Getting Building Technology Accepted

Developing and Deploying New Building Technologies

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

PATH
PARTNERSHIP FOR ADVANCING TECHNOLOGY IN HOUSING

About the Partnership for Advancing Technology in Housing

The Partnership for Advancing Technology in Housing (PATH) is a public-private partnership created to add value to and increase the affordability of housing through technology. PATH examines the issues and institutional problems related to technology development in the housing industry and creates viable, cost-effective solutions to improve the rate of change. PATH partners include the major research and housing agencies in the Federal Government; leaders in the manufacturing of homebuilding products; innovators in the homebuilding and contracting industry; researchers from diverse backgrounds; and officials from insurance, financial, and regulatory groups in housing and construction.

PATH has adopted far-reaching goals for the quality, durability, environmental impact, energy efficiency, affordability, and disaster risk of America's homes. PATH's partners contribute to this vision by:

- Developing new housing technologies (research and development).
- Disseminating information about new and existing housing technologies (information and outreach).
- Studying and establishing programs for sustained housing technology development and market acceptance (planning and barriers analysis).

PATH has created special activities to address every step taken toward acceptance of a new technology by the homebuilding industry. For more information, visit PATH at www.pathnet.org.

Visit PD&R's Web site at **www.huduser.org** to find this report and others sponsored by HUD's Office of Policy Development and Research (PD&R).

Other services of HUD USER, PD&R's Research and Information Service, include listservs; bimonthly special-interest publications (best practices, significant studies from other sources); access to public use databases; and a hotline (1–800–245–2691) for help with accessing the information you need.

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Prepared for the
Partnership for Advancing
Technology in Housing

Prepared by the
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Preface

As part of its strategic goal to increase the availability of decent, safe, and affordable housing in American communities, HUD has been involved in ongoing efforts to advance housing technology through its administration of the Partnership for Advancing Technology in Housing (PATH). This Federal initiative works to accelerate the creation and widespread use of advanced technologies to radically improve the quality, durability, environmental performance, energy efficiency, disaster resistance, and affordability of our Nation's housing. New building products and technology can contribute to the development of safer, higher quality, and more disaster-resistant housing.

This report explains how regulatory activities affect new building technology research, development, and deployment and how to apply regulatory information to develop and deploy building technologies. Without this technology, building technology developers may devote resources to research and development of a building technology only to discover too late that the technology does not meet building regulations and therefore must be tested, retested, or redesigned or that they must address another issue that is impeding or preventing the technology's deployment.

Applying this information will build an awareness of the need to perform *technology acceptance planning*—the integration of parallel rather than sequential efforts to address building regulations and technology development. By using the approaches in this report, product innovators and proponents will better understand the issues associated with codes and standards and be better prepared to develop successful strategies to bring new products to the marketplace. These new products will, in turn, contribute to the development of safer, better, and more affordable housing for all Americans.

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Introduction

Building technology developers are discovering that developing a new product does not necessarily mean that consumers will beat a path to their door. A new or innovative product or technology can only achieve market success if it meets the building codes, standards, and regulations adopted at the Federal, State, and local levels (and abroad). Products that have difficulty securing code approval are less likely to be specified for use. The result is a lack of sales.

This report is intended to facilitate the acceptance of new building technologies by helping developers and proponents of innovative building products more effectively plan for and address technology acceptance and approval. It defines and describes the benefits of technology acceptance planning; provides a general overview of how building regulations,[1] standards, and model codes are developed, adopted, implemented, and enforced; and describes who is involved in those processes. The report then integrates that information into a discussion of the activities associated with developing and implementing a successful technology acceptance plan to help technology innovators concurrently address product development and building construction regulations, resulting in more cost-effective and timely introductions of new building technology with increased confidence in technology acceptance and approval.

Taking a new building technology from idea through development and deployment to market acceptance is complex, requiring many activities. Because the building industry tends to be highly regulated with respect to building construction regulations, technology acceptance must be considered during technology research, development, and deployment (RD&D). If this issue is ignored, costs and resource needs will escalate, and the producer's ability to market the technology will be curtailed significantly.

[1] The terms *building construction regulations, building regulations, building codes, model codes,* and *standards* are used interchangeably in this report. They refer to a broad body of requirements that govern the design and construction of buildings and their component parts and systems. In this report, the term *building code* refers to a larger series of documents that include fire, mechanical, plumbing, energy, and other codes that collectively are considered "the building code."

Technology Acceptance Planning: Definition and Benefits

Technology acceptance planning—the timely and parallel consideration of building regulations and RD&D—can greatly enhance the probability of market success. All too often, however, consideration of building regulations is addressed after the technology is in the marketplace. The text boxes on pages 4 and 5 illustrate a problem resulting from a lack of technology planning and the payoff of adopting technology acceptance planning throughout the development process.

Technology acceptance planning can increase the probability of successful technology deployment if the following issues are addressed before the product is introduced into the market:

- Standards are available that cover testing of the technology.
- Model codes have specific provisions that pertain to the technology.
- The technology has been tested and meets referenced standards.
- The technology has been listed by a third-party quality-assurance or inspection agency.
- The technology is labeled for approval and use.
- Technology literature and information refer to the codes and standards.
- Builders and specifiers are familiar with the technology.
- Code officials have received training on the technology.
- Contractors are available that can apply the technology.

Technology acceptance planning is the timely treatment of building codes and standards issues to facilitate technology acceptance in conjunction with RD&D. In any

LACK OF TECHNOLOGY ACCEPTANCE PLANNING

In 1977 a central-heating equipment manufacturer introduced a new, more energy-efficient gas-heating product to the market. The product was so efficient that its very-low-temperature combustion byproducts could be vented horizontally through a small plastic pipe in the exterior wall of a house. The product was tested and listed as meeting a particular standard. No one, however, realized that installation of the product was covered by codes that at the time required the byproducts to be vented vertically through the roof via a masonry chimney or metal vent.

Approvals had to be secured initially on a case-by-case and city-by-city basis. Widespread acceptance was unavailable until the codes were modified approximately 3 years later to recognize this venting arrangement and type of product. During this hiatus the manufacturer was unable to fully market the product. Numerous installations could have been secured more readily through parallel code changes and technology development activities.

building technology development scenario, those with a financial interest will be focused on maximizing return on investment, and those with a marketing interest will be focused on expediting product availability. Together they will be pushing to shorten the RD&D timeframe and minimize the investments needed to develop and deploy a building technology, thereby maximizing revenue. A building product that takes fewer resources and less time than another to bring to market may have a clear advantage.

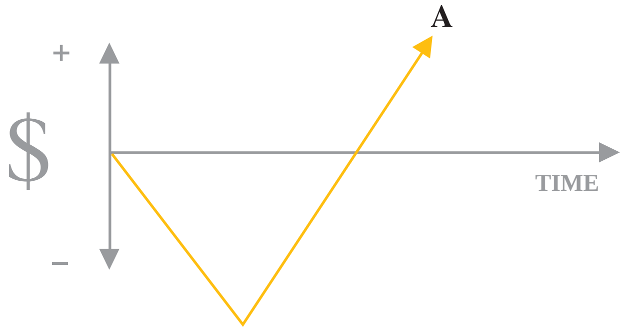
Those involved in research, product development, engineering, and production are often caught in the middle of the time-versus-money dilemma. They are less likely to be involved in financial and business decisions or product sales and marketing plans; however, they are responsible for bringing the technology to market within established marketing and business plans. Although not driving the time or money issues, they are the most likely to understand how codes, standards, and technology acceptance issues can affect return on investment. They should be involved throughout the entire business planning process, especially in the beginning, and given the resources to address technology acceptance during RD&D.

In exhibit 1, the vertical axis ($) describes manpower and financial resource investments (negative) and revenue (positive). The horizontal axis is time. Three scenarios will be shown, each with a different return on the initial investment.

Exhibit 1

In exhibit 2, Scenario A represents the original business plan. At time zero, investments are made in research, development, field testing, engineering, and other activities to bring a new building technology to market. The financial and investment side of the technology developer, venture capital firms, or other investors agree to invest certain manpower and financial resources. They project that at a specific point in time, the technology will go to market, and product sales will begin to pay off the investment. At another point in time, product sales will pay off that investment, and future sales will yield a profit.

Exhibit 2



With the business plan in hand and the first round of financing realized, research begins, eventually leading to the planned development and deployment of the technology. In this scenario, as in many real-world situations, there is little consideration of—or investment in addressing—codes, standards, and building regulations. Quite often, as in the example of gas-heating equipment presented previously, what was envisioned in the original business plan encounters a hiatus before or at market introduction.

In exhibit 3, Scenario B represents a lack of investment and highlights what can happen if building regulations are not addressed in parallel with RD&D. Instead of being able to sell the technology at the time projected in the original business plan (line A), the technology developer is faced with an approval hiatus. Marketing is curtailed or stopped, and an additional investment of unbudgeted money and manpower is required to change codes, develop standards, conduct testing, secure product certification, educate code officials, and engage in other activities integral to successful product acceptance and approval.

USE OF TECHNOLOGY ACCEPTANCE PLANNING

Fuel cells are now appearing on the market. Contemporary work on this technology, first proven in 1837, coupled with the recent emphasis on energy conservation, environment, security, economics, and continuity of power service, has stirred significant interest in stationary and portable power applications and transportation applications.

In the early 1980s the developer of fuel cells for the U.S. space program began to focus on other applications that led to the development of a stationary fuel cell that produced 200 kW of peak continuous power. To date, approximately 200 units have been installed. Since then, several new companies and companies traditionally engaged in power generation or storage have begun developing fuel cells.

Standards are currently available by which such equipment can be tested, listed, and installed, and codes have been adopted that incorporate those standards and provide direction for approval by building regulatory authorities. Much of this work was initiated almost 20 years ago by the original fuel cell developer and continued by others in this emerging industry. Code officials, builders, designers, and others have been educated about the technology, the codes and standards for fuel cells, and how it can be readily accepted and approved. By addressing building codes and standards in parallel with RD&D, the infrastructure to support regulatory acceptance of this technology is in place to support its widespread deployment as the industry grows.

Exhibit 3

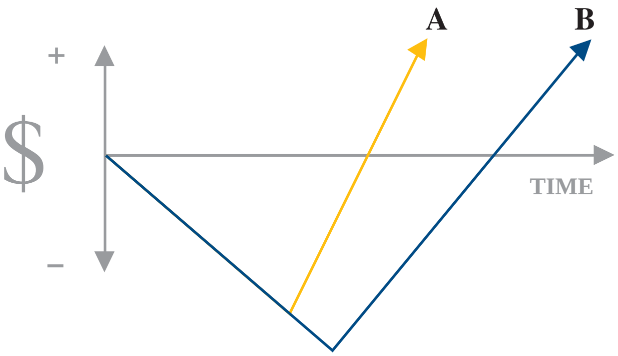
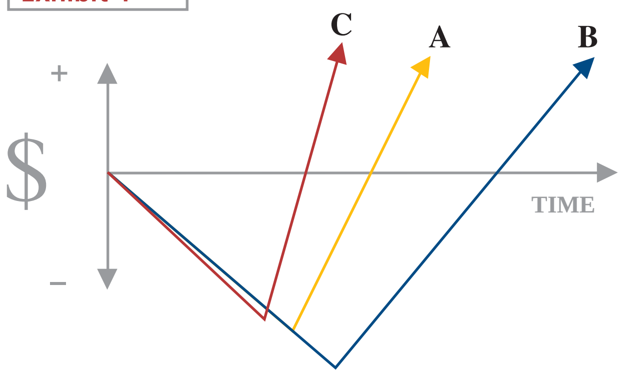


Exhibit 4



In the worst-case scenario, lack of attention to codes and standards early in the RD&D process leads to the creation of a product that, while manufactured and shipped for distribution, has little or no chance of being approved and accepted. In this case, the expenditure of money and resources continues over time, and management realizes—too late—that the technology is unacceptable and the investment has to be written off.

In exhibit 4, Scenario C depicts a resource investment to address codes and standards issues and highlights what can happen when codes, standards, testing, and product acceptance-related items are addressed in conjunction with RD&D. The availability of such a support infrastructure will facilitate widespread and timely acceptance of the technology. Instead of dealing with building regulations after the fact, as in Scenario B, they are addressed up front, and the building regulatory infrastructure is enhanced to readily accept the product.

As the graphs demonstrate, the development and implementation of a supportive building regulatory infrastructure, conducted in parallel with technology development, results in earlier sales and less resource investment than those expected or projected in the original business plan. The technology developer is encouraged to address these issues in conjunction with RD&D through technology acceptance planning. Technology acceptance planning supports the involvement of individuals familiar with codes, standards, product testing, certification, education, acceptance, and approval—as well as that of the building industry—during all phases of product research, development, demonstration, deployment, education, outreach, and subsequent cycles of product redesign. Relatively few resources are required for technology acceptance planning compared with other resources necessary to bring a product to market. That nominal investment in technology acceptance planning can reduce the manufacturer's total investment to bring the technology to market and enhance the manufacturer's overall rate of return by expediting acceptance and deployment of the new technology.

The following questions can help manufacturers determine if they need to increase their focus on technology acceptance planning:

- Do your business plans consider codes, standards, product approval, testing, certification, training of code officials, and other related activities?
- Do your business plans include the allocation of resources and time necessary to address building regulations?
- Are you driven to get the product to market as soon as possible at any cost?
- When addressing codes and standards is subsequently identified as being the critical path to success, who ends up solving the problem: marketing, finance, or engineering staff? Who pays for their efforts? How much time are they allocated?

Although this document focuses on building codes and standards, other criteria contained in legislation, regulations, insurance policies, utility tariffs, and other documents that address building construction and operation should be identified and addressed as part of technology acceptance planning.

LACK OF TECHNOLOGY ACCEPTANCE PLANNING

Exit from habitable rooms in homes is a vital issue in housing construction. When a door at grade level is unavailable—as is the case in many below-grade or basement areas—windows can provide an egress that may allow these spaces to be used as bedrooms.

The height from the floor to the bottom of the window and the width and height of the clear opening of the window are critical to the acceptance of a window assembly as a means of egress (and the subsequent use of a basement space as a bedroom). If a window manufacturer does not track changes to the code that modify the minimum acceptable dimensions for a basement or below-grade window, it will produce windows that do not meet the new codes. In this case, windows that were already manufactured could not be approved and would not be specified or sold.

Building Regulations, Standards, and Model Building Codes

Building Construction Regulations

Building construction regulations are the body of mandatory provisions that one must satisfy to construct, rehabilitate, operate, and maintain buildings and the products, systems, and equipment therein. These regulations affect the acceptability of new building technology in both new and existing buildings and the time and resources necessary to bring such technology to market. These regulations can also create opportunities for the development and use of new building technology to address issues such as accessibility, energy efficiency, sustainability, water conservation, air quality, and security.

Building regulations in the United States are based largely on standards and model codes developed and published by organizations in the private sector.[2] These documents—as part of a comprehensive set of building regulations covering building, mechanical, fire, electrical, plumbing, accessibility, energy-efficiency, and other issues—are adopted and enforced at the Federal, State, and local levels. These regulations protect public health, life-safety, and welfare, although as previously noted, legislation, regulations, codes, and other documents addressing issues outside the scope of building regulations can also affect technology acceptance.

The Federal Government does not mandate the development of building regulations or their adoption by State or local governments. The authority to develop, adopt, administer, and enforce building regulations has traditionally rested with the States. Some States, in turn, have delegated some or all of this authority to local governments. The Federal Government, however, has developed regulations over the years that govern the design and

[2] See "Standards" for a list of some of these organizations.

INTERNATIONAL CONSIDERATIONS

Understanding the international market is critical. The United States has its own unique way of developing, adopting, implementing, and enforcing building regulations. Knowledge of other countries' processes for developing standards and codes is crucial for producers exporting to or manufacturing in those countries.

Technology acceptance planning must consider the situation in each country when developing RD&D plans. Many countries develop and implement their own regulations and have unique conformity assessment requirements. Therefore, the activities of the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and other international standards developers must be considered. The American National Standards Institute helps coordinate U.S. involvement in ISO and IEC activities to ensure that U.S. interests are considered in the development of international standards.

construction of federally funded projects. Where authorized by law, Federal agencies have developed and implemented preemptive regulations, such as minimum energy-efficiency standards for certain consumer appliances and construction standards for manufactured housing. This is typically done when a multitude of differing State or local regulations could adversely affect a design or construction issue that is national in scope.

Standards

Standards are a key component of both model building codes and Federal regulations. For example, the inclusion of standards in model building codes provides a level playing field for materials within a generic product or technology area.

Standards are generally developed by those who have a vested interest in the deployment of a product or technology and think that there is a benefit to be gained by creating a standard. In most cases, the developer of a new technology or product will develop a prestandard or ask a testing agency to develop a bench standard to help the manufacturer identify what is required to show that its technology meets applicable health- and life-safety-related issues. To facilitate regulatory approval, the manufacturer can have its technology tested for compliance with this bench standard by a testing laboratory. The manufacturer can also provide the bench standard to a standards developer as the basis for a voluntary consensus standard. A voluntary consensus standard is a standard developed in the voluntary sector as opposed to the government sector. Consensus is defined as a general agreement by all interested and affected parties, but not necessarily unanimity.

Committees, subcommittees, or task groups composed of individuals with an interest in the product or technology typically develop voluntary consensus standards under the auspices of an organization that develops standards. Standards developers must ensure a balance of interests so that the standard, when approved, represents a consensus of all interested and affected parties. The process of developing a new standard for materials, testing, designs, products, and other areas or issues typically takes 2 or 3 years. In some cases development has taken more than 10 years because of technical issues, the need for additional research, or disagreement among those developing the standard. Published voluntary consensus standards are subject to periodic review and revision by the standards developing agency. The review and revision process for existing standards is similar to those for the development of new standards and includes development of needed revisions, public review and comment, and committee approval of the resultant revised standard.

U.S. organizations that develop standards for building products and construction include but are not limited to groups that generally use standards development procedures developed by the American National Standards Institute. These groups include but are not limited to the following:

- American Society for Testing and Materials (ASTM).
- American Society of Civil Engineers (ASCE).
- American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
- American Society of Mechanical Engineers (ASME).
- American Society of Sanitary Engineers (ASSE).
- Canadian Standards Association (CSA).
- Factory Mutual (FM).
- International Code Council (ICC).
- National Electrical Manufacturers Association (NEMA).
- National Fire Protection Association (NFPA).
- Underwriters Laboratories (UL).

Model Building Codes

Model building codes include enforceable technical and administration provisions, including references to standards, that can serve as a comprehensive set of building regulations. Model building codes include the national codes of the Building Officials and Code Administrators International (BOCA); the standard codes of the Southern Building Code Congress International (SBCCI); the uniform codes of the International Conference of Building Officials (ICBO); and the *One and Two Family Dwelling Code (OTFDC),* developed by the Council of American Building Officials.[3] In 1994 BOCA, ICBO, and SBCCI established the ICC. They ceased publication of their own model building codes and the *OTFDC* to concentrate on publication of the first edition of the ICC International Codes in 2000. The ICC currently is completing revisions to the International Codes that will be published in 2003. BOCA, ICBO, and SBCCI are consolidating their individual services—such as education, building-official certification, and product evaluation—under the ICC. These ICC efforts provide a comprehensive model code and supporting infrastructure to support Federal, State, and local building regulatory programs and the building industry.

A **prescriptive standard** prescribes the minimum criteria for a given type of material. For example, if a company wants to manufacture a load-bearing concrete masonry unit, it must show that the product complies with the requirements of the *American Society for Testing and Materials (ASTM) C 90 Specification for Loadbearing Concrete Masonry Units.*

Another type of standard is a **performance standard.** For example, to qualify a product for use as a fire-resistance rated assembly, a manufacturer must establish that the product has a given fire-resistance rating by testing the assembly in accordance with the criteria specified in *ASTM E 119 Standard Test Methods for Fire Tests of Building Construction and Materials.*

[3] The Council of American Building Officials, which became the ICC, was composed of BOCA, ICBO, and SBCCI.

A **direct prohibition** in a building regulation states that something is not allowed or is, through a requirement to do something else, prohibited by default. An **indirect prohibition** imposes requirements in such a way that what is proposed, although not directly prohibited, cannot be implemented. For instance, a requirement that a building product have certain fire-resistant characteristics would be an indirect prohibition if the product did not possess the necessary characteristics. Another example would be a requirement for a specific piping material that would not recognize a new piping material that could do the same job.

Standards and model building codes are written with existing products in mind and address known technologies and solutions to public safety issues in new and existing buildings. Because new technology development generally occurs before standards and model codes are developed and adopted, it is rare for the codes and standards infrastructure to be in place to support a new technology (or for any regulatory limitations or constraints that may inadvertently apply to a new technology to be eliminated) before the technology comes to market. Because of this time lag, building regulations may directly or indirectly preclude many new building technologies.

To remedy this situation, technology developers need to help develop new standards, change existing standards, and modify model codes. Participating in the process should increase technology developers' confidence that issues affecting their products have been addressed. The publication of these standards and model building codes creates a body of regulations that can be adopted and implemented to address the design, construction, renovation, operation, and maintenance of buildings in the interest of public health and life-safety.

Code Adoption

The Federal Government traditionally has undertaken adoption of building codes for certain Federal buildings and facilities. Some States have authority to adopt building codes that apply throughout the State. In the majority of cases in which there is a State-mandated code, code adoption and administration is legislatively granted to one or more agencies instead of being addressed directly by the legislature. Those agencies will, in turn, use their State regulatory process to adopt and administer the code. In States without such authority, the authority is delegated to the local government.

Today every State and almost every local government that adopts a building code has adopted one of the model building codes (BOCA National Codes, ICBO Uniform Codes, ICC International Codes, or SBCCI Standard Codes) as a basis for their building regulations. Some State and local agencies, however, amend these documents. Although their regulations may more appropriately address unique State or local situations, they can decrease the probability that a product meeting the model building codes can be readily accepted without some additional consideration of how State or local amendments would affect the product. This highlights the importance of participating in the development of standards and model codes as well as tracking State and local adoption of and amendments to those regulations.

When adopted, the model codes are law, and legal authority is granted for their implementation and enforcement as building regulations. The power to implement and enforce these regulations rests with the duly appointed code official or another authority having jurisdiction. Documenting compliance with these regulations rests with various private-sector entities—manufacturers, builders, designers, product specifiers, contractors, building owners, utilities, and others—involved in the design, construction, operation, and

Model codes typically contain three types of provisions that form the basis for approval: simple prescriptive, prescriptive based on testing or certification, and performance provisions.

A simple prescriptive provision—such as a requirement for a 24-inch-wide stair with a 7-inch riser and a 10-inch run—identifies exactly what is required. Compliance can be verified easily without additional data or documentation.

A prescriptive provision can also require testing and possible certification of continuing production. A requirement that a product have a specific property or perform in a certain way necessitates testing to determine the level of performance (e.g., thermal transmittance, flame spread, heat capacity, pullout resistance, and so forth) or compliance with a standard. Testing involves the independent determination that a specific product meets the provisions of a particular standard or performs in a manner pursuant to the provisions of a standard. Continual followup of production (e.g., certification and listing) would be needed to ensure ongoing conformance to the standard. An example is a requirement that a product, such as a water heater, be tested and listed as meeting a particular standard referenced in the code, or that a product performs in a specific manner based on a specified test standard, such as the one used to measure the flame spread of a material.

A performance provision is relevant when there are no specific provisions, standards, tests, or other criteria upon which to base approval. In those situations—which occur most often with new technology—testing, calculations, other data, and analysis are needed to document that what is proposed is no less safe or more hazardous than what is already specified in and allowed by the code. The model building codes provide for this path to compliance via their provisions for alternative materials and methods of construction. An example is the lack of specific code provisions for wood-plastic composite materials that are entering the market for certain decking, guardrail, and handrail applications. These products must be evaluated on the basis of their structural capacity, fire resistance, and resistance to the elements by comparing these characteristics with those of other products that are specified in and allowed by the codes.

Other types of performance criteria are those that establish a goal and objectives without necessarily prescribing how they are to be satisfied or even having a prescriptive solution as a baseline. Although there is generally much more freedom in developing design and production solutions that comply, documenting compliance and securing approval can be more challenging. Although not widely adopted in the United States, some codes and standards developers, including the ICC, have developed such documents.

use of the building and its systems. Responsibility for determining and adjudging compliance rests with code officials, fire marshals, or other authorities.

Code Compliance

The adoption of standards and model building codes by Federal, State, or local governments or other entities creates the need to document and verify compliance with the provisions. Demonstrating compliance generally falls on the building owner, who delegates relevant activities to the architect, engineer, builder, contractor, and others involved in building design and construction. They, in turn, rely on the manufacturer of the products to be used in the building to provide the necessary documentation to verify code compliance. All of these activities are included under the broader term *conformity assessment.*

Documentation that is needed to show compliance can include testing, certification, quality assurance, calculations, simulation, and other activities, all of which are intended to verify the degree to which the applicable standards and model building codes are satisfied. If the code provisions are simple and prescriptive provisions and compliance can be directly verified, no additional testing or documentation is needed unless the code requires certification that the product was manufactured to specific quality-assurance metrics such as a code requirement for dimensional lumber to meet a particular set of quality-assurance or ongoing inspection provisions.

Prescriptive code provisions can also rely on the provisions of a standard that requires testing—for example, satisfying specific fire or structural tests or meeting a particular product safety standard. In these situations, testing by an approved laboratory is required. The test results form the basis for initial acceptance of the product. Continuing compliance with the standard is based on inspections and possibly random testing of ongoing production at the plant by a third-party quality-assurance or inspection agency. If the product is in compliance, it is certified, labeled, and listed, eliminating the need for each enforcement agency to develop and conduct similar but duplicative activities.

Beyond prescriptive provisions, codes may not have specific provisions for a particular product or may be written in more performance-oriented language. Verifying code compliance in this situation is more difficult because the necessary metrics must be developed and then testing, certification, simulation, calculations, and other documentation must be provided to show the enforcement authority that the provisions of the adopted code have been satisfied. This situation is typically addressed through the development and issuance of a product evaluation report. Typically issued by an evaluation service, the report reviews the documentation provided by a manufacturer as evidence of the product's compliance with the model building codes. The service's findings can be used by Federal, State, and local officials when asked to approve the subject of the report.

Every product manufacturer must provide the necessary testing, certification, labeling, and other documents supporting code compliance. Code officials rely on this information, in part, to enforce the code.[4] Without this information it is difficult for code officials to approve the technology. Technologies that are more difficult to approve than others are less likely to be specified or used.

Code Enforcement

The code official, fire marshal, or other authority with jurisdiction is responsible for the enforcement of the adopted codes. Enforcement consists of:

- Reviewing construction documents, specifications, test data, evaluation reports, and so forth.
- Issuing construction permits.
- Inspecting buildings during construction.
- Issuing certificates of occupancy.
- Verifying that existing buildings continue to be maintained in a safe manner.

The responsibility for code enforcement varies from State to State and within both State and local governments. In some States, a State agency enforces the code for specific buildings (State-owned or university buildings) or specific issues such as plumbing or electrical. In States that adopt a statewide mandatory code but do not require all local governments to enforce the code, a State agency may assume responsibility for all enforcement activities. In other States, all local governments must enforce the statewide code, and the State supports their enforcement efforts. When a State

[4] Product users, such as architects, engineers, builders, contractors, and consumers, also rely on product manufacturers for this type of support.

does not adopt a statewide code, local governments are free to adopt a code as local conditions and resources warrant.

Although standards and model building codes are developed in the voluntary sector at the national level, they are generally adopted at the State or local level, although some Federal agencies also adopt them as part of their building regulations (e.g., Department of Defense adoption of the ICC International Building Code); or as part of their regulatory programs (e.g., reliance on certain standards by HUD in their regulations covering the construction of manufactured homes). As previously stated, during the adoption phase, States may amend the model codes upon which their regulations are to be based. The exact situation will vary from State to State. Building technology developers should be familiar with the administrative processes and technical requirements in each State in which they intend to do business.

Once a code has been adopted, a number of activities occur as part of the code enforcement process. During plan review, the plans and construction documents are reviewed to determine whether they are in compliance with the requirements of the code. Plan review typically applies to all types of construction and is specified in the scope of the enabling legislation or in the administrative section of the code.

As previously noted, the burden to document and prove compliance rests with the person requesting the construction permit, although the process involves several other entities, including the manufacturers of various building products and technologies, that the builder or specifier relies on heavily. In general, verifying compliance with simple prescriptive provisions is easy; verifying compliance in cases involving prescriptive provisions that require testing or certification may be more difficult. Those wanting to use alternative materials and methods of construction, which typically include new building technologies, must show compliance on the basis of performance equivalent to that required in the code.

The issuance of a construction permit is based on the plan review process. When compliance is verified, a building permit is issued. The permit grants the legal authority to undertake the intended construction. The inspection of construction for which a permit has been issued is intended to verify that work conforms to the approved plans and specifications and that code requirements are being met. The responsibility for verifying conformance is shared by the permit holder and those involved with the proposed construction such as the manufacturer or developer of the technology, who must document code compliance and then support users of its products as they specify and attempt to secure approval for the technology's use.

Educational Support

After testing, development of standards, and code development and adoption, a new building technology can be more readily approved. To ensure timelier acceptance and adoption of its products, the developer or proponent of the new technology should educate the building industry and the code communities about the correct use of the technology through field tests, educational programs, literature, and other mechanisms.

Because this infrastructure of codes and standards development, adoption, implementation, and enforcement exists and affects the acceptance and approval of building technology, the technology developer must develop a plan to facilitate technology acceptance. If technology acceptance issues are not addressed in parallel to RD&D, it will be difficult to secure timelier and less complicated technology approval. This, in turn, will affect technology acceptance by builders, architects, engineers, and others who must deal directly with building permitting and inspection and who

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Reuters Company News

BALLARD SAYS IT LEARNED FROM GENERATOR'S DELAYS

BURNABY, British Columbia, May 16 (Reuters)—Ballard Power Systems, Inc.'s chief executive said on Thursday the fuel cell maker has learned lessons from the delay in one of the first consumer products that will use its technology.

Ballard used its annual shareholders' meeting to show off for the first time a fuel cell-powered portable generator built by Sunbeam Corporation's Coleman Powermate unit, which the companies said they hope to get on the market "very soon."

Commercial production of the 1,000-watt generators had been expected to begin last year, but the first-of-its-kind product has been snagged by a number of delays, including U.S. regulatory approval of its fuel storage canister.

Firoz Rasul said Ballard knows now that it should have spent more time at the start of the process educating regulators about the basic technology, in which electricity is produced from hydrogen through a chemical process. "They understand the internal combustion engine, but this is something new," Rasul told reporters.

will experience difficulty in securing approval. Technology developers that shift that activity to the product specifiers and users—who may not have the time or resources to address technology acceptance issues—will find it more difficult to compete with technology developers that address these issues.

The following section describes how to develop and implement a technology acceptance plan that can increase the probability of successful technology deployment and business success.

Developing and Implementing a Technology Acceptance Plan

Codes and standards typically are developed in response to a health or life-safety need, although they also are developed to address issues such as environmental, durability, or energy-efficiency concerns. These documents generally trail technology development instead of anticipating the future and preceding the availability of the technology. Consequently, changes to and adoption of codes or standards to recognize the use of new materials or construction methods typically occur after the technology is developed and in the market. It is difficult for these documents to address new technology because they do not contain references to proprietary products. In addition, codes and standards typically do not specifically and prescriptively address products for which there is no industry standard. The key to securing new technology acceptance is developing and implementing a technology acceptance plan.

All innovators in new building technology must engage in the following activities to gain acceptance of its products. Once completed, these activities should be revisited, and enhancements or revisions to the technology should be identified and implemented.

- Identify existing codes and standards affecting the technology.
- Review and assess those documents and other regulations to identify problems or opportunities.
- Develop a rationale and supporting documentation showing that the technology complies with the intent of existing building regulations.
- Secure an evaluation report verifying the technology's compliance with relevant codes.
- Develop new standards or revise existing standards.

- Conduct research and prepare documentation in support of standards.
- Secure approval of standards.
- Conduct required conformity assessment activities.
- Revise codes and develop supporting documentation.
- Secure approval of revised codes.
- Develop informational materials that describe the technology and code compliance.
- Disseminate informational materials to code officials, builders, designers, and others.
- Monitor technology acceptance in the field.
- Conduct field research to shape the next version of the technology.

Exhibit 5, which includes these activities, lists and describes various activities in the RD&D process and the corresponding technology acceptance actions that the developer or proponent of a technology should consider. It can be used as a template for developing a technology acceptance plan.

Developing a plan that addresses the issues described in exhibit 5 and involves everyone in the implementation of the product's RD&D cycle will facilitate technology acceptance. Moreover, the technology acceptance plan will simultaneously generate an awareness of codes, standards, and product acceptance issues among all involved in product development and delivery. More important, it can reduce costs prior to market introduction and increase the probability of business success when the product is deployed.

Exhibit 5

Research, Development, and Deployment Activities and Technology Acceptance Planning

ACTIVITY	DESCRIPTION	TECHNOLOGY ACCEPTANCE PLANNING
Research		
Idea generation and brainstorming	Describe the vision of the technology, what it will accomplish, how it works, etc.	• Identify health and life-safety issues that may arise. • Identify relevant provisions in existing codes and standards. • Identify similar technologies in the market and how they are affected by codes and standards. • Determine what testing is required and what testing laboratories can perform the required tests. • Identify showstoppers that may limit the technology's deployment and acceptance. • Identify new or emerging issues that may create a demand for the technology.
Conceptualization	Begin to put "pencil to paper."	• Provide a summary of information gathered during brainstorming. • Verify that various product design or installation scenarios, as outlined, match the summary information. • Determine if there are any showstoppers. • Generate a list of changes that may be necessary to develop the technology concept or comply with codes and standards; identify areas for further research.

Exhibit 5 (cont.)

ACTIVITY	DESCRIPTION	TECHNOLOGY ACCEPTANCE PLANNING
Research (cont.)		
Business assessment and early investment development	Review the product's business potential, and start to garner internal or external financial support.	• Integrate the conceptual work into the business assessment process. • Identify codes and standards issues that may reduce the potential market for the product or increase costs associated with product development. • Determine whether codes and standards can support the application and use of the product. • Determine the costs of testing, quality assurance, certification, and other activities associated with technology approval. • Determine how long testing and certification will take and how to integrate that activity into the product development schedule.
Research and design	Begin to conduct research that will support product development, and initiate conceptual design work.	• Conduct testing and develop documentation that addresses the safety and performance of the product separately and in conjunction with any building systems and components with which it is intended to interact. • Use test results to guide further refinement of the product design or intended installation and application. • Begin to document conformance with codes and standards. • Begin to develop product-specific codes and standards. • Seek guidance and input from code officials and other regulatory authorities. • Seek support from the Partnership for Advancing Technologies in Housing (PATH) Technology Development Program.
Inhouse lab testing and validation	Conduct internal testing to confirm that product development can continue and that moving forward can pay off.	• Conduct testing to ensure that the product will satisfy life-safety and health concerns inherent in codes using existing standards or new standards under development. • Consider involving a third-party testing lab to validate the direction being taken. • Make product changes as necessary based on test results. • Make changes in installation and use scenarios based on test results. • Create a strategy to develop and realize codes and standards revisions if they appear warranted on the basis that testing indicates compliance with the general goals of the codes. (This can range from inhouse development and submittal of code revisions to the formation of an external task force that can work on several coordinated revisions.) • Conduct failure modes and effects analyses to support product validation, and identify needed redesign or changes in intended installation.

Exhibit 5 (cont.)

ACTIVITY	DESCRIPTION	TECHNOLOGY ACCEPTANCE PLANNING
Development		
Prototype	Develop, engineer, and build a working model of the product or building technology.	• Verify that the prototype meets the codes and standards provisions developed during testing and validation. • Document compliance with relevant codes and standards. • Identify necessary changes to the prototype or its intended installation based on codes and standards work. • Consider involvement of selected code officials, builders, and other key entities in a review of the prototype.
Field testing	Install the prototype, and gather data on its performance.	• Prepare a package of information that explains and documents code compliance. • Work with State and local agencies that are supportive of new technology to secure their approval of field-test prototypes. • Use the prototypes as code acceptance test beds or examples that can form a foundation of support for future product installations. • Communicate the field-test results to the building code community. • Adjust product acceptance strategies, design, etc., based on the field-test results.
Revisions	Revise the prototype based on field-test results.	• Adjust codes and standards work based on prototype field testing. • Adjust the prototype design or intended installation scenarios based on field testing.
Continued testing	Continue prototype testing leading to finalization of the product design.	• Continue work on codes and standards development, and use in parallel with additional prototype testing. • Begin to develop an acceptance package that presents and documents all the activities undertaken to address codes, standards, and acceptance issues.
Manufacturing process development	Design the process that will govern product production.	• Verify that the manufacturing process will not compromise product compliance with codes and standards. • Involve a quality-assurance agency that can oversee development of the manufacturing process to ensure that ongoing production will comply with relevant codes and standards provisions. • Document the manufacturing process and the manner in which it addresses quality-assurance issues.

Exhibit 5 (cont.)

ACTIVITY	DESCRIPTION	TECHNOLOGY ACCEPTANCE PLANNING
Development (cont.)		
Advanced investment and business organization	Develop product introduction, marketing, and deployment strategies.	• Work with inhouse business development and marketing interests to ensure that they are familiar with what is being done to address acceptance and can effectively integrate the results into their investment and business decisions. • Ensure that those making business decisions are aware of show-stoppers. Provide guidance on what may be necessary to take advantage of positive issues and address negative issues.
Institutional feasibility assessment and coordination	Review how product development and deployment will be integrated into the product developer's infrastructure.	• Integrate all efforts addressing codes and standards into the technology acceptance plan. • Ensure that all interests associated with the business are aware of codes and standards issues. Help them integrate and implement codes and standards issues into the technology acceptance plan.
Industrial Preparation		
Manufacturing processes	Determine how the product will be manufactured.	• Choose a test lab to test the product and a certification agency to list the product. • Develop a quality-control manual covering production of the product. • Involve a quality-assurance agency that can validate continued conformity to product standards.
Actual product manufacturing	Make the product.	• Implement a quality-control manual and monitor and enforce its application and use. • Retain a quality-assurance agency or product certification agency to conduct third-party production assessments.
Shipping and delivery	Label, package, and ship the product.	• Provide safeguards to ensure that the product is not adversely affected during shipping.
Development of customer support	Develop an infrastructure to support the product's sale, use, and service.	• Train service personnel about codes and product acceptance issues so they can effectively address them in the field. • Educate marketing, sales, and product distribution personnel about codes and approval issues so they can address them more effectively. • Get the product listed in the PATH Technology Inventory.

Exhibit 5 (cont.)

ACTIVITY	DESCRIPTION	TECHNOLOGY ACCEPTANCE PLANNING
Marketing		
Marketing materials	Develop and deploy the marketing message.	• Ensure marketing, installation instructions, and other communications materials adequately cover code issues and address the manner in which the product complies with codes and standards. • Direct communications materials to the appropriate places to yield the most impact. • Disseminate trademarks, logos, and other marks of approval to facilitate product approval and acceptance.
Sales staff and distributor education	Educate sales staff and distributor network about the product to ensure that they can support its successful deployment.	• Develop educational programs on the product—for internal and external audiences—that address code compliance and product acceptance issues. • Provide sales staff and distributors with copies of test reports, evaluations, listings, and other approval-relevant materials.
Field feedback	Secure information from the field, and make it available throughout the entire product RD&D infrastructure.	• Collect and evaluate field feedback on product performance, code acceptance, approvals, etc. • Ensure that information is available to guide future product development and modifications to current products. • Submit results for inclusion in PATH Field Evaluations and Demonstrations.

Conclusions

Building codes, standards, and regulations can affect new building technology in several ways. The development and implementation of regulations have established an infrastructure that must be addressed to effectively deploy new building technology. Technology developers and proponents are likely to expend significant effort to modify the infrastructure if they focus on it after a technology is developed and available in the market. Alternatively, they can engage in technology acceptance planning through the timely and parallel consideration of building construction regulations and technology development. Those that choose the latter are more likely to see a higher return on their investment in the new technology. The practice of technology acceptance planning can help ensure that the investment made in a new building technology is not in vain.

Additional Resources

For more information on the full technology development process, visit these Web sites:

American National Standards Institute
www.ansi.org

American Society for Testing and Materials
www.astm.org

American Society of Heating, Refrigerating, and Air-Conditioning Engineers
www.ashrae.org

American Society of Mechanical Engineers
www.asme.org

International Code Council
www.intlcode.org

National Conference of States on Building Codes and Standards
www.ncsbcs.org

National Evaluation Service
www.nateval.org

National Fire Protection Association
www.nfpa.org

National Institute of Building Sciences
www.nibs.org

National Institute of Standards and Technology
www.nist.gov

U.S. Department of Housing and Urban Development
www.pathnet.org
www.toolbase.org

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT