Residential Commissioning

Houses are complex systems of interacting components that do not always perform properly. Primary interactions are due to flows of air, heat, and moisture, all of which can affect occupant safety, health, or comfort, as well as building durability and energy use. Most homes are field assembled from a large number of components and there is no consistent process to identify related energy and non-energy problems or to correct them.

California has one of the most advanced energy codes in the U.S. Despite this, new homes often fail to meet health, safety, comfort, and energy-use expectations. For example, many studies indicate that duct leakage testing and sealing can readily improve system efficiency and achieve a 25% to 30% reduction in installed cooling capacity and energy consumption. Additionally, studies on California houses have found 50% variances in air tightness for homes with the same design and construction crews, within the same subdivision. Building envelope air tightness has a substantial impact on thermal loads, energy use, comfort and indoor air quality.

Residential commissioning is a comprehensive evaluation of a home to ensure the effective performance of the building and its systems. Commissioning combines component and system testing with improvements in home performance, energy efficiency, and comfort. Commissioning methods can be used to diagnose home performance for both new and existing homes, either single-family or multifamily.

Green Building Benefits

Home owners and occupants enjoy several benefits from commissioning:

- **Improved comfort.** Commissioning process can help identify unwanted air leakage and moisture problems, ensure that the heating, ventilating, and air conditioning (HVAC) systems efficiently deliver the intended space conditioning. Commissioning can help achieve better room temperature balance and surface temperatures by assuring correct insulation installation.
- **Improved health and well being.** Commissioning process can help identify moisture problems. Whole house commissioning also investigates and corrects the effects of building pressurization, and possible fireplace and combustion appliances backdrafting, which can introduce combustion gas products into the living space.
- **Reduced energy bills.** Savings typically come from such measures as sealing leaky ducts, optimizing airflow through the system, and correcting refrigerant-charge errors in air conditioning systems.

Likewise, residential building professionals can gain important benefits by incorporating commissioning into their practice:

- **Improved customer satisfaction.** Builders can show they delivered what their clients expected.
- **Reduced business costs.** Commissioning can reduce callback frequency and warranty costs. Professional liability insurance rates may also be reduced.
- **Construction defect litigation protection.** In the event a building professional becomes entangled in a lawsuit, the documentation produced in the course of commissioning can help support the argument that the project was well constructed.

What Needs to Be Commissioned?

A whole house commissioning process should be followed in order to identify all of the energy and non-energy opportunities for improving home performance. One might consider evaluating only the individual building components and/or systems and feel that this is an adequate job of quality control. However, in the real world, all of the building sub-systems interact. How they interact and affect the performance of the house as a whole is a major focus of residential commissioning.

A good commissioning process will first test individual components for defects and performance, then test each system, and finally

look at system interactions and the performance of the house as a whole under all anticipated operating conditions.

Building sub systems of particular concern with significant interactions are the building envelope and the HVAC systems. These areas include insulation quality, windows, air tightness, envelope moisture, fan and duct system airflows, duct leakage, cooling equipment charge, and combustion appliance backdrafting with spillage.

Building Envelope

The building envelope is important to the performance of a house, because envelope loads dominate the house heat transfer mechanisms. Assumed thermal loads, equipment sizing, structural durability, and occupant comfort for houses are based on having the building envelope perform as intended, including insulation levels, windows, and air tightness. In new houses, installation failures, especially in insulation and air sealing, can cause immediate energy consumption and comfort problems. As the building ages, subsequent loss of durability caused by poor material selection and installation (e.g., insulation settling, air barrier damage from UV exposure, moisture damage) can result in further performance reductions over time.

Figure 1. Blower door testing for building envelope leaks

Air Distribution Systems

Ducts that are part of the thermal distribution system may be the single worst performer in the energy performance of a house. Duct leakage, duct insulation compression, and other poor installation practices can reduce duct efficiency by 30% from even a moderate level of design performance. Poor operation of the air distribution systems wastes energy and can cause comfort problems, structural moisture problems, and poor indoor environmental quality.

Cooling Equipment

Even in new houses, cooling systems rarely perform as intended. In particular, refrigerant charge levels and airflow across coils often do not meet manufacturers specifications used in the system design. As a result, the capacity and efficiency of the equipment can be substantially degraded.

Combustion Appliances

Fueled appliances must vent as intended. Poor installation of either the combustion equipment or venting equipment can reduce efficiency and lead to backdrafting and combustion gas spillage or other hazards. Such events, along with insufficient ventilation for unvented combustion appliances, can directly affect the indoor environment and cause health or comfort problems.

Figure 2. Testing for duct leakage

House as a System

As an example of the complicated interactions that occur when a house operates as a system, consider the impacts of a leaky supply and return duct system located in a hot unconditioned attic (attics can reach 150°F or more on sunny summer days). When the airhandler operates, hot air from the attic is drawn into the return leaks. This leakage raises the temperature of the return air and acts to reduce the effective capacity of the air-conditioning system. Conditioned air that leaks out of supply ducts is essentially lost to outside, because the attic is outside the thermal and air barrier of the building envelope. As a result, occupant comfort may be impaired because insufficient cooling is delivered to the rooms that the supply ducts serve.

If there is an imbalance between the supply and return leaks, there are additional "indirect effects" of the duct leakage. The imbalance will result in pressurization (larger return leaks) or depressurization (larger supply leaks) of the house. These pressure changes, in turn, affect the infiltration rate of the house and thus the thermal and humidity load that the space-conditioning system must deal with to maintain comfort. When there is a central return grille, the increased return airflow can lead to excessive house depressurization if interior door undercuts are too small to allow supply air to flow easily from each room back to the return grille. If there is a combustion appliance in the house near the return, such as a fireplace, or water heater, the resulting depressurization may contribute to backdrafting of the flue and indoor spillage of toxic combustion gas products. Operating an exhaust fan for local ventilation, such as a kitchen fan during cooking, can cause further depressurization.

In the case where the return leaks are larger than the supply leaks, sealing the return leaks but not the supply leaks can also cause unintended problems. In particular, the supply leak now becomes an unbalanced leak with the attendant house depressurization problems described above. Clearly, in the house as a system view, the ducts are not simply the components attached between the airhandler and the house. Instead, they also include the occupied spaces and envelope of the house. Residential commissioning can account for these systemic issues, but needs to be done on both a whole-house and a component by component basis.

Commissioning Process

Residential commissioning process can have four main phases: audit and diagnostic; tuning and tweaking; opportunity identification; and final verification.

Audit and Diagnostic

The first phase of commissioning uses audit and diagnostic techniques to survey metrics for the house and then compares survey results with appropriate norms for the house. For new construction, the norms will be those such as California Title 24 standards or the equivalent local building codes. For an existing house, one might base the norms on what a particular component should be able to do relative to those in other similar houses.

Figure 3. Testing for supply airflow balancing

Commissioning tools and techniques include but are not limited to:

- Blower door tests for building shell leakage: aim for less than 0.5 air changes per hour (ACH)
- Duct leakage diagnostics: aim for less than 5 percent leakage

- Combustion safety tests to verify proper performance of appliance venting systems
- Carbon monoxide testing
- Supply airflow balancing
- Moisture content meters
- Infrared thermal imaging

Knowledgeable practitioners can utilize these and other diagnostic tools to help ensure the health, safety, comfort, and durability of the home.

Tuning and Tweaking

The performance of many components and systems may not meet the norms, but it may be possible to improve their performance immediately by making minor adjustments, repairs, or retrofits on the spot.

Examples include sealing leaky ducts or correcting a refrigerant charge deficiency in a central air conditioner. Such tuning and tweaking can often provide significant improvements in performance for very little marginal cost. The purpose of this step is to improve the performance of the house to at least the design intent.

Opportunity Identification

After the tuning and tweaking, there still may be components that are not performing up to their potential. This commissioning step provides the client with information about what potential repair or retrofit opportunities need further consideration. Even when components are performing to their norms, the improved performance of new components or systems may make replacement worthwhile.

Examples include adding insulation to areas such as the ceiling, walls, and floors; replacing windows to solve comfort, condensation, or maintenance problems; and replacing an oversized inefficient cooling or heating system that is near the end of its service life with a properly sized and more efficient system.

Final Verification

All changes will be verified using the same diagnostic testing and techniques as the original audit. This final verification leaves the homeowner with a new acceptable accounting of the performance of the home.

For more information

- **Guidelines for Residential Commissioning**. Craig Wray, Iain Walker, Max Sherman. Environmental Energy Technologies Division, Indoor Environment Department, Lawrence Berkeley National Laboratory eetd.lbl.gov/ied/pdf/LBNL-48767.pdf
- **Building Science Corporation** is a building science consulting firm specializing in building technology, preventing and resolving problems related to building design, construction and operation. www.buildingscience.com
- **California Building Performance Contractors Association** encourages a new kind of home improvement service for better energy efficiency, economy, air quality, structural soundness, long-term value, and the health, safety, and comfort for California homes www.cbpca.org
- **DOE Energy Efficiency and Renewable Energy**, describes a variety of tools and technologies to perform energy audits: www.eere.energy.gov/consumer/your_home/energy_audits/index.cfm/mytopic=11160
- For more information about Build It Green, visit our web site at www.BuildItGreen.org or call us at 510-845-0472.

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