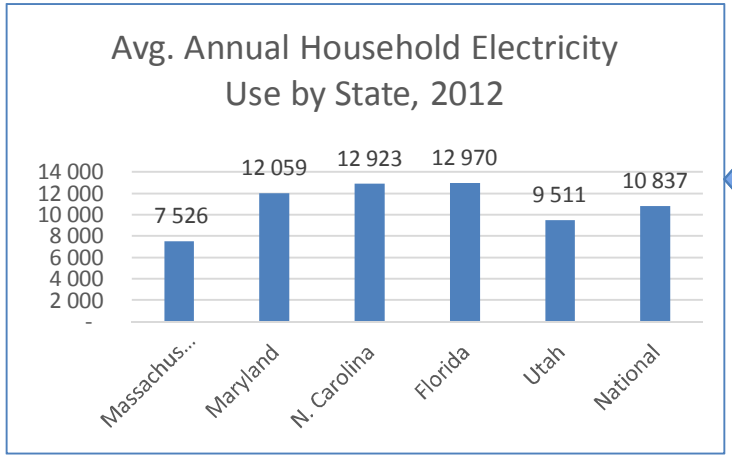
Boston, Massachusetts

Baltimore, Maryland

Charlotte, North Carolina

Miami, Florida

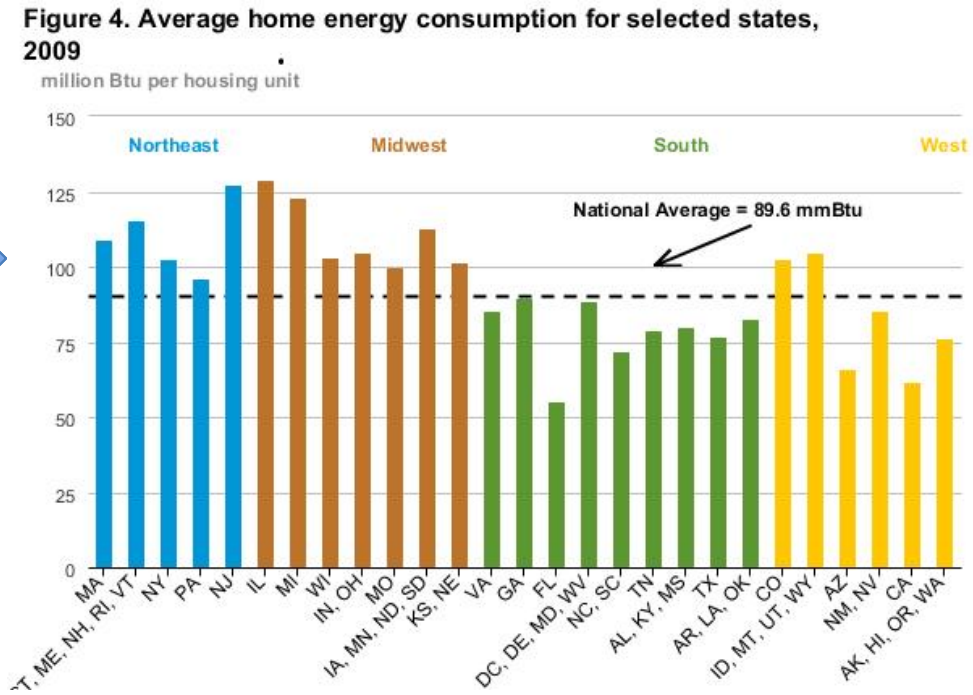
The Challenge for Cities



Avg An. Electricity varies from 7500 kwh in Mass. to nearly 13,000 in N. Carolina and Florida.

Hawaii = 6,530 kwh/year
Louisiana = 15,050 kwh/year

Avg An. energy varies from 56 mBtu in Florida to 129 in Illinois.



The Challenge for Cities

Other Important Difference across States and Cities:

- The size of housing and their construction characteristics
- The predominance of single-family versus multi-family housing
- The saturation of various household technologies (i.e. dishwashers)
- Cultural norms concerning how technologies are used

The Estimation Methodology

Goal: develop a low cost means of:

- Estimating the scale of savings opportunities from behavior at the city level.
- Determine the behaviors that offer the largest savings opportunities.

1 CENSUS DATA

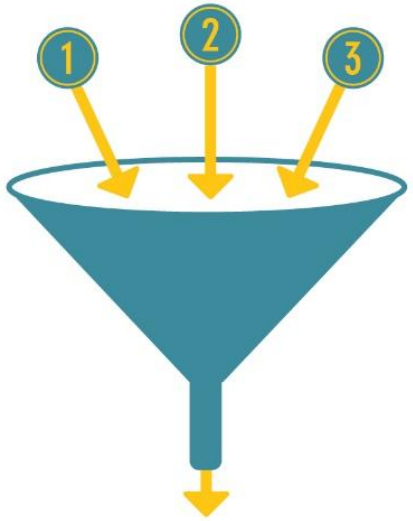
- Population & demographic information
- Housing stock characteristics
- Economic & poverty measures

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

Behavior Wedge Assessment Methodology

Primary Data Sources

- RECS (Residential Energy Consumption Survey)
- U.S. Census data on housing and household demographics

About the RECS

N = 12,083

Housing Characteristics *(Interviews)*

- Structural and geographic characteristics
- Square footage
- Household demographics
- Technology saturation and technology use
- Fuels used and end uses

Consumption & Expenditures
(Utility supplier data)

- Summary statistics
- By fuel
- By end uses
- By end uses by fuel

The Estimation Methodology

Three Core Elements

1. A focus on **achievable** savings opportunities:
   - (Eligibility) **x** (Likelihood of Participation) **x** (Range of Savings)

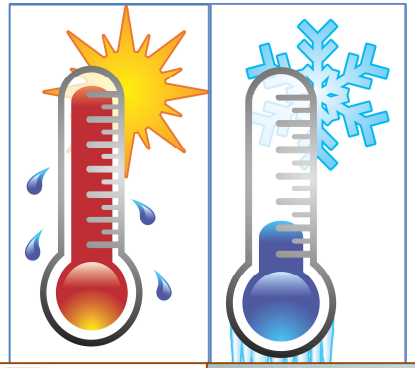
2. Targeting behavioral solutions:

Line-Drying
Versus
Dryer

3. Developing a short-list versus a laundry list of potential behaviors.

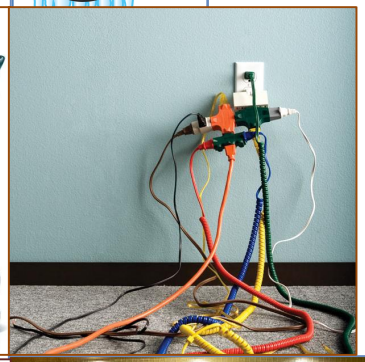
The Estimation Methodology

Heating
(6 behaviors)



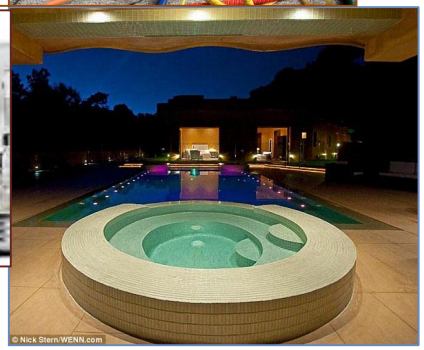
Cooling
(8 behaviors)

Appliances
(7 behaviors)



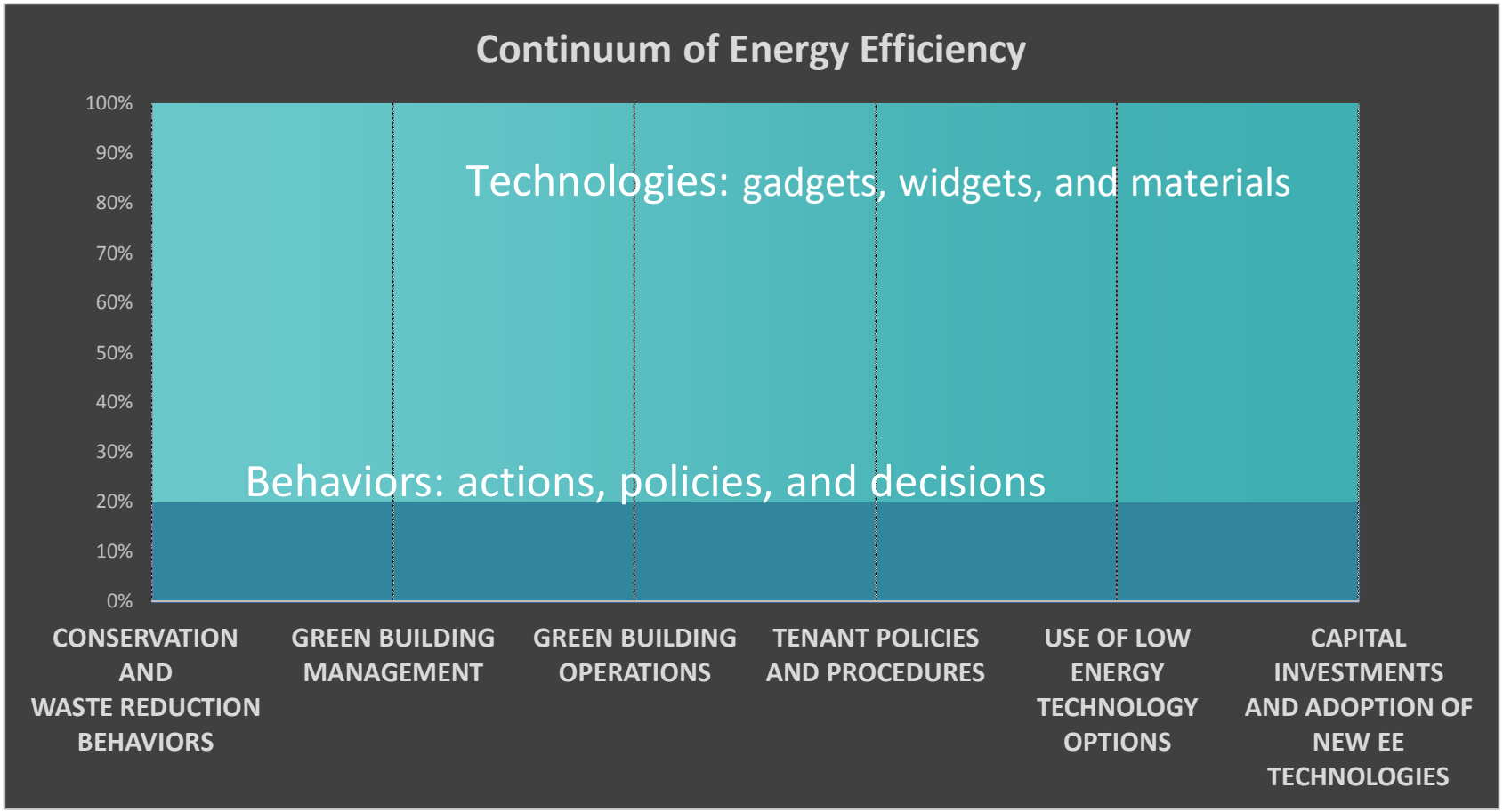
Plug Load &
Electronics
(4 behaviors)

Lighting
(3 behaviors)



Pools and
Spas
(4 behaviors)

“Behaviors” and Technologies



Behavior Wedge Assessment Methodology

Heating Behaviors

- Thermostat Settings and set backs
- Conservation
- Weatherization
- Heating Equipment Maintenance
- Window Insulation
- Accelerated Equipment Replacement

Cooling Behaviors

- Ceiling Fan use
- Window coverings/film
- Thermostat setbacks
- Accelerated Equipment replacement
- Weatherization
- Wall unit AC Settings
- Conservation
- Cooling Equipment Maintenance

Appliance Behaviors

- Unplug second fridge/freezer
- Cold water wash
- Air dry laundry
- Insulate water heater
- Reduce number of laundry loads
- Lower water heater settings
- Accelerated purchase of EE washer

Electronics Behaviors

- Home enter. vampire load mgmt.
- Misc plug load management
- Home office vampire load mgmt.
- Accelerated replacement of desktops with laptops

Behavior Wedge Assessment Methodology

Lighting Behaviors

- EE bulbs (CFLs, LEDs)
- conservation
- Turn off indoor lighting
- Turn off outdoor lighting

Pools and Spas Behaviors

- Change pool pump settings
- Accelerated pump replacement
- Use hot tub timers
- Use pool covers

Behavior Wedge Assessment Methodology

4 Sets of Algorithms across 32 Behaviors

		Savings Period	
Housing Type		Short-Term	Medium-Term
	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)

Behavior Wedge Assessment Methodology

4 Sets of Algorithms across 32 Behaviors

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

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

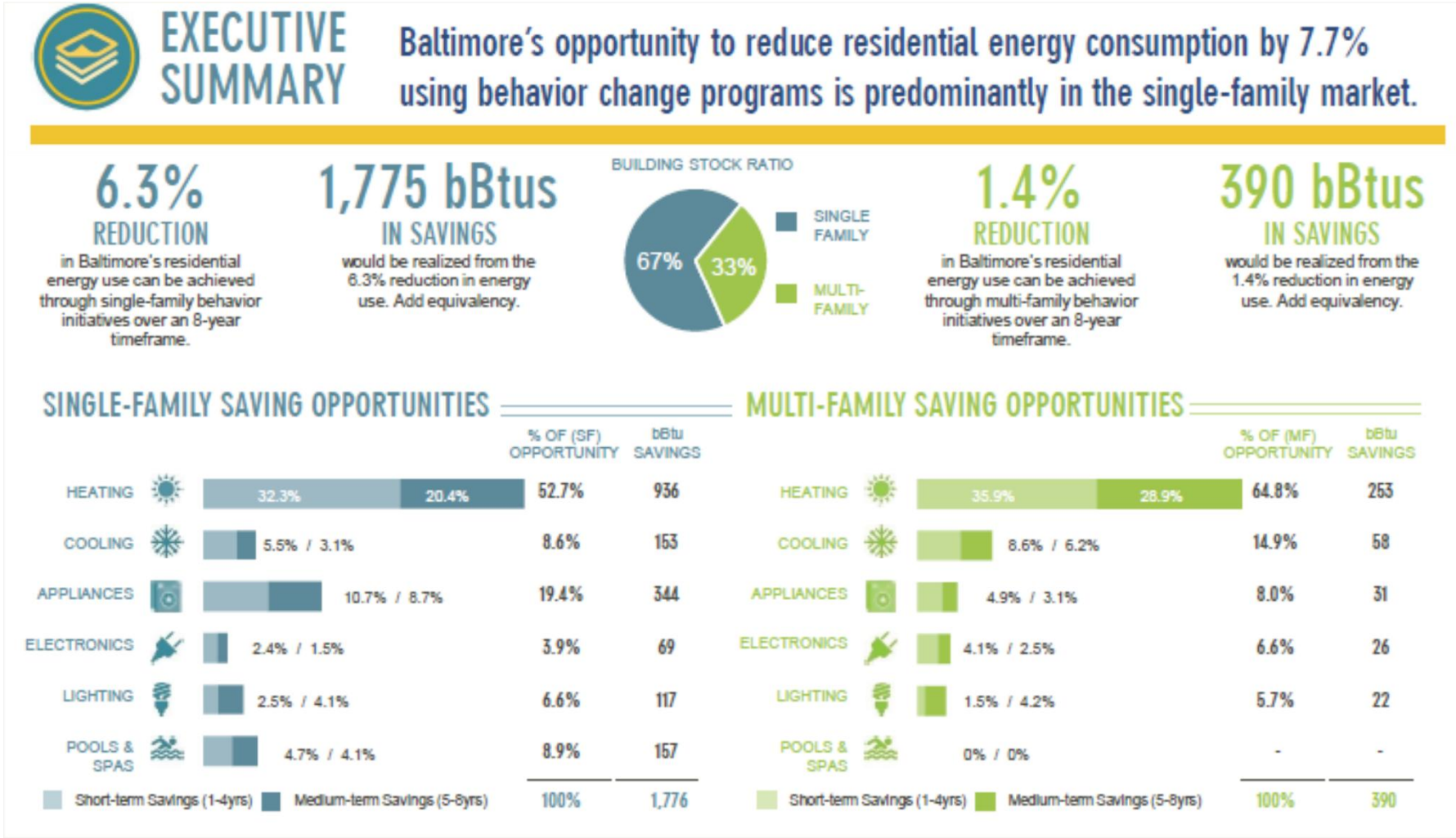
Behavior Wedge Assessment Methodology

The Step by Step Process

1. Identify existing data sources (RECS, Census)
2. Identify laundry list of potential behaviors
3. Narrow the list to most promising behaviors
4. Develop the algorithms to estimate *achievable* savings

5. Weight state-level energy data to reflect city-level housing characteristics and numbers
6. Run algorithms to develop estimates

Sample Findings: Baltimore



Findings Across Cities

	Baltimore	Boston	Charlotte	Miami	Park City
Number of Households	296,056	272,481	319,918	187,869	9,496
Total Energy Consumption (terajoules)	29,702	27,786	21,422	7,693	821
% Multi-family	34%	82%	34%	63%	51%
Achievable Energy Savings (%)	7.70%	8.40%	8.20%	11.50%	7.50%
Achievable Energy Savings (terjoules)	2,284	2,346	1,755	886	62
Avg An Consumption per Household (gigajoules)	100	102	67	41	86
Average Annual Achievable Savings per Household (megajoules)	7,715	8,611	5,484	4,717	6,555

Findings Across Cities

Estimates of Achievable Savings by City (%)

	Baltimore	Boston	Charlotte	Miami	Park City
TOTAL (tjoules)	2,284	2,346	1,755	886	62
Heating	55%	82%	34%	-	60%
Cooling	10%	2%	23%	60%	4%
Appliances	17%	8%	18%	14%	21%
Electronics	4%	4%	6%	6%	5%
Lighting	6%	3%	8%	8%	7%
Pools & Spas	7%	1%	11%	9%	3%

Findings Across Cities

Top Ten Residential Behaviors

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 Replacemer
Heating Equipment Replaceme	Heating Thermostat Settings	2nd Refrigerator	Cooling Equipment Replacemer	Heating Equipment Maintenanc
2nd Refrigerator	Heating Equipment Maintenanc	Energy Efficient Light Bulbs	Cooling Equipment Maintenanc	Heating Conservation
Heating Equipment Maintenanc	Heating Window Insulation	Heating Equipment Maintenanc	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

Findings Across Cities

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 Maintenanc	
3	Heating Window Insulation	
3	Pool Timers	
3	Heating Equipment Replacemer	
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 Replacemer	Miami
1	Cooling Equipment Maintenanc	Miami
1	Cooling Conservation	Miami
1	Energy Efficient pool Pumps	Miami
1	Air Dry Laundry	Park City

Findings Across Cities

	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%

Closing Points

The Behavior Wedge Model

- Provides low cost estimates to cities
- Identifies behavioral opportunities
- Reflects unique characteristics of city's climate, housing stock, etc.

Questions:

- Does it make sense to do something similar for cities outside the U.S.?
- What data sources could be used?

Contact and Acknowledgements

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Acknowledgements

Contributors:

Skip Laitner and Derrick Carlson

Supporters:

Urban Sustainability Directors Network

Kresge Foundation

Funder's Network for Smart Growth and Livable Communities

City Sustainability Directors:

Alice Kennedy, City of Baltimore

Nicole Storey, City of Charlotte

Charles Zhu, City of Boston

Matt Abbott, Park City

Glen Hadwen, City of Miami