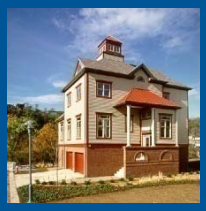

Quality Management for High Performance Homes

Quality, Environmental, Health & Safety (QEHS) Management System: Frequently Asked Questions

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INTRODUCTION

Characteristics of Companies Implementing High Performance Homes

Builders generally use a "spec and purchase" business management system (BMS) when implementing energy efficiency. A BMS is the overall operational and organizational systems and strategies that a builder uses to set up and run its company. This type of BMS treats building performance as a simple technology swap (e.g. a tank water heater to a tankless water heater) and typically compartmentalizes energy efficiency within one or two groups in the organization (e.g. purchasing and construction). While certain tools, such as details, checklists, and scopes of work, can assist builders in managing the quality of the construction of higher performance homes, they do nothing to address the underlying operational strategies and issues related to change management that builders face when they make high performance homes a core part of their mission. To achieve the systems integration necessary for attaining 30%+ levels of energy efficiency (with respect to the 2009 International Energy Conservation Code), while capturing the cost tradeoffs, builders must use a "systems approach" BMS, rather than a "spec and purchase" BMS. The following attributes are inherent in a systems approach BMS; they are also generally seen in quality management systems (QMS), such as the NAHB Research Center's National Housing Quality Certification program.

A. Cultural and corporate alignment
B. Clear intent for quality and performance
C. Whole house integrated design and specification
D. Measurement and verification of building performance
E. Better communication practices and systems
F. Increased collaboration across internal and external teams
G. Disciplined approach to quality control
H. Continuous feedback and improvement

While there are market leaders who are successful at implementing quality management systems to profitably deliver low first-cost "code" housing, there are very few who have developed quality management systems associated with a holistic systems approach to delivering high performance homes. In an effort to help the industry more widely adopt the technical results from the Building America (BA) program, IBACOS is undertaking an ongoing research project to:

- Characterize the organizational and operational structure of a systems approach BMS and supporting QMS for a profitable company building high performance homes.
- Identify the barriers, level of effort, and costs associated with transformation from a "spec and purchase" to systems approach BMS and QMS, and provide template solutions to these issues for builders to adopt.

The following Frequently Asked Questions have been grouped under the 8 general quality management attributes listed above. They are intented to be a companion to the "Quality, Environmental, Health, and Safety Management System Requirements" draft document (IBACOS 2010) Each FAQ is structured as follows:

X.1. Title

<Title of FAQ>

QEHS Section Reference

<References to the relevant sections in the draft "Quality Energy Health and Safety (QEHS) Management System Requirements">

Recommendations

.<Recommendations for inclusion in an organization's QEHS Management System>

Commentary

<Commentary on the topic.>

Resources have been provided where appropriate, typically as web links. These were last accessed on October 18, 2010.

CULTURAL AND CORPORATE ALIGNMENT

A.1. Why High Performance is a Cultural Issue

Question: How much does a company need to internalize high performance home thinking to successfully implement a high performance home technical strategy?

QEHS Section Reference

1.2 Leadership

Senior management shall demonstrate leadership regarding the company's quality, environmental, health, and safety (QEHS) initiatives. Leadership is demonstrated by:

- Setting policy and performance expectations
- Communicating to the organization the importance of quality, safety, and the environment, as well as meeting customer expectations
- Providing resources
- Reviewing the effectiveness of the management system

A fundamental aim of leadership is the full integration of QEHS initiatives, which inherently includes a focus on integrating design approaches, problem solving, implementation, and measurement systems.

1.3 QEHS, Environmental, and Safety Statement

Senior management shall prepare a written statement(s) that describes the company's commitment to QEHS, the environment, and safety, as well as addresses customer's expectations. This statement should have a direct link to the company's vision and mission statement. The statement(s) will commit the entire organization to continually improving, achieving measurable business performance metrics, and having a safe workplace, and it shall be communicated to all stakeholders, customers, suppliers, trade partners, and employees.

Recommendations

Consider including language in leadership statements related to the company's vision, mission, and QEHS on its commitment to higher performing houses. Taking this step will help connect the commitment to high performing homes directly to the strategic plan and can help emphasize the delivery of higher performance homes as part of everyone's job in the organization.

Strategic Integration of Annual Review and Self-Assessment & SWOT Analysis

It is recommended to link the Annual Management Review (and its review of audits and organizational performance) to the annual strategic planning of the organization, so the results from internal reviews and the opportunities for improvement from them can be addressed in the evaluation of the Strengths,

Weaknesses, Opportunities, and Threats (SWOT). This work can be supported by conducting a gap analysis and self-assessment using the National Housing Quality (NHQ) Award Criteria and the IBACOS Green Blueprint. Including the annual review as part of the strategic planning meeting ensures that the focus is kept on high performing homes, makes full use of the QEHS, and provides key input for the strategic decision making process.

Commentary

The success of adopting a high performance home strategy in an organization starts and ends with the leadership team. The leadership of the company provides the vision, direction, strategy, and especially the culture of the organization. Leadership actions and behaviors create the culture and the disciplines required to design, market, build, and sell high performing homes. If the leadership team does not really believe in high performance and relegates it only to one area of the company, the results will not be as robust had the entire organization been involved.

Many builders consider the overall performance of a house to be a function of the individual parts and pieces that make up the end product. While in a strict sense this is true, a house is a complex set of interrelated systems with individual parts that rely on one another. This same concept holds true for a company building high performance homes. Sustained success is virtually impossible if only one part of the company is delegated to “do that high performance homes thing.”

A parallel concept would be to delegate the goal of improving customer satisfaction to one department. It has been demonstrated that the entire homebuying process influences customer satisfaction and every member of the organization must be involved. Unless delivering high performance homes becomes one of the key cultural goals of the organization, supervisors and trades will not be motivated or even inspired by their work, the sales team will not discuss the benefits of a high performance home with buyers, and customer care may feel the brunt of unmet expectations.

Leaders in a homebuilding company must address the many implications associated with making delivery of high performance homes a core strategy. The leadership team must understand the strategy, be vocal champions for it at all levels within the organization, and integrate this thinking into as many aspects of the organization as possible. Some points to consider:

- All departments must align behind the strategy; it cannot be seen as simply a purchasing and construction exercise.
- High performance homes can positively contribute to bottom line business results through improved customer satisfaction, reduced risk, and increased retained earnings.
- Land planning and lot orientation may be impacted to optimize performance or enable the future addition of renewable energy systems, such as photovoltaic (PV) panels.
- Design strategies may need to be modified to achieve the energy performance goals.

- Marketing and sales departments must be knowledgeable about the high performance strategy and be able to share the story. They do not need to be technical experts, but they must be able to provide customers with the basic features and benefits.
- Purchasing and construction departments must be able to execute the strategy, and support the trades in collaboratively achieving the energy performance goals.
- The different trades need to be well-integrated and coordinated, since all of the systems in the house are relying on one another to perform. Each trade must properly execute its scope of work in order for the house to perform properly.
- Customer care must reinforce the difference with high performance products to buyers through the maintenance and operation of the homes.
- One aspect of incentive pay could be developed around the successful execution of the energy performance strategy companywide.
- Community giveback events can be focused around energy efficiency or improving the performance of a building.

CLEAR INTENT FOR QUALITY AND PERFORMANCE

B.1. Internal Standards

Question: What kinds of standards should I evaluate when developing a high performance home strategy?

QEHS Section Reference

1.11 Performance Measures

The company shall establish performance measures and goals that are indicative of the effectiveness of the QEHS Management System. These shall be defined, documented, and quantified for each functional area covered by the company's QEHS Management System. Progress towards meeting these goals shall be documented and reported quarterly to the management of the various functional areas.

(The topic in section 5.1.4 is repeated in sections 3, 6, 7, 8 and 9 and adapted for those departments.)

5.1.4 Company Standards

Company standards shall be documented to define the requirements for workmanship, including tolerance requirements, industry standards, design procedures, and material specifications. These company standards shall be included in scopes of work or other agreed upon document(s). When a conflict exists between local practice and other requirements (e.g. industry standards, manufacturer's instructions), there shall be a procedure for allowing exceptions while maintaining the QEHS. All plans will be approved by an Engineer or equivalent for that city/state/region.

Recommendations

Standards for high performance homes can be found in the following locations:

- Builders Challenge: http://www1.eere.energy.gov/buildings/challenge/pdfs/bcqc_version_1_3_060408.pdf
- EEBA Criteria: http://www.eeba.org/bookstore/cat-Builders_Guides-4.aspx
- ENERGY STAR Homes: http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_2011_comments
- Environments for Living: http://www.environmentsforliving.com/index.jsp?action=bd_pgm_details
- International Green Construction Code: http://www.iccsafe.org/cs/igcc/pages/default.aspx
- ICC-700-2008 National Green Building Standard: http://www.nahbgreen.org/Guidelines/ansistandard.aspx
- LEED for Homes: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2135#2008
- Local and regional green building programs: http://www.pathnet.org/sp.asp?id=20978
- DSIRE website (Database of State Incentives for Renewables and Efficiency): http://www.dsireusa.org/

Commentary

As a building company moves to high performance housing, it is important to define exactly what that means. Doing so will improve internal communications and provide a common understanding; it will also enable every employee in the company to be able to communicate the message to customers, trades, and others on the outside. It may be useful to create an overarching theme (i.e. "we build healthy, safe, durable houses that are 30% or more energy efficient than code with guaranteed comfort for our customer"); however, this messaging must be substantiated by clearly defined metrics associated with the actual performance of the houses and used by all departments.

A good set of company standards will document the climate-related issues that are being addressed by the thermal enclosure and mechanical systems. These issues include:

- Rainfall and wind – water management
- Heating and cooling degree days
- Humidity profile
- Vapor control / enclosure drying strategy

The standards should also explicitly state interrelationships and strategies the builder is implementing related to the high level systems. For example, the standards should describe in a narrative format how heat air and moisture are to be controlled by the building enclosure, how the mechanical system are to be integrated, and overall minimum levels of performance for the overall house using the HERS Index. The standard can also document why the company has taken this approach. Reasons include past failures, calculated future risk avoidance, or a response to customer input (past issues or stated needs). This set of standards can be integrated in the checklists for the product design and purchasing functions to help enable a quick review of critical factors throughout the various stages in the design process (schematic, design development, and construction drawings). It can also be integrated as a part of the development of the scopes of work, step-by-steps, and other construction documentation.

Some performance criteria for standards could include:

- Structural
  - Industry rating systems (e.g. floors and wind/hurricanes)
    - http://www.ilevel.com/services/s_T-Pro-Rating-System.aspx
    - http://www.disastersafety.org/text.asp?id=fortified_living
- Acoustics
  - Noise separation in multifamily buildings
    - https://www03.cmhc-schl.gc.ca/catalog/productDetail.cfm?cat=18&itm=11&lang=en&fr=1286468715281

        - http://www.cmhc-schl.gc.ca/en/inpr/bude/himu/coedar/upload/Sound-Control-in-multi-family-wood-frame-buildings.pdf
    - Exterior noise to interior
        - http://www.nrc-cnrc.gc.ca/eng/projects/irc/aircraft-noise.html
- Water management
    - Window installation
        - North American Fenestration Standard/Specification (NAFS) for windows, doors, and skylights (AAMA/WDMA/CSA 101/I.S.2/A440-08)
        - Residential Air Infiltration Standard for Windows: AAMA/WDMA/CSA 101/I.S.2/A440
    - Weather-resistive barriers
        - International Residential Code Section R703
    - Below-grade water management
        - International Residential Code Section R405 and 406
    - Roofing
        - Asphalt Roofing Manufacturer's Association (ARMA) Asphalt Roofing Residential Manual: Design and Applications Methods for Residential Roofing
        - ARMA's Good Application Makes A Good Roof Better - A Simplified Guide: Three Tab Asphalt Shingles For Maximum Life & Weather Protection
        - http://www.asphaltroofing.org/resources_publications_arma.html
        - International Residential Code Section R903 Weather Protection
        - International Residential Code Section R905 Requirements for Roof Coverings
    - Flashings
        - International Residential Code section R703
- Energy performance
    - HERS Index
        - http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_HERS
    - Building air tightness
        - http://www.homeenergy.org/archive/hem.dis.anl.gov/eehem/94/940110.html
        - http://www.energyconservatory.com/download/bdmanual.pdf
    - HVAC system tightness
        - http://www.energyconservatory.com/download/bdmanual.pdf
- Ventilation
    - ASHRAE 6.2 Compliance & Strategy
        - http://www.techstreet.com/lists/ashrae_standards.tmpl
- Water vapor control strategy
    - Climate zone
    - Vapor control layer location in building assemblies
    - Vapor barrier class (I,II, and III)

        - http://www.buildingscience.com/documents/information-sheets/3-water-management-and-vapor-control/info-sheet-310-vapor-control-layer-recommendations
- General design strategies for system integration of thermal enclosure, structure, and mechanical systems
    - HVAC location
    - Types of structural systems used to facilitate HVAC integration
        - http://www.toolbase.org/Design-Construction-Guides/HVAC/forced-air-system

B.2. Cost of Documentation

Question: What is the cost-benefit of providing a higher level of documentation for high performance homes?

QEHS Section Reference

1.11 Performance Measures

The company shall establish performance measures and goals that indicate the effectiveness of the QEHS Management System. These shall be defined, documented, and quantified for each functional area covered by the company's QEHS Management System. Progress toward meeting these goals shall be documented and reported quarterly to the management of the various functional areas.

(The topic in section 5.1.1, 5.1.3, and 5.1.6 is repeated in sections 3, 6, 7, 8, and 9 and adapted for those departments.)

5.1.1 Scope of the Design Operations

The Design operation shall define the scope of its Design operations.

5.1.5 Manufacturer's Product Installation Instructions

The Design operation shall develop, document, and implement procedures for obtaining and maintaining current copies of all installation/application instructions. Design operations shall ensure that all products/components are properly drawn, specified, and detailed.

5.1.6 Trade Partner and Supplier Contract Documents and Scopes of Work (Similar to Sections 6, 7, and 8)

Procedures shall be implemented to prepare and review the subcontracts and Design documents specific to the work of each trade utilized by the Design operation to ensure that builder requirements and typical homebuyer expectations will be met. Trade contracts, scopes of work, or other documents shall include mutually agreed-upon job ready conditions and procedures to follow when these conditions are not met.

9.1.3.2 Individual Trade's Performance Standards

Scopes of work or construction documents for trades providing warranty service shall define the warranty service performance requirements expected of the trade.

Recommendations

When determining the appropriate level of documentation, look at the total lifecycle cost of the documentation, including the cost of rework and repairs for building failures due to inadequate documentation, as well as the associated costs in referral sales and goodwill from customer dissatisfaction.

Commentary

FAQ E.3 covers the rationale for having comprehensive documentation as a tool to successfully implement a high performance home strategy. But what is the cost-benefit of the documentation?

In high performance homes, all of the systems and their interactions should be intentional and designed to enable the optimal performance at the lowest risk. These decisions should be made through an Integrated Design Process (see FAQ C.1). Once made, it is imperative to communicate the decisions to the entire team. When the chain of participants is mapped from design to warranty, there can easily be over 500 individuals who will in some way be a part of building the home. This chain includes the builder's internal team, as well as the external teams of designers, engineers, architects, trades, suppliers, and manufacturers' representatives. Without clear and effective documentation, it is impossible to communicate well to all of the participants and expect a high performance home as a result.

The incremental cost to achieve high quality documentation will depend on the documentation currently used in the construction process. Documentation can also be built up over time. Evaluate the critical aspects of material selection and purchasing, as well as construction execution that share the most risk associated with the strategy. If you have never had a window leak but find that your HVAC system has 50% of the system fan flow leaking to the outdoors, then creating installation guidance for sealing duct leaks moves to the top of the list.

Develop comprehensive strategies for looking at the embedded cost of change as opportunities to roll out new systems or strategies. Construction drawings typically need to be revised and updated as new codes are implemented. This cost must be included in the base operating plan. At this point, making a change, such as transitioning from 2x4 wall framing to 2x6, can be relatively small, provided that the implications have been thought through before creating the actual documentation.

Effective documentation is critical to overall customer satisfaction and the success of the high performance design. For example, one builder in the mid Atlantic region was faced with a situation where the documentation fell short. The builder spent additional money to have a mechanical engineer design and size the space conditioning system of a large, executive-type home. The engineer specified the right equipment, duct sizes, and diffusers but did not effectively integrate the duct layout with the framing plan on the drawings. As a result, many of the critical issues within the layout were left to the trade in the field. The trade essentially made sure the ducts reached their intended locations, regardless of the number of additional bends and serpentine routes made to avoid framing interferences. As a result, when the home was complete and fully operational, the homeowners complained of inadequate cooling and heating delivery. The first round of field measurements found that airflow volumes at the supply diffusers and return grilles were extremely low and did not match the engineering flow rates. After extensive troubleshooting and repair efforts, it was concluded that the initial trade installed an excessive number of elbows, pinched down the sizing of branch ducts to squeeze them through tight spaces, and used unnecessary lengths of ductwork. The cost of the rework was very high because a new mechanical

contractor had to be hired to make all of the necessary repairs. The original trade took no blame for the situation due to the lack of explicit details on the drawings.

WHOLE HOUSE INTEGRATED DESIGN AND SPECIFICATION

C.1. Integrated Design Process

Question: How does the design of the house impact my ability to implement a high performance home strategy?

QEHS Section Reference

5.1 Design Operations QEHS Policies and Procedures

5.1.1 Scope of the Design Operations

The Design operation shall define the scope of its Design operations.

5.1.2 Process Flow

The company shall define and document a sequence or sequences of activities (process flow) for the Design operation of the company. This sequence shall include all major planning, Design phases by trades, and interactions with other departments in the company during design and QEHS assurance activities. This can be in list form or any other clear logical sequence. It is recommended that flowcharts are used where possible.

Recommendations

Recommended scope of the Design operations:

- Utilize an integrated design approach involving a team from marketing and sales, design and purchasing, home construction, customer care, and key trades. Review each plan with the team at the schematic design stage, design development stage, and prior to issuing the final construction drawings. Do so to gain feedback on potential defects and errors and to design a customer-oriented home built efficiently and effectively.
- Consider each interrelated component of the home for function, design/aesthetics, and cost with input from those team members closest to that component.
- Provide the construction department and trades with accurate plans and details.
- Provide the sales department with accurate plans for the homebuyer.
- Each time a new home plan is first built, make sure the team completes a walkthrough to gather detailed feedback on how to improve the plan and construction based on the experience.

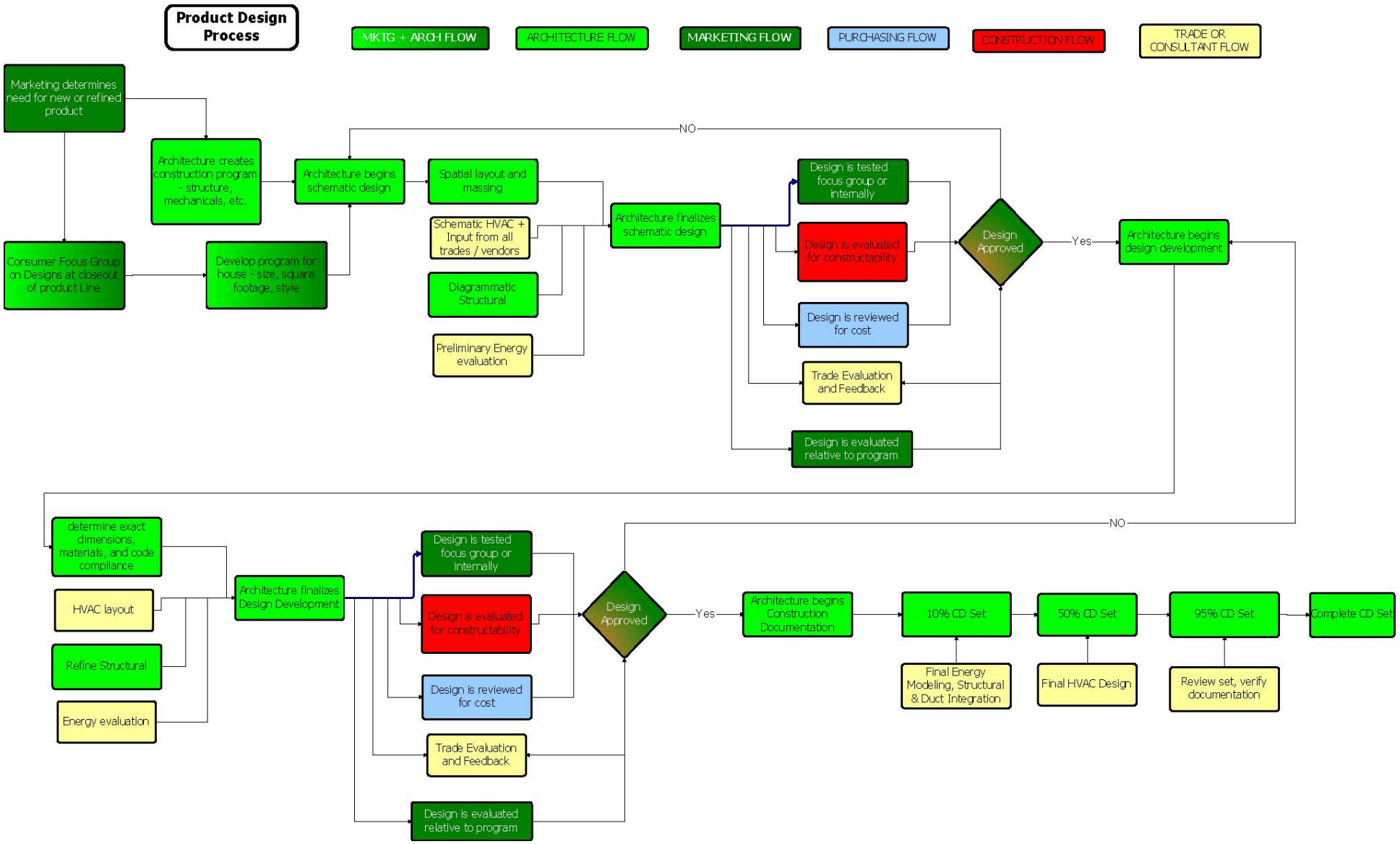
Commentary

Integrated Design Process (IDP) is a mechanism that builders can use to more successfully integrate all aspects of building performance with the entire team. By using an IDP, the builder can ensure the compatibility of the higher performance systems and design while capturing all cost-saving opportunities to offset the higher performance practices. A fully implemented IDP will make clear the interrelated

systems in the house, the tradeoffs that can take place, and help to rally the team toward the goal. In establishing an IDP, it is critical for builders to have a set of overall performance criteria or a specific performance metric for the team to achieve, such as meeting ENERGY STAR® requirements, participating in DOE's Builders Challenge, or using the EEBA Criteria or other criteria from the green building program of your choice. Meeting these requirements will be much easier when the entire team has a voice in the initial design. The team can agree on decisions that significantly impact performance (like number of windows, orientation, thermal enclosure options, mechanical system routing, and structure) that are balanced with aesthetic goals and cost constraints. The IDP gives the team the opportunity to understand and work through the interrelated components of the home, such as the floor space vs. mechanical system vs. thermal enclosure vs. size of the windows.

IDP is a forward-looking process and not the time to assign blame for things in the past. The focus must be on working collaboratively to achieve the project goals. Everyone at the table must be open, honest, and able to accept responsibility for their actions and develop proactive solutions.

Below is a flow chart of a generic integrated design process and all of the parties involved. For more information, see FAQ C.2.


Product Design Process
MKTG + ARCH FLOW
ARCHITECTURE FLOW
MARKETING FLOW
PURCHASING FLOW
CONSTRUCTION FLOW
TRADE OR CONSULTANT FLOW
Marketing determines need for new or refined product
Consumer Focus Group on Designs at closeout of product Line
Architecture creates construction program - structure, mechanicals, etc.
Develop program for house - size, square footage, style
Architecture begins schematic design
NO
Spatial layout and massing
Schematic HVAC + Input from all trades / vendors
Diagrammatic Structural
Preliminary Energy evaluation
Architecture finalizes schematic design
Design is tested focus group or internally
Design is evaluated for constructability
Design is reviewed for cost
Trade Evaluation and Feedback
Design is evaluated relative to program
Design Approved
Yes
Architecture begins design development
determine exact dimensions, materials, and code compliance
HVAC layout
Refine Structural
Energy evaluation
Architecture finalizes Design Development
Design is tested focus group or internally
Design is evaluated for constructability
Design is reviewed for cost
Trade Evaluation and Feedback
Design is evaluated relative to program
Design Approved
NO
Yes
Architecture begins Construction Documentation
10% CD Set
Final Energy Modeling, Structural & Duct Integration
50% CD Set
Final HVAC Design
95% CD Set
Review set, verify documentation
Complete CD Set

C.2. Team Roles for Integrated Design

Question: Who should be involved in the product design process when implementing a high performance home strategy?

QEHS Section Reference

5.1 Design Operations QEHS Policies and Procedures

5.1.1 Scope of the Design Operations

The Design operation shall define the scope of its Design operations.

5.1.2 Process Flow

The company shall define and document a sequence or sequences of activities (process flow) for the Design operation of the company. This sequence shall include all major planning, trades' Design phases, and interactions with other departments during design and QEHS assurance activities. The sequence can be in list form or any other clear, logical sequence. It is recommended that flowcharts are used where possible.

5.3.3 Trade Partner QEHS Program Support

The Design operations QEHS Management System shall support the QEHS, programs of trades and other materials and service providers. Communication shall be established between the Design QEHS representative of the company and the QEHS representatives of the trades to support the QEHS initiatives of each other. Feedback shall be periodically provided to the trade to enable the trade to improve the QEHS and safety of its work. Feedback shall be periodically solicited from the trade in order for the company to improve the QEHS and safety of its work.

Recommendations

Recommended scope of the Design operations:

- Use an integrated design approach involving a team from marketing, sales, design, purchasing, construction, customer relations and key trades. Review each plan with the team at schematic design and design development stages, as well as prior to issuing final construction drawings, to gain feedback on potential defects and errors and to design a customer-oriented home built efficiently and effectively.
- Provide the construction department and trades with accurate plans and details.
- Provide the sales department with accurate plans for the homebuyer.
- Each time a new home plan is first built, conduct a walkthrough of this "pilot"' home with the team to gather detailed feedback on how to improve the plan and construction based on their experiences.

Commentary

When implementing a high performance home strategy, design can play a powerful role in helping to achieve the company standard (see FAQ B.1) cost effectively. Key energy efficiency strategies like integrating the HVAC system with the structural system, bringing the HVAC system inside the conditioned space, and optimizing glass-to-floor area ratios are all within the realm of the design group. Unfortunately, this group rarely has the amount of information needed to make important decisions during the design phase, leading to marketable houses that frequently have sub-optimal solutions from the standpoint of energy efficiency or building performance. By bringing additional individuals to the table through an integrated design process (see FAQ C.1), the product can be developed to meet the overall high performance goals while still meeting all aesthetic and market criteria. Below are some of the additional parties to invite to the table during the design phase and what roles they might play.

HERS Rater

A rater can provide guiding parameters, so the design can hit specific energy targets, such as Builders Challenge, ENERGY STAR®, or local utility program targets. Items can include window-to-floor area ratios, insulation packages, window and mechanical equipment specification, and various design strategies (e.g. all ducts inside conditioned space). Many design teams feel that an energy analysis cannot be performed until it is "designed," but many rating tools can provide designers with guiding parameters to hit specific energy targets if they undertake a collaborative exchange of very early in the design process. With as little information as the intended floor area, aspect ratio of the house, number and height of stories, and the number of bedrooms, a rater can generate an energy model to evaluate the HERS Index and energy cost impacts of different window-to-floor area ratios, thermal enclosure elements, and different space conditioning system locations.

Customer Care

Builders should thoroughly examine and determine the root causes of historical failures and customer service issues. If these root causes are in the design of the building (e.g. roof intersections prone to leaks, room placement with difficult HVAC runs leading to comfort complaints), then they should be addressed during the design stage. If a design solution is not possible, then the team needs to make sure a robust technical solution is in place to eliminate the problem.

Voice of the Customer

Customer feedback from tools like surveys and focus groups (see FAQ E.6) should always inform the design team. This feedback should not just be on aesthetic issues but also on function and operational issues related to how customers actually live in their houses and what makes it easier or more difficult for them to enjoy the experience. Look at maintenance and other warranty call data that relates to difficulties occupants are experiencing with their home that do not pertain specifically to just defects. For instance, if a house has 10' ceilings, how practical is it for a homeowner to change the furnace filter in a ceiling-mounted grille?

Purchasing

The purchasing group receives direct feedback from trades on details that are difficult to execute or are high-priced features/strategies that may not add value for the customer. This group should be able to provide general costs for various strategies in the early stages of the design phase.

Trades

Trades can directly contribute to the design phase by providing input on constructability; costs; and new products, systems, and materials up for consideration. This information can be valuable in the earliest stages when the basic massing of a building is being decided, which inherently dictate the structural strategies and mechanical system layouts.

C.3. Design vs. Products: Understanding Product Performance with Respect to the Design

Question: What is the relationship between specific products and systems approaches when developing a high performance home strategy?

QEHS Section Reference

1.11 Performance Measures

The company shall establish performance measures and goals that are indicative of the effectiveness of the QEHS Management System. These shall be defined, documented, and quantified for each functional area covered by the company's QEHS Management System. Progress toward meeting these goals shall be documented and reported quarterly to the management of the various functional areas.

5.1.1 Scope of the Design Operations

The Design operation shall define the scope of its Design operations.

(The topic in section 5.1.4 and 5.1.8 is repeated in sections 3, 6, 7, 8 and 9 and adapted for those departments.)

5.1.4 Company Standards

Company standards shall be documented to define the requirements for workmanship, including tolerance requirements, industry standards, design procedures, and material specifications. These company standards shall be included in scopes of work or other agreed-upon document(s). When a conflict exists between local practice and other requirements (e.g. industry standards, manufacturer's instructions), there shall be a procedure for allowing exceptions while maintaining QEHS. All plans will be approved by an Engineer or equivalent for that city/state/region.

5.1.8 Approval and Selection of Trade Partners, Materials, and Other Support Services

Procedures shall be established and implemented for review, approval, selection, and monitoring of:

- 5.1.8.1 Trade Partners
- 5.1.8.2 Materials and Suppliers
- 5.1.8.3 Other Support Services

There shall be a procedure for adding and removing suppliers, trades, or support services firms from the builder's approved vendor list.

Recommendations

Develop a process where the specific properties of the materials and products being used are evaluated in the context of the overall system. Taking this step helps ensure that long-term risks are not introduced inadvertently.

Commentary

The development of a systems strategy to high performance homes must be evaluated at many scales - the whole house, the various systems and subsystems, and the products used.

Example: Cathedralized Attics as a System Strategy

Cathedralizing the attic is one strategy that brings the space conditioning system inside the conditioned space of the house. However, this seemingly simple decision requires examining and evaluating a host of product questions, as well as risks.

The first question to ask when considering a cathedralized attic is “How often does the roof leak due to installation failures?” Roofs frequently leak from installation failures and degradation to roofing materials over time. Roofing underlayment should be installed as a secondary drainage layer, but it is often mishandled. If the roof is a zero defect item, then the next question is “What is the longevity of the roofing material?” Is the longevity 25 years for the asphalt shingles or 100 years for concrete tile? The risks associated with cathedralizing a 100-year roof with no history of leaks are considerably lower than one with a 3% failure for a 25-year product.

With a 3% failure rate, the builder has a reasonable “early warning system.” With a conventionally insulated attic, the homeowner typically sees water staining the drywall ceiling under the roof system. If the builder switches to a cathedralized attic with closed-cell spray foam on the underside of the roof deck, leaks may not be identified for long periods of time, leading to repeated wetting of the roof sheathing, which can cause rot in the sheathing and possibly roof structure. The failure may not become apparent for five to ten years, and it is costly to repair. The question of liability also comes into play. While the roofer may be responsible for the actual leak, the fact that the builder chose spray foam (which prevented an early detection of the leak) would likely put more liability on the builder to make the repair.

This sequence of events does not mean closed-cell foam should not be used on the underside of the roof deck. It simply means that a builder must apply broader thinking when evaluating a system or product. In this case, if a 0% roof leak rate is achievable with a proven history, spray foam may be the best choice. Or other strategies may work equally well, depending on the climate and construction methods. Eliminating roof leaks should be the first order of business, so if it is impossible to achieve to a 0% failure rate, then evaluating other system strategies for bringing the space conditioning system inside the conditioned space may be more appropriate.

For more information specifically on unvented roof assemblies, see http://www.buildingscience.com/documents/reports/rr-0301-unvented-roof-summary-article.

MEASUREMENT AND VERIFICATION OF BUILDING PERFORMANCE

D.1. Performance Testing: Why Do It and What Does It Get You?

Question: When implementing a high performance home strategy, how can building performance testing and inspections be useful beyond just "getting the label"?

QEHS Section Reference

1.11 Performance Measures

The company shall establish performance measures and goals that are indicative of the effectiveness of the QEHS Management System. These shall be defined, documented, and quantified for each functional area covered by the company's QEHS Management System. Progress towards meeting these goals shall be documented and reported quarterly to the management of the various functional areas.

(The topic in section 7.1.3, 7.1.4, 7.1.5, and 7.3.1 is repeated in sections 3, 5, 6, 8, and 9 and should be adapted for those departments.)

7.1.3 Codes and Regulations

Procedures shall be implemented to ensure that all applicable codes and governmental regulations are identified and complied with. The company shall have access to all applicable codes.

7.1.4 Company Standards

Company standards shall be documented to define the requirements for workmanship, including tolerance requirements, industry standards, purchasing procedures, and material specifications. These company standards shall be included in scopes of work or other agreed-upon document(s).

7.1.5 Manufacturer's Product Installation Instructions

The purchasing operation shall develop, document, and implement procedures for obtaining and maintaining current copies of all installation/application instructions.

7.3.1 Corrective and Preventive Actions

The purchasing operation shall define and implement on-going actions to eliminate recurring QEHS issues. These documented actions shall include identification, prioritization, root-cause analysis, and development and implementation of an action plan. The effectiveness of these actions shall be evaluated. When identified issues have not been eliminated, the plan shall be reassessed and appropriate alternate actions initiated. Structured Plan-Do-Check-Act methodologies are recommended for the corrective and preventive actions, as are creating defined charters for improvement teams.

8.2 Construction Operations Inspections

8.2.1 General

Various inspections will be conducted by construction operations to ensure construction activities comply with codes, regulations, scopes of work, manufacturer's instructions, and company standards. Consistent with the builder's experience with each trade, the frequency and detail of these inspections shall be sufficient to ensure compliance. Construction operations will develop checklists and/or other documentation for recording the inspection results. The inspection criteria shall be consistent with the company standards and scopes of work. Items requiring corrections shall be recorded, corrected, and their status documented. The construction operation shall take steps to ensure that any item requiring correction is not covered up before the correction is completed and documented. The QEHS Management System shall document who, what, when, where, and why/how inspections are to be recorded for the inspection processes. The personnel conducting inspections will be trained in the inspection and documentation process.

8.2.2 Job Ready Inspection

The construction operations shall ensure the jobsite is prepared for the work of the next trade to begin via an inspection consistent with agreed-upon job ready requirements. If a trade is required to begin work when the job ready conditions are not met, the construction operations will ensure that the proper procedure is followed. Deviations from the job ready conditions shall be recorded on the job ready inspection record.

8.2.3 In-Process Inspections

Activities and work done in the construction operation shall have in-process inspections to ensure that the builder's QEHS policy and procedures are being followed. These inspections shall be documented. Items requiring correction shall be documented, corrected, and confirmed prior to the covering or concealment of any trade's completed work. The inspection criteria shall be consistent with the company standards and scopes of work.

8.2.4 Final Inspection

Each completed house shall have a final inspection. Any non-conformance(s) to the builder's documented standards for completed work shall be recorded. Corrections shall be completed and documented.

Recommendations

Once internal standards have been set, it is critical to verify that they are being met. In the same way that financial metrics are not tracked on a pass/fail basis, building performance test results can provide a wealth of information to evaluate individual trade performance and overall company performance related to certain building performance goals. Performance test results can also help the management team identify opportunities for improvement, as well as when an advance in building performance standards may be possible.

Commentary

Many builders rely on their HERS rater to provide them with energy efficiency certification (e.g. ENERGY STAR®, Environments for Living, and green certifications); however, very few builders actually breakdown, report, and analyze the data that is collected for certifications. A typical HERS rating or performance path includes insulation and other thermal enclosure component inspections, building airtightness measurements, HVAC distribution system air tightness testing, and HVAC system commissioning. Some programs include other building performance and durability verifications, such as the proper installation of water management features and ventilation system performance. In many cases, this information is provided to the builder in a pass/fail format. But this data is incredibly rich, and if analyzed, can yield trends and opportunities for improvement, as well as provide the organization with the means to determine when to pursue the next level of performance.

In addition, this data can be used for root cause analysis when there are longer-term warranty requests. Many of these inspections or performance tests provide information not only on the energy efficiency of a house but also on the long-term durability and comfort issues. HVAC systems with airflows that barely pass may lead to occupant discomfort more readily than those that pass the criteria by a wide margin. Houses that required rework to pass may have a higher likelihood of long-term customer complaints. This information can help identify needs for training and enhancing trade skills or transferring best practices from one trade to another within a particular area (e.g. HVAC installation).

Some of these performance measurements can be leading indicators of other issues surrounding customer satisfaction, such as:

- Comfort
    - Air tightness and duct performance impact customer comfort (comfort and utility bills)
    - Insulation quality and levels impact customer satisfaction (comfort and utility bills)
    - HVAC basic measurements confirm airflow and system performance (comfort and utility bills)
- Building durability (long-term repair risk)
    - Verifying air tightness provides information on the movement of warm moist air through the building enclosure, which can cause mold, rot, or decay
    - Water intrusion testing verifies window/door installation (e.g. ASTM E110)
- Indoor air quality
    - Fresh air ventilation airflows

D.2. How Much Testing and Why?

Question: When implementing a high performance home strategy, how much performance testing should be undertaken and why?

QEHS Section Reference

1.11 Performance Measures

The company shall establish performance measures and goals that are indicative of the effectiveness of the QEHS Management System. These shall be defined, documented, and quantified for each functional area covered by the company's QEHS Management System. Progress toward meeting these goals shall be documented and reported quarterly to the management of the various functional areas.

(The topic in sections 7.1.3, 7.1.4, 7.1.5 and 7.3.1 is repeated in sections 3, 5, 6, 8, and 9 and should be adapted for those departments.)

7.1.3 Codes and Regulations

Procedures shall be implemented to ensure that all applicable codes and governmental regulations are identified and complied with. The company shall have access to all applicable codes.

7.1.4 Company Standards

Company standards shall be documented to define the requirements for workmanship, including tolerance requirements, industry standards, purchasing procedures, and material specifications. These company standards shall be included in scopes of work or other agreed-upon document(s).

7.1.5 Manufacturer's Product Installation Instructions

The purchasing operation shall develop, document, and implement procedures for obtaining and maintaining current copies of all installation/application instructions.

7.3.1 Corrective and Preventive Actions

The purchasing operation shall define and implement on-going actions to eliminate recurring QEHS issues. These documented actions shall include identification, prioritization, root-cause analysis, and development and implementation of an action plan. The effectiveness of these actions shall be evaluated. When identified issues have not been eliminated, the plan shall be reassessed and appropriate alternate actions initiated. Structured Plan-Do-Check-Act methodologies are recommended for the corrective and preventive actions, as are creating defined charters for improvement teams.

8.2 Construction Operations Inspections

8.2.1 General

Various inspections will be conducted by construction operations to ensure construction activities comply with codes, regulations, scopes of work, manufacturer's instructions, and company standards. Consistent with the builder's experience with each trade, the frequency and detail of these inspections shall be

sufficient to ensure compliance. Construction operations will develop checklists and/or other documentation for recording the inspection results. The inspection criteria shall be consistent with the company standards and scopes of work. Items requiring corrections shall be recorded, corrected, and their status documented. The construction operation shall take steps to ensure that any item requiring correction is not covered up before the correction is completed and documented. The QEHS Management System shall document the inspection process, including who performs the inspection; what is inspected; when and where it is inspected; and the process for recording and storing inspection documentation. The personnel conducting inspections will be trained in the inspection and documentation process.

8.2.2 Job Ready Inspection

The construction operations shall ensure the jobsite is prepared for the work of the next trade to begin via an inspection consistent with agreed-upon job ready requirements. If a trade is required to begin work when the job ready conditions are not met, the construction operations will ensure that the proper procedure is followed. Deviations from the job ready conditions shall be recorded on the job ready inspection record.

8.2.3 In-Process Inspections

Activities and work done in the construction operation shall have in-process inspections to ensure that the builder's QEHS policy and procedures are being followed. These inspections shall be documented. Items requiring correction shall be documented, corrected, and confirmed prior to the covering or concealment of any trade's completed work. The inspection criteria shall be consistent with the company standards and scopes of work.

8.2.4 Final Inspection

Each completed house shall have a final inspection. Any non-conformance(s) to the builder's documented standards for completed work shall be recorded. Corrections shall be completed and documented.

Recommendations

"You can expect what you inspect" – Dr. W. Edwards Deming

For higher performance homes, everything needs to work right and work together in order to perform properly and meet the customer's expectations. There are two schools of thought regarding performance testing. One school of thought is to test 100% of houses built to verify that every house has met the internal standards set by the builder (see FAQ B.1) or certification program requirements. Another is to undertake a sampling protocol after a certain number of 100% inspections, usually one house in seven (~15%) for a production builder. Third-party quality control (QC) provides can offer a valuable service by helping to ensure that performance goals for houses are met, but the construction operations must not rely solely on these programs. They should be regarded as serving a supportive role alongside regular and ongoing internal QA/QC protocols.

Commentary

While 100% performance testing is a cost of building homes, it is also a valuable data set and potential way to reduce risk and protect against litigation. Below is a discussion of the pros and cons of 100% testing in relation to random sampling.

100% Testing: Pros

- The builder is assured that every house meets internal standards and certification program requirements and can promote that fact to the customer.
- If the customer ever questions the performance of the house (e.g. high utility bills or a comfort complaint), the builder has the data to substantiate claims that the house meets the standards.
- If multiple trades use any single scope of work, it is easier to identify variations between the companies and design and implement actions plans to correct any issues.
- In certain cases, the testing can be integrated as part of the trade's scope of work as an inspection "test out" documented on the job complete checklist (e.g. duct tightness).
- Builders and trades may find that having internal HERS raters conduct testing is a cost effective way to achieve 100% inspections. While 15%of homes may need a third party rating for certain certification programs, internalizing HERS ratings (or at least the testing) can give immediate feedback on construction issues.
- This type of testing provides a complete data set of house performance attributes, enabling builders to analyze between trades, communities, site supervisor, crew leader, and model type, etc.

100% Testing: Cons

- The testing may add to the costs on the construction budget (however, this con needs to be weighed in light of potential liability for random sampling in the event of a customer complaint on a house that was not tested).
- The testing may add time to the schedule.

Sampling after a period of 100% Testing: Pros

- Sampling reduces the cost of testing (however, this pro needs to be weighed in light of potential liability for random sampling in the event of a customer complaint on a house that was not tested).
- If only one trade is performing the work, there may be less of a need to verify the installed performance (provided that the trade has a reasonable quality control and assurance program.

Sampling after a period of 100% Testing: Cons

- Sampling may not detect variations from crew-to-crew or among multiple trades following the same scope of work, risking undetected, intermittent non-compliance.
- The builder may have harder time explaining to customers why their house was not specifically tested.

It is important to recognize that all testing is not simply to “get the label.” It can also verify other performance attributes of the house, such as water intrusion or comfort. Testing may be localized (e.g. one or two windows for water intrusion) or conducted frequently when working on process improvement (e.g. 100% testing when trying to get air leakage numbers down). Over time, the number of inspections may decrease as the results grow more consistent; however, decreasing the amount of testing should correspond with the consistency of the workforce. Once new people come onboard (e.g. new trade, new trade crew, new trade crew lead, or new site supervisor), the amount of testing may need to occur more frequently to verify that new workers are trained properly and performing the work according to company standards.

D.3. Types of Testing

Question: What types of tests can be done on a home, and what do they mean?

QEHS Section Reference

1.11 Performance Measures

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8.2.4 Final Inspection

Each completed house shall have a final inspection. Any non-conformance(s) to the builder's documented standards for completed work shall be recorded. Corrections shall be completed and documented.

Recommendations

Document the tests that are needed to verify the high performance home strategy being established. Use the results from these tests to analyze trends and identify opportunities for improvement.

Commentary

Below is a list of common performance tests and what they mean.

Test	What it means
HVAC blower running, static pressure between air handler cabinet and filter	Test only when using the supply side fresh air intake located between the filter and the air handler. It allows an estimate of the outside air flow through the outside air duct. http://www.buildingscience.com/documents/reports/rr-0413-the-snapshot-a-quick-description
HVAC blower running, supply	It allows for a comparison between the design and as-built static

and return plenum static pressures	pressure. Can help verify if duct installation is close to what was designed.
Ventilation system airflows	It allows for a comparison between the design and as-built ventilation airflows.
Baseline house stack pressure (with blower door installed and covered)	It determines the pressure difference between the inside of the house and the outside of the house at the moment of testing (this is a baseline measurement for dominant duct leakage and house tightness).
Dominant duct leakage (with blower door installed and HVAC fan operating)	It shows if the duct leakage to the outside predominantly on the supply side, the return side, or relatively balanced. This test does not provide the magnitude of the leakage, only a likelihood of where it is.
Master Bedroom Door Closure Effect (HVAC fan operating, door closed to master bedroom)	It tests the change in pressure from the baseline due to the master door being closed. It gives a relative indication of how much HVAC induced air leakage (exfiltration or infiltration) is occurring from the master bedroom area.
All Doors to Isolated Rooms Closed Effect (HVAC fan operating, door closed to all bedrooms and other rooms with doors)	It tests the change in pressure from the baseline due to all of the doors being closed. It gives a relative indication of how much HVAC induced air leakage (exfiltration or infiltration) is occurring from all closed, isolated rooms.
Pressure with respect to main space in each room with a door that can be isolated from the main space (HVAC fan operating)	It measures the relative supply and return airflow for each room. The pressure difference between the room and main body of the house should not be more than 3 pascals.
Blower door test (cfm 50)	This test is a direct measure of a house's air tightness. It is typically converted to ACH50 (air changes per house at 50 pascals, or cfm50/sq. ft. of shell area). See http://www.buildingenergysolutions.com/pdfs/bdtest.pdf.
HVAC system tightness (total leakage)	It measures the total amount of air leaking from the HVAC system (equipment and ducts) at 25 pascals. The test gives an indication of how much air is actually getting delivered to the intended locations as opposed to unintended locations (e.g. interstitial cavities, outside the conditioned space).
HVAC system air leakage to outside	It measures how much of the air leakage in an HVAC system is going outside, as opposed to staying within the conditioned space.
Room airflows (supply and return)	It allows a comparison between the design airflows and as-built conditions. This test can help to predict or diagnose comfort complaints (too hot or too cold rooms).

HVAC Oversizing (runtime method)	It compares the runtime of equipment to the inside / outside temperature difference to establish if the HVAC equipment is oversized
Water intrusion testing (ASTME110)	It allows for an evaluation of the effectiveness of a window or door installation with respect to water intrusion. The test involves spraying water at a specific rate on the exterior of the building assembly while depressurizing the enclosure to a specific test pressure with a blower door or calibrated fan to simulate a wind-driven rain event.
Worst case scenario	It tests the house while all of the fan and air handling systems are running to determine the potential for depressurization and backdrafting of combustion appliances. This test is unnecessary if only sealed combustion appliances are installed within the conditioned space.
Exhaust fan flow	This test ensures that exhaust fan ducts are installed correctly and working properly.

D.4. Compensation Metrics and Building Performance

Question: Is there a way to use data collected from the high performance homes built to tie into compensation incentives for employees?

QEHS Section Reference

1.11 Performance Measures

The company shall establish performance measures and goals that are indicative of the effectiveness of the QEHS Management System. These shall be defined, documented, and quantified for each functional area covered by the company's QEHS Management System. Progress toward meeting these goals shall be documented and reported quarterly to the management of the various functional areas.

Recommendations

Make the measured results of the houses part of companywide or individually-based incentive compensation (bonuses) to help instill high performance as a core part of the company's mission, vision, and values.

Commentary

Historically, a site supervisor's performance has been linked to measures that relate to the number of houses under construction (or closed), cycle time, and customer satisfaction. While these measures drive efficiency and focus on the customer, they may work at odds with achieving higher performance homes, especially when a company is embarking on the implementation of ENERGY STAR® or similar programs.

Another method companies use is to link bonus pay purely to customer satisfaction, sometimes providing incentives to all employees based on achieving certain scores. While building high performance homes can naturally boost these scores, they are also a direct measure of the quality, durability, and energy efficiency of a house, elements that are linked to customer satisfaction. It may be beneficial to include key indicators that are routinely measured to validate energy performance as a component of the individual or companywide compensation incentive program.

D.5. Having the Right Measures to Evaluate your High Performance Strategy

Question: What metrics should be used during various phases of implementation of high performance homes in a building company?

QEHS Section Reference

1.11 Performance Measures

The company shall establish performance measures and goals that are indicative of the effectiveness of the QEHS Management System. These shall be defined, documented, and quantified for each functional area covered by the company's QEHS Management System. Progress toward meeting these goals shall be documented and reported quarterly to the management of the various functional areas.

(The topic in section 8.2.1, 8.2.2, 8.2.3, and 8.2.4 regarding continual improvement (preventive actions and training) are repeated in sections 3, 4, 5, 6, 7, and 9 and adapted for those departments)

8.2.1 General

Various inspections will be conducted by construction operations to ensure construction activities comply with codes, regulations, scopes of work, manufacturer's instructions, and company standards. Consistent with the builder's experience with each trade, the frequency and detail of these inspections shall be sufficient to ensure compliance. Construction operations will develop checklists and/or other documentation for recording the inspection results. The inspection criteria shall be consistent with the company standards and scopes of work. Items requiring corrections shall be recorded, corrected, and their status documented. The construction operation shall take steps to ensure that any item requiring correction is not covered up before the correction is completed and documented. The QEHS Management System shall document the inspection process, including who performs the inspection; what is inspected; when and where it is inspected; and the process for recording and storing inspection documentation. The personnel conducting inspections will be trained in the inspection and documentation process.

8.2.2 Job Ready Inspection

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8.2.3 In-Process Inspections

Activities and work done in the construction operation shall have in-process inspections to ensure that the builder's QEHS policy and procedures are being followed. These inspections shall be documented. Items requiring correction shall be documented, corrected, and confirmed prior to the covering or concealment

of any trade's completed work. The inspection criteria shall be consistent with the company standards and scopes of work.

(Note: If an NHQ certified trade provides the builder with a copy of its inspection reports, this will satisfy this requirement for work of that trade, provided the builder maintains a copy of this inspection document and periodically verifies the accuracy of the trade's inspection.)

8.2.4 Final Inspection

Each completed house shall have a final inspection. Any non-conformance(s) to the builder's documented standards for completed work shall be recorded. Corrections shall be completed and documented.

Recommendations

Metrics are typically used to gauge the general financial and operational health of a company. General metrics (such as those recommended by the Shinn group) help builders evaluate if things are "on track" and can alert management if action needs to be taken.

When implementing a high performance strategy, it can be helpful to collect and analyze various key metrics related to achieving the strategy. Different metrics are used at different times and are can be grouped by the phase of integration within the organization: adoption, sustained implementation, and improvement.

Commentary

The Shinn Group recommends the following minimum metrics for an operational and financial dashboard for a company.

Accounting / Financial Metrics

INCOME STATEMENT	Calculation
Cost of sales	Cost of sales / sales
Gross profit	Gross profit / sales
Indirect construction	Cost Indirect cost / sales
Financing expenses	Financing / sales
Sales & marketing expenses	Sales & marketing / sales
General & administrative exp.	General & administrative / sales
Total operating expenses	Operating expenses / sales
Owner's compensation	Owner's compensation / sales
Net profit	Net profit / sales
BALANCE SHEET	
Current ratio	Current assets / current liab.
Debt to equity	Total liabilities / owner's equity
Receivable days	365 / (Sales / avg. accounts rec.)
Payable days	365 / (Purchases / avg. accts payable)

Sales	Traffic at communities Conversion of traffic to sales Sales contract cancellations Sales per community Sales per plan type
Inventory	Raw land Finished lots Unsold under construction Unsold completed houses
Production Operations	(Track deviations from accepted or target rather than actual) Cycle time (average lost days from schedule) Cost (percentage of actual to budget) Supervisor efficiency (houses per supervisor)
Warranty	Average aging of outstanding items Group requests by "type"
Customer Satisfaction	Willingness to refer

When it comes to home performance, there are a number of possible metrics to track, all of which can be used for different purposes. These metrics can be broken down by phase of implementation in the high performance strategy: adoption, sustained implementation, and improvement, which are described below.

- Adoption: This phase is the initial transition to a comprehensive, systems approach (e.g. Builders Challenge, ENERGY STAR® version 3, Environments for Living). This period may last from three months to a year, depending on the volume of production, sophistication of trades, level of internal and external team training provided, feedback mechanisms, resources and materials available to support the transition, and company culture.
- Sustained Implementation: This phase is the time period that follows adoption where the desired strategy is being executed consistently.
- Improvement: This phase is where opportunities for improvement are identified and teams are formed to capitalize on these opportunities and develop a plan to implement solutions. This plan is the basis for the activities to take place in the adoption phase.

Different departments may be in different phases at the same time. For example, the company as a whole may be at the sustained implementation level of executing a high performance home strategy with existing plan types that have not been developed using an integrated design process. At the same time, the design group may be in the adoption phase as they create and refine a new set of plans using the integrated design process for the first time. Simultaneously, the sales staff may be in the improvement phase, working on the next generation of strategies to market and sell the high performance features of the builder's product.

The following is a list of possible metrics that can be used in the adoption, sustained implementation, and improvement phases, and their importance.

Adoption Phase

Metric	Importance
HERS Index	Aggregate numeric indicator of whole house energy efficiency; allows quick understanding of how close product is getting to energy efficiency goal
Building Air Tightness	Specific measure of a key attribute that impacts comfort and durability in a home; an attribute that is "invisible".
HAVC System Tightness	A specific measure of how much air is escaping from the HVAC system that was intended for delivery to a specific space.
Percentage Re-Inspect to Pass Thermal Enclosure Checklists	This checklist verifies that insulation systems have been installed properly and other thermal enclosure components are being installed as required by ENERGY STAR; if re-inspection is needed to pass this checklist, it is an indication that trades and site supervisors are not fully versed in the proper installation methods and strategies needed to build a higher performance enclosure.
Percentage Re-Inspect to Pass Rater HVAC Checklists	This checklist verifies that the HVAC system has been installed properly by the HVAC trade and that key aspects were verified by the HRES Rater; if the rater needs to re-inspect to pass this checklist, it is an indication that HVAC trade and site supervisors are not fully versed in the proper installation methods and strategies needed to design and install a high performance HVAC system.
Percentage Re-Inspect to Pass Rater Water Management Checklists	This checklist verifies that the water management system has been installed properly as verified by the HERS Rater; if the rater needs to re-inspect to pass this checklist, it is an indication that trades and site supervisors are not fully versed in the proper installation methods and strategies needed to achieve acceptable water management strategies for higher performance houses.
Costs by Department	Implementing a high performance home strategy involves all aspects of the building company's people, departments, outside trades, and suppliers; ultimately, the decision to move to higher performance homes should provide financial benefits to the company. Some costs may increase, but others should decrease. Cost increases should be expected for construction documentation, construction, and inspections. Cost decreases should be expected with the first-year warranty, long-term defect repair, customer satisfaction, and positive referrals. Setting up cost tracking systems early (if they do not already exist as part of the operational dashboard) can help evaluate the effectiveness of adopting a high performance approach and provide ongoing data for making operational decisions.
Cycle Time	During the adoption phase, cycle time will likely deviate, as new systems and techniques are being learned and consistently applied. Additional inspection by the HERS Rater may also add time to the schedule. This data can be used in the following two phases to look for improvement opportunities.

Sustained Implementation Phase

Metric	Importance
HERS Index	Aggregate numeric indicator of whole house energy efficiency; allows quick understanding of how close product is getting to energy efficiency goal.
Building Air Tightness	Specific measure of a key attribute that impacts comfort and durability in a home; an attribute that is “invisible”.
HAVC System Tightness	A specific measure of how much air is escaping from the HVAC system that was intended for delivery to a specific space.
Warranty Items by High Performance Strategy Area	Warranty items related to water intrusion and comfort should be reduced. Tracking these items will verify that the high performance strategy is working and may lead to price renegotiations with key trades if their warranty work has decreased significantly. These measures may also be correlated to customer satisfaction scores.
Thermal Enclosure Checklist Failure Items	Track the specific items that fail at the first inspection by the HERS Rater. These items are an indicator of improvement opportunities to undertake in the improvement phase. Once in sustained implementation, these failures will likely be the result of a change in trades or new crews who are unfamiliar with the specific construction methods needed to achieve the high performance strategy.
Rater HVAC Checklists Failure Items	Track the specific items that fail at the first inspection by the HERS Rater. These items are an indicator of improvement opportunities to undertake in the improvement phase. Once in sustained implementation, these failures will likely be the result of a change in trades or new crews who are unfamiliar with the specific construction methods needed to achieve the high performance strategy.
Rater HVAC Checklists Failure Items	Track the specific items that fail at the first inspection by the HERS Rater. These items are an indicator of improvement opportunities to undertake in the improvement phase. Once in sustained implementation, these failures will likely be the result of a change in trades or new crews who are unfamiliar with the specific construction methods needed to achieve the high performance strategy.
Costs by Department	Evaluate the metrics that were tracked from adoption, and evaluate them for opportunities for improvement. Are there system tradeoffs that should be more aggressively pursued? Are the cost reductions in areas being achieved? The full impact of some issues may take several years to become apparent (e.g. the elimination of historical systemic water management failures that may only appear 3–5 years after closing).
Cycle Time	Use the days deviating from the schedule to see if systemic issues are arising with specific high performance systems implementation. These areas could be the focus for additional training or discussing staffing with trades.

Metrics for the Improvement Phase

At a very high level, the following general metrics can be used as part of an improvement phase.

Metric	Importance
HERS Index	Aggregate numeric indicator of whole house energy efficiency; allows quick understanding of how close product is getting to energy efficiency goal.
Building Air Tightness	Specific measure of a key attribute that impacts comfort and durability in a home; an attribute that is “invisible”.
HAVC System Tightness	A specific measure of how much air is escaping from the HVAC system that was intended for delivery to a specific space.
Costs by Department	Use costs as benchmarks for improvements. Based on the specific improvement measures, the costs implications should be understood, both to form a historical standpoint and to set targets for the improvement activity. It may be that costs in one area may need to rise in order to achieve a net overall reduction in costs across several areas.
Cycle Time	Evaluate any changes in the system strategies with trades to see the impact on cycle time. Changes may require re-evaluating sequencing or staff level s on crews to meet cycle time targets.

A discussion of using metrics for the improvement phase can be found in FAQ H.1 and H.2.

BETTER COMMUNICATION PRACTICES AND SYSTEMS

E.1. Company Meetings

Question: How can the high performance home strategy be integrated in regular meetings held by the company?

QEHS Section Reference

1.9 Corporate Communications

Procedures shall be implemented to ensure that communication exists between all areas of the company and the trade partners of the company. This includes identification of and communication to other functional areas to address recurring non-conformances in QEHS. There shall be procedures implemented to communicate with new home buying customers and to manage their expectations.

2.3 Annual Management Review

At least annually, the QEHS management committee shall review the operation and effectiveness of its respective systems with the senior management of the company. This annual review shall include a summary of the internal and external audits of the activities of each functional area of the company, performance measures, customer feedback, trade and supplier feedback, complaints, and recommendations from the QEHS department representatives. The annual review shall also include ensuring compliance with these requirements, setting new annual goals, and addressing needed changes to the management system. Records shall be maintained for each review. The records shall be in sufficient detail to disclose the participants, significant issues, conclusions, recommendations, and planned changes. The aim is to ensure that the QEHS Management System is working to the satisfaction of the leadership and management of the organization. The annual review is an opportunity to make significant changes to the QEHS Management System and make sure it is functioning effectively and efficiently.

8.3.3 Trade Partner QEHS Assurance Program Support

The construction operations QEHS Management System shall support the QEHS, environmental, and safety programs of trades and other material and service providers. Communication shall be established between the construction QEHS representative of the company and the QEHS representatives of the trades to support the QEHS initiatives of each other. Feedback shall be periodically provided to the trade to enable the trade to improve the QEHS and safety of its work. Feedback shall be periodically solicited from the trade in order for the company to improve the QEHS and safety of the company's work.

1. Training will be provided to all trades on basic quality principles, tools, and techniques.
2. The builder will conduct each month regular meetings with the trades to discuss QEHS, schedules, and opportunities for improvement (OFIs).

3. The builder will develop a Trade Council to improve communication with the trade base and ensure that the builder focuses on how to improve the daily life of the trade. This will therefore allow the builder to focus on OFIs that it needs to implement in its own business and practices.

Recommendations

Continual communication is a key factor in the successful execution of any strategy within an organization. Regular meetings can help to both chart the progress toward the strategic objective and identify barriers and opportunities for improvement. It is important to include key metrics that relate to the execution of the high performance home strategy (see FAQ D.5) in the meetings as appropriate. Do not duplicate work or efforts.

Commentary

Effective meetings are a crucial part of a well-functioning communication process in an organization. Common types of meetings where the high performance home strategy can be integrated include the following.

Annual leadership strategic planning
This meeting can include a review of the past building performance strategy, the goal targets for future improvements, and the contribution to other success metrics in the company.

Annual or quarterly all-company meetings
These meetings provide an opportunity for the leadership team to communicate the high performance strategy, the successes and challenges in implementation, and the impact it is having within the company. Taking this step reinforces the strategy as a key cultural foundation for the company.

Semi- annual trade partner meetings
These meetings provide an opportunity to review trend data on the implementation of the high performance strategy, identify opportunities for improvement in a blame-free environment (see FAQ F.2), review completed improvement team activities, and communicate new directions in the high performance home strategy. If possible, having the trades own the meeting by forming a Trade Council (see FAQ E.5) can help create a more collaborative environment as opposed to the builder “calling in the trades.”

Regular meetings with key trades
Based on production volume, it may be advantageous to met on a regular basis with key groups of trades (e.g. site prep to foundation, framing to rough mechanicals, insulation to paint, finishes to house completion) to help build relationships, identify opportunities for improvement, and create solutions. The successes and challenges associated with the implementation of the high performance home strategy can be a part of the agenda of these meetings and form a key part of the company’s quality standards (see FAQ B.1).

Weekly departmental and management team meetings
The company goals and key metrics for high performance homes (see FAQ D.5) should be reviewed to help reinforce the strategy within the company culture (see FAQ A.1) and to communicate interdepartmental changes and procedures as they relate to the strategy. These meetings should not be a

laundry list of updates; rather, they should focus on relevant actions for achieving key strategic objectives for the company.

General meeting best practices

Weekly meetings communicate fast, ongoing changes. Department meetings can be conducted on a weekly basis to keep track of key metrics so changes are as proactive as possible and reactive approaches are as fast as possible. These meetings are perhaps in danger of growing boring or routine, but they should actually be high pressure. With just a week to prepare and achieve assigned work, attendees should be very focused. These meetings are the closest to daily operational activities and the key way for departments to implement strategy and tactics and to see an impact.

Monthly meetings are conducted for those issues that need close, ongoing observation or have a short timeframe for implementation of solutions. Monthly meetings are used for improvement teams to ensure that work continues with a sense of purpose and to keep the cycle of sharing information, establishing deadlines, and achieving work on track. Meetings with trade groups can also be conducted on a monthly cycle, perhaps having two to three trade groups meeting on the same agreed day the first week of each month, with other groups meeting during the other weeks. As a result, the entire trade base will have met each month, one key method for quickly communicating, training, and rolling out changes in materials, specifications, scopes of work, and installation methods. For example, during the first month, the builder alerts trades about changes and asks for input; during the second month, the builder shares the specifications and new scopes of work; the third month is used to conduct training and the fourth month to implement changes. During each month, the trade representative communicates the information and specifications to their company, coordinates training, and prepares for the launch date. In this manner, any changes can be communicated, scheduled, trained, and implemented in a quarter.

An example of a bi-annual meeting could be a Trade Council. These meetings are held on a regular basis but are not needed every week or month. They are held to ensure that past goals and assignments have been achieved and to elicit the next goals from the group. A bi-annual basis provides a long enough period of time to gather and analyze trend data to evaluate the success of the previous work of the team. Like the annual meeting, the bi-annual is a critical event, since the parties will not be together again for another six months; so, it is vital that the meeting be well-organized, attended, coordinated, and facilitated. It is also vital that those attending be well-prepared, coming to the meeting with the proper information and decisions made in order for the meeting to be effective.

Annual meetings are used for significant events like strategic planning that may take an entire day (or up to three days) to conduct and in many cases are held offsite to make sure there are no distractions. These meetings need strong agendas built around a very focused goal for the event. The day (or days) is broken up into distinctly defined segments to compile a self-assessment of the organization and its environment, creating a list of Strengths, Weaknesses, Opportunities, and Threats (SWOT). The list can then be used to identify how the strengths and opportunities can be best taken advantage of and how the weaknesses and threats can be minimized and leveraged.

The Annual Strategic Planning Meeting takes the most advantage of staging various levels of meetings to gather information beforehand. It also takes advantage of the opportunity to communicate the results, ensuring that the strategic plan is accurate, understood, deployed, and implemented effectively at every level of the organization. Therefore, its information is shared at department meetings and specific team meetings formed perhaps specifically to address an aspect of the strategic plan.

E.2. Scopes of Work

Question: How much information should be in a scope of work to communicate a high performance home strategy?

QEHS Section Reference

(The topic in Section 5.16 regarding trade partners, supplier contract documents and Scopes of Work is repeated in sections 3, 6, 7, 8 and 9 and adapted for those departments)

5.1.6 Trade Partner and Supplier Contract Documents and Scopes of Work

Procedures shall be implemented to prepare and review the subcontracts and Design documents specific to the work of each trade utilized by the Design operation to ensure that builder requirements and typical homebuyer expectations will be met. Trade contracts, scopes of work, or other documents shall include mutually agreed-upon job ready conditions and procedures to follow when these conditions are not met.

9.1.3.2 Individual Trade's Performance Standards

Scopes of work or construction documents for trades providing warranty service shall define the warranty service performance requirements expected of the trades.

Recommendations

Having detailed scopes of work for implementing the high performance home strategy is critical. Scopes of work create clarity as to who is doing what work, how the work is performed, conditions for starting and completing work, and means and methods of construction. Resources for scopes of work for high performance homes can be found here:

- IBACOS High Performance Scopes of Work: http://www.ibacos.com/resources/publication (to be used alongside Linda Haas Davenport's "Scope of Work Program")
- NAHB Research Center Scopes of Work: http://www.toolbase.org/ToolbaseResources/level3.aspx?BucketID=5&CategoryID=62
- BuildIQ Toolbelt: http://toolbelt.buildiq.com/
- Atlanta Homebuilders Association Trade Partnering Guide

Commentary

Scopes of work are a vital component of the homebuilding process. They are an integral connection between construction drawings, details, material specifications, and trade contracts. The scopes of work communicate accurate and agreed-upon methods of construction, performance standards for work, and warranty responsibilities, and they can be used as a basis for documenting improvement activities.

The scopes of work should not be developed by the builder in isolation. A cross-functional team representing design and purchasing, home construction, and customer care should work closely with suppliers and trades to create scopes of work that communicate the key information needed to price the

work and execute it in the field in the agreed-upon manner. Working collaboratively ensures that the trades and suppliers (as experts in their areas) have an opportunity to incorporate the most up-to-date best practices to achieve the builder's performance standards (see FAQ B.1). Working together in this manner also makes sure the trades and the builder agree on the exact work requirements, training needs, process issues, acceptable materials, and installation sequencing and methods. It also identifies the working relationships between the various trade groups and between each individual trade and the builder. By using this approach, multiple departments and trade groups have a vested interest in each scope of work.

This level of detail and buy-in is critical to implementing a high performance strategy, because each component and sub-system must perform its intended function to enable the entire house to perform as designed. A failure by one trade to properly execute the work can result in the failure of another trade. For instance, if the insulation and air sealing trades fail, the house may not provide the occupant's desired level of comfort, which may be perceived as a problem with the HVAC system.

Scopes of work need to be used onsite as key reference documents kept by the trades and builder's staff in trucks and site offices. The scopes of work should be used as regular onsite verification tools and meeting reference materials. If the central source of information is the scopes of work, miscommunications and misunderstandings can be avoided. These documents communicate and enforce a single method of construction in order to ensure consistency from house-to-house and community-to-community, as well as across multiple trades performing similar work. Scopes of work are common basis of understanding that both the builder and trade have agreed-upon, helping to avoid conflicts onsite. They are living documents that should be updated as better methods, processes, and materials are discovered. This improvement can take place through regular trade meetings or Trade Councils (see FAQ E.1 and E.5).

Scopes of work also provide legal protection. Contracts, drawings, specifications, and scopes of work all provide solid evidence of the builder designing and proposing to build a quality home. For a builder, this evidence is critical when a homeowner brings a problem to the forefront that was caused by a trade not completing the work correctly.

E.3. Construction Documentation for High Performance Homes

Question: How much construction documentation should be created when implementing a high performance home strategy?

QEHS Section Reference

(The topic in Section 5.1.1, 5.1.3 and 5.1.6 is repeated in sections 3, 6, 7, 8 and 9 and adapted for those departments.)

5.1.1 Scope of the Design Operations

The Design operation shall define the scope of its Design operations.

5.1.5 Manufacturer's Product Installation Instructions

The Design operation shall develop, document, and implement procedures for obtaining and maintaining current copies of all installation/application instructions. Design operations shall ensure that all products/components are properly drawn, specified, and detailed.

5.1.6 Trade Partner and Supplier Contract Documents and Scopes of Work

Procedures shall be implemented to prepare and review the subcontracts and Design documents specific to the work of each trade utilized by the Design operation to ensure that builder requirements and typical homebuyer expectations will be met. Trade contracts, scopes of work, or other documents shall include mutually agreed-upon job ready conditions and procedures to follow when these conditions are not met.

9.1.3.2 Individual Trade's Performance Standards

Scopes of work or construction documents for trades providing warranty service shall define the warranty service performance requirements expected of the trade.

Recommendations

Examples of documentation for high performance homes can be found in the following locations.

Construction documents:

- http://www.buildingscience.com/documents/primers/bsc-building-america-greensburg-plan-1-drawings/view?searchterm=greensburg
- http://www1.eere.energy.gov/buildings/challenge/pdfs/bcqc_version_1_3_060408.pdf
- http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/builders_challenge_quality_criteria.pdf

Scopes of work and pre and post-installation checklists:

- IBACOS High Performance Scopes of Work: http://www.ibacos.com/resources/publication (to be used alongside Linda Haas Davenport's "Scope of Work Program")

- NAHB Research Center Scopes of Work: http://www.toolbase.org/ToolbaseResources/level3.aspx?BucketID=5&CategoryID=62
- BuildIQ Toolbelt: http://toolbelt.buildiq.com/

Installation step-by-steps:

- BuildIQ Toolbelt: http://toolbelt.buildiq.com/, http://toolbelt.buildiq.com/media/16795/dpstandardwindowsbs.pdf

Commissioning checklists:

- BuildIQ Toolbelt: http://toolbelt.buildiq.com/, http://toolbelt.buildiq.com/media/16789/dpentrydoorchk.pdf
- http://www.buildingscience.com/documents/information-sheets/reports/rr-0413b-snapshot-form/view?topic=/doctypes/researchreport
- http://www.buildingscience.com/documents/reports/rr-0413-the-snapshot-a-quick-description
- http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/InspectionChecklists.pdf

Commentary

To effectively build high performance homes, it is critical to document the full intent of the design and methodologies to construct the home. Traditionally, the primary purpose of construction drawings and scopes of work was to obtain permits, secure pricing for trades, and provide a set of “guardrails on the road” of how to build the house. Trades were relied on for their expertise in executing their particular area of the work, and the builder provided the general framework and schedule to get the house completed.

This methodology works for code construction, but as the builder progresses toward a full systems integrated strategy for implementing high performance homes, the road must become narrower, the guardrails higher, and the map much more clearly defined. Everything in a high performance house is about attention to detail. To increase energy efficiency, the thermal enclosure must be well airsealed with higher levels of properly installed insulation. With lower energy flows through the enclosure, water management becomes critical—flashing, drainage planes, roofing, and site drainage—all elements must be correct to prevent the intrusion of bulk water. In addition to bulk water management, materials must be selected properly to control vapor diffusion and enable the building assemblies to dry. HVAC systems must be correctly designed, installed, and commissioned to ensure energy savings and occupant comfort. All of these steps require a higher level of documentation than is traditionally provided in the industry today. Plans must have accurate details. Complex assemblies must be clearly drawn (in isometric, if necessary) to eliminate “field decisions” whenever possible. The plans and scopes of work must be free of conflicting details and specifications.

A list of the minimum documentation to consider developing includes:

- Construction drawings
- Scopes of work

- Material specifications
- Installation step-by-steps
- Pre and post-installation checklists (Job ready, job complete)
- Commissioning checklists

This documentation is used in all aspects of the design, construction, and servicing of the house.

- Design and purchasing: Comprehensive documentation aids in understanding potential conflicts prior to construction and helps to communicate the high performance strategy embodied in the Builder's Standard to all parties in the integrated design process (see FAQ C.1). Documentation is critical in getting accurate pricing and setting expectations for the work.
- Home construction: This documentation is used in the field for day-to-day evaluations of the work, as a training tool for new employees (builder or trade), as a quality assurance mechanism, and as a means to capture recurring construction issues (see FAQ G.1).
- Customer care: This documentation describes what was actually built and can assist in evaluating customer warranty issues. In addition, some of this documentation may be useful in the builder's homeowner manual. Some aspects of these documents may even be included in the customer manual, particularly in the manufacturer's maintenance instructions and warranty information.

E.4. Step-by-Steps

Question: How can various specific means and methods of construction be communicated effectively when executing a high performance home strategy?

QEHS Section Reference

(The topic in Section 5.1.1, 5.1.3 and 5.1.6 is repeated in sections 3, 6, 7, 8 and 9 and adapted for those departments.)

5.1.1 Scope of Design and Operations

The Design operation shall define the scope of its Design operations.

5.1.5 Manufacturer's Product Installation Instructions

The Design operation shall develop, document, and implement procedures for obtaining and maintaining current copies of all installation/application instructions. Design operations shall ensure that all products/components are properly drawn, specified, and detailed.

5.1.6 Trade Partner and Supplier Contract Documents and Scopes of Work

Procedures shall be implemented to prepare and review the subcontracts and Design documents specific to the work of each trade utilized by the Design operation to ensure that builder requirements and typical homebuyer expectations will be met. Trade contracts, scopes of work, or other documents shall include mutually agreed-upon job ready conditions and procedures to follow when these conditions are not met.

9.1.3.2 Individual Trade's Performance Standards

Scopes of work or construction documents for trades providing warranty service shall define the warranty service performance requirements expected of the trade.

Recommendations

Use step-by-step instructions to convey the building process to all members of the internal and external team. Examples of step-by-steps can be found here:

- BuildIQ Toolbelt: http://toolbelt.buildiq.com/, http://toolbelt.buildiq.com/media/16795/dpstandardwindowsbs.pdf, http://toolbelt.buildiq.com/media/16822/sogmonopenetrsbs.pdf, http://toolbelt.buildiq.com/media/16759/shpcustomshowerpansbs.pdf, http://toolbelt.buildiq.com/media/16893/dwallinstallationsbs.pdf, http://toolbelt.buildiq.com/media/39213/stcapplic3coatsbs.pdf
- http://www.dow.com/PublishedLiterature/dh_0415/0901b80380415783.pdf?filepath=styrofoam/pdfs/noreg/179-07303.pdf&fromPage=GetDoc
- http://www2.dupont.com/Tyvek_Weatherization/en_US/assets/downloads/01IntFlangeWindowAFTER.pdf

Commentary

Step-by-steps are visual and sequential guides to the work process. They are becoming a commonplace tool to convey specific information about how to properly put work in place. These documents can come from a variety of sources—manufacturers, consultants, trades, design team, or a combination of all of these. Ideally, step-by-steps are created in a collaborative environment with special emphasis on involving the trades. A program is likelier to succeed if all parties who use the documents have input and agree on the specifics. Manufacturers' instructions and associated standards should also be reflected in the documents; however, builders may find slight variations that comply with the intent of these standards but provide for lower risk and greater ease of installation. These modifications should be vetted by the team and approved by the manufacturer to establish material compatibilities, expected performance, and warranty applicability. The documents can begin and end with a "work ready" checklist. Formalizing the hand-off between trades will help ensure that the following trade does not cover up incomplete or insufficient work.

Step-by-steps are intuitive documentation for constructing a house; however, they can be used in virtually every stage of the process and can help drive consistency and accountability in all departments. For example:

- Design and purchasing: The design team cannot create designs that violate the intent or ability of those in the field to execute the step-by-steps. This encourages designers to acknowledge how the building is assembled and can inherently imbed the performance standards in the design. The purchasing team has a clear set of actions and methods expected of the trades when bidding projects and can use them as a basis for discussing opportunities for improvement.
- Construction: Step-by-step documents clearly convey the builder's expectations of the trade to execute the work in the field and can serve as the basis for pre and post-construction checklists. The step-by-step documents can serve as a training tool for new workers and site supervisors.
- Customer care: Step-by-steps document how materials and products were installed and by who when evaluating customer warranty claims.
- Step-by-steps serve as a guide for facilitating process improvement across all departments.
- Step-by-steps serve as a common language and tool to use when evaluating and documenting process improvement to speed construction or avoid failures.

E.5. Trade Councils

Question: What kind of mechanisms can be used to get trade partners to fully participate in executing a high performance home strategy?

QEHS Section Reference

(The topic in section 5.3.3 regarding trade partners is repeated in sections 6, 7, 8, and 9 and adapted for those departments.)

5.3.3 Trade Partner QEHS Program Support

The Design operations QEHS Management System shall support the QEHS, programs of trade partners, and other material and service providers. Communication shall be established between the Design QEHS representative of the company and the QEHS representatives of the trades to support the QEHS initiatives of each other. Feedback shall be periodically provided to the trade to enable the trade to improve the QEHS and safety of the work. Feedback shall be periodically solicited from the trade in order for the company to improve the QEHS and safety of the company's work.

Recommendations

A Trade Council can be a critical way to support the implementation strategy for building high performance homes. It can develop a forum for two-way communication not simply with the builder but between trades and can be a key way to help drive quality improvement efforts throughout the trade base. By creating a team approach to the homebuilding process, there is less of an opportunity to point fingers or lay blame. A blame-free workplace (see FAQ F.2) is one aspect of operational excellence, and a Trade Council can help foster constructive dialogue and interactive problem solving among the different parties; the builder does not have to play referee.

Commentary

In order to consistently build higher performing houses, everyone involved—including both the internal team (see FAQ A.1, F.1, and C.1) and the external team (FAQs C.1, H.2, and F.3)—must work together as a team. Generally, the builder is responsible for the larger tasks of land acquisition, marketing and sales, design, construction project management, and customer care. The trades are the ones who actually construct the house, so if a key strategy is to improve the house's performance, then their involvement is integral to the project. This point is important to understand, since many of the systems that are critical to a house's performance (e.g. the thermal enclosure) are touched by multiple trades. All parties must be aligned with a common goal and respect the work of others.

One method to begin collaborative dialogue between trades is through the formation of a Trade Council. This method brings together the leaders or representatives from key trades to improve their working relationships, and more importantly, to focus on the builder improving issues that the trades have in common.

Trade Councils can operate and meet in different ways. Council members may meet monthly as an executive committee, quarterly for all-member quality site walks, and biannually or annually for a formal business meeting with senior builder management. The bi-annual and annual meetings tend to be large events that last a full day and involve large numbers of trade representatives and builder team members. These larger events are a time to gather input on the trades' attitudes, conduct training, present changes for the upcoming year, and work together to address key strategic issues. The quarterly meetings tend to distribute the work over the course of a year or are used to conduct quality site walks. Each meeting addresses a particular area of focus.

Trade Councils are primarily about working together to reduce problems, frustrations, and impediments to efficiently and effectively conducting their work and achieving the performance standards set by the builder. This work can be from trade-to-trade or result in recommendations for how the builder can better facilitate the process at any stage of interaction with its trades. Ideally, the builder shares the strategic plan with its trades, enabling them to appropriately plan their business on an annual and quarterly basis. The meetings are led, facilitated, and organized by the trades, which shows a huge amount of respect and provides more control of their relationship with the builder. The councils are not recognition events or social parties but working sessions to improve business relationships and operational and strategic efforts during the homebuilding process.

Trade Councils have firm agendas and stay on schedule to ensure the best use of time. It is essential to start with only a few topics and make sure they are achieved, which will help demonstrate the council's value and secure its success and continuation. A typical structure for a council includes a Chair and Vice-Chair with future Chairs earmarked so that each trade has a chance to lead and participate over time. A set of bylaws can also help to define the relationships and organizational structure of the council.

Resources:

- http://www.tpcva.com/news/tpc-article-in-professional.html
- http://jarasek.com/PDFs/HomeBuilderTradeCouncils.pdf

E.6. Focus Groups

Question: How can focus groups help the team develop a high performance home strategy?

QEHS Section Reference

1.10 Customer Feedback

The company shall establish and implement procedures to evaluate customer satisfaction with the company's work. This assessment shall be conducted at least annually and shall identify overall satisfaction, as well as satisfaction with the functional areas of the company that come in contact with the new customer. This will include move- in and one-year customer satisfaction scores. These customer satisfaction scores will be shared with all builder employees. The results of this assessment shall be considered in analyzing the effectiveness of the QEHS Management System and initiating changes to the system. These procedures shall be documented and records kept of the customer feedback.

Recommendations

Third-party customer surveys are a good way to gather quantitative information about the homebuyer's experience and perception of the process for purchasing a home. Focus groups could be included in the implementation of a high performance home strategy, helping the builder gain more qualitative information regarding key local and regional demographic attitudes of high performing homes.

Commentary

There is danger assuming what the customer thinks. While customer satisfaction surveys and warranty data provide significant insight into customers' views and needs, they often do not provide enough detail. When developing a high performance home strategy, it can be valuable to use focus groups to gather details on specific areas. Past buyers, prospective buyers, and non-buyers can help to formulate marketing messaging and product positioning and to identify the key benefits for various demographic groups and customer profiles. While high performance homes can generally be said to be energy efficient, safe, healthy, durable, and comfortable, each of these attributes will likely have different meanings and value to different buyers. Using focus groups can help uncover these values.

Focus groups can also be useful when evaluating different system strategies and understanding the range of reactions sales agents may encounter with buyers. Consider this example—a new house series is being developed where the duct system is brought inside the conditioned space, requiring a mechanical room in the house and architectural soffits in a market where this is not standard practice. Here, a focus group can generate feedback prior to building models that may impact the floor plan layout or architectural treatment of the soffits.

INCREASED COLLABORATION ACROSS INTERNAL AND EXTERNAL TEAMS

F.1. Traditional Silos in Building Companies

Question: Will the internal and external team members associated with the organization be required to act differently when implementing a high performance home strategy?

QEHS Section Reference

1.2 Leadership

Senior management shall demonstrate leadership regarding the company's quality, environmental, health, and safety (QEHS) initiatives. Leadership is demonstrated by:

- Setting policy and performance expectations
- Communicating to the organization the importance of quality, safety, and the environment, as well as meeting customer expectations
- Providing resources
- Reviewing the effectiveness of the management system

A fundamental aim of leadership is the full integration of QEHS initiatives, which inherently includes a focus on integrating design approaches, problem solving, implementation, and measurement systems.

1.9 Corporate Communications

Procedures shall be implemented to assure communication exists between all areas of the company and the trades of the company. This includes identification of and communication to other functional areas to address recurring non-conformances in QEHS. There shall be procedures implemented to communicate with new home buying customers and to manage their expectations.

1.12 Company Process Flow

The company shall define and document a sequence or sequences of activities (process flow) for the overall company and their relationships to each other. Each sequence shall include all major planning, work, and QEHS assurance activities. Flowcharts are recommended where possible to assist with articulating the sequence.

2.1 QEHS Management Committee

A QEHS management committee shall be established and at a minimum shall consist of the QEHS Manager/Coordinator, a representative for each functional area, and a senior management representative. This committee shall meet periodically to review the regular operation of the QEHS

Management System, review the results of any internal audits, and discuss opportunities for improvement. Minutes of the committee meetings shall be documented.

2.2 Internal Audits

The company shall conduct internal audits at periodic intervals to assess effectiveness of the QEHS Management System. The company QEHS management committee, or similar group, shall provide the oversight of planning, conducting, and reporting results of internal audits of the departments covered under the QEHS Management System to assure that the policies and procedures are being met. The auditor shall be trained and independent of the functional area being audited. Results of these audits shall be documented. Deficiencies in the operation of the QEHS Management System will be identified and actions to correct any nonconformance shall be taken in a timely manner and further documented. Frequency and scope of internal audits shall be sufficient to ensure the effectiveness of the QEHS Management System but shall be conducted at least twice each year.

2.3 Annual Management Review

At least annually, the QEHS management committee shall review the operation and effectiveness of its respective systems with the senior management of the company. This annual review shall include a summary of the internal and external audits of the activities of each functional area of the company, performance measures, customer feedback, trade and supplier feedback, complaints, and recommendations from the QEHS department representatives. The annual review shall also include ensuring compliance with these requirements, setting new annual goals, and addressing needed changes to the management system. Records shall be maintained for each review. The records shall be in sufficient detail to disclose the participants, significant issues, conclusions, recommendations, and planned changes. The aim is to ensure that the QEHS Management System is working to the satisfaction of the leadership and management of the organization. The annual review is an opportunity to make significant changes to the QEHS Management System and make sure it is functioning effectively and efficiently.

(The topic in sections 5.1.1 and 5.1.2 is repeated in sections 3, 6, 7, 8 and 9 and adapted for those departments)

5.1.1 Scope of the Design Operations

The Design operation shall define the scope of its Design operations.

5.1.2 Process Flow

The company shall define and document a sequence or sequences of activities (process flow) for the Design operation of the company. This sequence shall include all major planning, Design phases by trades, and interactions with other departments during design and QEHS assurance activities. This information can be in list form or any other clear logical sequence. It is recommended that flowcharts are used where possible.

Recommendations

When developing the scope of operations and key processes, create interdepartmental dependencies and relationships that provide feedback and input. Each department must support the others in executing the company's high performance home strategy. Organizational "silos" can significantly restrict the flow of information that is the basis of this support.

Commentary

When identifying your core processes to implement a high performance home strategy, it is important to break down departmental and functional silos to help ensure an integrated approach. Breaking down the silos means that marketing and sales, design and purchasing, construction, and customer care must all be involved in a multi-disciplinary project team for the development, design, construction, sale, and occupancy of high performance homes. Operationally, your business is an interconnected set of processes and not a series of isolated blocks of activity with the minimum amount of overlap to "get the job done."

Using a matrix or spider diagram concept of creating and visualizing such teams can be more effective than the traditional hierarchical organizational chart approach. Operational processes should involve input from a variety of sources within the company. Getting this level of input can help make sure the appropriate level of documentation is created to enable site supervisors and trades to succeed in the field, ensure that the houses are designed to incorporate buildable solutions that will achieve the company's high performance home standards and meet customer needs, reduce long-term warranty items and associated risk, and increase customer satisfaction.

Examples of areas where organizational silos can create challenges with implementing a high performance home strategy include:

- Design creates a product that does not facilitate cost effective implementation of the company's performance goals
- Implementing high performance as simply a group of individual measures to be purchased and applied to the house like a coat of paint or a granite countertop, as opposed to a set of interrelated systems with inherent synergies and tradeoff opportunities
- Understanding customer satisfaction and warranty issues that high performance strategies may solve
- Inconsistent messages to customers from different departments regarding the company's high performance home product and strategy

Deconstructing silos can be addressed by focusing on leadership (FAQ A.1), corporate communications (FAQs B.1, E.1-E.6), improvement processes (QEHS Sections 5.3, 6.3, 7.3, 8.3 and 9.3), and especially through conducting audits and strategic reviews.

F.2. Blame-Free Workplaces

Question: What sort of organizational culture and employee mindset can lead to successful implementation of a high performance home strategy?

QEHS Section Reference

(The topic in section 3.3 regarding continual improvement (preventive actions and training) are repeated in sections 5, 6, 7, 8, and 9 and adapted for those departments)

3.3 Land Development Training Continual Improvement

3.3.1 Preventive Actions

The land development operation shall define and implement ongoing actions to eliminate recurring QEHS issues. These documented actions shall include identification, prioritization, root-cause analysis, and development and implementation of an action plan. When appropriate, these actions shall include recommendations of changes in land development procedures or documents. The effectiveness of the corrective actions shall be evaluated. When identified QEHS issues have not been eliminated, the plan shall be reassessed and additional appropriate actions initiated. Structured Plan-Do-Check-Act methodologies are recommended for the corrective and preventive actions, as are creating defined charters for improvement teams.

3.3.2 Land Development Operations Training

A program of training for all employees involved in land development shall be implemented. This training shall include identified opportunities for improvement that leads to continual improvement on department-specific metrics and reducing recurring issues in the land development operation. This training shall also include both task-specific skills and training in the operation of the company's QEHS Management System. Suggestions for and coordination of the training subjects from the construction operation and the warranty and service operation may be utilized to meet some of the requirements of this section. Land development personnel will be trained on the use of approved documents and procedures for ensuring that a complete and accurate land development documentation process meets the expectations of the customer. Land development personnel shall be trained on any different versions of the company's land development documents and when those different versions apply. Land development personnel shall be trained on applicable industry practices and safety regulations.

Recommendations

Create a company culture where providing input on how to improve work and pointing out issues are regular events that are recognized and rewarded. Doing so can significantly speed implementation and reduce the costs of a high performance home strategy. Leadership should endorse strategies like Plan-Do-Check-Act (PDCA) or Define, Measure, Analyze, Improve, and Control (DMAIC) to help provide the team with a structured or step-by-step approach to making improvements. Providing such tools during training events are important part of starting an improvement program and keeping it sustained and fresh.

Commentary

All too often in the homebuilding industry, the parties involved take an “Us vs. Them” approach. This approach shows up internally when leadership sets up goals that place two departments at odds with each other or when the builder pits trades against each other to garner the lowest price without regard for the long-term well being of the trade’s business or ability to perform quality work. When implementing a high performance homes strategy, this mentality can be disastrous. To truly succeed, an organization must strive to drive fear from the workplace. This task involves creating collaborative relationships internally and externally, as well as fostering a sense of innovation and support. When individuals fear retribution for seeking to make improvements to processes, systems, or strategies that may or may not succeed, then there will be little, if any, innovation.

To achieve the highest level of home performance at the lowest cost, it is necessary to create a company culture that encourages internal and external team members to freely identify improvements in any area, where nothing is treated as a “sacred cow.” Leadership should support creating teams to evaluate improvements and their associated risks, take deliberate steps to implement the improvement, and honestly evaluate its success or failure. If any individual or group believes they will be made into a scapegoat if success is not immediate and dramatic, then there will be little incentive to participate.

Using quality improvement teams to address problems and create solutions will only work if “blame” is not assigned. If the teams feel supported and safe, then they will be more open to trying new processes, suggesting new methods, testing them out, and being comfortable with change. This also means people will be more open and honest about current processes that do not work or on checklists and audits about the number and type of error or defects they are finding or even creating. Honesty means issues can be highlighted and improvements made.

Individuals, departments, and trades must be encouraged to identify opportunities, evaluate and modify processes, and allowed to succeed or fail while managing risks. The result may harness the entire mental capacity of the organization. While high performance homes costs more to build that code-minimum construction, it is critical to develop a mindset it every employee and trade to discover opportunities to drive out waste while maintaining consistent delivery or even improving results at lower costs.

F.3. Non Traditional Trade Partners

Question: Who should be considered "trades" when implementing high performance homebuilding strategies?

QEHS Section Reference

(The topic in sections 5.1.1, 5.1.3, and 5.1.6 is repeated in sections 3, 6, 7, 8, and 9 and adapted for those departments.)

5.1.1 Scope of the Design Operations

The Design operation shall define the scope of its Design operations.

5.1.2 Process Flow

The company shall define and document a sequence or sequences of activities (process flow) for the Design operation of the company. This sequence shall include all major planning, Design phases by trades, and interactions with other departments in the company during design and QEHS assurance activities. This can be in list form or any other clear logical sequence. It is recommended that flowcharts are used where possible.

5.1.4 Company Standards

Company standards shall be documented to define the requirements for workmanship, including tolerance requirements, industry standards, design procedures, and material specifications. These company standards shall be included in scopes of work or other agreed-upon document(s). When a conflict exists between local practice and other requirements (e.g. industry standards, manufacturer's instructions), there shall be a procedure for allowing exceptions while maintaining QEHS. All plans will be approved by an Engineer or equivalent for that city/state/region.

5.1.6 Trade Partner and Supplier Contract Documents and Scopes of Work

Procedures shall be implemented to prepare and review the subcontracts and design documents specific to the work of each trade utilized by the Design operation to ensure that builder requirements and typical home buyer expectations will be met. Trade contracts, scopes of work, or other documents shall include mutually agreed-upon job ready conditions and procedures to follow when these conditions are not met.

8.2 Construction Operations Inspections

8.2.1 General

Various inspections will be conducted by construction operations to ensure construction activities comply with codes, regulations, scopes of work, manufacturer's instructions, and company standards. Consistent with the builder's experience with each trade, the frequency and detail of these inspections shall be sufficient to ensure compliance. Construction operations will develop checklists and/or other documentation for recording the inspection results. The inspection criteria shall be consistent with the company standards and scopes of work. Items requiring corrections shall be recorded, corrected, and

their status documented. The construction operation shall take steps to ensure that any item requiring correction is not covered up before the correction is completed and documented. The QEHS Management System shall document the inspection process, including who performs the inspection; what is inspected; when and where it is inspected; and the process for recording and storing inspection documentation. The personnel conducting inspections will be trained in the inspection and documentation process.

8.2.2 Job Ready Inspection

The construction operations shall ensure the jobsite is prepared for the work of the next trade to begin via an inspection consistent with agreed-upon job ready requirements. If a trade is required to begin work when the job ready conditions are not met, the construction operations will ensure that the proper procedure is followed. Deviations from the job ready conditions shall be recorded on the job ready inspection record.

8.2.3 In-Process Inspections

Activities and work done in the construction operation shall have in-process inspections to ensure that the builder's QEHS policy and procedures are being followed. These inspections shall be documented. Items requiring correction shall be documented, corrected, and confirmed prior to the covering or concealment of any trade's completed work. The inspection criteria shall be consistent with the company standards and scopes of work.

8.2.4 Final Inspection

Each completed house shall have a final inspection. Any non-conformance(s) to the builder's documented standards for completed work shall be recorded. Corrections shall be completed and documented.

8.3 Construction Operations Continual Improvement

8.3.1 Corrective and Preventive Actions

The construction operation shall define and implement ongoing actions to eliminate recurring QEHS issues. These documented actions shall include identification, prioritization, root-cause analysis, and development and implementation of an action plan. The effectiveness of these actions shall be evaluated. When identified issues have not been eliminated, the plan shall be reassessed and appropriate alternate actions initiated. Structured Plan-Do-Check-Act methodologies are recommended for the corrective and preventive actions, as are creating defined charters for improvement teams.

8.3.2 Construction Operations Training

A program of ongoing training shall be implemented for all construction operations employees involved in meeting QEHS requirements, and meeting new homebuyer customer expectations. This training shall include identified opportunities for improvement that lead to continual improvement on department-specific metrics and reducing recurring issues in the construction operation. Training of construction personnel shall include how to ensure that job ready conditions exist for all phases of construction work and how to maintain a safe jobsite. This training shall include both task-specific skills and training in the operation of the construction operation's QEHS Management System and shall be documented.

Recommendations

Consider including other members of the extended team to participate in regular meetings and provide data as you implement and continually improve high performance home solution sets. External designers and architects can be involved in conducting root-cause analysis, developing action plans, documenting corrective activities, and developing training tools (see FAQ E.3). Designers should be informed of internal actions to prevent recurring problems that can be eliminated at the design phase. HERS Raters have a wealth of information related to a building's tested performance and may be able to assist with documenting recurring building performance issues, transferring best practices from other builders, and providing ongoing data on key building performance metrics. A proactive dialogue with local building officials can provide them with insight into key building science-based strategies being considered for implementation. This type of dialogue can garner their feedback and reveal any concerns to address prior to construction. Taking this step can also proactively stop building officials from issuing stop work orders because they are unfamiliar with certain constructions practices. In addition, creating an environment of accountability and self-inspection by trades performing the work dramatically reduces the likelihood of failing third-party inspections. However, in order for this to be effective, trades must have a very clear understanding of what is being inspected, what the pass/fail criteria are, and how their work impacts and interacts with others.

Commentary

Designers, architects, HERS Raters, and building officials are integral players in how well the end product performs and meets the builder's internal standards and performance targets. But they are not typically considered part of the "trade base." These players can provide valuable insight and data on the successes and challenges of implementing various high performance home strategies, as well as facilitate streamlined inspections and verification processes.

One aspect of profitable building is even flow production and the ability to consistently meet predefined schedules for trades. The intent is to eliminate dry runs, rework, and delays due to incomplete items at key inspection points. Consider some of the inspections and their implications for a typical high performance house.

Construction Stage or Performance Verification	Trades Impacted	Inspector	Possible Delays
Foundation: Below-grade water management	Excavator/Foundation	Building official, site supervisor, trades	Rework to achieve proper drainage, capillary breaks; possible building official concerns regarding full vapor retarder under slab and grade beams

Construction Stage or Performance Verification	Trades Impacted	Inspector	Possible Delays
Above-grade water management	Drainage plane / siding installer, window and door installer, roofer	Third-party, building official, site supervisor, trades	Rework to address improperly installed drainage plane and flashing materials
Thermal bypass checklist	Framer, insulator, air sealing trade	HERS Rater, building official, site supervisor, trades	Rework of thermal bypass checklist items, stop work order to resolve building official's concerns regarding insulation / vapor control strategies
Insulation and other thermal enclosure component inspection	Insulator, window and door supplier/installer, framer	HERS Rater, building official, trades	Rework or stop work order to achieve appropriate grade certification for insulation installation (RESNET Grade 1, 2, or 3), or correct window/door specifications to achieve overall energy performance targets
Building air tightness	Insulator, air sealing trade, drywall installer, painter	HERS Rater, trades	Rework to meet maximum air leakage targets to comply with builder standards
Duct tightness and HVAC system performance	HVAC	HERS Rater, trades	Rework of installation to meet overall performance targets (e.g. duct tightness, system airflow, refrigerant charge, and temperature rise)

In addition, the design team has a critical role in the implementation of an overall high performance home strategy. Architects and designers are constantly blamed for an "ivory tower" mentality, creating designs that take significant gymnastics to achieve in the field and may embody significant flaws (e.g. windows placed in close proximity to bulk water drainage locations or building configurations with virtually

inaccessible spaces that cannot be easily and effectively insulated). One goal of an integrated design process (see FAQ C.1) is to deliberately engage the design team with the trades who are building the house, and give them an opportunity to evaluate the design as it progresses for constructability and opportunities for value engineering. Similarly, involve the HERS Rater early in the design phase to help ensure that the project will meet energy performance targets and to guide the design team on modifications (e.g. window areas or truss designs) that will enhance the energy performance and more cost effectively meet the overall energy performance targets. HERS Raters can also be a valuable resource to help train trades and “connect the dots” for them on the interrelated nature of the work in the house needed to achieve higher performance levels.

DISCIPLINED APPROACH TO QUALITY CONTROL

G.1. Checklists: Friend or Foe

Question: What purpose can checklists play in the implementation of a high performance home strategy?

QEHS Section Reference

(The topic in sections 8.2.2, 8.2.3, 8.2.4, and 8.2.5 regarding job ready, in-process, and final inspection processes are repeated in sections 3, 5, 6, 7, and 9 and adapted for those departments.)

8.2.2 Job Ready Inspection

The Construction Operations shall ensure the worksite is prepared for the work of the next trade to begin via an inspection consistent with agreed upon job ready requirements. If a trade is required to begin work when the job ready conditions are not met, the Construction Operations will ensure that the proper procedure is followed. Deviations from the job ready conditions shall be recorded on the job ready inspection record.

8.2.3 In-Process Inspections

Activities and work done in the Construction Operation shall have in-process inspections to assure that the builder's QEHS policy and procedures are being followed. These inspections shall be documented. Items requiring correction shall be documented, corrected, and confirmed prior to the covering or concealment of any trade's completed work. The inspection criteria shall be consistent with the company standards and scopes of work.

(Note: If an NHQ Certified trade contractor provides the builder with a copy of their inspection reports, this will satisfy this requirement for work of that trade provided the builder maintains a copy of this inspection document and periodically verifies the accuracy of the trade contractor's inspection.)

8.2.4 Final Inspection

Each completed house shall have a final inspection. Any non-conformance(s) to the builder's documented standards for completed work shall be recorded. Corrections shall be completed and documented.

8.2.5 Inspection Records

Records shall be maintained of all code compliance, third-party inspections, company QEHS inspections, and the correction of noted non-conformances.

Recommendations

Ensure that checklists address the most important issues for each functional area. Develop them by collaborating with all of the parties who are part of the work so the documents are user friendly and beneficial. Checklists should not be exhaustive pages with items to check off; rather, they should only

include items that are critical to the success of the work and recurring defect issues, as well as be representative of recent changes in the process. Sources for model high performance home checklists include:

- IBACOS High performance Scopes of Work: http://www.ibacos.com/resources/report (used in conjunction with the "Scope of Work Program" by Linda Haas Davenport)
- NAHB Research Center Scopes of Work: http://www.toolbase.org/ToolbaseResources/level3.aspx?BucketID=5&CategoryID=62
- Building Science Corporation's "SNAPSHOT" form http://www.buildingscience.com/documents/reports/rr-0413b-snapshot-form

Commentary

Checklists—who likes them? But when implementing a high performance home strategy, checklists can have a huge impact, ensuring work is done right the first time and preventing rework, which can save costs. In a high performance house there will be many changes to the products, materials, systems, and methods of construction that all need to be implemented correctly. Failure to do so can result in long-term defects and not meeting customer expectations. Checklists can quickly reinforce a scope of work, documenting specific responsibilities. Some areas where checklists can be helpful include:

- Critical aspects of a water management strategy
- Key components of the thermal enclosure and space conditioning strategy
- Performance test results (house tightness, duct system tightness, and heating and cooling system commissioning measurements)

Make sure the checklists are focused rather than pages of issues that are unessential. Do not assign one person to create the checklists in isolation from those who will use them. Having internal teams and trades participate in creating the checklists is also critical for achieving buy-in. Test them out and change them where needed. Checklists can also provide hard data for analysis and identify areas for improvement. If the data from the checklists are not reviewed and used with the team as a feedback mechanism, then the team will likely stop using them or check off all the right boxes simply to get the list done. Have the teams be honest on the checklist, noting where there are problems. It is important to emphasize that the information is not intended to assign blame but to identify recurring issues, which should then be addressed by finding the root cause and eliminating it. This process could include implementing training programs if the methodology is sound, developing new processes, using different materials, or creating ways of working.

Checklists should cover the job ready, in-progress, and job complete stages. They should be user friendly and comprehensive. A useful checklist will help reduce errors, rework, and defects. Keeping checklists provides a wonderful record of the work and proof that it was done correctly. Tracking the decrease in the amount of time spent on rework and warranty calls can show the impact on the bottom line and cause

buy-in and success. Ultimately, checklists are about reducing callbacks and warranty work and saving money.

Audits can support the effective use of checklists and inspections. Audits are a review of organizational performance and can help focus on what to improve. They are an opportunity to take a fresh, honest look at how processes are performing and identify what is going well and what needs to be changed. Leadership must seriously review and prioritize audits and the resulting data and put action plans in place in consultation with the team. It is helpful to try and identify risk costs or opportunity costs associated with the data. How much do water leaks cost the company? How much savings could be accrued by reducing HVAC callbacks from three per house to three per 100 houses? What value does this have in long term customer satisfaction and willingness to refer rates? Be prepared to receive some bad news while analyzing the data, but take a “glass half full” approach, since bad news reveals an opportunity to develop a way to improve. Audits give insights on how an organization is functioning in its key processes at various departmental levels, as well as in cross-department functions.

CONTINUOUS FEEDBACK AND IMPROVEMENT

H.1. Monitoring HERS Scores and Key Building Performance Metrics

Question: How can the data collected on building performance be used in continual improvement processes and to develop the next generation of high performance strategy?

QEHS Section Reference

1.11 Performance Measures

The company shall establish performance measures and goals that indicate the effectiveness of the QEHS Management System. These shall be defined, documented, and quantified for each functional area covered by the company's QEHS Management System. Progress toward meeting these goals shall be documented and reported quarterly to the management of the various functional areas.

8.3.1 Corrective and Preventive Actions

The construction operation shall define and implement ongoing actions to eliminate recurring QEHS issues. These documented actions shall include identification, prioritization, root-cause analysis, and development and implementation of an action plan. The effectiveness of these actions shall be evaluated. When identified issues have not been eliminated, the plan shall be reassessed and appropriate alternate actions initiated. Structured Plan-Do-Check-Act (PDCA) methodologies are recommended for their corrective and preventive actions, as are creating defined charters for improvement teams.

Recommendations

Combine systems integration strategies with results of performance tests and the HERS Index to continually evaluate the high performance strategy. Look for opportunities to achieve the same level of performance at a lower cost or to make improvements at the same cost.

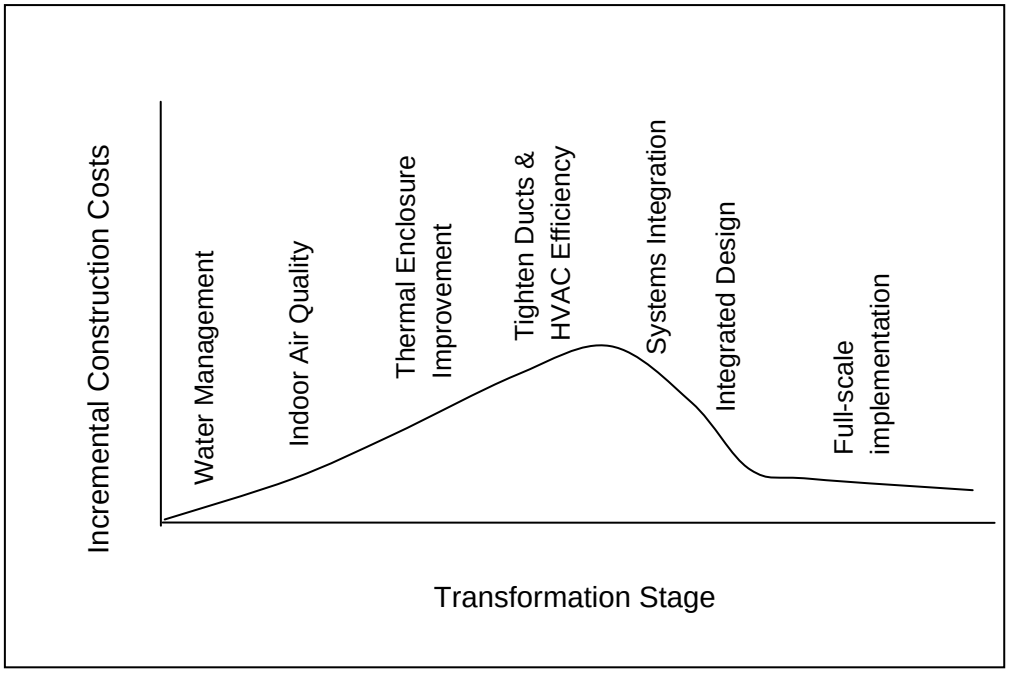
Commentary

FAQ D.5 delves deeper into the rationale behind using building performance metrics as key performance indicators in the adoption, sustained implementation, and improvement phases from an implementation standpoint. When undertaking improvement activities, gather, analyze, and use more specific data from the adoption and sustained implementation phases.

For example, an opportunity may be to evaluate achieving lower HERS scores while keeping current construction costs level. This effort could involve redesigning the framing and insulation systems to enable better energy performance, increasing the air tightness by using different sheathing materials, improving air sealing strategies, and looking for ways to simplify the mechanical system to reduce materials and the tonnage due to the thermal enclosure improvements. There may be costs involved in redesigning, creating new documentation, repurchasing, training, and rollout. Data from a variety of the

areas will be needed to make reasonable judgments and decisions. These costs could be mitigated by integrating this process into a new community rollout and new series of house plans (or into a mandated code change cycle). What is important here is to identify those metrics that impact the decision, use historical data to inform the decision making process, monitor them to see if the desired results are achieved, and if not, why. This process is commonly referred to as the Plan-Do-Check-Act cycle.

One set of metrics that could easily be overlooked are the individual building systems used to achieve the high performance strategy. These add up to the overall HERS Index; however, they are a result of many decisions. Periodically reevaluating them with the design team, HERS Rater, and trades may yield new ways to achieve the overall company standards. Similarly, there may be a five-year vision for the ultimate system strategy to provide the highest value to the customer at the lowest cost but to get there may take a number of iterative strategies. How to sequence these strategies is important to map out with the internal and external teams, gauge progress, and identify opportunities for transitions. The following is a schematic transformation curve a company should follow to implement high performance homes.



The first four steps can be done fairly prescriptively; however, the systems integration and integrated design stages are where the rubber meets the road. The following items are the broad categories that go into a HERS rating.

Component	Energy Impact
Insulation	Amount (R values), quality of installation
Windows	U value (conductive losses), SHGC (solar gain)

Building Air Tightness / Mechanical Ventilation	Heat loss / gain through infiltration / mechanical ventilation
Heating and Cooling System Performance	Equipment efficiency, distribution system conductive and air leakage losses to outside the conditioned space
Domestic Hot water	Equipment efficiency, water consumption
Lighting, Appliances, and Miscellaneous Electric Loads	Device efficiency, contribution to internal loads

These items can be individually and iteratively manipulated and a matrix developed with the resulting HERS Index providing a “price per point” for each incremental upgrade. This work will typically yield the highest incremental cost, as it simply looks at the first four stages in the transformation curve and does not inherently value systems integration. It also does not account of other attributes of various components and systems.

For example, evaluate advanced framing with 2x6 studs at 24” on center (o.c.) instead of 2x4 studs at 16” o.c. Numerous studies have shown that that a 2x6 wall uses less labor and material to build; however, the increased amount of insulation to fill the cavity may add to the cost. In addition, applying stucco over open frame construction may require reasonably stiff foam board and a one-coat application (as opposed to double metal lath with a traditional three-coat stucco application).

From an energy and building performance standpoint, the 2x6 wall is a superior system. But if only one component–going from 3 ½” cavity fill insulation to 5 ½” cavity fill insulation—is evaluated and all other parts of the system are held the same (e.g. no advanced framing, same exterior cladding system), then the cost increase will not justify the energy savings. However, if the whole system is evaluated, it may be cost competitive.

H.2. Engaging Trades in Continuous Improvement for Higher Performance Homes

Question: How can trades be used to continually improve a high performance home strategy?

QEHS Section Reference

7.3.7 Trade QEHS Assurance Program Support

The purchasing operations QEHS Management System shall support the QEHS, environmental and safety programs of trades, and other material and service providers. Communication shall be established between the purchasing QEHS representative of the company and the QEHS representatives of the trades to support the QEHS initiatives of each other. Feedback shall be periodically provided to the trade to enable the trade to improve the QEHS and safety of its work. Feedback shall be periodically solicited from the trade in order for the company to improve the QEHS and safety of the company's work.

8.3.1 Corrective and Preventive Actions

The construction operation shall define and implement ongoing actions to eliminate recurring QEHS issues. These documented actions shall include identification, prioritization, root-cause analysis, and development and implementation of an action plan. The effectiveness of these actions shall be evaluated. When identified issues have not been eliminated, the plan shall be reassessed and appropriate alternate actions initiated. Structured Plan-Do-Check-Act methodologies are recommended for the corrective and preventive actions, as are creating defined charters for improvement teams.

8.3.3 Trade Partner QEHS Assurance Program Support

The construction operations QEHS Management System shall support the QEHS, environmental and safety programs of trades, and other material and service providers. Communication shall be established between the construction QEHS representative of the company and the QEHS representatives of the trades to support the QEHS initiatives of each other. Feedback shall be periodically provided to the trade to enable the trade to improve the QEHS and safety of its work. Feedback shall be periodically solicited from the trade in order for the company to improve the QEHS and safety of the company's work.

- Training will be provided to all trades on basic quality principles, tools, and techniques.
- The builder will conduct regular monthly meetings with the trades to discuss QEHS, schedules, and opportunities for improvement (OFI).
- The builder will develop a Trade Council to improve communications with the trade base, ensuring that the builder can focus on how to make the “daily life of the trade better.” This effort will focus on OFIs that the builder needs to implement in its own business and practices.

Recommendations

Developing trades to become an integral part of the decision making process helps to grow the trust and interconnectedness that is needed for high performance homes. Instead of being viewed as a disposable

commodity, trades can help develop and achieve a high performance home strategy. Providing training, developing a Trade Council (see FAQ E.5), making trades part of an integrated design process (see FAQ C.1), and enlisting true two-way dialogue can help bring valuable experience and new ideas to the table.

Commentary

When looking for ways to improve the high performance strategy, do not overlook the opportunity to engage the trades who complete the bulk of the work associated with homebuilding. Using the company standards (see FAQ B.1) and the scopes of work (see FAQ E.2) as a starting point, request suggestions on how work activities, schedules, work handoffs from trade-to-trade, and/or sequencing can be improved to meet the desired performance result while driving waste (and frustration) out of the process. Using a Trade Council can be a perfect mechanism that provides a regularly structured forum for individual or group innovation. Look for opportunities to expand their input, such as getting involved in the integrated design process (FAQ C.1) or analysis of checklist data (FAQ G.1).

Trades should also regularly enlist in bringing new products, systems, and strategies to the table. Work with trades so they fully understand the role that high performance homes play in the overall the mission of the organization; foster an environment that continually evaluates (in a structured way) alternatives that meet the overall goals of the company and the intent of the company standards.

About IBACOS

Since 1991, IBACOS has helped builders address issues in the field so they can deliver better homes today and has conducted forward-thinking research that leads the industry to great homes tomorrow. The goal is an industry that delivers high performance homes that are designed and built to new standards of quality. For more information, please visit www.ibacos.com.

About the Best Practices Research Alliance

The Best Practices Research Alliance is a research-based community of production homebuilders collaborating with building performance specialists, quality and business management experts, and product and material manufacturers. Its ultimate goal is to identify and share how to deliver high quality, zero energy homes as an everyday part of mainstream America. These homes produce as much energy as they consume, while offering higher levels of comfort, durability, safety, and earth friendliness. The Alliance was created and is operated by IBACOS. For more information, please visit www.theresearchalliance.org.

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