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ROADBLOCKS AND/OR OPPORTUNITIES TO TECHNOLOGY
TRANSFER

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BUILDING CONSTRUCTION REGULATIONS AND THE FUEL CELL: ROADBLOCKS AND/OR OPPORTUNITIES TO TECHNOLOGY TRANSFER

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Abstract

A significant amount of effort is underway to develop new technologies for the buildings sector. To be implemented in buildings, however, new technologies must meet a host of codes and standards, many of which vary from state to state. Technology development efforts frequently neglect an analysis of codes and standards until late in the development phase (typically just prior to commercialization) or even worse, not until after commercialization. Because of the time lag in either making necessary technology modifications to meet codes or updating codes to accommodate the new technology, such neglect often results in significant delays in new technology implementation. Under new circumstances, codes and standards can encourage the use of certain technologies, enhancing their market performance. Analysis of codes and standards should be undertaken as early as possible in the technology development phase, preferably in parallel to technology development so that requirements to meet codes and standards can be integrated into the technology as it is developed, and so that required codes and standards modifications can be initiated and perhaps finalized in anticipation of new technologies. Several codes and standards considerations must be assessed before fuel cells can be widely employed in the U.S. buildings sector.

Introduction

Building construction regulations (i.e., model codes, standards, regulations, ordinances, and so on) are developed, adopted, implemented, and enforced throughout the United States and the world. These regulations define what is and is not acceptable in building design, construction, and operation. Since the settling of North America over 300 years ago, provisions to regulate buildings have been a familiar part of the built environment.

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As problems associated with building safety and use have arisen, those regulations have evolved. Such evolution has consistently been time-intensive and has required a firm technical basis for change. Significant amounts of money may be involved in bringing new building technologies, products, and design practices from the research laboratory to the marketplace. The time needed to bring the technology to the marketplace directly impacts the business success associated with the technology. Because the regulatory evolution to address the new technology typically lags technology development and availability, significant time delays can occur before technologies are recognized and accommodated by the regulations and can be fully implemented in the built environment, adding to their costs.

For example, in 1984, development of a 40 kW phosphoric acid fuel cell power plant was being sponsored by the Gas Research Institute (GRI). Field test units had been manufactured and were being evaluated throughout the United States. It was found that although the technology had been reviewed from a product standard standpoint, no assessment of the unit in relation to building design and construction had been undertaken. From 1984 until 1986, an assessment of building codes and standards on the phosphoric acid fuel cell technology was undertaken (GRI, 1986). Thirty-six areas of concern were identified and analyzed, leading to revisions in the design, construction, and intended installation of the phosphoric acid fuel cell. This work was applied in the development of the 200 kW fuel cell power plant (GRI, 1986). It could have taken one to two years if this work not been undertaken additional years to ultimately bring an acceptable 200 kW fuel cell power plant to market.

A technology assessment in relation to building construction regulations early in the research phase of technology development can help minimize any need to redesign, delays associated with regulatory change, and other impacts such regulations might have on the technology when it finally comes to market. Such an assessment affords the technology an unencumbered, and potentially supported, introduction into the marketplace because issues associated with regulations have been identified and addressed in parallel to technology development, rather than in sequence.

A familiarity with the universe of building construction regulations is required to adequately perform such assessments. Areas for concern can be identified, isolated, and then addressed through redesign, further research, and/or revisions to the regulations. Each of these activities takes time. The sooner they are addressed in product research and development, the more quickly the technology can enter the marketplace undaunted. Ideally, regulations already recognize a new technology when it first enters the market, further establishing its credibility and need.

A case in point is the recent development of new refrigerants. Although developments have been under way for about 15 years and the new refrigerants have been commercially available for at least 5 years, their specific recognition in the building construction regulations in effect today in the United States is relatively limited. Standards and model codes are only now addressing the conditions for refrigerant acceptability. Another 5 years will likely be required for state and local codes to be updated and officials responsible for their administration to become familiar with their application.

The process of standards and model code development takes time, 5 years or more even under ideal conditions. Because state and local governments must then adopt these documents, another 5 years may go by before widespread acceptance of a new technology throughout the United States is actually realized in building construction regulations.

Building Construction Regulations

The process of development, adoption, administration, and enforcement of building construction regulations has an impact on new technology acceptance. To minimize adverse impacts and enhance positive impacts, one must understand this process and know how to integrate work on new technologies within it. In addition, the technical provisions in these regulations must be understood and their relationship to the technology identified and assessed. These requirements apply not only to the technology itself but to its installation in relation to other aspects of the building or facility design and operation. These regulations can provide roadblocks by adversely impacting the technology, or they can provide opportunities where the technology becomes a solution to a problem addressed by the regulations.

The regulatory process is briefly described here.

The term "building construction regulations" is intended to include all codes, standards, ordinances,

laws, and other injunctions that impact the design and construction of buildings and facilities and their associated systems and equipment. *Standards* typically apply to a narrow subject area or a particular product or set of testing requirements. *Codes* will reference standards as well as establish requirements for particular aspects of building design and construction. A standard for a fuel cell would govern the design, construction, and performance of the technology. A code would establish the criteria for its installation and integration into the building or facility.

Development of Standards

Standards are developed by numerous private sector organizations such as the American Society of Mechanical Engineers (ASME), Underwriters Laboratory (UL), and American Gas Association (AGA). A balanced committee of interested and affected parties typically drafts a new standard, or revisions to an existing standard, and circulates them for public review and comment. Subsequent to consideration of the comments received and revision of the draft, the standard is finalized, approved, and published. Anyone can participate in the development of such standards as a commentator and/or seek participation on the committee developing the standard.

In the case of a new technology, such as the fuel cell, standards may already be available and applicable to individual components such as wiring and piping. While these play a role in ensuring the performance and safety of fuel cell components, a standard covering the entire fuel cell and all its components as a system will foster product recognition and acceptance of the technology. This allows the entire unit to be evaluated and found acceptable for building applications. Development of such a standard is presently underway under the auspices of AGA.

Development of Model Codes

Model codes cover all aspects of building design and construction and are written to facilitate adoption and administration of building construction regulations by those wishing to regulate building design and construction. Rather than develop their own provisions, state and local governments, as well as federal agencies, generally rely on model codes.

Three major organizations in the United States develop and publish model codes covering building, mechanical, plumbing, fire, and other issues. The Building Officials and Code Administrators International (BOCA) publishes the National Codes. The International Conference of Building Officials

(ICBO) publishes the Uniform Codes. The Southern Building Code Congress International (SBCCI) publishes the Standard Codes. In addition the National Fire Protection Association (NFPA) publishes numerous documents which are related to fire and life safety.

These model codes are updated through the submittal of proposed changes by any interested and affected party. Although the procedures for model code development and revision vary slightly amongst the three model codes they all include publication of proposed changes, a public hearing at which time a disposition (approval, approval as revised, or disapproval) on each code change proposal is determined, and a second public hearing at which time a final disposition is made. Changes approved subsequent to the second public hearing are included in the model code. A new edition of each model code is published every three years. Depending upon when a code change enters this process it can take from about one and one half to four years or more until it is available in a new edition of the model code.

Standards are typically referenced within the model codes. For instance a standard applying to the design, construction, and performance of a fuel cell would be most appropriately referenced in a model mechanical code. Such a reference would likely be framed to require all fuel cells to meet the standard. The time to develop the standard would, therefore, also have to be considered in addition to the time to submit an gain approval of a code change to reference the standard in a model code.

The model codes do recognize that many new technologies may not have applicable standards or model code criteria to address their acceptance or appropriate application. For this reason the model code groups can conduct an individual evaluation of a technology to determine if the technology and its intended application meets the intent of the code. These evaluations must be reissued periodically and must still be recognized by state and local officials administering the code.

Adoption of Model Codes

The regulation of buildings design and construction and the equipment and materials in buildings and facilities is under the purview of many different entities. Unlike other countries, the United States has no national preemptive building design or construction regulation for buildings in which the fuel cell might be applied. Those wishing to regulate building design and construction look to the model code groups as the basis for their regulations.

For Federal buildings, the authority to regulate building design and construction rests with the agency responsible for the building, although there may be some overriding and preemptive Federal regulations that each agency must follow. Although adoption and use of voluntary sector standards and model codes by the Federal government has increased over the years, numerous unique Federal criteria are still applicable to building design and construction.

For state-owned and -funded construction, the responsible state agency (i.e., Education, Transportation, etc.) controls the applicable design and construction criteria. Most utilize voluntary sector codes and standards and include additional provisions deemed important.

In private construction, the state may have the authority to adopt preemptive building construction regulations that apply throughout the state. For commercial construction about half of the states have some authority along these lines. Where the state does not have preemptive authority, units of local government (counties, cities, townships, boroughs, etc.) are free to adopt regulations as they deem appropriate. The state or locality may also want to regulate noise, water quality, zoning, air quality, and other subject areas not typically addressed in the model codes.

Model codes and standards can be adopted by legislation or regulations. When adopted by legislation, they are typically adopted by reference, with the legislation specifying how they are to be administered and applied. Adoption by regulation occurs through a public process carried out by a regulatory agency that has been given such authority by the legislature. At the state level this authority typically rests with an agency such as the State Fire Marshal, Department of Insurance, Department of Community Affairs, or Building Commission. At the local level this authority typically rests with the county or city council.

The process of state or local adoption of a model code takes time. It can be automatic when the "latest edition" of the model code is referenced. In most instances, adoption at the state level will occur within 2 years of the publication of a new edition of a model code and at the local level within three years. Subsequent to adoption there is a period (typically six months) before the new code becomes effective.

Administration and Application of Regulations

After a code has been adopted, state or local officials will be responsible for its enforcement. Even though a new technology may be acceptable for installation under the regulations, it will still take some time for these officials to become familiar with the technology and its application. The more unique the technology, the longer it will take for these officials to achieve some degree of familiarity with it.

This adds time until the new technology has achieved widespread acceptance and is considered "routine" for building and facility applications.

New Technology Development

Bringing a new technology to market typically requires considerable expenditures of both time and resources. From the inception of the idea for the technology countless hours and investment dollars are spent on activities such as market research, proving the technology concept, research, field testing, engineering, and marketing. These other areas are outside the scope of this paper and are hence not further detailed.

The important point is this: as soon as the technology concept is proposed, the impacts of building construction regulations should be identified and reviewed. By paralleling related efforts with the technology development, steps can be taken to ensure that when the technology comes to market, it is not only unencumbered by building construction regulations, but also supported by those same regulations. These efforts fall into four basic areas: Technology Review, Identification of Building Construction Regulations, Compilation and Analysis of the Regulations, and Recommendations for Technology Redesign or Regulatory Revision.

Technology Review

Those intimately familiar with building construction regulations, including product standards, model codes, ordinances, and other documents that have a regulatory impact on the technology, must review the technology concept, specifications, reports, data, etc. available on the technology. From this review they gain an understanding of the goals associated with the technology development and are equipped to conduct further tasks. The sooner this is done in the conceptual stage, the more likely subsequent technology work and resource allocations can be effectively targeted, thereby enhancing the probability for success. From this review comes a list of major subject areas that must be considered.

This review also provides input to the other members of the technology development team and affords them the opportunity to begin thinking about the impacts associated with building construction regulations.

Identification of Building Construction Regulations

Based on the results of the technology review and identification of major subject areas, the provisions in building construction regulations that address those areas and specific issues must be identified. Because the majority of Federal, state, and local provisions find their basis in national standards and model codes, those documents and a few unique state and local documents form the universe for the review.

Compilation and Analysis of the Regulations

The provisions identified are compiled by issue or subject area and analyzed as to their impact on the technology. Such a determination may include a positive impact, where the provisions would foster the use of the technology, or a negative impact, where the provisions might present roadblocks to the technology. Such impacts can also be direct and indirect. A direct impact is one that has a specific and direct bearing on the acceptability of the technology. An indirect impact only imposes other provisions should the technology be used. For example, the prohibition of gas-powered equipment on the roof of a building would have a direct impact on the fuel cell. A requirement that a roof supporting gas-powered equipment have a 4 hour fire rating would have an indirect impact on a fuel cell. The latter requirement would not prohibit use of a fuel cell, but rather impose some additional provisions that could impact the cost associated with its use.

Recommendations for Technology Redesign or Regulatory Revision

Based on the results of the analysis, a determination is made that either: 1) the technology and/or its intended installation needs to be redesigned; 2) the technology and its intended application meets the intent of the regulations but those regulations need to be revised to specifically reference and recognize the technology; or 3) further research is needed before one of the above two situations can be determined.

Where appropriate, technology redesign and/or reapplication can be undertaken during the research

and development stage with the assurance that the field test, and ultimately the commercial product, meets the regulations. Where regulatory revision is suggested, that process can begin in parallel with technology development and hopefully result in acceptable regulations being developed, adopted, and available by the time that the technology comes to market.

Impacts on the Phosphoric Acid Fuel Cell Power Plant

A review of standards, model codes, and regulatory provisions found that several issues will have to be addressed before Phosphoric Acid Fuel Cell (PAFC) power plant installations can proceed on a widespread basis. These are delineated below. When applied to an existing versus new building, additional complications may surface because the existing building may need additional modifications that might not be necessary if "in-kind" equipment, as opposed to the fuel cell, were used. Depending on the nature of the consideration, it may provide a fuel cell with advantages, disadvantages, or no impact relative to alternative technologies in terms of the installation. Some considerations, among others, are listed below for fuel cells. They are grouped as to impact (positive or negative) and if that impact is direct or indirect. It is recognized that some of these issues are being addressed, however, some are shown as having a negative impact on the basis that if not addressed they would pose a problem for the acceptance of phosphoric acid fuel cells.

Issues with Direct Positive Impact

- Where emission regulations exist, the fuel cell will have to comply. Based on the favorable emissions characteristics of the PACF, continued passage of emissions regulations will likely provide a direct advantage to their application.
- Since standby power systems are required for certain buildings by most codes, the PACF provides an opportunity to eliminate the need for a standby power generator and on-site fuel supply.

Issues with Direct Negative Impact

- Testing, listing, and certification of various components of the PACF, as well as for the overall system will be required. It will be advantageous to develop a standard for the

entire PACF for use in testing, listing, and certification.

- The storage, use, and potential for leakage of phosphoric acid will impose additional requirements. These are especially important when considering floor drains and neutralization of the acid before introduction into the building drainage or storm sewer system.
- Assurance that the PACF is not classified as processing natural gas, which could lead to the application of additional regulatory provisions.

Issues with Indirect Positive Impact

- Where a basis for comparison to other technologies exists in energy standards and codes, the high efficiency of the PACF may be recognized and used to an advantage.

Issues with Indirect Negative Impact

- Where the installation is located outdoors, the design must consider wind and snow loads and the impact of other environmental conditions on the unit. These should be addressed in the standard for the equipment.
- The utilization of waste heat from the PACF raises issues such as cross connections to potable water systems, piping systems, insulations, etc. Depending upon temperatures and pressures, certain provisions applicable to boilers may also be applicable.
- Depending upon state or local regulations, the fuel input rate of the PACF may classify it as a boiler, subjecting the installation to requirements for a licensed boiler or generator operator that otherwise would not apply to the building.
- The use of nitrogen associated with the PACF could necessitate compliance with additional ventilation requirements.
- Connections to other building services such as gas, electric, ventilation/exhaust, and water supply and drains must be addressed.

- Depending upon location, potential damage from seismic activity, vehicle impact, and building fires will have to be addressed. These issues will have a direct bearing on the advantages of particular installation locations.
- The weight of the PACF must be considered, especially where supported by the building.
- Assurance that any makeup water connections are protected from cross connections. Depending upon the need for makeup water, a permanent connection to a water supply could be required.
- Classification of the exhaust system, and required construction materials and location.
- Requirement for the remote cooling tower to be of non-combustible construction and specified distances from ignition sources.
- Requirements for safety relief discharge temperatures, their piping, and location.
- Requirement for separation of the cabinet ventilation system on the gas side of the PACF from the electric side.

Conclusions

Issues in standards, model codes, and regulations that must be addressed before fuel cells can be implemented on a large scale in buildings applications. These are ideally addressed as early as possible in the development of a technology.

In the short term, each fuel cell installation will have to be considered on an individual basis by the state or local officials having jurisdiction over the site. Availability of an overall test standard for the fuel cell and installation instructions that address the above issues in concert with recognized standards and model codes will help facilitate approval. In the long term, additional provisions should be included in the model codes to specifically address the installation of the fuel cell and other advanced energy system technologies within buildings and facilities.

In addition, increased consideration of fuel cells can be encouraged through recognition of fuel cells in codes and standards that provide specific details for the installation of fuel cells and allow for a comparison of their advantages relative to alternative technologies. These might include, among others, installations favoring low emissions characteristics, installations where reliable backup power supplies are required, or installations where the energy use advantages of the technology can be used.

The sooner the impacts of codes and standards on fuel cell (or other advanced technology) installations in buildings are considered, the greater the opportunity for mitigating or avoiding adverse impacts on the technology while enhancing or even developing new positive impacts.

References

Gas Research Institute 1986. Fuel Cell Technology in Relation of Building Codes and Standards. Chicago, IL.

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