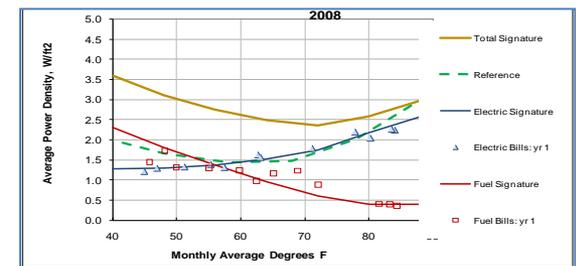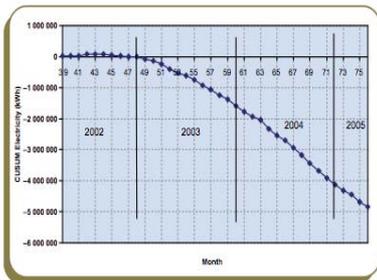# Commercial Building Energy Information Handbook

Technical Advisory Committee Meeting

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New Buildings Institute

January 25, 2011
http://eis.lbl.gov

Meeting Agenda

- Participant introductions – name and organization (10 min)
- Prior work and project introduction (10 min)
- Tasks, timeline, and TAC role (5 min)
- Progress to-date (15 min)
  - High-level definition of the Handbook design/layout
  - Template to guide development of analysis methods
  - List of candidate analysis methods
- Prioritization of analysis methods (60 min)
  - Identify top methods from candidate list of methods
  - Review of high-priority analyses not on the candidate list
- Next steps (5 min)

Prior LBNL Work

- Information Monitoring and Diagnostic System, 1993-1998 CIEE/CEC/DOE

- UCSB enterprise energy management case study, 2002 CEC

- Web-based EIS study, 2003 CEC

- GSA Energy Maintenance Network, 2003 GSA

- EIS state of the technology and user case studies, 2009 CEC

- Advanced EIS for UCM, 2009-present DOE

- EIS best practices, users and service providers, DOE 2010

Data → Information → Action

Please visit eis.lbl.gov for further information

Project Introduction

- **Purpose:** Develop a handbook detailing energy analysis and performance monitoring methods for commercial buildings

- **Audience:** Software developers and service providers, building operators and energy managers, controls companies

- **Relevant technologies**: Spectrum of performance monitoring tools, from utility tracking, to EIS, to CCx to HVAC FDD

- **Outcome:** Web and paper-based handbook detailing ~25 analysis methods in this phase of the multi-year effort

  - Prior best practice and case study findings to be included in application examples of the handbook methods

- **Phase II Scope:** TBD

Tasks and Timeline

Task	Description	Due Date
1	Develop template for summaries of analysis methods	December 2010
2	Select analysis methods for inclusion	February 2011
3	Develop 3-5 sample summaries of methods	March 2011
4	Identify examples of application benefits	Ongoing
5	Develop initial draft analysis guide	July 2011
6	Finalize analysis guide	September 2011
7	Define and scope Phase 2 research plans	September 2011

2010   2011

Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec

Tasks   1   2   3   5   6
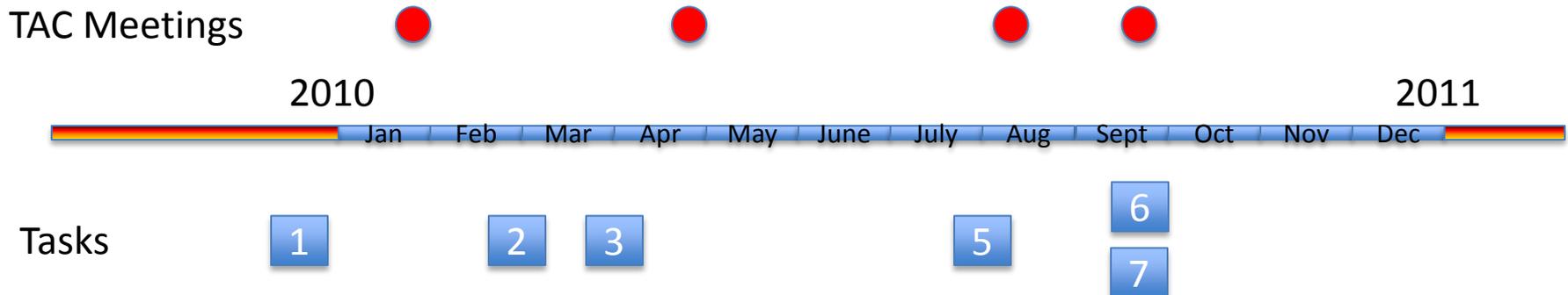   7
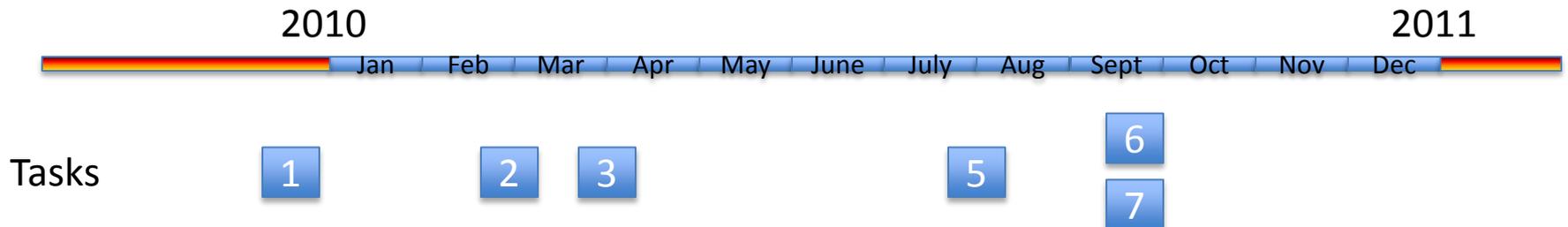
Role of the TAC

- ## External technical advisors
  - Provide review and feedback to deliverables
  - Benefit from results of research
- ## Tasks and meetings
  With ongoing collaboration to identify application benefits
  1. Analysis methods and template (current)
  2. Feedback on 3-5 sample analysis summaries (April)
  3. Feedback on draft handbook, paper version (August)
  4. Review full handbook and make comments on Phase II (Sept)

TAC Meetings

2010   2011

| Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |

Tasks   1   2   3   5   6   7

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Handbook Progress To-Date

- ## Layout and Style
  - Adapted from **Lstiburek -** *Builder's Guide to Mixed Climates*
  - Glossary, introduction, ~25 analysis method summaries, appendices
  - Hyperlinks and graphics to illustrate relationship between methods

- ## Formats
  - Printed Version
  - Online Version

Handbook Progress To-Date

- Proposed Analysis Method Structure
  - 3 primary sections to group analyses
    - Benchmarking and Reporting
    - Fundamental and By-Inspection Analysis
    - Advanced Analysis
  - Within each primary section, subsections for:
    - Whole-building
    - System and end use
- This is an initial structure and input is still welcome

Handbook Progress To-Date

```
                          ┌──────────────┐
                          │   Methods    │
                          └──────┬───────┘
         ┌───────────────────────┼───────────────────────┐
┌─────────────────┐   ┌─────────────────────┐   ┌─────────────────┐
│ Reporting and   │   │ Fundamental and  By- │   │    Advanced     │
│ Benchmarking    │   │ Inspection Analysis  │   │    Analysis     │
└─────────────────┘   └─────────────────────┘   └─────────────────┘
```

Reporting and Benchmarking:
- Whole Building
- System – End Use

Fundamental and By-Inspection Analysis:
- Whole Building
- System – End Use

Advanced Analysis:
- Whole Building
- System – End Use
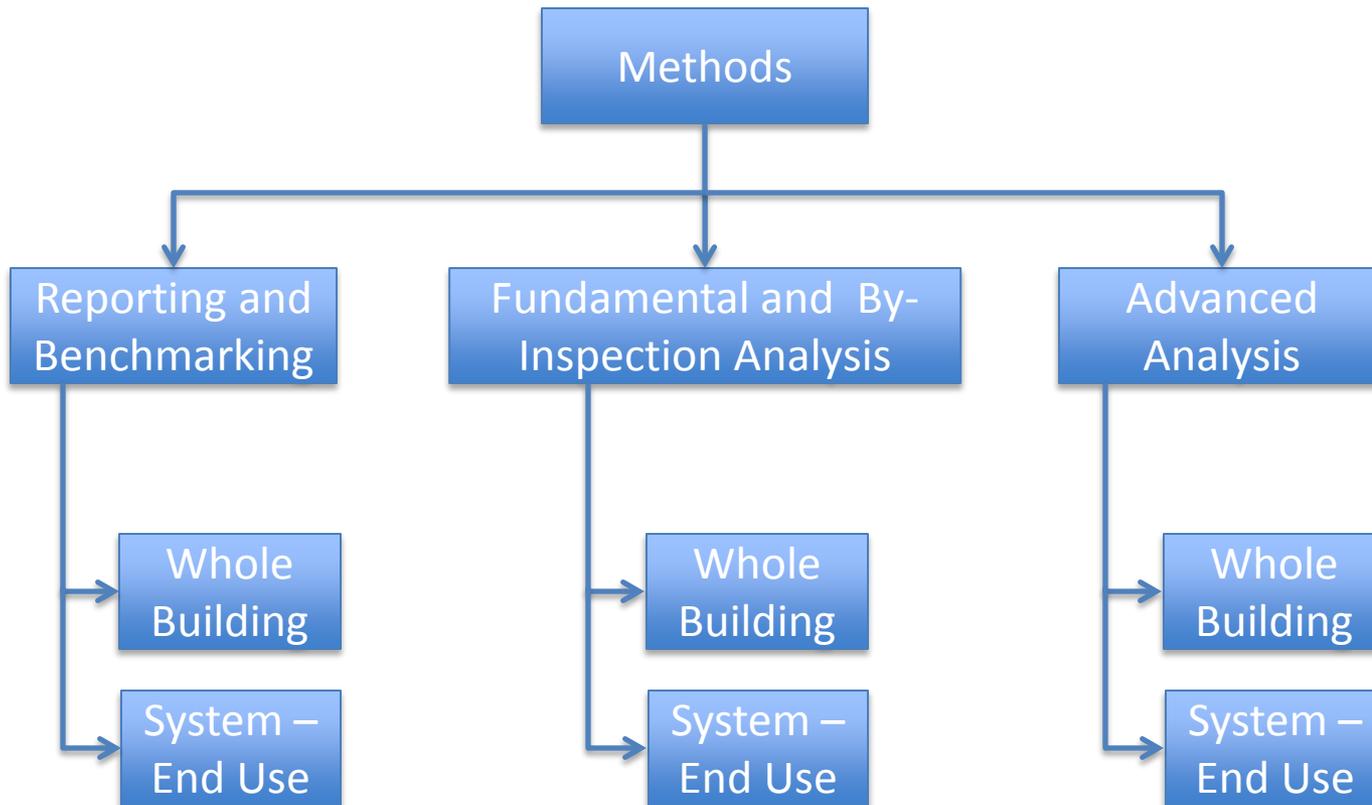
Candidate Analysis Methods

- Key Organizational Challenge:

  How to define naming convention that accurately summarizes method and allows for a coherent and useful structure.

  - General high level method definition, e.g.:
    a. Weather normalization of energy consumption
    b. BIN or neural network models
  - Framing the method according to specific uses, e.g.:
    a. System level energy signature of heating load versus outside air temperature
    b. Baselining 'typical' consumption according to the BIN or neural network models

- This challenge will also arise in your consideration of high-priority methods to include in the Handbook

Handbook Progress To-Date

- What we have now:
  - Template to guide authoring of analysis methods. Sections:
    - Summary
    - Application examples and benefits
    - Detailed supplementary information, resources, and references
  - Sketches/drafts of 3 analysis methods to evaluate template
  - Candidate list of ~40 analysis methods

Handbook Progress To-Date

- Let's look at the CUSUM example summary

Candidate Analysis Methods

Benchmarking and Reporting

- Whole-building
  - Whole-building source energy consumption
  - Utility cost accounting
  - Whole-building cross-sectional benchmarking (you vs others)
  - Whole-building longitudinal benchmarking (current vs. baseline)
  - Rolling quantification/tracking of metrics
  - Return on investment
  - Simple payback period
  - Internal rate of return

- System or end-use
  - Longitudinal component benchmarking
  - System or end-use tracking
  - Tracking of on-site PV generation

Candidate Analysis Methods

By-inspection and Fundamental Analysis

- Whole-building
  - Base-to-peak load ratio
  - Whole-building or enterprise baselining
  - Whole-building load vs. OAT (energy signature)
  - Load shape overlaid with weather conditions
  - Load shape compared to occupancy schedule (overlays or vs. hr of day)
- System or end-use
  - Chiller efficiency over time (kW/ton)
  - Overall boiler efficiency (input-output method) over time
  - As-operated lighting power density
  - Lighting operational efficiency (kW/Total installed kW) over time
  - Cooling system or chiller efficiency versus cooling or chiller load (kw/ton vs tons)
  - Histogram of load vs. hours for system sizing analysis
  - Cooling or heating system power versus OAT (system-level energy signature)

Candidate Analysis Methods

Advanced Analysis

- **Whole-building**
  - Benchmarking against an energy model
  - Whole-building energy anomaly detection
  - Cumulative sum
  - Load shed quantification for demand response
  - Whole-building load prediction
- **System or end use**
  - Component energy anomaly detection
  - Estimate financial or energy impact of recommended improvement measures
  - System life cycle analysis
  - Cumulative sum
  - 'Normalization' ala IPMVP/M&V
    - extrapolate baseline to post-measure period to quantify savings
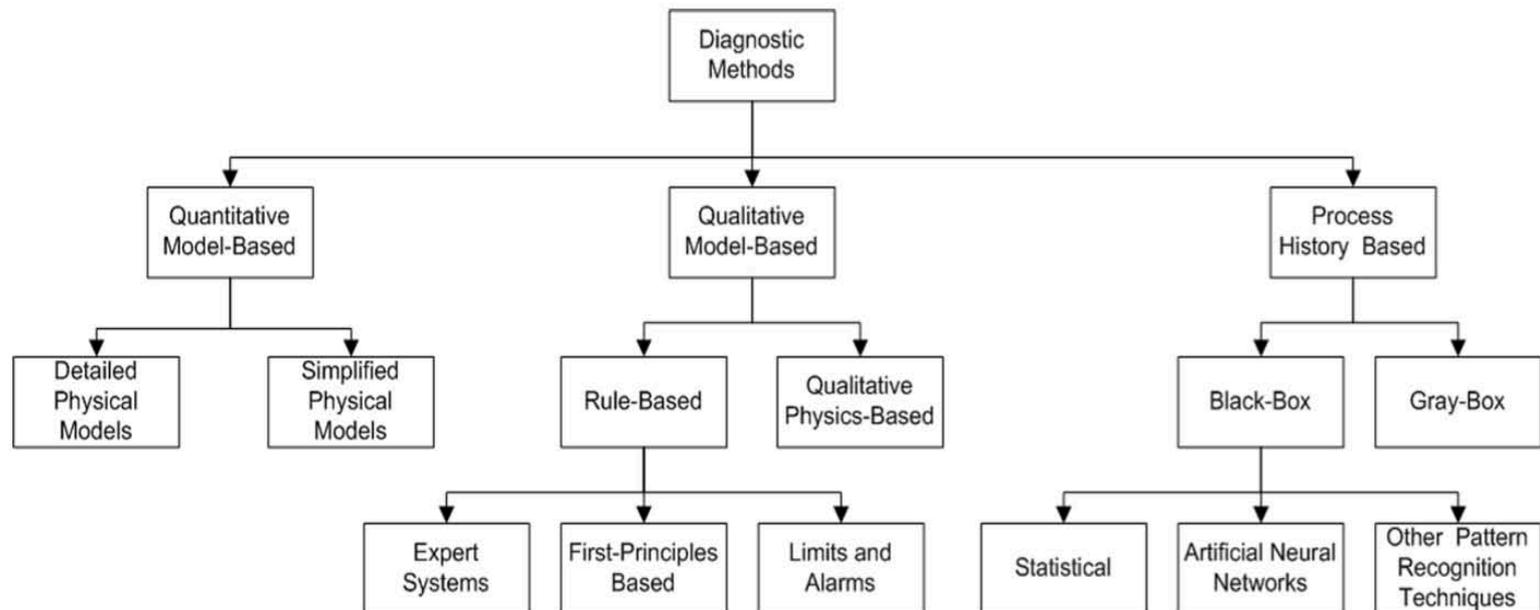 - FDD (next slide)

Candidate Analysis Methods

Advanced Analysis – Fault Detection and Diagnostics

- Classification scheme from Katipamula and Brambley 2005, HVAC&R

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Candidate Analysis Methods

Advanced Analysis – Fault Detection and Diagnostics

- Qualitative physics rule-based: AHU/OAE
  - E.g. Outdoor Air Economizer Diagnostician, developed by PNNL in collaboration with industry
- Qualitative expert rule-based: AHU
  - E.g. ENFORMA where 7 different modes of AHU operation are defined, then 28 APAR, AHU perf. assmt. rules (House 2001) + 31 AEC rules are combined into fault/cause pairs
- Qualitative expert rule-based: chillers, boilers, CHW distribution, and towers
  - E.g. Sisk and Brambley 2003, 28 faults and causes using equipment status, temperature, and chiller pump and fan power.
- Process history based: VAV boxes
  - E.g. NIST VPACC (?), using cusum analysis to identify 8 faults related to damper and coil valve position and flow sensing/stability
- Qualitative expert rule based: WB, AHU, zone distribution., chiller, hydronic systems
  - E.g. PACRAT
- Quantitative model-based: Radial basis function with first principles model
  - E.g. Haves et al 1996, to detect and diagnose fouled coil and leaking valve faults in AHU cooling coil

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Prioritization of Analysis Methods

Process

- Each organization to names 3 favorite methods from each category
  - Benchmarking and reporting
  - Fundamental and by-inspection
  - Advanced
    - FDD (which seem most useful, which types do you use or offer in your technologies)
- "Favorite" in terms of
  - Effectiveness in revealing energy waste and savings
  - Usefulness in generating actionable information
  - Impact on improving WB energy performance
  - Prospective penetration rate
  - Universal applicability to the availability of data in commercial buildings
- **Please provide feedback on any high-priority methods that did not appear on the list of candidates**
- We will document your responses and highest priority methods will be included in the handbook

Next Steps

By February 8 please send Jessica feedback on:

- The template design
  - Suggested revisions to titles, content, terminology, the 3-section breakout for methods, overall organization
- The CUSUM sample summary
  - Clarity, usefulness of material, organization, missing information…
- Content or design elements that will make the handbook most useful to your organization

Next TAC meeting, April 2011

- 3-5 fully drafted analysis summaries for your review and comment
- The remaining ~20 analysis methods will be developed through July according to feedback and application examples from the TAC