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Lessons from the United States and China for Increasing Transparency and Harmonizing Measurement and Verification Practices in the Buildings Sector

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Presentation for the 2017 ECEEE Summer Study on Energy Efficiency

Agenda

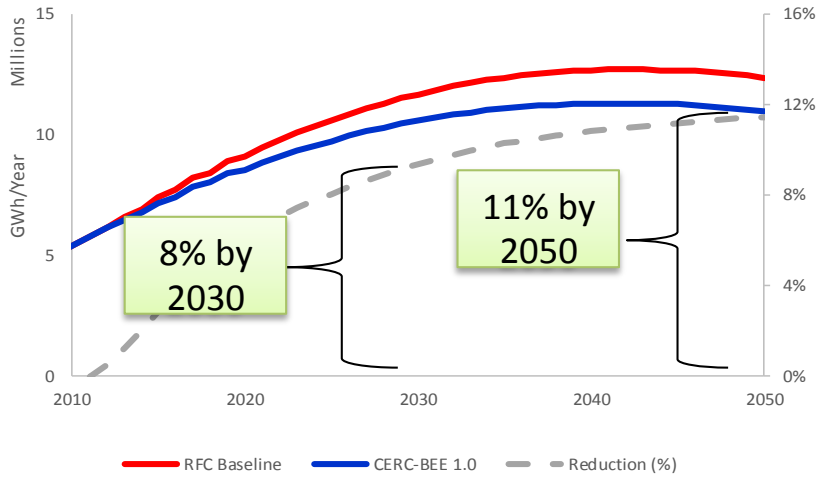
- Background
- Research Objective and Methodology
- Key Findings and Recommendations for Policymakers
- Conclusions

Background on US-China Clean Energy Research Center Building Energy Efficiency (CERC-BEE)

- Initiated at the presidential level in 2009 (CERC 1.0), renewed in 2014 (CERC 2.0).
- Vision: Achieve large scale adoption of very low energy buildings in the U.S. and China.
- CERC 1.0 (2010-2021): $100M+, ten-year program with shared investment from government and industry.

CERC Annual Steering Committee Meeting, Beijing, China July 2016.

Annual Energy Savings of CERC-BEE 1.0 Technologies Against BAU*



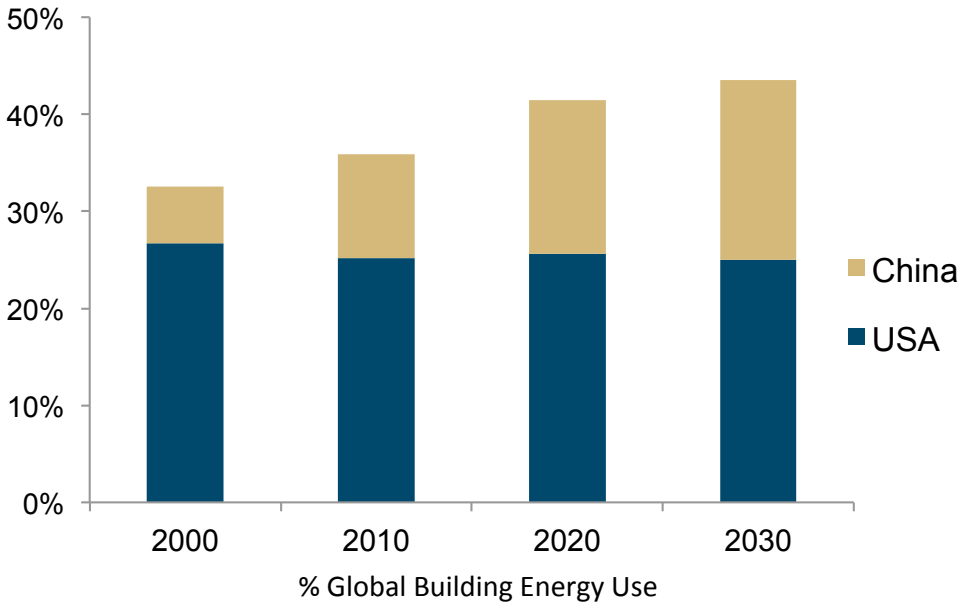
Signing of CERC-BEE 2.0 US-China Joint Work Plan, Beijing, China July 2016.

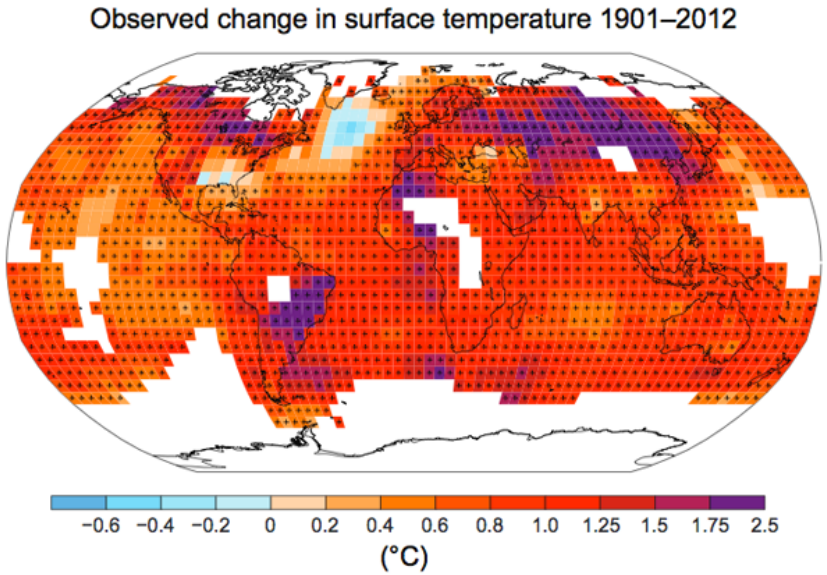
*Nachtrieb et al. "CERC-BEE Impact Model." Unpublished report, last modified December 9, 2016. Adobe PDF file.

Global Challenge

- Keeping global surface temperature rise below 2°Celsius (C) by the end of the 21st century will require an estimated **77% reduction in total CO_2 emissions in buildings by 2050** compared to a baseline of 2012 (IEA 2013, 10).

US and China account for close to 40% of the global building energy use.





Source: IPCC Fifth Assessment Report (AR5)

Critical Barriers and Solutions

Barrier: lack of information and asymmetric information

- Prevents building owners from calculating the costs and benefits of building energy efficiency (EE) (Hsu 2013).
- Prevents buyers, renters, and investors from incorporating energy characteristics into purchasing, leasing, and financing decisions (Palmer, Walls 2015).

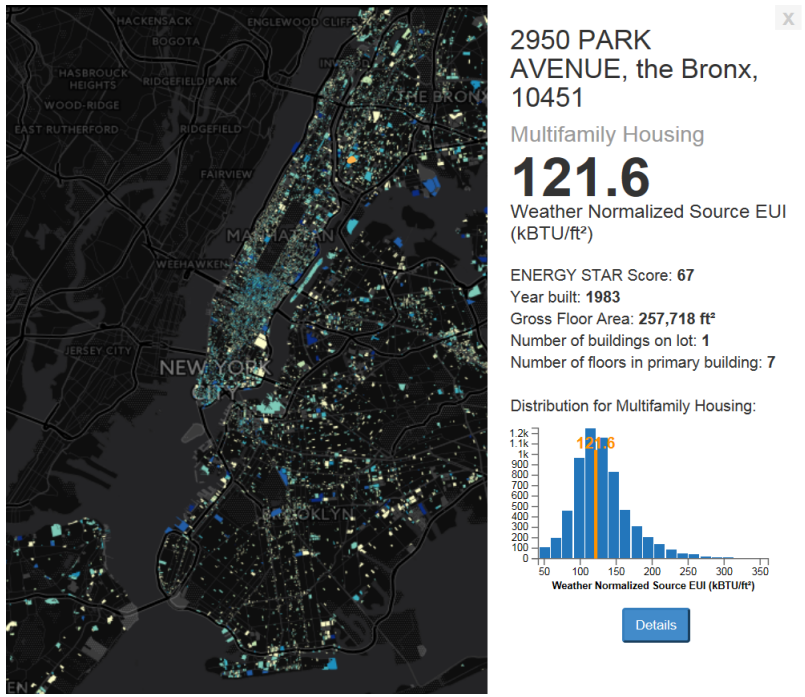
Solution: Disclosure and benchmarking policies

- Require building owners to evaluate a building's energy performance using standardized rating tools and to disclose these results:
  - **Triggered Disclosure**: to buyers, renters, financiers, or to the general public at either the time of sale or lease or
  - **Scheduled Disclosure**: at annual intervals (Dunsky and Hill 2013).
  - Audit policies often accompany disclosure and benchmarking policies.

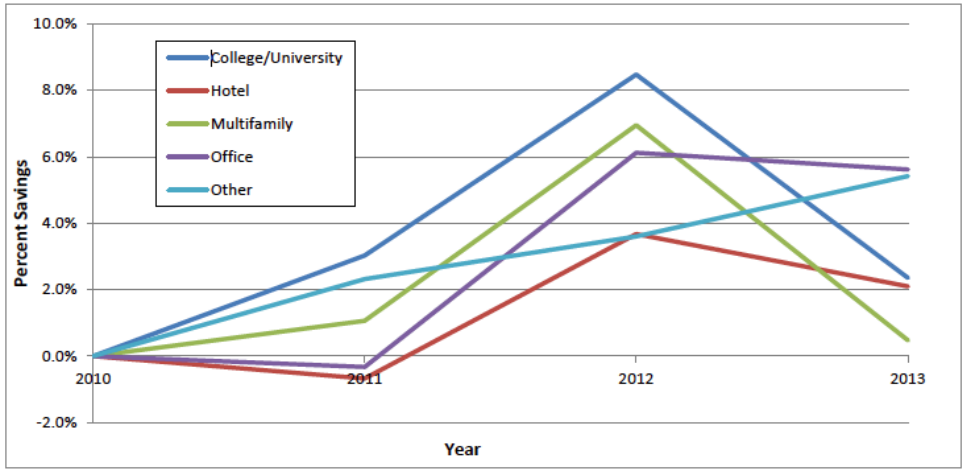
Recent Policy Success

- **30+ countries** around the world have in place some type of mandatory building energy rating policy (Buss, Majersik, Zigelbaum 2013).
- Select cities in the United States shows that energy savings per unit of floor space for these programs range between **6% and 8% over a two-year period** (Pan et al. 2016, 10).

On-line Map of Energy and Water Benchmarks in New York City



New York City Impact (2010-2013)



Gross Energy Savings Impacts	**5.7%**
Gross GHG Emissions Reductions	**9.9%**
Gross Cost Savings Impacts	**€250,000,000**
Jobs Created	**3,132**

Remaining Challenges

While municipal disclosure and benchmarking policies are valuable, shortcomings have been identified:

1. The need for additional analysis of results (Dunsky et al. 2009; Palmer and Walls 2015; Pan et al. 2016).
2. The need for additional data to conduct policy evaluation, measurement, and verification (EM&V) (Todd et al. 2012; Palmer and Walls 2015).
3. More efficient and cost-effective auditing approaches (Hsu 2013, 266).
4. Greater standardization and automation of policy implementation (Kontokosta 2013; Pan et al. 2014).

Research Objective and Methodology

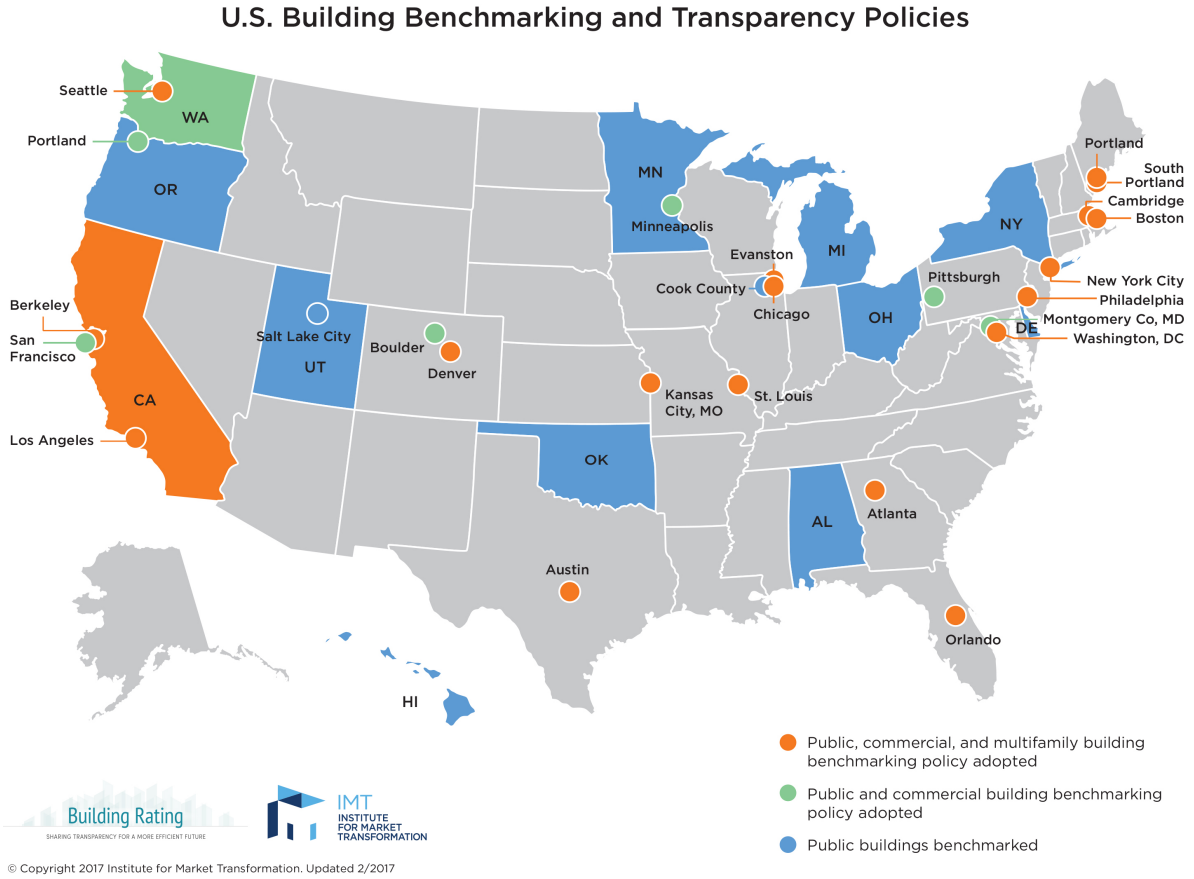
Objective: Identify modifications in benchmarking and disclosure policies in China and the United States that will address policy shortcomings and lead to greater investment in building EE.

Methodology:

1. Desk research to assess the data currently collected and made public as part of U.S and Chinese benchmarking and disclosure programs.
2. Identified the retrofit analytical tools available in the U.S. and Chinese markets today and assessed the data input requirements and output information of these tools.
3. Cross-mapped the data disclosure requirements with the data inputs and outputs for the retrofit analytical tools and determined the minimum set of data points that could be utilized with these tools.
4. Identified current policy shortcomings.
5. Determined what additional data, if any, could be collected and/or made public to overcome policy shortcomings.

U.S. Disclosure and Benchmarking Policies

- **2007:** California Assembly Bill 1103.
- **2008**: Washington, D.C enacted the first municipal policy (Burr, Majersik, and Zigelbaum 2013).
- **Today**: 26+ city, state, and county commercial benchmarking policies (BuildingRating 2016b).



Copyright Institute for Market Transformation (2007).

Chinese Disclosure and Benchmarking Policies

- **2007**: Building energy performance disclosure policies emerge in China.
- **2008**: China Ministry of Housing and Urban-Rural Development (MOHURD) promulgates real-time online energy monitoring platforms in Beijing, Shenzhen, and Tianjin.
  - 8,432 buildings have disclosed energy usage information to the central government (Pan et al. 2014, 9).
- **2008**: MOHURD issued the *Civil Building Energy Efficiency Regulation*
- **2014**: The World Bank and GEF fund MOHURD Energy Performance Benchmarking and Disclosure Program (EPB&PD).
  - Beijing and Ningbo pilot projects.

China Building Energy Benchmarking Tool

http://115.29.110.113/

Key Finding

- **Finding:** High level of consistency between data required for benchmarking building energy performance in the U.S. and China.

Common Data Collected for U.S. and Chinese Benchmarking Tools
▪ Property Name
▪ Property Location
▪ Property Type
▪ Year Built
▪ Gross Floor Area
▪ 12 consecutive months of energy usage (broken down by fuel type)

[a] Additional data points are required for each property type in order to normalize for the statistically significant drivers of energy usage for that property type. These data points vary by type. Samples include operating hours, number of workers, number of computers.

Key Finding

- **Finding:** At least 75% of U.S. and Chinese cities surveyed disclose the following data publicly.

Data Points Disclosed Publicly on Websites	Percent of U.S. Cities [a]	Percent of Chinese Cities [b]
Property Name	100%	100%
Location	100%	100%
Gross Floor Area	100%	100%
Benchmark Score	100%	100%
Annual Total Greenhouse Gas (GHG) Emission	100%	0%
Property Type	100%	100%
Annual Site EUI	100%	0%
Annual Source EUI	88%	0%
Annual Weather Normalized Site EUI	75%	0%
Annual Weather Normalized Source EUI	75%	100%
Year Built	75%	100%

[a] Percent is out of a total 8 U.S. cities that disclose commercial data publicly (on website).
[b] Percent is out of a total of 2 Chinese pilot benchmarking and disclosure cities.

Key Finding

- **Finding:** Only six (42%) of U.S. cities surveyed required post-benchmark audits. Of these, only two (33%) require post-audit action

City Names	Retrofit Analytical Tools Applied?	Audits In-Person?	Action Required?	Description of Audit Policy
Austin	No	Yes	Yes	Audits required for multifamily every 10 years and upgrades required for high energy use buildings
Atlanta	No	Yes	No	ASHRAE level II audits every 10 years
Boston	TBD	TBD	Yes	Policy in development, audits or actions every 5 years anticipated
New York	No	Yes	Yes	ASHRAE level II audits, retro commissioning (RCx) for buildings 5,000 square meters or more every 10 years
San Francisco	No	Yes	No	ASHRAE level I or II audits or RCx every 5 years
Seattle	No	Yes	Yes	Building systems tune-up required for nonresidential buildings over 5,000 square meters every 5 years
# of Cities	0	4	4	
% of Cities [a]	0%	28%	28%	

Key Finding

- **Finding:** The minimum data points needed to generate energy savings recommendations are monthly utility data, simple building characteristics (e.g., gross floor area, building type), and weather data.

	Building Performance Database (BPD)	C3 Commercial	Agilis Energy	FirstFuel	Chicago Loop Energy Retrofit Tool (Chicago area	HELiOS	Retroficiency/Ecova	Consortium for Building Energy innovation (CBEI)	Commercial Building Energy Saver (CBES)	Customized Calculation Tool (CCT)	Johnson Controls Inc. (JCI) LEAN Energy Analysis
Tool Inputs											
Accessibility for the public (Yes/No)	Yes	No	No	No	No	No	No	[a]	Yes	Yes	No
Utility Bills	X [b]	X	X	X	X	X	X	X	X	X	X
Time Series Interval Energy Data		X	X	X		[a]	X		X		
Climate/Weather Data [c]	X	X	X	X	X	X	X	X	X	[a]	X
Simple Building Characteristics [d]	X	X	X	X	X	X	X	X	X	X	X
Detailed Building Characteristics [e]					X	X	X	X	X	X	
Tool Outputs											
Energy and Cost Savings Estimates	X	X	X	X	X	X	X	X	X	X	X
Recommended ECMs	X	X	X	X	X	X	X	X	X	X	X
Benchmark Again Peers	X	X	[a]	X					X		X

Lee, Hong, and Piette 2015

[a] Unknown; [b] Yearly source and site EUI; [c] A range of factors, including but not limited to, indication of climate zone, daily outdoor temperature, daily wet bulb temperature, heating degree day (HDD), cooling degree day

Policy Opportunity and Recommendation

Additional Data that Should be Made Public for Retrofit Identification and M&V

Policy Opportunity 1: Need for additional analysis of results, such as ECMs, financial analyses, M&V of savings, etc. (Dunsky et al. 2009; Palmer and Walls 2015; Pan et al. 2016).

Research Finding 1:

- The minimum data points needed to generate these metrics are: monthly utility data, simple building characteristics (e.g., gross floor area, building type), and weather data.
- Simple building characteristics are generally available from benchmarking and disclosure public datasets, and weather data can easily be obtained.
- Monthly data is not usually published. However, monthly data is usually collected and used to comply with benchmarking requirements.

Recommendation 1:

- Make public monthly energy usage data (broken down by fuel type) to support application of private retrofit analytical tools to quantify energy and cost savings potential; identify ECMs; and conduct M&V.
- Where no retrofit analytical / M&V tools exist (i.e., China), develop new, web-based, open-source tools to screen for energy and cost savings opportunities; identify ECMs; and perform M&V.

Policy Opportunity and Recommendation

Additional Data that Should be Made Public for EM&V

Policy Opportunity 2: Need for additional data to conduct effective EM&V for benchmarking and disclosure programs Todd et al. 2012; Palmer and Walls 2015).

Research Finding 2:

- The randomized control trial (RCT) is generally seen as the most accurate method of EM&V for a behavior-based energy efficiency program.
- In a RCT, there are three methods for calculating net savings (1) post-period comparison (2) difference-in-differences (DiD) approach, and (3) linear fixed effects regression (LFER) (Todd et al. 2012).

Recommendation 2: To apply the post-period comparison or DiD methodology, increase the data made public to monthly energy usage (which is not made public now in U.S. and Chinese disclosure policies).

Policy Opportunity and Recommendation

Additional Data that Should be Made Public for Greater Cost-Effectiveness, Standardization, and Automation

Policy Opportunity 3: Single building audits can be time-consuming and costly, and there is a need for greater standardization and automation.

Research Finding 3:

- According to statistics from the U.S. Department of Energy (DOE), cost differs by as much as 10 times between benchmarking and disclosure programs that require audits and those that don't.
- The benchmarking and disclosure component of New York City's GGBP is estimated to cost €450-€1,400 per building. Auditing adds an additional €1.41 per square meter. Assuming a typical New York City building is 20,000 square meters, the difference between benchmarking and disclosure and auditing amounts to almost €29,000 (Hsu 2013, 266).

Recommendation 3:

- Develop a new, public, web-based, open-source retrofit analytical tools to screen for energy and cost savings opportunities and identify ECMs using the minimal amount of data possible (monthly utility bills, simple building characteristics, and weather data) for the U.S. and China.
- Make public monthly energy usage data (broken down by fuel type).

Policy Opportunity and Recommendation

Disclosure of Interval Data Should be Considered

Policy Opportunity 4: Many of the U.S. retrofit analytical tools that were reviewed require interval data for electricity as an input, instead of monthly utility data.

Research Finding 4:

- In 2015, there were about 64.7 million advanced (smart) metering infrastructure (AMI) installations in the United States. Approximately 88% of the AMI installations were for residential customers (EIA 2016).
- Washington D.C. is one of the first known cities in the United States to publicly disclose 15-minute interval data, which it does on its BuildSmart DC website.

Recommendation 4:

- Consider is whether interval data should be disclosed, in some form, to obtain better data to target EE opportunities and carryout peak-load shifting.
- This is a more complex undertaking, since interval data are not currently necessary to comply with current benchmarking and disclosure requirements.
- Additionally, interval data are also often limited to electricity, whereas analytical tools that use monthly data incorporate all fuel types.

BUILDSMART DC

Electricity Interval Data: Washington, DC Case Study

Electricity Interval Data recorded by smart meters. Delivered daily by Pepco (electric utility) to Department of General Services' Sustainability & Energy Division (DGS-SE), where it is processed and posted to BuildSmartDC.

Summary of Findings

- Simple modifications to current U.S. and Chinese disclosure and benchmarking policy could overcome identified shortcomings:
  - More comprehensive analysis of results;
  - More cost-effective methods to identify and quantify energy savings opportunities, conduct M&V, and conduct EM&V; and
  - Greater standardization and automation.
- Making monthly energy usage data public, pre-and post-policy, would advance toward the above-mentioned objectives.
- Interval data should also be explored, although this is a more complex undertaking, since interval data are not necessary to comply with current benchmarking and disclosure requirements in the United States or China.
- Finally, to address the policy shortcomings from another direction, new retrofit and M&V tools should be developed to make better use of existing public data from benchmarking and disclosure programs.

Open-Source Retrofit Screening Tool

Overview:

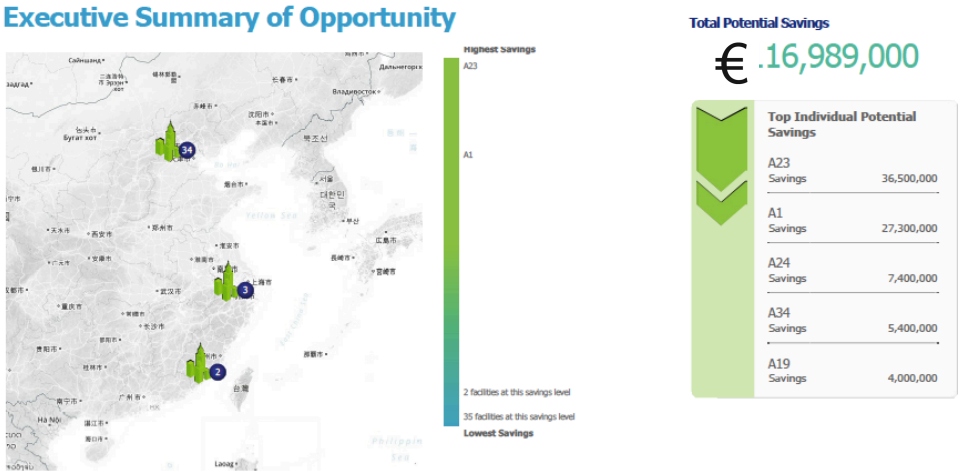
- Pre-audit tool to target and screen for energy and cost saving opportunities.
- M&V tool that tracks EE savings against baseline.
- Uses empirical data and inverse regression modeling techniques.
- Identifies ***both*** building equipment and operational opportunities.

Inputs:

- 2+ years' monthly energy usage (all fuels)
- Building size and location

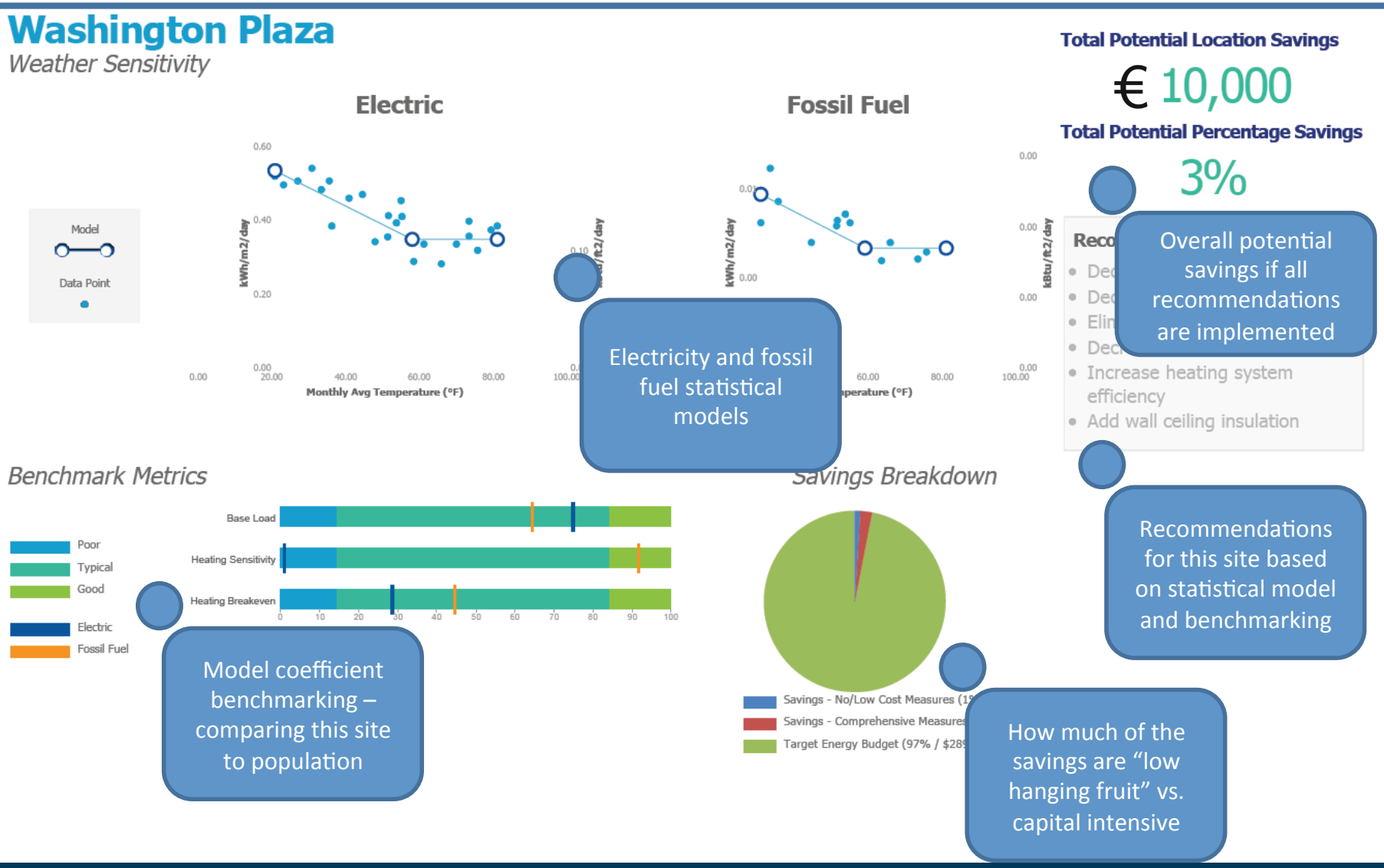
Outputs:

- Benchmark score for different weather metrics
- Energy savings
- Energy cost savings
- Energy conservation measures



Potential Annual Savings by 2025 in US and China Markets	Total
Energy savings in U.S. and Chinese existing commercial buildings (EJ)	2.36
CO_2 reductions in U.S. and Chinese existing commercial buildings (Million tons CO_2)	2.14

Open-Source Retrofit Screening Tool– Individual Site Results



Acknowledgments and Contact Information

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Extra Slides

BUILDSMART DC

Electricity Interval Data: Washington, DC Case Study

Electricity Interval Data recorded by smart meters. Delivered daily by Pepco (electric utility) to Department of General Services' Sustainability & Energy Division (DGS-SE), where it is processed and posted to BuildSmartDC.

Typical Data Disclosure Requirements for U.S. Cities

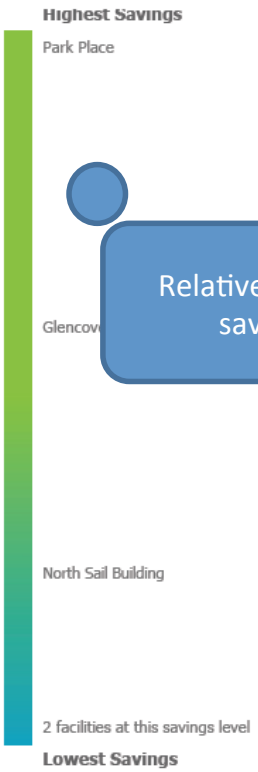
	Building Type			Recipient of Disclosure		Time of Disclosure	
U.S. Jurisdiction	**Municipal**	**Commercial**	**Multifamily Residential**	**Local Government**	**Public Website**	**Annual**	**Point of Transaction**
Austin	X	X	X	X		X	Buyers
Atlanta	X	X	X	X		X	
Berkley	X	X	X	X	2018	X	Buyers, Lessees
Boston	X	X	X	X	X	X	
Cambridge	X	X	X	X	X	X	
Chicago	X	X	X	X	X	X	
Kansas City	X	X	X	X		X	
Minneapolis	X	X		X	X	X	
New York	X	X	X	X	X	X	
Philadelphia	X	X	X	X	X	X	Buyers, Lessees
Portland, OR	X	X		X	2017	X	
San Francisco	X	X		X	X	X	Buyers, Lessees, Lenders
Seattle	X	X	X	X		X	Buyers, Lessees, Lenders
Washington, D.C.	X	X	X	X	X	X	Buyers
# of Cities	**14**	**14**	**11**	**14**	**8**	**14**	**5**
% of Cities [a]	**100%**	**100%**	**79%**	**100%**	**57%**	**100%**	**36%**

[a] Percentage is out of a total 14 cities that disclose data publicly (on websites) in the United States. (BuildingRating 2016b; IMT 2015; DC.gov)

Advanced Benchmarking Tool – High-Level Results Summary

Executive Summary of Opportunity

Map of site locations.



Relative range of savings.

Total Potential Savings

€ 603,000

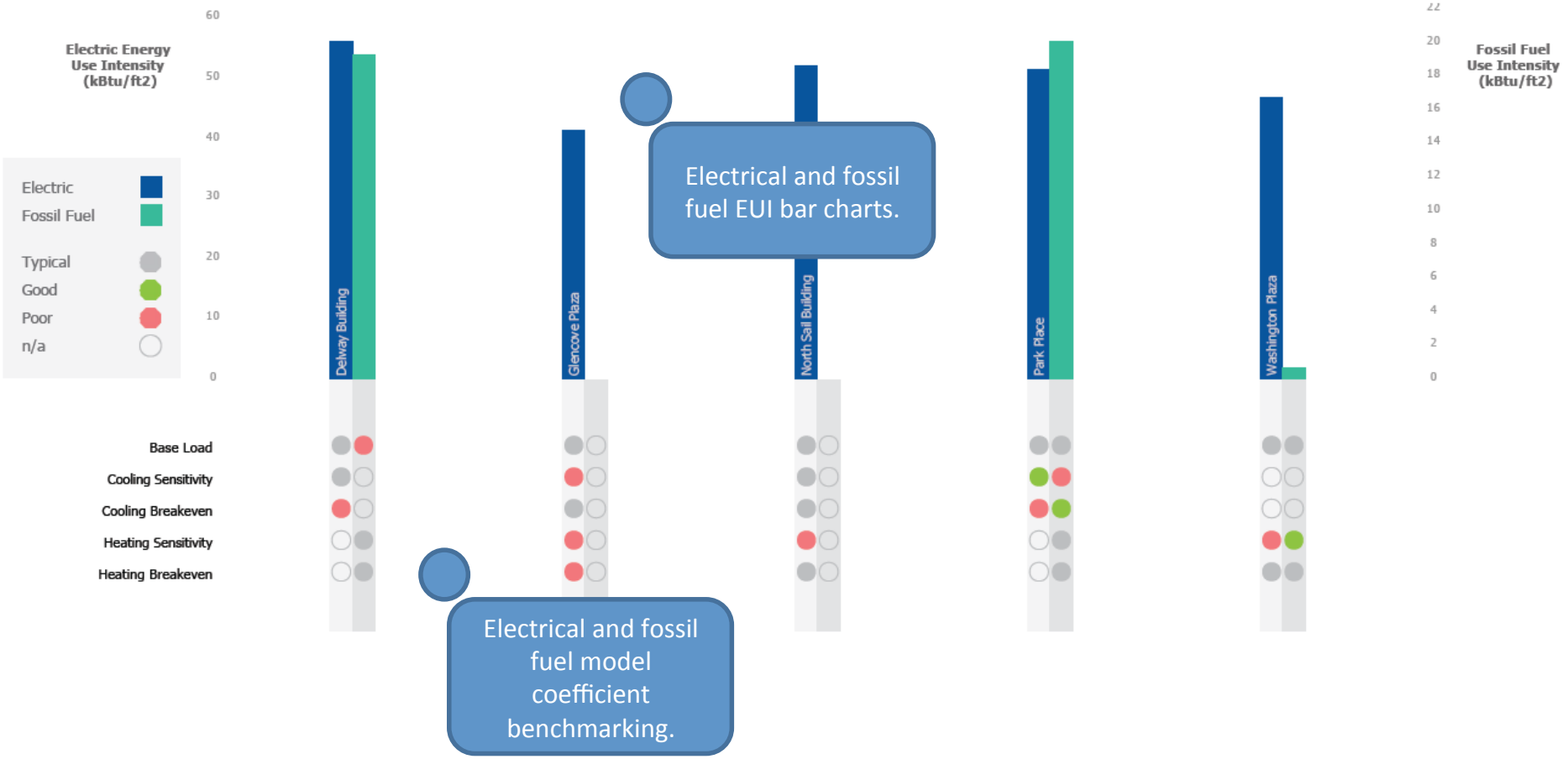
Total potential savings for all buildings.

Savings	290,000
Glencove Plaza	
Savings	180,000
North Sail Building	
Savings	90,000
Delway Building	
Savings	33,000
Washington Plaza	
Savings	10,000

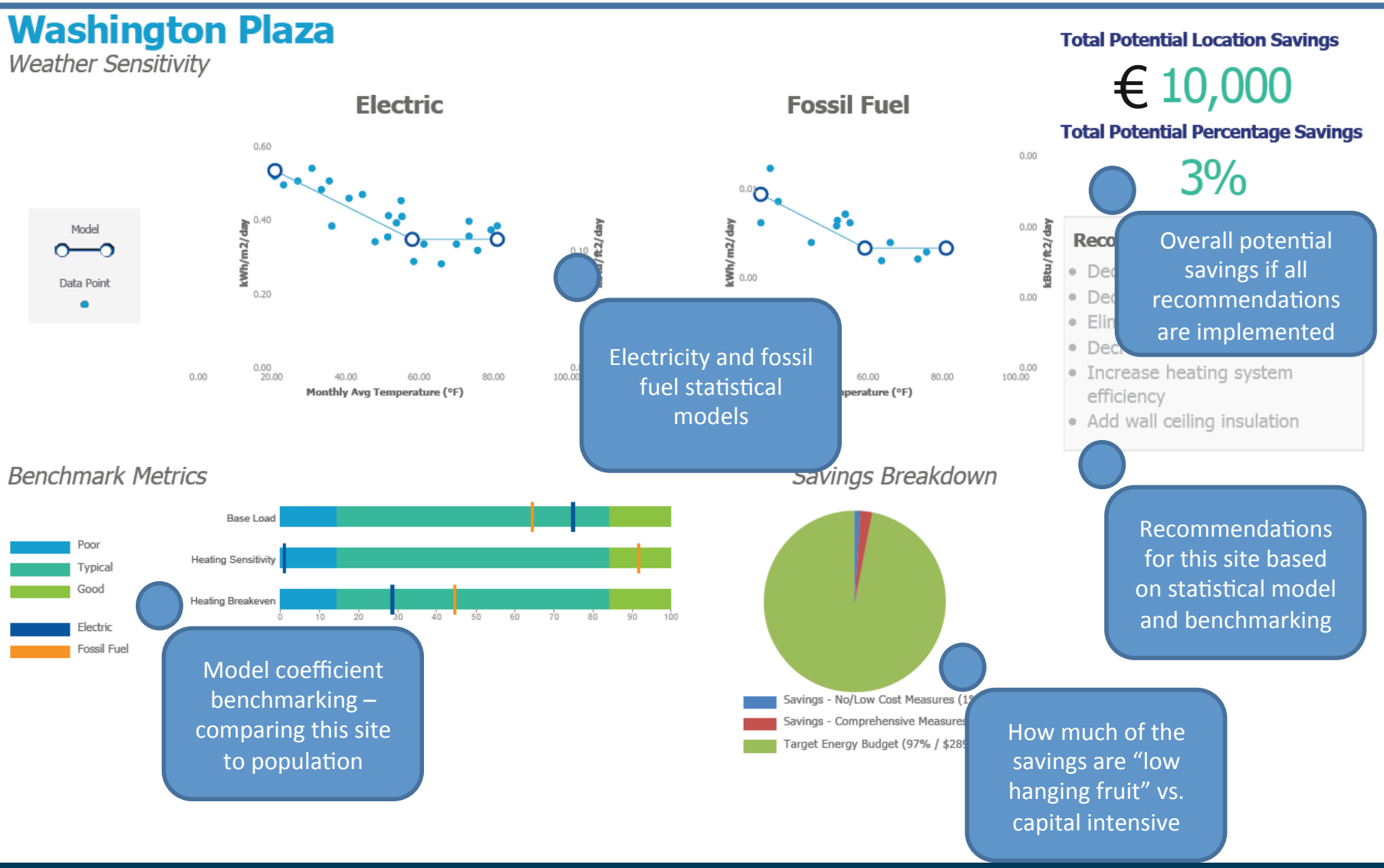
Savings for top 5 sites.

Advanced Benchmarking Tool – Performance Summary

Summary of Performance Benchmarks for Electricity and Fossil Fuels



Advanced Benchmarking Tool – Individual Site Results



Typical Data Disclosure Requirements for Chinese Cities

- In the **Beijing and Ningbo pilot programs**, disclosure of the following data are mandatory for government buildings and voluntary for privately owned buildings.

- Data are disclosed on an **annual basis** and posted to a website for limited users to analyze. It is likely that any forthcoming national policy will follow suit.

Year Built	Gross Floor Area
Property Name	Benchmark Score (1 to 100)
Property Address	Annual weather normalized source energy use intensity
Property Type	