Better Buildings Data and Summary Report

2014 Building Technologies Office Peer Review

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Project Summary

Timeline:

Start date: Oct. 2010

Planned end date: September 2014

Key Milestones

1. BBNP Summary of Reported Data
2. BBNP Data Release
3. BBNP Energy Savings Analysis Report

Budget:

Total DOE $ to date: $2,845,000 (for data tasks)

Total future DOE $: 0

Using funds from the American Recovery and Reinvestment Act (ARRA) and annual appropriations, the Better Buildings Neighborhood Program provided $508 million in one-time grants to states and localities in 2010.

Target Market/Audience:

Residential Energy Efficiency Program Researchers and Program Managers

Key Partners:

41 BBNP Grantees
National Renewable Energy Lab (NREL)
Navigant Consulting
Booz Allen Hamilton

Project Goal:

Collect data from organizations awarded financial assistance (i.e. BBNP grantees) to test energy upgrade business models and improve building energy efficiency across the country. Use data to:

1) **Populate the Buildings Performance Database (BPD),**
2) **Track grantee progress,**
3) **Evaluate impact, and**
4) **Identify successful strategies.**

Purpose and Objectives

Problem Statement: More data is needed to understand the effectiveness of upgrade strategies and program models that reduce building energy use. More empirical data supporting effective strategies is foundational to the development of a self-sustaining building energy upgrade market.*

Target Market and Audience: Researchers, program administrators, building contractors, and investors, that want to reduce building energy use, are interested in effective strategies, supported by data, to help them make program design, business model and investment decisions.

Impact of Project:

- **Programmatic data from 41 grantees across multiple states implementing diverse program strategies over 2½ years**
  - **75,000+ Residential Single-Family Building records**
  - **9,600+ Residential Multi-family Unit records**
  - **800+ Residential Multi-family Building records**
  - **3,500+ Commercial Building records**
- **21,000+ records with some energy consumption data, including about 5000 with 12 months of energy consumption before and after the upgrade.**
- **12,000+ records with loans**

*** SEE Action Residential Retrofit Working Group *Roadmap for the Home Energy Upgrade Market* http://www1.eere.energy.gov/seeaction/pdfs/retrofit_energyupgradesroadmap.pdf**

Approach

Approach: Collect program and building data from grantees to contribute to a national Building Performance Database (BPD), measure progress, evaluate impact and identify successful strategies.

Identify where empirical data can validate the effectiveness of program design, driving demand, financing, and workforce development strategies.

Hypothesis: Demonstrating a variety of upgrades and program strategies can achieve energy savings will support more investment in energy efficiency.

Key Issues:

- Funding Opportunity Announcement (FOA) issued before data collection requirements.
- Real world programs are not randomized control trials.
- Data collection underestimated diversity of strategies tested by grantees.
- Data collection system was delayed and underestimated data quality challenges.

Distinctive Characteristics:

- FOA scope was multi-sector
- Grantees were state and local governments
- Data collection and analysis effort of this size had not been attempted before by DOE

What Data Was Reported?

Programmatic Data by Quarter

- BBNP Spending and Leverage Expenditures (Other federal and non-federal)
- Number of Assessments
- Number of Trained and Certified Workers
- Job Hours Worked
- Total Program Energy Savings

Building Data by Upgrade Project

- Building Information (e.g. zip code, building type, floor area, year built, occupancy)
- Invoiced Cost, Incentives (assessment and upgrade), and Loan amount
- Auditor, contractor, and professionals certifications
- Job Hours Worked (assessment and upgrade)
- Upgrades Installed (e.g. Attic Insulation, Water Heater, Air Sealing, Heat Pump, Boiler, etc.)
- Audit software and method of predicting energy savings
- Estimated Savings (assessment and upgrade)
- Monthly Energy Consumption

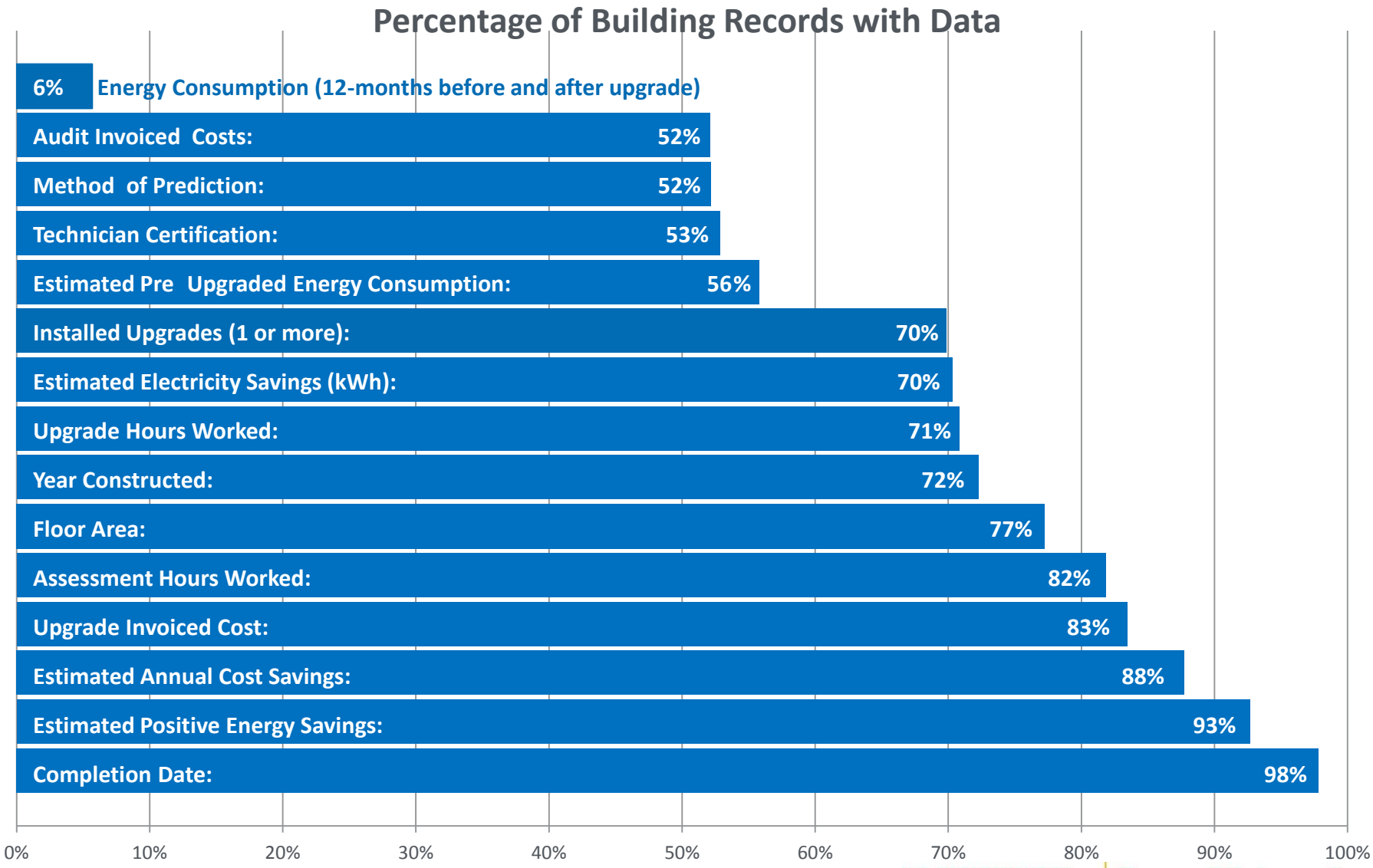
Data Quality

Information was reported by grantees using DOE reporting forms and processes. Steps were taken to verify data quality, but 100% accuracy cannot be ensured.

Three potential types of errors in data

- Non-response—data that is not available, not applicable, or not reported.
- Incorrect Response—data that is incorrect because the requested information was not understood; there was a lack of attention to detail; or information was intentionally misrepresented.
- Processing Errors—data that is incorrect because of errors introduced when processing reports (e.g. loading data into database or querying database to extract data).

Buildings Data Completeness



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Project Integration and Collaboration

Project Integration:

- Grantees submitted reports to web portal (or XML web service)
- Data used by grants management team to identify grantees needing technical assistance.
- Emailed grantees reporting issues, data health report, and summary data following each quarterly report submissions.
- Reporting check-in calls with grantees Dec. 2012 – Jan. 2013 and Sept.-Oct. 2013 to review reporting issues and answer questions.
- Data provided to evaluation team used for process and impact evaluations.

Partners, Subcontractors, and Collaborators:

41 BBNP Grantees, NREL (data queries and analysis), Navigant Consulting (grantee communications and report processing), Booz Allen Hamilton (data system development and maintenance)

Communications:

- Multiple webinars for 41 grantees about reporting process.
- Quarterly tables of grantee metrics for internal progress tracking
- Presented preliminary data at grantee meeting May 2013
- Webinar on Measuring Outcomes and Using Benchmarks Aug. 2013
- Webinar for grantees on the Summary of Reported Data reports Feb. 2014
- Emails and calls with grants management team and evaluation team as needed to provide updates and address questions.

BBNP Independent Evaluation

Evaluation Team: Research Into Action, Nexant, Evergreen Economics, and NMR Group

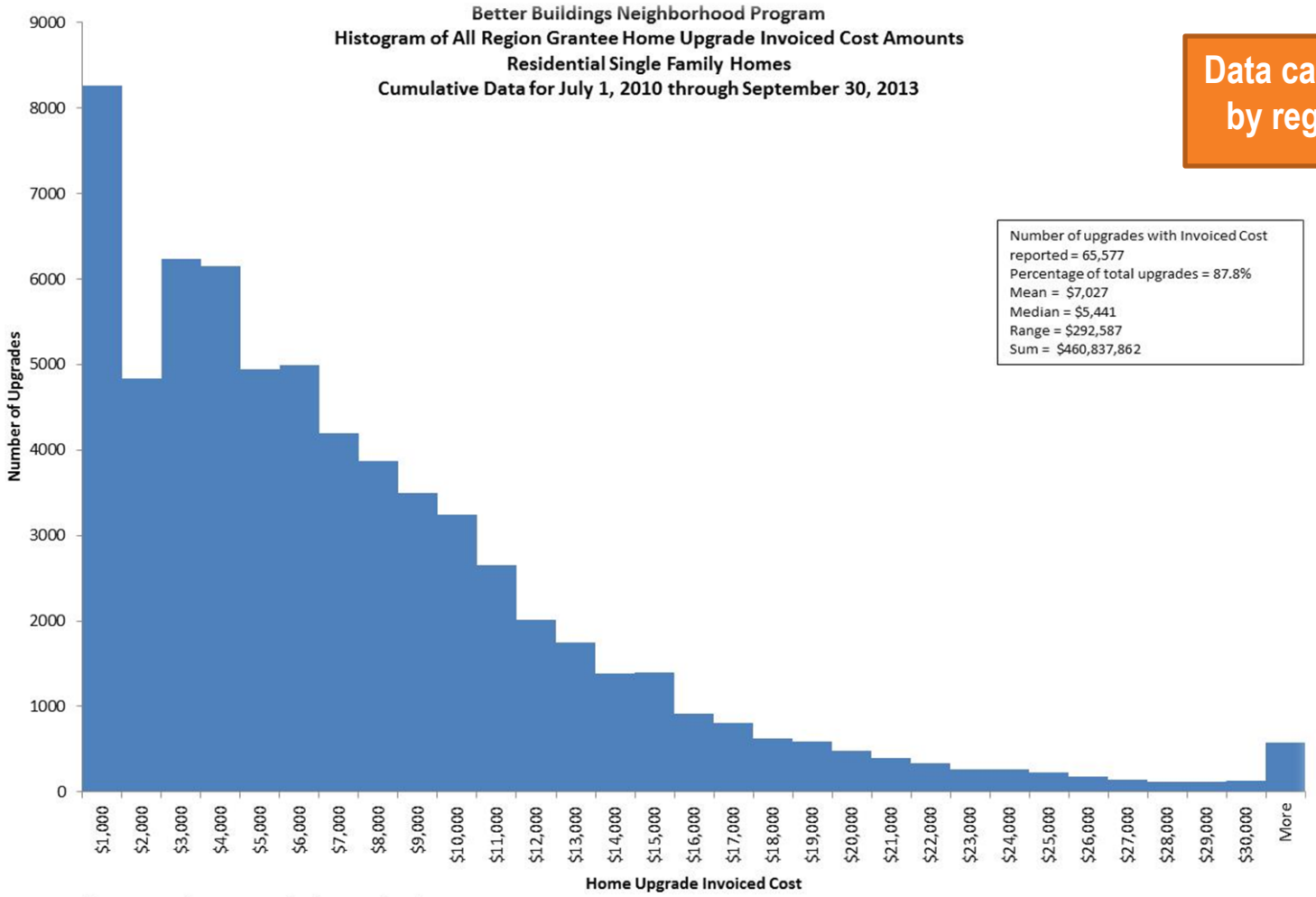
- Kick-off Meeting January 2012 ($4M budget not BTO funding)

- Preliminary Process and Market Evaluation
  - Completed Spring 2013
- Preliminary Energy Savings Impact Evaluation
  - Completed Fall 2013
- Final Process and Market Evaluation
  - Report Anticipated Late 2014
- Final Energy Savings Impact Evaluation
  - Report Anticipated Early 2015
- Additional “Lessons Learned” Research Questions
  - Anticipated 2015

Original "Lessons Learned" Research Questions

	Research questions were divided to match performer resources.	NREL	Evaluation Team
1	Which program delivery models improve performance metrics?		✓
2	What (funding) partnerships have grantees leveraged?		
3	Which marketing tactics have been the most successful?		✓
4	Did timing of a marketing campaign impact interest in the program?		✓
5	Did using a trusted messenger approach correlate with higher program interest?		✓
6	Did limited time offers, competitions, and other deadlines motivate customers to complete upgrades in shorter time periods or invest in a certain level of energy savings?		✓
7	Has the use of social media affected program metrics?		✓
8	Is there a correlation between financial incentives for the customer and program metrics?		✓
9	Is there a correlation between financial incentives for the contractor and program metrics?		✓
10	Which financial incentives (see slide 11) help programs achieve better program metrics?		✓
11	Does contractor sales training correlate with program metrics?		✓
12	What impact does contractor technical training have on program metrics?		✓
13	What impact does contractor certification have on program metrics?	✓	
14	Did programs that actively listened to their contractors have better results?		✓
15	Which energy savings estimation method have been the most consistent and accurate in predicting actual energy savings?	✓	
16	What improvements or combination of improvements are most common?	✓	
17	What is the distribution of energy cost savings for homes with the same improvements?	✓	
18	What improvements or combination of improvements contribute to better program metrics?	✓	

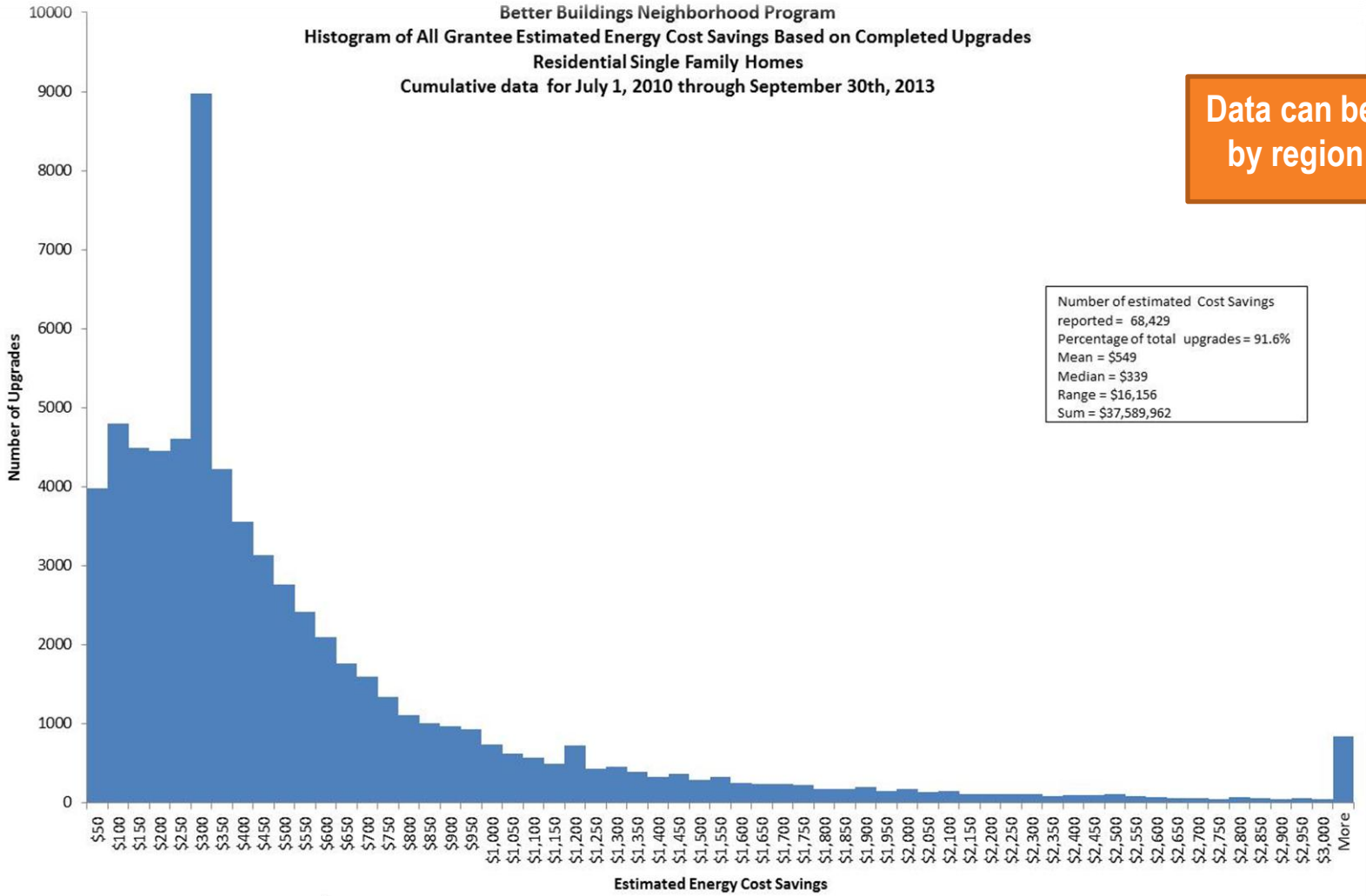
Single-Family Home Upgraded Invoiced Cost Example



Data can be segmented by region or climate.

- 580 projects have Invoiced Cost reported to be more than $30,000.
- This histogram does not include 43 projects with incorrect building type.
- Invoiced Costs between $0 and $1,000: State of Michigan has 4,856 projects, Kansas City has 862 projects , and Indianapolis has 705 projects.
- Invoiced Costs between $2,000 and $3,000: NYSERDA has 1,096 projects, and Chicago has 948 projects.
- Invoiced Costs between $3,000 and $4,000: NYSERDA has 1,745 projects, and Chicago has 1,202 projects.

Single-family Home Estimated Cost Savings Example



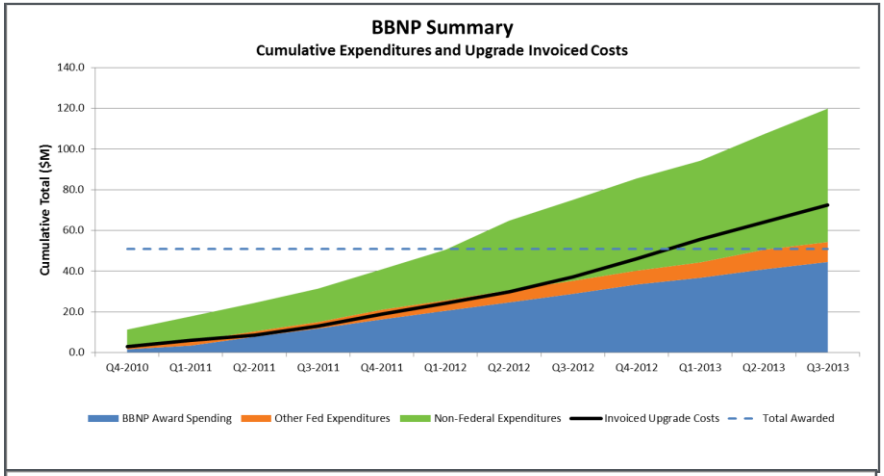
Data can be segmented by region or climate.

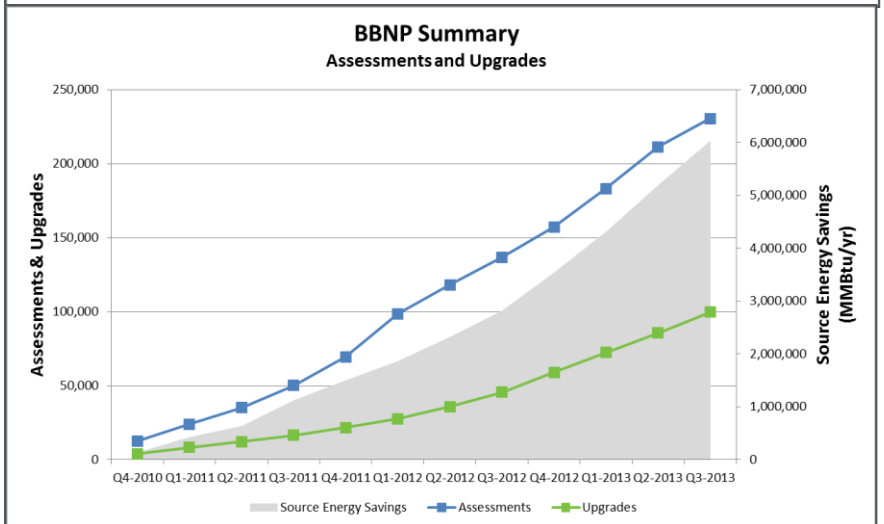
- 848 projects have Cost Savings reported to be more than $3,000.
- This histogram does not include 9 projects with incorrect building type.
- Cost Savings between $50 and $100: State of Michigan has 1,737 projects, Boulder County has 866 projects and NYSERDA has 680 projects .
- Cost Savings between $250 and $300. State of Maine has 4,106 projects, NYSERDA has 958 projects, and Indianapolis has 878 projects.
- Cost Savings between $1,150 and $1,200: CSG, Bainbridge Island has 233 projects.

BBNP Summary of Reported Data

- 1 program summary and
  41 recipient summaries
  - ✓ not an evaluation of the BBNP program.
  - ✓ not the grantees' final technical report.
- Brief narrative to provide context

  Consistent Structure
  - Funding Synopsis
  - Program Design Synopsis
  - Driving Demand Synopsis
  - Financing Synopsis
  - Workforce Development Synopsis
  - Energy Savings Synopsis
- Consistent graphs and tables





	Residential Single-Family	Residential Multi-Family Units	Commercial Buildings	Industrial Buildings	Agricultural Buildings
Assessments	138,323	84,476	7,323	36	276
Upgrades	74,690	21,330	3,547	15	163

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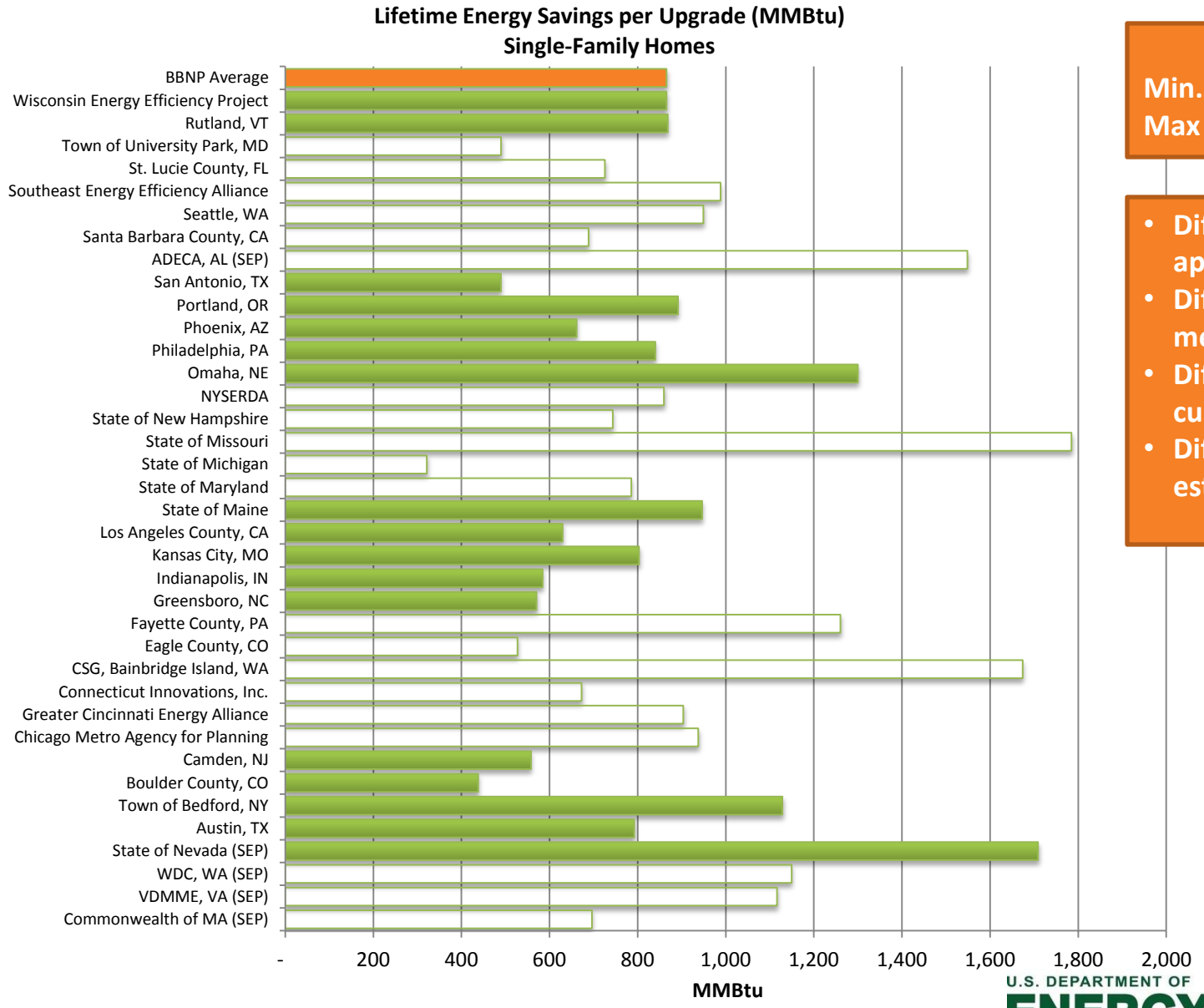
Estimated Energy Saving/Upgrade



Single Family Homes
Min….321 MMBtu/upgrade
Max 1785 MMBtu/upgrade

- **Different program design approaches**
- **Different mix of EE measures**
- **Different building types and customer segments.**
- **Different methods for estimating savings**

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Analysis of Upgrades and Energy Savings

Lifetime Energy Savings Calculation

The Lifetime Energy Savings, LES, is the total source energy savings over the expected life of the installed efficiency upgrades, expressed in MMBTU. An LES value is calculated for each grant recipient as follows:

$$LES_r = E_{svgs,r} \times \overline{L}_r$$

where,

LES_r is the Lifetime Energy Savings for grant recipient *r*

$E_{svgs,r}$ is the total estimated annual energy savings for all projects reported by the recipient (MMBtu/yr)

$\overline{L}_r$ is the project weighted lifetime of the efficiency upgrades reported by a recipient, expressed in years and calculated as follows:

$$\overline{L}_r = \frac{\left(\overline{L}_{res} \times E_{svgs,res}\right) + \left(\overline{L}_{com} \times E_{svgs,com}\right)}{\left(E_{svgs,res} + E_{svgs,com}\right)}$$

where,

$\overline{L}_{res}$ is the energy-savings-weighted lifetime of the residential efficiency upgrades installed for a recipient

$E_{svgs,res}$ is the total estimated annual energy savings in MMBtu for all residential upgrades reported by the grant recipient

$\overline{L}_{com}$ is the project-count-weighted lifetime of the commercial efficiency upgrades installed for a recipient

$E_{svgs,res}$ is the total estimated annual energy savings in MMBtu for all commercial upgrades reported by the grant recipient

$\overline{L}_{res}$ is calculated as follows:

$$\overline{L}_{res} = \frac{\sum_{i=1}^{4}\left(Cnt_i \times E_{svgs,i} \times L_i\right)}{\sum_{i=1}^{4}\left(Cnt_i \times E_{svgs,i}\right)}$$

where,

i is the type category of efficiency upgrades installed as shown in

Cnt_i is the number of energy efficiency upgrades of type *i* installed by a recipient

$E_{svgs,i}$ is the assumed annual energy savings in MMBtu for each energy efficiency upgrade of type *i* as shown in the table A (next slide).

L_i is the assumed lifetime in years for energy efficiency upgrades of type *i* as shown in the table A (next slide).

Lifetime Energy Savings Calculation (continued)

Table A

Type Category	Description	Assumed Lifetime (Years)	Assumed Source Energy Savings (MMBtu/yr/measure)
R1	Simple direct-install measures including CFL's and low-flow showerheads, etc.	5	0.5
R2	HVAC replacement, refrigerators, dishwashers, hot water heaters and any large appliance.	15	7
R3	Duct sealing and duct insulating.	15	10
R4	House air sealing, house insulating, window replacement and any other insulating (except duct insulating).	20	20

$\overline{L}_{com}$ is calculated as follows:

$$\overline{L}_{com} = \frac{\sum_{j=1}^{4}(Cnt_j \times L_j)}{\sum_{j=1}^{4}(Cnt_j)}$$

where,

j is the type category of efficiency upgrades installed as shown in Table B.

Cnt_j is the number of energy efficiency upgrades of type *i* installed by a recipient

L_j is the assumed lifetime in years for energy efficiency upgrades of type *j* as shown in Table B.

Table B

Type Category	Description	Assumed Lifetime (Years)
C1	CFLs and faucet aerators	5
C2	Commercial kitchen equipment, thermostats	11
C3	HVAC (packaged), refrigeration, hot water heaters, LED and linear fluorescent lighting	15
C4	Chillers, boilers, PV, solar thermal, insulation, windows	20

Upgrades and Energy Savings Analysis Report

Analysis of single-family residential projects performed by NREL; analysis questions include:

- What is average lag time between an audit and an upgrade?
- Across all projects, how many of each measure type were installed?
- What methods of prediction were used and how frequently?
- What is the distribution of annual energy savings for homes with particular improvements and combinations of improvements?
- What individual improvements or combinations of improvements are correlated to better program performance?
- For homes with sufficient PRE/POST utility data, how do estimated energy savings compare to utility-bill-calculated savings?

Plan to Anonymize Building Data To Protect Privacy

- Replace the project id with a new unique id (not used by the grantee)
- Replace zip code with State
- Add noise to building square footage and top-coding and bottom coding for outliers (e.g. any building with a square footage > 5000 will be reported as 5000)
- Replace year built with decade built
- Add noise to loan amount and invoiced cost
- Replace audit, upgrade and loan date with month and year
- Remove service provider names (electric, natural gas, contractors)
- Remove loan details such as customer income, customer FICO score, customer debt, and customer home valuation
- Exclude agricultural and industrial projects and any project with renewable energy systems from public release due to small sample size
- Convert monthly energy usage histories to a normalized (relative to TMY3 weather data) annual energy consumption before and after the building upgrade completion date

Progress and Accomplishments

Lessons Learned:

1. Data collection plan (supporting analysis, evaluation, and grant management) should be identified in original Funding Opportunity Announcement (FOA).
2. All grantee reporting forms and evaluation surveys should be planned and coordinated prior to awards to reduce duplication and inconsistency.
3. Dashboards showing grantee data summaries and data health should be tested prior to awards and available during first quarter.

Accomplishments:

- Data collected through 12 quarters (CY Q4 2010 – CY Q3 2013).
- Quarterly summaries provided for internal progress tracking.
- Significant improvements in data quality realized through continuous monitoring of data health and feedback to grantees.
- Draft *Summary of Reported Data* compiled and reviewed by grantees.
- 89,000+ building records (~5000 with 12-months energy consumption data)

Market Impact:

- Data to support BBNP Process and Impact Evaluation (prelim. complete, final in process)
- Data to support documenting effective strategies in Better Buildings Solution Center (online information repository).
- Expand residential data in Buildings Performance Database

Next Steps and Future Plans

(April)

- Anonymize Building Upgrade Project Data to protect privacy
  - Grantee Project Summary Files
- Draft Upgrades and Energy Savings Analysis Report

(May – June)

- Release Summary of Reported Data and Data Files
  - BBNP Website and /or OpenEI
- Stakeholder Webinar on Summary of Reported Data
- Add buildings data to the Building Performance Database
  - Estimate that up to 15,000 records may meet criteria
- Calls with Evaluation Team to answer questions about data
- Developing Residential Guide for Benchmarking Program Progress
  - Plan to include example benchmarks based on BBNP data
  - Stakeholder comment period and pilot testing

REFERENCE SLIDES

Project Budget

Project Budget: Ongoing task to support the BBNP with data collection and data analysis. Total funding since 2010 has totaled approximately $2.8 million.
Variances: Original plan included lessons learned analysis. This could be accomplished more efficiently by shifting some research questions to Evaluation Team. The Summary of Reported Data and Upgrade and Energy Savings Analysis were substituted.
Cost to Date: ~96% of budget has been expended
Additional Funding: No additional funding is planned. Lessons learned analysis shifted to independent evaluation time with ARRA funding.

Budget History

	FY2010– FY2013 (past)		FY2014 (current)	
Partners	DOE	Cost-share	DOE	Cost-share
NREL	$450K		$190K	
Navigant	$520K		$175K	
Booz Allen Hamilton	$1.8M			

Project Plan and Schedule

Collect data from organizations awarded financial assistance (i.e. BBNP grantees) to test energy upgrade business models and improve building energy efficiency across the country. Use data to: 1) Populate the Buildings Performance Database (BPD), Track grantee progress, Evaluate impact, and Identify successful strategies.