Sensor Suitcase: A Turnkey Technology to Enable Small Buildings Retro-Commissioning

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Outline

• **Background**
  – Problem and solution
  – Primary use case
  – Development pathway

• **Turnkey Solution (Sensor Suitcase)**
  – Components, application process
  – Suitcase, sensors, and handheld device
  – Software, algorithms

• **Field Testing Demonstration**
  – Procedures and site characteristics
  – Key takeaways and findings
  – Early market feedback

• **Next Steps in Commercialization**
Background, Problem and Solution

• Problem
  – Small commercial buildings do not typically have budgets or business economics that allow investing in enhancements, such as the comfort, cost, and energy improvements that retro-commissioning (RCx) provides
  – They also do not have ‘in-house’ staff with expertise in building systems, who can perform retro-commissioning or identify improvement opportunities

• Solution
  – Develop a turn-key hardware/software solution (the RCx Sensor Suitcase) that can be used by non-experts to automatically generate low/no-cost recommendations to improve building operating costs, comfort and efficiency
Background, Technology Value Proposition

- The technology extensively streamlines the RCx process thereby
  - Reducing labor costs of retro-commissioning through decreases in labor time and expertise required
  - Enabling penetration of RCx into the small buildings sector, where low energy expenditures place tight constraints on payback and human capital
- 50% reduction in labor time/costs
  - Guided, substantially automated sensor configuration and installation, in contrast to logger solutions such as HOBOs, which require expertise to select and deploy properly
  - Software and sensors eliminate need for walk-through, spot measurements, and engineering expertise to interpret data
- Delivery of at least 10% average site energy savings - traditional RCx saves 16% on average
Background, Primary Use Case

- **Initial target application: small (< 50K sf) commercial buildings**
  - Does not have on-site energy management staff, in-house buildings expertise, or a building automation system

- **Services staff use the sensor suitcase to initiate the building RCx process**
  - Suitcase user installs and retrieves sensors, transfers data to PC for storage and analysis
  - Sensors log data for 4 to 8 weeks

- **Skilled employee, owner affiliate, or 3rd party contractor uses the software to generate improvement recommendations**
  - Recommendations implemented directly by user, or other decision maker
  - Estimated utility cost impacts of recommendations are provided to motivate action
• Proof-of-concept (POC) prototype, FY13
  – Intent: demonstrate concept, technical viability of turnkey prototype

• Phase II development, FY14
  – Intent: conduct POC field testing, get early market feedback

• Phase III commercialization pilot, FY15-17
  – Intent: move suitcase from lab-developed prototype to a market-ready commercially available product
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Turnkey Solution, Components

1. Easy-install suitcase kit of sensors, with supporting installation guidance
2. Handheld device (tablet) to document location, number, and type of sensors
3. Algorithms to analyze sensor data, generate recommendations to improve building operations and energy performance
4. Software to collect, process, and analyze data, display recommendations and fault/energy findings to user
5. Graphical user interface to guide transfer of data from sensors, display recommendations and energy/cost findings to user

3 Sensor types: light, temperature, and vibration
**Turnkey Solution, Application Process**

**1.** Microsoft tablet device, with application to log sensor location, type, active sensor, and retrieval sensor data.

**2.** Sensors install in the building, collect data ~ 1 month.

**3.** Bluetooth.

**4.** CSI data file with common format to be ‘read’ by software application.

**5.** Software application that ‘reads’ CSV data, runs algorithms, outputs recommendations.

**6.** Software application outputs recommendation.
Turnkey Solution, Suitcase

- Sensor transport, configuration, installation, retrieval, and data transfer to a personal computer
  - 16 sensors: 2 RTU status (vibration), 14 others (light, room temperature, diffuser air temperature, outdoor air temperature, types can be set upon activation)
  - Data control module to communicate with handheld device via Bluetooth, launch sensors upon installation
  - Pre-wired sockets to “seat” and communicate with sensors
  - Rechargeable battery
Turnkey Solution, Sensor Platform

Top: Sensor platform
Right: Sensor packaging
Turnkey Solution, Handheld Device

• Guide installation and retrieval of sensors
  – Entry of building information
  – Selection of a specific type of sensor
  – Entry of installation location (roof, outdoors, or a particular room)
  – Installer is provided simple instructions to guide the installation process
Turnkey Solution, Diagnostic Algorithms

- The 8 algorithms related to HVAC and lighting control and operation
- Identify most common, high-impact opportunities in small commercial buildings
- Rule-based algorithms, designed for the available sensor types
  - Light, temperature, RTU operating mode

Setpoint deadbands, over(under) heating/cooling

RTU short cycling, not economizing

Scheduling, setbacks

Excessive daytime lighting

Excessive nighttime lighting
Turnkey Solution, Software

1. Create new project

2. Select targeted building

3 & 4. Enter utility info and occupancy schedule

5. Start analysis and get recommendations
Open-Source Software Output Report

Left: Software Output report summarizes
a) user-defined Occupancy Schedule and Utility expenses,
b) Building Details entered by the user and extracted from the sensor data
c) problems identified from the data, actionable recommendations, and estimated cost savings from implementing recommendations
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Field Test, Site Characteristics

- Site A – office building
  - Building size: 5,500 sqft
  - Location: Berkeley, California
  - Seven packaged rooftop units with gas heat, 2 monitored in test

- Site B – Mixed office/warehouse
  - Building size: 10,000 sqft
  - Location: Lake Oswego, OR
  - Three packaged rooftop units with gas heat, 3 monitored in test
Field Test, Procedure

Testing partners KW Engineering and NorthWrite

- Activate and configure the sensors individually
- Install the sensors
- Acquire ~3 weeks of data
- Download data from sensors
- Run analysis software to identify recommendations
- Provide feedback on usability, functionality, performance
- Additional evaluation of performance by LBNL and PNNL
Field Test, General Takeaways

• The first field tests of the technology were successful

• Testers provided suggestions for improvements and questions

• Early market feedback indicated strong interest and broad applicability from potential users
Field Test, Hardware findings

- Hardware is well designed, and the tablet to configure of sensors is easy to use
- Sensors provided data sufficient for analysis and problem identification
- Refinement opportunities for next collaborative phases of development
  - Solar and weatherproofing for durability
  - Further validation of RTU operation mode sensing
  - Diversity of sensor mounting configurations is needed
Field Test, Software findings

• Software was easy to use, and the installation instructions were helpful
• Analysis outputs and recommendations “seemed reasonable” to users
• Analysis outputs and recommendations validated by PNNL and LBNL building science staff
• Refinement opportunities for next phase of development (Laboratory-delivered)
  – Further vetting of diagnostic thresholds used in algorithms to identify opportunities
  – Association of RTUs with zone ambient and diffuser air temperature sensors
Field Test, Early Market Feedback

- **Companies Interviewed**
  - McKinstry, NorthWrite, KW Engineering, Exergetics, and Greenpath Energy Solutions were each interviewed for Market feedback.

- **Interest, Market Segmentation, Delivery**
  - Potential users confirmed value proposition of streamlining, simplicity, and ability to deliver services to small commercial.

“... [this would give] us another high-end tool ... as well as an opportunity for carry-on services. From a setting standpoint ... that’s what I’m excited about. [It] complements our existing products and services.”
General Applicability

- Technology could serve wide set of building system types and regions
  - The algorithms and problems targeted have wide applicability with a few exceptions for specialized buildings (e.g., laboratory buildings)

“The technology is pretty versatile and could give you data where you wouldn’t otherwise know what the actual operating conditions are.”

“This would allow us to penetrate a market that is in dire need – we’ve not been able to offer an inexpensive enough solution.”
Viability of price points

• The price point of $1,000-$1,500 seemed reasonable to all firms interviewed
  – Consider, value add with respect to other tools available
    • E.g., sixteen Hobos could easily cost $1,600
    • How do labor/time cost reductions compare?

  “We would use [the technology] as another tool of doing business. That fits well within our cost model.”
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Next Steps

Identify Manufacturing Partner

• Evaluate most effective sales and distribution channels for the RCx sensor suitcase

• Develop the RCx sensor suitcase manufacturing plan.

• Design/develop the commercial product version of the retro-commissioning suitcase

Any Recommendations?
Next Steps

Secure Deployment Partners

• Conduct field tests for deployment partners
• Work with partner’s preferred customers and early adopters to establish deployment channels and obtain third-party validation of the “enhanced” design under realistic field conditions
THANK YOU

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Year 1: business plan, techno-economic analysis, target market definition with manufacturing and deployment partners; extended field tests to gauge customer satisfaction and interest, and further validate performance.

Year 2: once partner is convinced of market and fit for the RCx sensor suitcase within their product line, a next generation prototype product will be designed considering partner’s existing products and preferred architectures; Labs to provide technical assistance; business plan updated.

Year 3: batch production and final testing of the commercial product, finalization of business and marketing plans, and product launch.

Early milestones focus on securing agreements with manufacturer and deployment partners.