Panelists/Energy Data Experts

**Data Collection & Tracking**
- Emily Soontornsaratool | State of Maryland
- Anand Natarajan | City of Cleveland
- Willie Overmann | City of Columbus
- Jessica Granderson | LBNL
- Leslie Cook | EPA

**REEOs**
- Steve Kismohr | MEEA
- Ken Baker | NEEA
- Carolyn Sarno Goldthwaite & Charlie Taylor | NEEP
- Ann Livingston | SWEEP
- Chris Herbert | SPEER

**Data Cleansing & Analysis**
- Kathy Pecora | Will County, IL
- Zach Wilson | New City Energy
- Elise Anderson | MA DOER
- Andrea Hessenius | MA DOER
- Elena Alschuler | DOE
- Paul Mathew | LBNL
- Ben Cohen | CBEI
State of Maryland
Energy Data Tracking

Emily Soontornsaratool
Maryland Department of General Services
Office of Energy Performance & Conservation

- Energy Performance Contracting
- Energy Planning
- Electricity & Natural Gas Purchasing
- Renewable Energy Purchasing
- Measurement & Verification
- Demand Response
- Tracking State Government Energy Usage & Cost
LEGISLATION

2006 - SB267
• Leading By Example
• DGS must track and report on energy reduction across all State government facilities

2008 - EmPOWER Maryland Energy Efficiency Act
• Mandates a 15% in per capita electricity consumption and peak demand by 2015
• Leading by Example
STATE ENERGY DATABASE

- 1st contract awarded 2008
- ~1M / year
- Contracted responsibilities:
  - Create and maintain a comprehensive utility database
  - Process ~12,000 invoices / mo
  - Audit data
  - Technical Support
  - Training (70 hrs/year)
STATE ENERGY DATABASE

- Tracks **all commodities**: electricity, gas, oil, propane, water, sewer, steam, and chilled water
- **All energy using facilities** (buildings, traffic lights, stadiums, hospitals, fisheries, university campuses, etc.)
- **58 State Agencies** (including the University System of Maryland)
- Includes over **22,000 accounts** (16,000 active)

- Gather data from **120 accounts payable offices**
- Bills are from **124 vendors**
- Over **1 million invoices** in the database
- Comprehensive utility database services contract (~ 1.1M /yr)
- Runs on EnergyCAP software
# State Energy Database

![Database Interface](image)

**Total Cost All Bills:** $1,556,294.13

<table>
<thead>
<tr>
<th>Account Code</th>
<th>Billing Period</th>
<th>Begin Date</th>
<th>End Date</th>
<th>Total Cost</th>
<th>Usage</th>
<th>Usage Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4954610060WG</td>
<td>Feb 2014</td>
<td>02/01/2014</td>
<td>02/28/2014</td>
<td>$13,983.05</td>
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<td>01/31/2014</td>
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<td>02/17/2014</td>
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<td>kWh</td>
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<td>12/31/2013</td>
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<td>Dec 2013</td>
<td>12/17/2013</td>
<td>01/17/2014</td>
<td>$2,424.39</td>
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<td>kWh</td>
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<td>4954610060WG</td>
<td>Nov 2013</td>
<td>11/01/2013</td>
<td>11/30/2013</td>
<td>$12,483.09</td>
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<td></td>
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<tr>
<td>4954610060WG</td>
<td>Nov 2013</td>
<td>11/15/2013</td>
<td>12/17/2013</td>
<td>$2,290.42</td>
<td>116,200</td>
<td>kWh</td>
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<td>4954610060WG</td>
<td>Oct 2013</td>
<td>10/01/2013</td>
<td>10/31/2013</td>
<td>$13,668.71</td>
<td></td>
<td></td>
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<tr>
<td>4954610060WG</td>
<td>Oct 2013</td>
<td>10/17/2013</td>
<td>11/15/2013</td>
<td>$2,661.03</td>
<td>117,600</td>
<td>kWh</td>
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<tr>
<td>4954610060WG</td>
<td>Sep 2013</td>
<td>09/18/2013</td>
<td>10/17/2013</td>
<td>$2,927.71</td>
<td>145,600</td>
<td>kWh</td>
</tr>
</tbody>
</table>
STATE ENERGY DATABASE

Maryland DGS
- ESPCs
- M&V Analysis
- Energy Purchasing
- Demand Response
- Energy Data Program Manager
- Engineering

State Agencies
- Energy Coordinator
  - Anomaly Correction
  - Project Execution
- Accounts Payable Offices
  - Invoice Receipt, Approval & Payment

Utilities
- Electronic (87%)

Third Party (Bith)
- Paper invoices

Energy Database
- Billing data
- Access to Database

Paper invoices
### Bill Validation
#### QA/QC

<table>
<thead>
<tr>
<th>Third Party</th>
<th>DGS</th>
<th>Agencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing Bills</td>
<td>Rates</td>
<td>Account Ownership</td>
</tr>
<tr>
<td>Double Entries</td>
<td>Usage Spikes</td>
<td>New Accounts</td>
</tr>
<tr>
<td>Late Fees</td>
<td>Random Audits</td>
<td>Addresses</td>
</tr>
<tr>
<td>Data Entry Errors</td>
<td></td>
<td>Square ft.</td>
</tr>
</tbody>
</table>

#### Key Issues
- **Third Party:** Missing Bills
- **DGS:** No Savings
- **Agencies:** Data Mess

#### Solutions
- **Third Party:** Electronic data when possible; Regular audits; Communication with agencies
- **DGS:** DGS investigates spikes, better comm. with agencies
- **Agencies:** Agencies work to verify buildings and accounts

---

**STATE ENERGY DATABASE**
DATA USES & APPLICATIONS

Energy Performance Contracts
- Identifying opportunities
- Establishing a baseline of usage
- Measurement & Verification of Savings / holding vendors accountable

Energy Planning
- Agencies identify their energy consuming entities and analyze their energy usage
- Track progress and results of initiatives
DATA USES & APPLICATIONS

Reporting
• Measuring savings & Progress towards goals
• Reporting to the Governor’s Office

Electricity & Natural Gas Purchasing
• Identifying State utility accounts and providing data to bidders
• Historical rate information for budget and forecasting
• Holding suppliers accountable

Competitions
• 16 Agency Energy Competition (State)
• EPA National Building Competition
Public Facing Database:
QUESTIONS?

Emily Soontornsaratool
Energy Data Program Manager
Office of Energy Performance & Conservation
MD Dept. of General Services
Emily.Soontornsaratool@maryland.gov
(410) 767-3061
Anand Natarajan
City of Cleveland, OH
Energy Data Access & Tracking

Leveraging Resources

Public Sector Data Workshop

Better Buildings Summit

May 29, 2015
City Utility Costs

2014 Total Cost = $66.8 million
Energy Data Management - EnergyCAP

**Utilities**
- Electricity
- Natural Gas
- Steam
- Chilled Water
- Water and Sewer
- Fleet Fuel (Diesel, Gasoline)

**Vendors**
- Cleveland Public Power (CPP)
- Illuminating Company/First Energy, Deregulated Suppliers
- Ohio Edison
- Dominion
- Hess
- Columbia Gas
- Cleveland Thermal (Steam and Chilled Water)
- Cleveland Water Division (CWD)
- City’s Motor Vehicles Maintenance (MVM) & Airports Fuel Management
- Water Pollution Control (WPC)
- Northeast Ohio Sewer District (NEORSD)
Leveraging Resources

- Financial System
- Energy Data Mgmt System
- ENERGY STAR
- Document Repository
- Utilities (Flat Files & Bills)
- CAP ‘Inventory Management System’ (IMS)

- Energy Graduate Assistant
- Bill Administrator
- Accounting Clerks

- EnergyCAP & Energy STAR
- DOE – BBC Resources

Expertise

Personnel

Systems
EnergyCAP – ENERGY STAR Interface

Email address to notify when results are available
mgrm@city.cleveland.oh.us

- Submit all ENERGY STAR buildings
- Select buildings to submit

Selective Building Submittal

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>CROWN_TREATMENT_PLANT</td>
<td>Crown Water Treatment Plant</td>
<td>OK</td>
</tr>
<tr>
<td>THURGOOD_MARSHALL_REC</td>
<td>Thurgood Marshall Recreation Center</td>
<td>OK</td>
</tr>
<tr>
<td>COCHRAN_HARPER_INTERCO</td>
<td>Cochran Harper Interconnect Vault</td>
<td>OK</td>
</tr>
<tr>
<td>J_GLEN_SMITH_HEALTH_CEN</td>
<td>J. Glen Smith Health Center</td>
<td>OK</td>
</tr>
<tr>
<td>MCCAFFERTY_HEALTH_CENTER</td>
<td>McCaffery Health Center</td>
<td>OK</td>
</tr>
</tbody>
</table>

Submit

Submit Log

<table>
<thead>
<tr>
<th>Submit Date</th>
<th>Receive Date</th>
<th>User</th>
</tr>
</thead>
<tbody>
<tr>
<td>04/10/2015</td>
<td>04/13/2015</td>
<td>Matthew Gim</td>
</tr>
<tr>
<td>03/30/2015</td>
<td>03/30/2015</td>
<td>Matthew Gim</td>
</tr>
<tr>
<td>03/26/2015</td>
<td>03/30/2015</td>
<td>Matthew Gim</td>
</tr>
<tr>
<td>03/26/2015</td>
<td>03/26/2015</td>
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<tr>
<td>03/26/2015</td>
<td>03/26/2015</td>
<td>Matthew Gim</td>
</tr>
</tbody>
</table>
Energy Data Access & Tracking - Applications

- Benchmarking
- Greenhouse Gases (GHG) Inventory
- Measurement & Verification
Thank You!

Anand Natarajan, Energy Manager
City of Cleveland, Mayor’s Office of Sustainability
anatarajan@city.cleveland.oh.us

Join us at :
www.SustainableCleveland.org
Jessica Granderson
Lawrence Berkeley National Laboratory
Energy Management and Information Systems: Performance Monitoring, Analytics, Diagnostics

Jessica Granderson
Lawrence Berkeley National Laboratory
Energy Management and Information Systems

* The boundaries can be fuzzy; some tools cross categories, e.g., energy information systems with FDD and benchmarking capabilities.
EMIS Examples

Benchmarking and Monthly Utility Bill Analysis

Fault Detection and Diagnostics

Energy Information Systems

Building automation system (BAS)
LBNL’s EMIS Program

- Accelerates adoption and technical advancement of monitoring, diagnostic, and control solutions that are under-utilized in national stock
  - Yet shown to enable up to ~20% site energy savings

- Laboratory technical expertise and market intelligence connects owner/operator community, vendors of commercial tools, and BTO program objectives
  - Development of new analytical approaches, identification of best-practice uses
  - Knowledge and technology transfer to facilitate market push and market pull

LBNL w Better Buildings Alliance members, public sector, GSA, DoD, vendor community
BBA EMIS Project Team Overview

• Activity: adopt or expand use of EMIS in your organization

• Members from public and private sector, retail, hospital, real estate

• Existing and ongoing resources
  – Peer learning, public/private/utility pilots and demos
  – Technology costs and benefits, business value proposition
  – Synthesis of existing EMIS resources, “Cliff’s Notes”
  – Regional guide to EMIS utility incentives
  – Vendor overviews and guest login access
  – Procurement support materials: master spec and RFP, selection guidance
Small Group Discussions
Round 1
Discussion Format

Step 1: Pick a topic table

Step 2. Write down a question for the facilitator

Step 3: Facilitator reviews all questions and uses them as a guide for ensuing discussion

Step 4: Report Out (1 min each)

- Barriers discussed
- Solutions/successes discussed
- Connections/contributions made, concrete action items or next steps
- Remaining questions
## Small Group Discussions: Data Access and Tracking

### Round #1  9:30 AM to 10 AM

<table>
<thead>
<tr>
<th>Table Topic</th>
<th>Facilitator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Perfecting the value proposition for energy data management</td>
<td>Steve Kismohr</td>
</tr>
<tr>
<td>2. How to pay for data management services</td>
<td>Jessica Granderson</td>
</tr>
<tr>
<td>3. Leveraging limited time and resources</td>
<td>Anand Natarajan</td>
</tr>
<tr>
<td>4. Working with utilities on automated data access</td>
<td>Zach Wilson</td>
</tr>
<tr>
<td>5. Working with third parties and across departments</td>
<td>Emily Soontornsratool</td>
</tr>
</tbody>
</table>
Kathy Pecora,
Will County, IL
Zach Wilson
District of Columbia/New City Energy
Data Tools Overview

May 2015

Elena Alschuler
Elena.alschuler@ee.doe.gov
Building Technologies Office
U.S. Department of Energy
Goals: Integrate energy-related information throughout building lifecycle
Goals: Increase availability & consistency of energy-related information

Transmit
- HPXML Residential Audit
- BUILDINGSYNC Commercial Audit
- GREEN BUTTON Utility Energy Data

Combine
- SEED Platform: Software platform for building portfolio data management

Compare
- BPD: Public database of building energy performance
- BEDES: Dictionary of common terms to ensure the interoperability between data tools
Building Energy Asset Score

- Rating tool that provides a whole-building score and identifies inefficient systems and potential capital upgrades, based on as-built physical characteristics (independent of operations)
- User input data is used to run an energy model, generate a 1-10 score, and identify opportunities to upgrade building efficiency
Standard Energy Efficiency Data Platform

- Open source software that manages data about large groups of private and/or public buildings
- Users can combine data from multiple sources, clean it, and share it with others
- The open source and extensible platform can support apps and connect to other software
Buildings Performance Database

- The BPD is the largest publicly-accessible dataset of information about the physical and operational characteristics of real buildings
- Allows users to explore data across real estate sectors, compare trends in the energy performance, and tailor programs and policy design based on the conditions of the local building stock
Building Energy Data Exchange Specification

- Dictionary of terms, definitions, and field formats to facilitate the exchange of information on building characteristics and energy use
- Improve data quality and decrease the cost and time involved in aggregating and sharing data
- Support for industry-wide standardization increases the efficiency of business processes and helps grow the market of products and services that utilize energy data
Data Cleansing:
Lessons from the BPD

Paul Mathew
Lawrence Berkeley National Lab
The Buildings Performance Database

- The BPD is the largest publicly-available dataset of information about the energy performance of real commercial and residential buildings.
Lots of data from many sources...

- >790,000 buildings from both public and private datasets. More datasets are being added regularly.
- Significant effort to map and cleanse data before it can be used.

Data contributors include...

U.S. Energy Information Administration
U.S. General Services Administration
U.S. Environmental Protection Agency
New York City Dept. of Citywide Administrative Services
Pennsylvania Keystone HELP Home Energy Loan Program
San Francisco Department of the Environment
State of California Public Utilities Commission
State of California Energy Commission
University of Arizona
University of Dayton
District Department of the Environment: Washington, DC
Vermont Energy Investment Corporation
Virginia Beach City Public Schools

Brandywine Realty Trust
Connexion Asset Group
Kohl’s
EnergyIT.com
Liberty Property Trust
Lucid Design Group
Prudential
Related
Tishman Speyer
Transwestern
USAA
Vornado Realty Trust
Data analysis

Data cleansing
Data Cleansing: Why Do It?

• Bad data happens!
  – Errors in collection, collation, transmission, transformation...

• Bad data “contaminates” the data set and can lead to inaccurate analysis and erroneous decisions.

• Bad data can lead to lack of confidence in results, potentially undermining the credibility of the underlying program or policy.
## Data issues and cleansing actions...a selection

<table>
<thead>
<tr>
<th>Data Issue</th>
<th>Cleansing Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inconsistent units of measure (e.g. kBtu vs. therm)</td>
<td>Convert to common units</td>
</tr>
<tr>
<td>Inconsistent formats (e.g. 100,000 vs. 100K vs. 100000)</td>
<td>Convert to common format</td>
</tr>
<tr>
<td>Inconsistent naming conventions (e.g. RTU, Roof top unit, packaged unit)</td>
<td>Convert to common terms</td>
</tr>
<tr>
<td>Missing data</td>
<td>Delete record or interpolate value</td>
</tr>
<tr>
<td>Obvious incorrect values (e.g. Floor area &lt; 0)</td>
<td>Out-of-range checking, Delete or correct values</td>
</tr>
<tr>
<td>Possible incorrect values (e.g. Hospital EUI &lt; 10 kBtu/sf/yr)</td>
<td>In-range checking, Delete or correct values</td>
</tr>
</tbody>
</table>
Tips for an effective data cleansing process

• Before you begin: Develop *your* criteria based on *your* use cases
  – Determine what rules to apply (e.g. minimum data to keep a record)
  – Determine tradeoff between accuracy and level of effort to cleanse
  – Determine cleansing options (e.g. Is interpolation ok? How much?)

• Allocate adequate resources

• Develop an explicit set of cleansing rules and procedures
  – “Checklist Manifesto”

• Automate as much as possible
  – But ensure automation is rigorously tested and periodically retested.

• If possible, quantify data quality and uncertainty
  – Or at least qualitatively characterize it

• Communicate!
  – Don’t be shy. Publish your cleansing rules.
  – Provide guidance on how it can/cannot support various types of analysis and decision-making.
DOE WIPO
Benchmarking Data Cleansing Guidance

DOE BPD
Data Cleansing Technical Report

Thank you

Paul Mathew
pamathew@lbl.gov
Creating A Cleaner Energy Future For the Commonwealth

Data-Based Program Design
Better Buildings Challenge Summit
May 29, 2015

Elise Anderson      Andrea Hessenius
Massachusetts Dept. of Energy Resources
Key Discussion Points

- **State Policy Drivers**
  - Green Communities Division
  - Leading by Example Program

- **Data Requirements**

- **MassEnergyInsight**
  - An example of how DOER collects data

- **DOER Data-Based Opportunity Design**
  - Case Studies
State Policy Drivers

• Global Warming Solutions Act (GWSA)
  ➢ Mandated 80% reduction of greenhouse gas (GHG) emissions from all sectors in the economy by 2050 (1990 baseline)

• Clean Energy and Climate Plan 2020
  ➢ 25% interim target for GHG emission reductions by 2020

• Green Communities Act (GCA)
  ➢ Assists all 351 Massachusetts cities and towns in finding clean energy solutions that reduce long-term energy costs and strengthen local economies

• Leading by Example E.O. 484 (LBE)
  ➢ Sets GHG, renewable generation, and energy usage intensity goals for state facilities

• Renewable and Alternative Portfolio Standard
  ➢ Electricity suppliers obligated to supply energy from renewable and alternative clean energy sources; increases annually.
The energy hub for all Massachusetts cities and towns, not just designated “Green Communities.”
Leading by Example (E.O. 484)

**LBE—Clean Energy and Efficient Buildings**

- Sets short, medium, and long-term goals for state agencies:
  - GHG emission reductions
  - Energy reductions
  - Renewable energy
  - Water conservation
- Requires all new construction to meet Mass. LEED Plus Standard
- Includes executive agencies, community colleges and university campuses, Trial Court

### EO 484 Targets

- **Use of Renewable Energy**
- **Energy Use Reductions**
- **GHG Emissions Reduction**

<table>
<thead>
<tr>
<th>Year</th>
<th>0%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Energy Efficiency & Renewable Energy)
Green Communities & LBE

Programs & Resources for Municipalities & State Facilities

- Green Communities Designation and Grant Program
- Leading by Example Program Grant Opportunities
- MassEnergyInsight energy tracking and analysis tool
- Municipal Energy Efficiency Program
- Energy Management Services Technical Assistance
- Clean Energy Results Program (CERP)
- Dedicated Regional Coordinators for municipalities
- Collaboration with multiple state partners for E.O. 484

Website filled with tools & resources:
www.mass.gov/energy/greencommunities
www.mass.gov/eea/leadingbyexample
Data Requirements

For Municipalities

Provides grants to **qualifying Green Communities** to fund energy efficiency initiatives, renewable energy, innovative projects

1. Adopt as of right siting for RE/AE generation, R&D, or manufacturing
2. Adopt expedited permitting process
3. **Create an Energy Reduction Plan to reduce energy use by 20% in 5 years**
4. Purchase only fuel efficient vehicles
5. Minimize life cycle cost in new construction -- adopt the Stretch Code

For State Agencies

*Leading by Example, LBE*

- EO requires reporting and collaboration on data with LBE Program
- Requires annual reporting by LBE staff
- Track progress toward goals
- Better Buildings Challenge annual reporting
MassEnergyInsight (MEI)

A web-based tool fine-tuned for municipal energy data management, analysis, and reporting
How MEI Works

MEI provides users with a platform to do the following items:

- Identify utility accounts
- Align accounts with facilities
- Gather building information
- Collect utility data
- Gathers various fuel data (fuel oil, propane, gasoline/diesel, biomass, renewable generation)
- Assigns all accounts to a Category
- Provides graphs for data
DOER Data-Based Opportunity Design

• Create grant initiatives based on energy trends
• Find sites/ projects open to grant opportunities
• Establish baselines
• Implement projects
<table>
<thead>
<tr>
<th>Program Opportunity</th>
<th>Example Projects</th>
<th>Data Sources</th>
</tr>
</thead>
</table>
| • Renewable Thermal at state facilities | • State Parks  
   • Trial Courts  
   • Fish Hatcheries | • MassEnergyInsight  
   • Statewide contracts  
   • Feasibility Studies |
| • Green Communities Competitive Grants | • Municipal Facilities  
   • Public Schools  
   • Police Stations | • MassEnergyInsight  
   • MassSave  
   • Portfolio Manager  
   • Feasibility Studies |
| • SAPPHIRE                          | • Regional School Districts  
   • Public Housing | • MassEnergyInsight  
   • Portfolio Manager  
   • Feasibility Studies |
| • Energy Leaders Roundtable         | • WWTP  
   • DWTP  
   • DW/WW Districts | • MassEnergyInsight  
   • MassSave  
   • Portfolio Manager |
Case Study #1

Leading by Example established Renewable Thermal Implementation Grants targeting projects displacing electric, oil, or propane heating for renewable thermal technologies.

• Using MEI and other data sources, LBE collects monthly utility consumption, fuel oil deliveries, geographic location, and square footage
• For a portion of the grant funds, LBE focused on agencies that consumed over 5,000 gallons of fuel oil annually for operations and would be open to biomass fuels and other renewable thermal technologies
• By targeting sites through data, LBE was able to design projects that would benefit the most from alternative fuel sources
**Case Study #2**

Green Communities Division provides cities and towns with **Designation and Competitive Grants for energy projects.** To date, more than $40M awarded in designation and competitive grants.

- Projects include building EE measures, LED streetlights, solar PV, incremental costs for hybrid vehicles, and more
- As a GC, municipalities submit energy use baselines and inventories to reach their 20 percent Energy Reduction Plan. Many municipalities use MEI to track their energy
- As different grant rounds open to municipalities, past data and performance help GC find new opportunities for energy efficiency opportunities
DOER established the SAPHIRE program (“Schools and Public Housing Integrating Renewables and Efficiency”) providing dedicated assistance and funding support for renewable thermal & energy efficiency at public housing and regional school districts.

- Department of Housing and Community Development (DHCD) manages capital planning and pays energy costs for public housing
- Better access to data on entire building portfolio to compare similar buildings
- Target buildings with relatively high EUIs
- Scheduled HVAC replacement, evaluate renewable options

Winthrop Public Housing: Outdoor Condenser Unit for Heat Pumps
Case Study #4

In partnership with U.S. EPA, MassDEP, MassSave®, and multiple state partners, DOER was a part of the Massachusetts Energy Management Pilot for Drinking Water and Wastewater Treatment Facilities (Energy Leaders Program) as a multi-pronged approach to reach statewide energy goals.

- Set out to identify how the state could achieve a higher level of energy efficiency at water and wastewater utilities.
- The pilot program was designed to: reduce the amount of energy that municipal facilities use in treating the water that flows through the plant by 20%; reduce greenhouse gas emissions by 20%; and save communities money.
- The program transformed the wastewater and drinking water sector to act as clean energy resource for the community, even as they continue to deliver clean water as part of their primary mission.
Ben Cohen
Consortium for Building Energy Innovation
Better Buildings Summit
Benchmarking Data Analysis
From Broad to Narrow

May 29, 2015
Benchmarking Data Analysis
Better Buildings Summit

Broad Vs Narrow
Benchmarking Considerations

Benchmarking Data as Whole Dataset

- Nation Wide Benchmarking
- City/Municipality Wide Benchmarking
- Property Type Parsing
- Size, Climate, Fuel Type Parsing
- General Data Analysis

Less Specific Energy Information
Broader Communication Required

Start Here

More Specific Energy Information
Targeted Communication Possible

Individual Buildings Within the Dataset

- Asset Information
- Smaller Data Intervals
- Deeper Data Analysis
- $
Benchmarking Data Analysis
Better Buildings Summit

Philadelphia Benchmarking Dataset

Cleansing of Initial Benchmark Data

<table>
<thead>
<tr>
<th>Type of property removed</th>
<th># Removed</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplicate entries</td>
<td>16</td>
<td>5 exact duplicates, 11 properties with multiple entries</td>
</tr>
<tr>
<td>Small buildings</td>
<td>65</td>
<td>Any property under 50,000 square feet</td>
</tr>
<tr>
<td>No property type</td>
<td>17</td>
<td>Reclassified to “Not Available” in the EPA calculated field</td>
</tr>
<tr>
<td>No EUI</td>
<td>32</td>
<td>Not studied regardless of other information entered</td>
</tr>
<tr>
<td>Extremely high and low ES scores</td>
<td>73</td>
<td>100’s, 99’s, 1’s, and 2’s removed</td>
</tr>
<tr>
<td>Extremely high and low EUI’s</td>
<td>9</td>
<td>Under 2 and over 1000 (property type dependent – industrial and utility related properties remained)</td>
</tr>
<tr>
<td>Zero electric use</td>
<td>2</td>
<td>29 other zero electric sites already removed from above cleansing</td>
</tr>
</tbody>
</table>
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Simple High Level Analysis

Square Footage of all Properties by Decade Constructed

Energy Star Score Distribution
Philadelphia Median = 60

Median Site and Source EUI for all Properties with Weather Normalized Values

Quantity and Median EUI of all Properties by Decade Constructed

- 10,000,000 20,000,000 30,000,000

Energy Star Score

0 5 10 15 20 25 30 35 40 45 50

Number of Properties with Score

3 13 23 33 43 53 63 73 83 93

Energy Star Score

Quantity

Median EUI

Weather Normalized Median EUI

Site EUI

Source EUI

Philadelphia Median = 60
**Simple Mid Level Analysis**

### Quantity Parsed by Property Type

- **K-12 School**: 1,737,678
- **Office**: 4,963,628
- **College/University**: 2,243,185
- **Warehouse Non-Refrigerated**: 295,447
- **Distribution Center**: 289,932
- **All Others**: 3,316,067

### Area Parsed by Property Type

- **K-12 School**: 1,737,678
- **Office**: 4,963,628
- **College/University**: 2,243,185
- **Warehouse Non-Refrigerated**: 295,447
- **Distribution Center**: 289,932
- **Hospital**: 3,316,067

### Energy Use Parsed by Property Type

- **K-12 School**: 12,918,745
- **Office**: 2,243,185
- **College/University**: 2,243,185
- **Warehouse Non-Refrigerated**: 295,447
- **Distribution Center**: 289,932
- **All Others**: 3,316,067

**Median ES Score and Site EUI Parsed by Property Type**

<table>
<thead>
<tr>
<th>Property Type</th>
<th>Median Score</th>
<th>Median Site EUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-12 School</td>
<td>29</td>
<td>260</td>
</tr>
<tr>
<td>Office</td>
<td>29</td>
<td>247</td>
</tr>
<tr>
<td>College/University</td>
<td>37</td>
<td>142</td>
</tr>
<tr>
<td>Warehouse Non-Refrigerated</td>
<td>42</td>
<td>134</td>
</tr>
<tr>
<td>Distribution Center</td>
<td>46</td>
<td>129</td>
</tr>
<tr>
<td>Hospital</td>
<td>46</td>
<td>106</td>
</tr>
<tr>
<td>Courthouse</td>
<td>72</td>
<td>95</td>
</tr>
<tr>
<td>Hotel</td>
<td>72</td>
<td>94</td>
</tr>
<tr>
<td>Refrigerated Warehouse</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>Office</td>
<td>72</td>
<td>78</td>
</tr>
<tr>
<td>Retail Store</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td>K-12 School</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td>Other</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Worked Facility</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Distribution Center</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Non-Refrigerated Warehouse</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
**Benchmarking Data Analysis**

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**Broad Energy Analytics**

### Fuel Shares Parsed by Selected Property Type

- **Office**
- **Hospital**
- **College/University**
- **Manufacturing/Industrial Plant**
- **K-12 School**

### Quantity & Square Footage of Properties Parsed by Heating Fuel Type

- **Electric**
- **Gas**
- **Oil**
- **Steam**
- **Unknown**

### Fuel Cost per Square Foot for Office Buildings

- **Electric Cost/SF**
- **Gas Cost/SF**
- **Fuel Oil Cost/SF**
- **Steam Cost/SF**

**Philadelphia Average Utility Costs**

- **Electric Rates** = $0.0293/kBTU = $29.30/million BTU
- **Gas Rates** = $0.0136/kBTU = $13.60/million BTU
- **Fuel Oil Rates** = $0.0205/kBTU = $20.50/million BTU
- **Steam Rates** = $0.0340/kBTU = $34.00/million BTU
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**Narrowing the Analysis**

**Energy Cost per Square Foot vs Energy Star Score**  
Parsed by Property Type

- K-12 Schools
- Offices
- Warehouses

**Energy Use Intensity vs Energy Use for Offices**  
Parsed by Energy Star Score

- Score 3-50
- Score 51-74
- Score 75-98

**EUI vs Energy Use for Office ES Scores Below 75**

- Below Median EUI
- Above Median EUI
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Getting to Individual Building Analysis

Energy Data Intervals < 1 year.
Local Temperature Data.

Utility Rebates
$ Drive Energy Reduction Programs

- Property Type
- Contact Information
- Property Size
- Energy Use
- Asset Information

- Benchmark Score
- Property Owner/Bench-marker
- Area Use (parking, restaurant, data center, etc.)
- Fuel Shares
- Weather Normalization
- Asset Scoring Tool Benchmarking
- Missing/Default Data
- Estimated Utility Cost
- Monthly Interval Data
- Capital Investment Suggestions
- Estimated Savings from Energy Reduction
- Daily/Hourly Interval Data
- Energy Reduction Strategies
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Analyzing Interval Data by Load Shape

ECAM Analysis

Green Button Utility Data
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**Predictive Analysis Using Inverse Modeling Toolkit**

1-paramenter

2-paramenter model

3-paramenter model (heating)

3-paramenter model (cooling)

4-paramenter model (heating)

4-paramenter model (cooling)

5-paramenter model

---

**Regression Analysis**

Regression Analysis

- Natural Gas
- Natural Gas
- Electricity
- Electricity

Temperature (°F)

Electricity Usage

- 500 kWh/day
- 400 kWh/day
- 300 kWh/day
- 200 kWh/day
- 100 kWh/day
- 50 kWh/day
- 0 kWh/day

Ambient Temp

Ambient Temp

Ambient Temp

20°F 30°F 40°F 50°F 60°F 70°F 80°F

- 500 CCF/day
- 400 CCF/day
- 300 CCF/day
- 200 CCF/day
- 100 CCF/day
- 50 CCF/day
- 0 CCF/day

Ambient Temp

Ambient Temp

Ambient Temp
Common Findings

- Benchmark score is being artificially increased
- Benchmarking data was not properly entered
- Benchmarking data was missed or defaults were used
- Building sectors to focus rebate programs on
- Fuel type prevalence

- High building resting loads
  - Occupancy hours need adjustment
  - Setback points not enabled
  - Lighting retrofit opportunities
  - Continuously running equipment

- High loads during occupancy
  - Set points can be tweaked
  - Building envelope needs sealing
  - AHU economizing not enabled
  - Simultaneous heating and cooling
  - Equipment failure

- Predictive modeling can help reduce energy consumption
  - Peak load shaving
  - Preventive maintenance scheduling
  - Retrofit timing optimization
  - Retrofit savings validation
Small Group Discussions
Round 2
## Round #2 11:30 AM – 12:30 PM

<table>
<thead>
<tr>
<th>Table Topic</th>
<th>Facilitator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Data cleansing</td>
<td>Paul Mathew</td>
</tr>
<tr>
<td>2. Benchmarking data analysis</td>
<td>Ben Cohen</td>
</tr>
<tr>
<td>3. Interval data</td>
<td>Zach Wilson; Charlie Taylor</td>
</tr>
<tr>
<td>4. DOE data resources</td>
<td>Elena Alschuler; Leslie Cook</td>
</tr>
<tr>
<td>5. Data-driven program design</td>
<td>Andrea Hessenius</td>
</tr>
</tbody>
</table>
Buildings Performance Database
Live Demo
Paul Mathew
LBNL