Providing Vision and Leadership for the Future of the HVAC and Sheet Metal Industry

THE HVAC AND SHEET METAL INDUSTRY FUTURES STUDY

INDUSTRY TRENDS AND DRIVERS SHAPING ALTERNATIVE FUTURES

NEW HORIZONS FOUNDATION
A Chance to Grow
An HVAC and Sheet Metal Industry Initiative™

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INDUSTRY TRENDS AND DRIVERS SHAPING ALTERNATIVE FUTURES

2008 Prepared By:

FMI

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"People always overestimate how much will change in the next three years and they underestimate how much will change in the next 10 years." – Bill Gates

1 EXECUTIVE SUMMARY

NHF is to be congratulated for taking the leadership role in helping define the future of the HVAC industry. While absolute certainty regarding the future can never be predicted, the results of this study will provide the foundation for more informed discussions and planning by the industry's stakeholders and their respective organizations. Now the hard work begins with the task of interpreting these findings, determining the potential implications for the HVAC and sheet metal industry, and developing the appropriate action plans to prepare for the future. By stimulating these discussions, NHF has provided a valuable planning platform and tool for the industry's stakeholders' collective benefit and use.

The outlook for unprecedented change within the HVAC industry is certain; the specific state of the HVAC industry in 2018 is, however, far from certain. Through this futures study, FMI, with strong support from the NHF Task Force and other industry stakeholders, has secured input for this "future state."

The cornerstone factors driving change in the industry—sustainability, globalization, work force, and technology—are explored in the Key Findings and other sections of this document. This report shows that the expectation from the NHF HVAC Futures Advisory Group is for rapid growth in the demand for HVAC services. The combination of code creation and compliance, performance issues related to energy costs, the sustainability movement, and consumer preference will align to create this significant market demand for HVAC services.

A few of the more significant expectations for the HVAC industry of 2018 include the following:

- Residential and nonresidential building will become heavily focused on energy conservation, sustainability issues, and "green" (environmentally friendly) construction. All these factors create opportunity for leading HVAC contractors and suppliers.
- The demand for retrofit and service work will grow at an unprecedented pace to meet the future building performance expectations and to serve an ever-growing supply of building inventory.
- Building Information Modeling (BIM), Building Information Systems, Lean[1] management, and other productivity tools will be required to successfully compete in the HVAC market of 2018.

[1] Principles of Lean Thinking and Lean management are presented in *Thinking Lean—Implementing a Methodology for Decreasing Costs and Increasing Profits*, a study funded by NHF and published in 2008.

- The emerging trade of energy/environmental specialists is expected to be a highly desired discipline in the future, with a requirement for a highly skilled work force to meet future demand.

With this enormous opportunity comes the challenge of choice and focus. Individual contractors and suppliers, labor organizations, trade associations, and other industry organizations will be required to clearly target the markets where they choose to participate. For example, the residential market has long been a declining market for contractors and union labor. *Will the new market dynamics provide the impetus for getting reengaged in this market?* In addition, new technology such as photovoltaic (PV) energy systems will be in demand for residential and nonresidential buildings. *Will this become a mainstay for the HVAC contractor or abdicated to the other trades?* The emergence of the energy/environmental specialist will be seen particularly in the nonresidential market. *Can the HVAC industry quickly mobilize to lead and control this market?*

To position the HVAC industry for future success, these are just a few of the decisions that will likely result from the industry's planning efforts. To successfully compete in the HVAC world of 2018 will require thoughtful consideration of these potential market changes and a careful challenge of the industry's current direction and strategy. FMI and NHF encourage industry stakeholders to begin this planning process now to capitalize on these opportunities.

2 INTRODUCTION

Rapid change and uncertainty in the United States (U.S.) heating, ventilation, and air conditioning (HVAC) and sheet metal contracting industry will be driven by a variety of factors—economic fluctuations, environmental issues, regulatory shifts, labor shortages, competition, and technological advancements. To increase the understanding about factors influencing the business and to gain greater clarity for the future of the industry and its constituents, the New Horizons Foundation (NHF), an HVAC and sheet metal industry initiative, contracted with FMI Corporation to study industry trends and fundamental drivers that will shape the HVAC and construction industries and to document its findings in this report.

The objective of this initiative was to research and analyze potential industry trends that may materially affect the HVAC business and its stakeholders over a 5- to 10-year horizon. While trends identified over the 5-year horizon are largely a continuation of current trends, as FMI projects those out further into the future, it develops several scenarios that could have a great impact on the industry of the future. The identification of trends and drivers captured in these scenarios will enable the HVAC and sheet metal industry to better position the business to contend with, and capitalize on, threats and opportunities; gain greater clarity of the future for the HVAC industry; and enable organizations to adopt long-term plans to manage change. Specifically, this project

- Identified factors and potential scenarios that will define the HVAC and sheet metal industry over the course of the next 10 years;
- Provided industry perspectives as to what the HVAC and sheet metal industry will look like in 2018; and
- Projected the potential future state of the industry.

While the future state of the HVAC and sheet metal industry is full of uncertainty, the identification of trends will enable the industry stakeholders to create a strategy to adapt and capitalize on the changing marketplace. Within this study, several key areas are identified as critical influencers contributing to the changing dynamics of the HVAC industry, namely, the availability of labor, shifting regulations, economic conditions, and increasing global pressures. The intent of the study is to identify the *potential* future state of the industry. It is not to be considered the absolute, quantifiable industry outlook. Industry stakeholders are encouraged to use the information contained in this study for their planning purposes and for developing strategies to prepare for industry changes.

3 KEY FINDINGS – THE HVAC FUTURE IN 2018

The next decade in the building industry and, in particular, the HVAC industry promises to bring enormous change for industry stakeholders. The intent of this study is to develop a picture or, in some cases, several pictures of what the industry will look like in 10 years. Many of the thoughts and findings will be obvious outcomes, while some suggestions will be discounted as "never going to happen in our industry." *The findings outlined represent the collective thinking of more than 80 people in the industry, coupled with primary and secondary research by the FMI project staff.* The findings are not positioned as "fact" and a definitive portrayal of the future of the HVAC industry, but rather as an informed look at what "could be," based on the input FMI received from the study participants.

Four primary factors, shown in Figure 1, will drive the HVAC industry of the future: sustainability, globalization, work force, and technology. These factors have helped to frame the input provided by the HVAC Futures Advisory Group on this project.

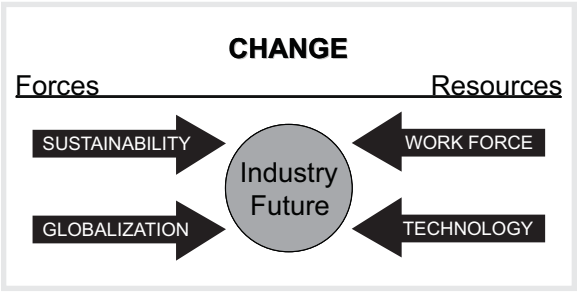

Figure 1: Primary Factors Driving the HVAC Industry of the Future

From all indications, the industry will undergo radical change and is poised to realize unprecedented growth and opportunity. This future demand will be performance-driven, code-driven, and consumer preference-driven, and it will represent a unique confluence of factors that will result in enormous levels of HVAC work, albeit work that may be different from today's work.

To better understand the potential industry future, FMI looked at the built environment (residential and nonresidential) of 2018 as well as the business environment of 2018. Again, the findings presented represent opinions on the future state of the industry. It is possible to look back at a number of years and evaluate the predictive and forecasting skills of the many stakeholders involved in this effort. Some of the expected and, perhaps, not-so-expected findings are presented below.

3.1 Nonresidential Building

- The major nonresidential markets are expected to realize modest growth with the *health care, education, and power-related markets deemed to have the greatest upside.* One major market that may experience a downturn is the traditional commercial office market with more and more telecommuting/office-at-home workers expected in 2018. Also, a modest decline is expected in the industrial market with more and more manufacturing done offshore.

- Like the residential market, *much of the building activity will take place in the Sunbelt and occur in urban areas.* Drivers include energy costs, weather, employee preference, and perceptions regarding quality of life.

- *By 2018 Building Information Modeling will have become standard operating procedure* on virtually all mid-size to large projects. The BIM movement was initially led by the owners, then moved to the larger construction managers/general contractors, and then permeated the entire building process. Significant cost savings will be realized through BIM, and any contractor doing new construction and/or large renovation work must be BIM-proficient to survive.

- *Everywhere one looks in the industry, the color is green; it will have become an accepted, and even required, industry practice*. Although green building is somewhat amorphous today, it will be a well-defined practice that will be understood and ingrained in the way business is done in 2018. Owners, design professionals, contractors, labor, suppliers, and various industry support organizations will have internal and external programs to become more green in virtually all of their functions.

- Of all the opportunities in the nonresidential building market, the *retrofit market is expected to grow at the fastest pace*. This is particularly true for the HVAC market with a tailwind provided by energy management; indoor air quality (IAQ); testing, adjusting, and balancing (TAB); commissioning; and related work. Again, the combination of performance requirements, code requirements, and owner preference should guarantee a vibrant retrofit business for many years.

3.2 Residential Building

- Despite the current downturn in the residential market, *all indications are that this market will continue to be strong* in future years. The demographics are such that demand for residential building should remain in the 1.6 million to 2.0 million units per year range in the next decade.

- *A large shift is expected in the mix of single-family (SF) units versus multifamily (MF) units*. The MF growth will be fueled by a variety of factors, including the desire to live closer to work, the high cost of SF units, retirees moving to urban areas, greater demand for assisted living, and other factors. This creates a different type of residential structure with different building and HVAC requirements.

- *Growth will continue in the Sunbelt for both SF and MF units*. This growth follows job creation and population growth and continues a long-standing migratory trend.

- The *average size of both SF and MF structures is expected to decline in terms of square feet*. This would reverse a long trend to increase the dwelling size and is driven by the belief that building costs will significantly increase due to material escalation and land costs as well as code- and compliance-driven cost increases.

- For both SF and MF building, *a desire and preference for performance will take precedence over cosmetic appearance*. Consumers (homeowners, apartment owners and tenants, etc.) are expected to be highly concerned about issues such as green, sustainability, energy costs, and codes, and they will be willing to pay for performance at the expense of amenities (granite countertops, etc.).

- *Increased efficiency in the building process will result through such tools as BIM*. Most of the study participants believe that these efficiencies are required to help moderate the cost increases and will result through the numerous improvement opportunities available in residential building; BIM is one of a number of improvement tools expected to be used in residential building.

- *High expectations exist for remodeling, renovations, and retrofit work* in the residential market, both SF and MF. Again, code-driven, performance-driven, consumer-driven opportunities will be staggering, particularly for trades such as the HVAC and electrical contractors.

- The general sentiment from the HVAC Futures Advisory Group was that *the residential market will become even more nonunion*. The apparent inference is that the union work practices, wage scales, and lack of focus will contribute to the ongoing share decline for all trades.

3.3 Business Environment

3.3.1 Market Dynamics

- *A much more consolidated industry is expected to exist in the future* as mergers continue through both vertical and horizontal consolidation. The demographics of the current business owners and a move for perceived economies of scale will drive consolidation for all industry stakeholders. The private equity market will continue to provide exit opportunities for HVAC business owners.

- *New competitors in the HVAC contracting business are expected to emerge over the next decade*. Of particular note is the expectation that utilities will reenter the HVAC market via acquisitions and will be positioned to "own their market" in the sense that they would own, monitor, and maintain the HVAC system in a leaseback-type situation, primarily in the residential market. In addition, it is believed that several HVAC manufacturers will become contractors via acquisitions to control their destiny in the market. And, last, home centers and other suppliers are expected to become more influential in the residential market.

- In the nonresidential market, *larger HVAC firms are expected to expand to full mechanicals (even mechanical/electrical/plumbing (MEP))* to be better positioned to partner with the larger construction managers/general contractors and program managers. This expansion of services is driven by the construction managers'/general contractors' desire to partner with fewer, larger, mission-critical trade contractors as well as the blending of trades that occurs through BIM technology and a need for enhanced efficiency in project delivery.

- Most participants in this study expect that *globalization is inevitable in the HVAC industry*. Examples of this globalization include the emergence of large non-U.S. suppliers entering the market. The outsourcing of labor by the equipment manufacturers is already evident, and even the contractor is expected to outsource engineering services and duct fabrication.

- *Larger HVAC contractors are expected to enter the design market* in an effort to remain a

value-added entity in the nonresidential building process. Many believe that failure to do so will relegate the remaining firms to a second-tier role in the market and more of a commodity position.

3.3.2 Work Force Environment

- *Tomorrow's labor, both in the field and in the office, will be different from today's and will require different recruitment, training, development, and retention*; failure to do so will severely limit growth in the industry. We've all heard the story and seen the statistics on the composition of the future work force; by the year 2018, we'll be able to see the new work force as well.

- *The HVAC industry has a severe image problem that will be extremely difficult to overcome*. It is almost impossible to be attractive to potential new workers when key stakeholders in the industry do not believe that the industry is attractive for new workers.

- Even with the current residential downturn, *a labor shortage in the HVAC industry exists that will continue to grow through 2018*. This shortage applies to trained labor required to meet the accelerated HVAC demand of the future. Developing and controlling trained labor (not necessarily the most training, but rather the most appropriate training) will create success for both the contractor and labor.

- *The old model of "one-size-fits-all" training will become a relic of the past*. The many different HVAC applications require different skills, significantly different training, different people, and a different reward system to remain successful. *A more flexible just-in-time training model will exist to enhance efficiency, and a culture more oriented to "pay-for-performance" will evolve.*

- *It is expected that a number of factors will occur to at least partially mitigate this perceived labor shortage*. The outsourcing of labor (e.g., offshore fabrication), modularization/panelization (e.g., factory-type building), and productivity improvement tools (e.g., pre-job planning, BIM, etc.) will likely reduce the current labor intensity of HVAC work in both the residential and nonresidential markets.

- *Labor unions in the building industry are expected to decline without reorganization, consolidation, and repurposing*. The expectation is that fewer, larger multitrade labor organizations that have fewer work rules and jurisdiction guidelines will exist in the future. It is generally felt that, without these changes, labor unions will lose significant influence and even more market share.

- *Union strength and geographic market positioning is severely misaligned today* and will be radically different for the surviving organizations. To be successful, unions must have a real presence in those markets where growth is occurring and buildings are being built; the Sunbelt is the obvious target market.

- *The union membership of the successful trade union in 2018 will represent the demographics of the work force*; women and minorities will be well represented for any union that expects to be a real factor in the market.

- *Labor unions are expected to have a more tiered structure* in the sense that there will be different skill requirements (ranging

from duct installers to environment/energy controls technicians) that necessitate different training (length and type) and different compensation levels. An ongoing skills matrix-manpower requirement forecasting system will enable the labor resources to best match market demand.

- The expectation exists that in the HVAC industry *a number of labor niches will require targeting to be successful*. Some of these niches have existed for years (e.g., TAB), some are emerging (e.g., IAQ, commissioning, etc.) and some are in the early stages of development. The union needs to be purposeful and flexible to meet emerging market needs, such as the PV energy market, or risk losing the market to other trades.

3.3.3 Technology Issues

- Participating *stakeholders in the study universally believe that breakthrough technology* will exist in 2018. Much of the input pointed to more complex, but easier to install, equipment as the expected equipment of the future. This belief is driven primarily by the perception that *there will be very high energy costs and a shortage of trained labor*.

- In addition to BIM, the development of *the Building Information Systems (BIS) discipline will emerge as a new tool for improving building performance* of the future. By capturing performance results, future design will incorporate these learnings to create even greater operational efficiency as well as occupant comfort and safety. *At this point, no group or trade is clearly expected to control this discipline*.

- Although unfulfilled expectations have existed for years, *there is a belief that various forms of factory-built construction (ranging from manufactured housing to modularization and panelization)* will increase in an effort to enhance efficiency and reduce the labor intensity in construction. As it relates to HVAC, more prefabricated wall assemblies are expected, including ductwork that snaps in place at the site with sophisticated duct sealing systems.

3.4 The HVAC Contractor of 2018

- The relatively homogeneous market of today with many fabrication-installation firms is expected to be replaced by a *highly niche-oriented market*. It is expected that, in an effort to become more focused to meet market demand, HVAC contractors will gravitate to one of these models.

  - ***Large, Full-Service, Design-Oriented Firms:*** These firms will become the preferred source on larger project work, both new and retrofit, and will work with the mega-general contractors in an alliance-type relationship. Some of these top-tier contractors will serve as full mechanicals and as MEPs on major nonresidential work.

  - ***Installation-Only Firms:*** These firms will install duct and equipment on residential and/or nonresidential work, be a subcontractor to the mechanical or MEP in the nonresidential market, and deal directly with the builder on residential work. The orientation will be more of a labor broker with a focus on productivity and cost control.

- ***Fabrication-Only Firms:*** These firms will become the major source for duct fabrication and will often sell directly to the owner, general contractor, or other buying entities. Plans will often be provided directly to the fabricator with no involvement by the installing contractor; BIM and other tools will frequently be used in this process.

- ***Energy/Environmental Specialists:*** These firms will become the sought-after technical specialists that understand energy management, sustainability, IAQ, TAB, commissioning, and the myriad of niche specialties provided by the HVAC contractor of today, including service. It is expected that these firms will also include new disciplines such as PV and other alternative energy controls systems; monitoring, service, and systems remediation will be managed by these firms. These firms will be, in effect, the general contractors of the buildings' energy and environment.

- ***Niche Specialties:*** These firms will be smaller firms providing support to energy/environmental specialists and working independently on small project work. Some firms will be focused on specialty residential applications and residential service, but many will focus on the nonresidential market.

- The successful HVAC contractor in 2018 is expected to be *more focused, more sophisticated, and more productive* than the contractors of today. Lean, BIM, and other business improvement, productivity-oriented tools will be embraced and will be commonly employed by the HVAC contractor of the future.

- The *expected leaders within the HVAC contracting community are expected to be leaders in energy management/green building/ sustainability practices*. This expertise will provide these firms with the opportunity to be on the front-end, value-creation side as opposed to the back-end, commodity side of the value chain. The firms will have project managers certified at the highest levels of Leadership in Energy and Environmental Design (LEED) existing in 2018 who will be writing the standards for future certification levels.

- The *expected leaders within the HVAC contracting community will develop "intelligence" as a core competence*. Whether it is technical intelligence as it relates to new equipment and systems, labor intelligence as it relates to attracting and retaining key people, or cultural intelligence as it relates to the future multilingual work force, this core competence typifies the successful HVAC organization of the future.

Each group of stakeholders (contractors, manufacturers, labor and trade organizations, etc.) is encouraged to evaluate, challenge, and apply these findings, as appropriate, as it builds its strategies for moving forward.

4 RESEARCH STUDY METHODOLOGY – OVERVIEW

A number of future studies methodologies have been used for this study including focus groups, forums driven by experts in the industry, trend extrapolation, scenario analysis, Delphi polls, and other planning tools. The use of the scenario planning process to identify the potential industry conditions that have a high likelihood of occurring, as well as factors that are more dependent on uncontrolled variables, enables researchers to establish key events that will shape the future. By tracking the determinants of the dependent variables and associated conditions, the industry will be better prepared to respond to areas of dynamic and continuing change.

The process and methodology outlined in Figure 2 was the strategy employed and designed to identify issues that are most likely to have the greatest impact on the HVAC industry over the next 10 years through 2018. The study was separated into four tasks, involving the HVAC Futures Advisory Group, NHF Task Force, and FMI. An overview of the project methodology is highlighted below; additional detail on the methodology is included in a later section of this report.

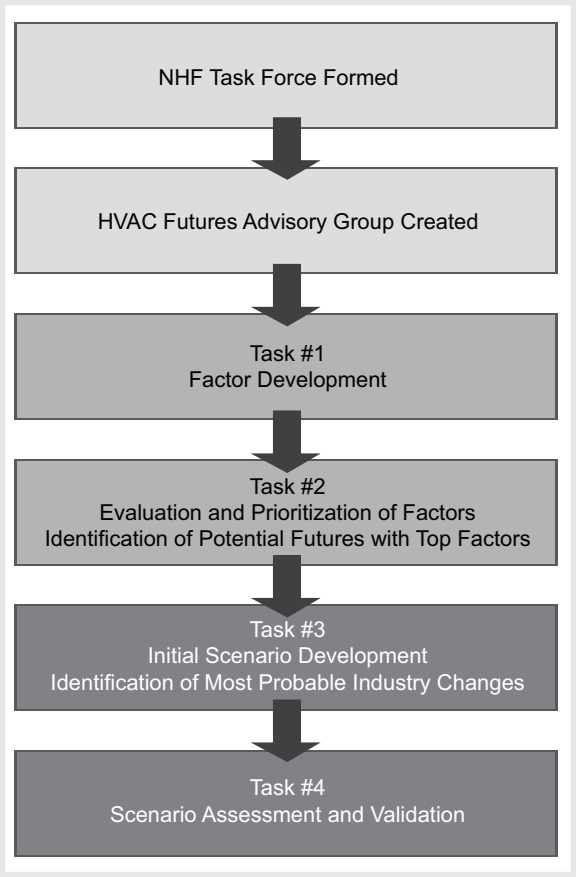

Figure 2: HVAC Futures Study Process and Methodology

5 EXPECTED INDUSTRY FUTURE

5.1 Introduction

This section presents a collection of industry and subject matter leaders' opinions of how the HVAC industry and its immediate driving forces are likely to look during the next 10 years. The views for the future are organized into the following major subsections:

A. Nonresidential Market

B. Residential Market

C. The HVAC Contractor of 2018

D. Changes in the Business Environment

E. HVAC Equipment of the Future

5.2 Preface

Besides the external factors that will be the primary drivers of change in the HVAC industry, there is a fundamental, and completely unpredictable, factor that is internal to the industry and will be an overarching determinant of how the industry looks in 2018—the rate at which contractors in general and HVAC contractors specifically choose to adopt innovations. Historically, contractors have been very conservative and risk-averse due to the potential losses they face if a new approach or technology were to fail in a crucial area. However, the pace of change, particularly in building science and technology, is most likely to accelerate, and the pressures imposed from labor constraints and energy costs will provide significant rewards to those who can successfully adopt the new technologies.

To the extent that some technologies and building methods are developed and proven in other countries, any reluctance to adopt the new approaches here in the U.S. will very likely result in a greater threat from foreign competitors. An example of a very likely competitor to enter the U.S. market is Toyota. This firm has been building homes in Japan and could partner with Japanese manufacturers of building products, such as Panasonic's HVAC division, to minimize their individual risk while at the same time creating a very large and powerful team.

5.3 A. Nonresidential Market

Introduction

This subsection summarizes the industry's leaders' expectations of how the nonresidential building market will develop during the next 10 years. These expectations are organized into the following contexts:

1. Shifts in the Level of Demand
2. Shifts in Where Nonresidential Buildings Will Be Located
3. Shifts in How Nonresidential Buildings Will Look and Perform
4. Shifts in How Buildings of the Future Will Be Built

Shifts in the Level of Demand

5.3.1 Market Overview

Pressures are expected to temper demand. Expectations for the demand for new nonresidential construction in 2018 appear to be, for the most part, rather modest compared to recent years. A primary suppressant is expected to be the challenging economy and the cost of labor, due to shortages, that will result in making many projects economically infeasible. In addition, many expect the trend to work from home to continue to build, which will reduce the need for commercial office buildings. Some believe that fewer nonresidential buildings will be needed in a more green and energy-efficient marketplace. Reluctance to build will be greater still if there is a significant amount of social unrest related to terrorism or a severe economic downturn.

5.3.2 Institutional Market

Institutional Demand in General: An underlying assumption is that the demand for institutional construction will be heavily dependent on the condition of the U.S. economy, government funding, and the availability of sufficient, and sufficiently skilled, labor. Two subsectors specifically mentioned in this study are health care and education.

Health Care: Driven by the aging population, there should be a continuing strong demand for health care facilities. Due to the generally predictable aging rates of the population and the relationship between aging and health care needs, this expectation is relatively solid. Projections for hospitals, outpatient clinics, and long-term care facilities remain strong. For a variety of reasons, this market is expected to be a "sweet spot" for the HVAC industry.

Education: The demand for educational buildings will be affected by the decline in the population of younger age groups. In contrast, the demand for educational buildings will increase if the rate of immigration continues and the family sizes and/or birth rates of those who immigrate are significantly greater than the norm. The future of immigration policy presents an area of uncertainty in our look at the future and will need ongoing monitoring, as it has a significant impact on a number of industry issues.

5.3.3 Industrial Market

Industrial Demand in General: Similar to the institutional market, the industrial market demand is dependent on the condition of the U.S. economy and the availability of sufficient, skilled labor. A perspective for a softening in the industrial market assumes a weak U.S. economy and low labor availability. Such conditions could result in industrial demand even below the current (2007) level of demand. A perspective for a strong industrial market assumes that the economies

Projections for hospitals, outpatient clinics, and long-term care facilities remain strong. For a variety of reasons, this market is expected to be a "sweet spot" for the HVAC industry.

of Asia and Europe will be performing well, even if the U.S. economy softens due to high regulatory demands and an insufficient labor pool. The rationale behind this is that U.S. corporations with "local" production facilities and plants, and particularly those who export their U.S.-made products, will continue to update their facilities in order to complete in the global markets.

One industrial subsector specifically mentioned in this study is the power generation market, which is expected to do well.

Power Plants: Given the strong relationship between energy production and global warming, there may be a strong drive for the construction of new power plants that produce dramatically fewer greenhouse gases (GHGs), many of which may be based on alternative energy sources, such as solar, wind, geothermal, and algae. There is also an increased interest in construction of additional nuclear power plants as well as cleaner coal-based facilities. Due to the lengthy permitting process, this expected growth in nuclear plants will not be seen for a number of years. In addition to the expected increase in demand for new power plants, it is also expected that there will be considerable demand for renovating many of the existing power plants. Furthermore, an echo effect from the construction and renovation of power plants will be an increase in the demand for construction of facilities that manufacture the components used to build power plants.

5.3.4 Commercial Market

In the commercial market, the HVAC industry could possibly experience a serious "one-two punch" if the fallout from the subprime mortgage crisis spreads as far as some predict and the effect lingers for a number of years. A protracted decline in the residential market could extend deeply into the commercial markets. In addition, the continued trend to work from home, possibly increasing as a way to diminish traveling and related production of GHGs, will have a negative impact on the nonresidential market in general, but particularly for the construction of office buildings.

5.3.5 Nonresidential Service-Related Demand for HVAC

Renovation: Regardless of the degree of regulations and the amount of labor availability, there are high expectations that there will be a considerable amount of renovation/retrofit work of older, less-efficient buildings. The need for improved energy efficiency, building sustainability, and meeting IAQ standards will drive this demand, and the demand will be greater to the extent that the regulations are more demanding and well-enforced. The current trend of the demand for renovation/retrofit work being greater than that for new installations will accelerate.

Given the strong relationship between energy production and global warming, there may be a strong drive for the construction of new power plants that produce dramatically fewer greenhouse gases (GHGs).

Commissioning, Maintenance, and Service: Along with the expected high level of demand for renovation/retrofit work is a similar expectation for a high level of demand for service and related work. Most industry experts believe that there will be a greater demand for services (either independently or in combination with renovation/retrofit work) than for new installations. Of the 35 questions about the likelihood of future outcomes, a strong demand for the technical side of the HVAC business (service, TAB, commissioning, and certifications) was the most widely agreed to outcome, with the vast majority of respondents believing that this outcome is likely or very likely, as shown in Figure 3.

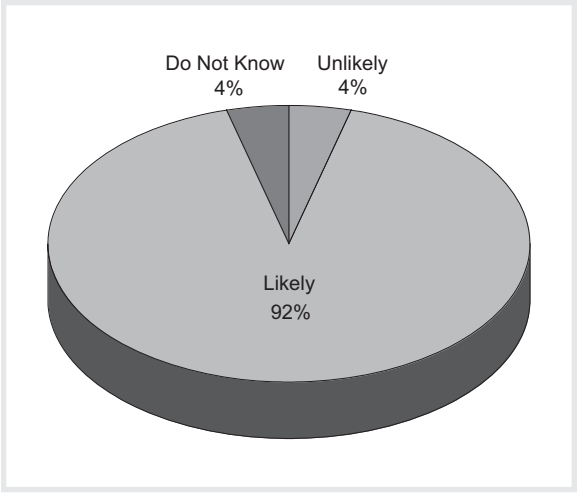

Figure 3: Demand Will Increase for Service, TAB, Commissioning, and Certifications

Shifts in Where Nonresidential Buildings Will Be Located

5.3.6 Geographic Shifts Will Follow Those of the Residential Market

In general, the expected pattern of demand for nonresidential buildings, geographically, is the same as that for the residential market—a shift from rural and suburban to urban and urban-suburban, and a shift from north to south.

5.3.7 Energy-Centric Locations

Another driving force for where communities and related nonresidential construction will flourish in the future is based on the availability of renewable energy. This concept is a model based on what social economist Jeremy Rifkin and others call the Third Industrial Revolution. In this model, the next generation of communities will be located in areas that have a large amount of renewable energy, such as geothermal and wind, as well as solar to some extent.

Shifts in How Nonresidential Buildings Will Look and Perform

5.3.8 Potential for Revolutionary Change

Due to the drivers of the increasing cost of traditional energy, the expected new regulations related to minimizing GHGs, and increasing pressures to minimize water usage and waste production, buildings a decade from now are expected to have dramatically different equipment for managing the functions related to these issues. As one industry stakeholder put it, "Environmental considerations [will have] completely changed the face of nonresidential HVAC."

It is impossible to quantify how fast and how widespread any particular change will be, but there is no doubt that a significant number of the nonresidential buildings constructed in 2018 and beyond will be different in the ways outlined below. The most overarching category of change will be sustainability.

"Environmental considerations [will have] completely changed the face of nonresidential HVAC."

5.3.9 Sustainability

The move to become sustainable and green in construction has led to a wide array of building products claiming to be green: concrete, copper, plastics, asphalt, steel, lumber, and virtually every other building product. There appears to be a race for who can be the most green. Being green has benefits that go far beyond the original intentions of reducing a building's carbon footprint—public relations benefits as being a good corporate citizen, higher-quality employee recruitment, and better retention of those hired, and ultimately an improved return on investment due to lowered operating and maintenance costs as well as increased employee productivity. Recent interviews with owners, indicate that almost all new construction will have some level of certification, LEED or otherwise, of sustainability. Government agencies and private universities are among those leading the way, as comments from survey interviews with owners demonstrate:

> "Experience in LEED is important; it would not deter us from choosing a contractor but, if the experience is not there, it can lead to nightmare situations. It speaks to the contractor's credibility and is in line with our goal of achieving sustainability."

> "Our policy now is that everything will be built using LEED practices, even if not all are certified. We seek certification occasionally. We don't make it a qualification with contractors, but most contractors have LEED-accredited professionals on staff. It is here, and we are doing it. We are kind of going LEED lite, seek accreditation on larger, over $10M, projects."

During the next 10 years, many feel that almost all the major changes in the built environment will relate, in one way or another, to sustainability. In general, the concept of sustainability includes all the ways that a structure (as well as the construction processes in the building of a structure) affects the natural environment, including energy usage, air quality, water usage, and waste management. Although the definition of terms like "green" and "sustainability" is still unsettled, by 2018 we expect that currently nebulous definitions will become detailed specifications requiring qualified builders to perform the work on all new or renovation projects.

During the next 10 years, many feel that almost all the major changes in the built environment will relate, in one way or another, to sustainability.

Figure 4 shows major areas of concern for LEED certification.

1. Energy System Performance
2. Refrigerant Management
3. On-Site Renewable Energy
4. Green Power
5. IAQ System Performance
6. Tobacco Smoke Control
7. Outdoor Air-Delivery Monitoring
8. Increased Ventilation
9. Low-Emitting Materials: Adhesives and Sealants, Paints and Coatings, Carpet Systems, Composite Wood and Agrifiber Products
10. Indoor Chemical and Pollutant Source Control
11. Controllability of Systems: Lighting, Thermal Comfort
12. Thermal Comfort: Design, Verification
13. Elimination/Extreme Minimization of Landscape Irrigation
14. Reduced Demand for Potable Water for Non-Irrigation Purposes
15. Reduced Generation of Wastewater
16. Increased Local Aquifer Recharge

(**USGBC Web site**: *"Rating System Guidelines for New Construction")*

Figure 4: Major Areas of LEED Prerequisites and Credits for Energy Usage, Indoor Atmosphere, Environmental Quality, Water Usage, and Wastewater Management

On-Site Power Production: One of the major changes in the buildings of 2018 will be self-production of energy. Most, if not all, the buildings constructed at that time will have the capability of producing at least some of the electrical energy they require for lighting, running manufacturing equipment, and operating office equipment (e.g., computers, printers, copiers, etc.). Frequent use of PV energy systems is expected in future building systems.

Alternative HVAC and Advanced IAQ Systems: Many smaller buildings will meet their HVAC needs using geoexchange-based systems (geothermal heat pumps), while commercial and institutional buildings are most likely to employ advanced electronic and nanotechnologies that enable temperature and IAQ management for individual rooms and hallways. IAQ systems will be sensitive to and eradicate mold and germs (particularly in hospitals) as well as other unhealthy or deadly biological contaminants that could enter buildings accidentally or by acts of terrorism.

Intelligent Buildings: Most, if not all, new buildings are likely to be "intelligent," with all MEP functions as well as security, computer/information technology (IT), and telephone systems designed and installed in an integrated manner that is monitored at a central location, which in many cases will be off the premises. The predesigned, integrated basis of these systems will enable monitoring and controlling of all the building's functions, making the setup, commissioning, monitoring, and diagnostic work logistically much easier and faster, reducing the delay time caused by startup problems and reducing the costs of ongoing maintenance. Widespread use of sensing units will virtually eliminate the need to manually override settings.

5.3.10 Pace of Change and Potentially Negative Outcomes

Potential for the Change to Sustainability to Be Slow: It seems realistic to believe that only dire conditions would significantly suppress the expected revolution in sustainability-based building. The regulatory process could get bogged down and/or enforcement of stringent regulations could be lax, but, given the current momentum of social and legislative efforts, these outcomes appear to be wild cards, with very low levels of probability to occur. However, some in the industry believe that the clients' demands for better IAQ and comfort, along with the need for greater energy efficiency, are potentially conflicting goals.

Potentially a Lower Quality of Construction: There are concerns that, if a significant shortage in the labor supply develops in the nonresidential market, labor will be used that has insufficient skills and that the amount of training needed would not be able to occur quickly enough to meet demand. The result would be that the cost of construction would increase and, at the same time, the quality of construction could actually decrease. If the use of labor outsourcing increases too quickly, the industry would not be able to provide sufficient training or have the necessary supervision skills to enable the new work force to produce a quality product.

Shift in How Buildings of the Future Will Be Built

The topics presented in this section focus on the methods and processes involved in the construction of nonresidential buildings of 2018. Topics related to the critical area of labor are included in a subsequent section of this report.

5.3.11 New Delivery Methods

Some believe that improvements in delivery methods will be forced on the industry. Consistent desires for improved productivity and efficiency will likely drive the usage of new delivery methods. Design-build, design-build-own-manage, and European-like public-private partnerships involving build-own-operate will be employed outside the usual applications of infrastructure projects and will begin to be used for buildings such as sports facilities and other public facilities.

Among the drivers of change in delivery methods is the owner's desire to increase the level of collaboration on projects, thereby providing a team effort that not only reduces risk for all parties, but also improves efficiency and time to completion. Owners are becoming more dependent on the use of construction management and program management to oversee their projects or construction programs. The confrontational atmosphere set up by low-bid delivery

Among the drivers of change in delivery methods is the owner's desire to increase the level of collaboration on projects, thereby providing a team effort that not only reduces risk for all parties, but also improves efficiency and time to completion.

methods, where contractors often seek to make up for low bids with change-order charges, has become unworkable for many owners, especially on larger, more complex projects in the private sector. As in the increasing use of BIM technologies discussed in this report, owners are seeking more input from contractors and subcontractors in earlier stages of the project including predesign. The goal for the future would be to assemble a team for each project, all working to mutual benefit. (Reference: *FMI/CMAA [Contract Management Association of America] Survey(s) of Owners, 2005 through 2007*.)

5.3.12 Green Construction Practices

High Demand for Green Construction Practices: As noted earlier in this report, the demand for green construction and the use of green construction methods, including demands for reductions in energy consumption, water usage, and production of waste, will be considerably greater in 2018. Being green is as much about the greenness of the construction process as it is about the greenness of the constructed building. According to FMI's 2008 U.S. *Markets Construction Overview*, construction industry stakeholders are increasingly recognizing green building capabilities as "good"—and being a necessary part of a firm's best practices. FMI estimates green nonresidential construction put in place was $13.4 billion in 2006, and, by 2008, $21.2 billion of all new nonresidential construction will employ green building principles. An estimate for the growth in the green building materials market, which has been growing at a rate of 23 percent annually through 2006, is that growth will slow to 17 percent in 2011.[2]

For FMI's *Nonresidential Construction Index* (NRCI), 1st quarter, 2008 survey, FMI asked executives of nonresidential building firms how much of their backlogs were currently considered green construction and how the green construction trend was affecting their businesses or markets. The NRCI panelists expect that, in five years, 38 percent of their backlogs will be green construction (see Figure 5).

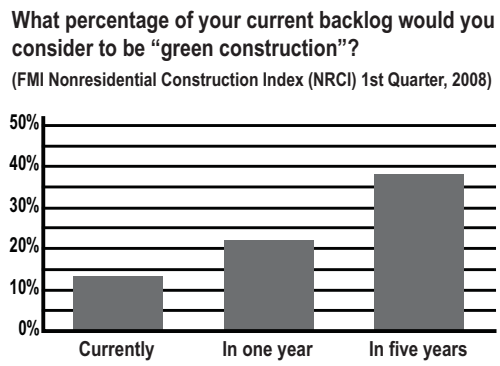

Figure 5: Projected Green Construction (Nonresidential)

The NRCI panelists expect that, in five years, 38 percent of their backlogs will be green construction. Most respondents expect significant growth in this area with a few noting that it may be helping their business.

[2] *State of Green Business 2008*, 2008 Greener World Media, Inc.; www.greenbiz.com; citing report by the Sustainable Business Institute (SBI).

Most respondents expect significant growth in this area with a few noting that it may be helping their business. While a couple of respondents think this green thing is a passing fad, a number of comments indicate that owners are asking for green solutions in their Requests for Quotations; however, most owners aren't yet prepared to pay the extra cost. Nonetheless, contractors are scrambling to get their people LEED-certified and to become more intelligent on green construction practices. In some cases, not having an understanding of green technology may mean not being considered for the project. At this point, we think it is safe to say that the green revolution is here and will have a significant impact on the industry and the built environment in the next five years and well into the future. The following are some selected comments from the survey concerning green construction:

- "All federal owners are mandated to meet LEED standards."
- "Green considerations are driving the basis for power projects; we expect nuclear will resurface as a major part of the portfolio. Green construction in facility design, material selections, construction-generated waste, etc., is impacting all project execution decisions."
- "Green construction is becoming more important. We are now working in preconstruction on LEED-accredited projects."
- "Green is now part of the business. All markets will 'go green' in time. This trend has no effect on our ability to identify and get work as we are tuned in to 'green.'"
- "Hot topic to the point of an unreasonable fad. Owners are requesting green with no idea what they are asking for. Designers are pushing green as a marketing tool, seeking to win awards regardless of project impact. Green will have a long-term positive impact if the industry starts using the concept correctly."
- "It is just picking up steam in Indiana over the past year and is on a rapid growth pace."
- "It seems to be a consideration for almost every project. There still is a lot of ignorance and confusion in the marketplace. Cost misconceptions are the primary issue."
- "Questions about it are raised in almost every interview. A year ago, it was rarely brought up. We are getting [project managers] PMs certified at this time."
- "We are seeing more private developers having an interest in green construction. We have a major push on to get more associates LEED-certified."
- "We have changed the vehicles we drive, and all our people now have to get 20 [miles per gallon] mpg. We are lowering idle times thinking in terms of carbon footprint now."
- "Raising awareness about sustainable products and procedures has had a positive effect. Still trying to find out the products and practices that are truly effective."
- "Mainly with systems such as geothermal or PV-solar energy. And the type of

materials utilized and how to recycle trash and waste."

- "We are in the Portland, Oregon, market. This market has led the country and the world in sustainable design and construction. We spend a significant amount of training and marketing resources to develop expertise and differentiate ourselves. Fifty percent of our professionals are LEED-accredited."

In 2008 the three largest segments for nonresidential construction green building—office, education, and health care—will account for more than 80 percent of total nonresidential green construction. Other segments such as lodging and commercial are also experiencing green construction growth, with a 20 percent gain expected from 2007 to 2008.[3]

5.3.13 Drivers of Demand for Green Construction Practices

Intrinsic Demand of Owners in General: As noted by the organization GreenBiz, rapid growth in the materials for green construction is being driven by owner/occupants looking to be more sustainable, have cleaner air, and reduce energy usage. "These groups are now considering energy efficiency, indoor air quality, and other measures of sustainability fundamental to occupying homes and offices."[4] In particular, many owners of owner-occupied structures see having a green building as an added perquisite for attracting the younger-generation workers who are expected to be more green-oriented than prior generations. For owner-occupied and "spec-built" (structures built on speculation), the owners will also expect that the green features will make the buildings more valuable as real estate assets and more attractive to tenants.

Desires for Government Buildings: As the largest owner and operator of buildings, the U.S. government has the ability to exert tremendous influence over practices in the construction industry. Currently, more and more municipalities, states, and Canadian provinces are making increasingly high levels of LEED certification mandatory for their new structures. By 2018 it is likely that this trend will have thoroughly swept both the U.S. and Canada.

Desires of Private Owners: Some see the current and future growth in demand for system efficiency being driven by the building owner's desire to be green as a corporate responsibility, particularly in the case of owner-occupied buildings. As long as these efforts prove profitable, it is likely that the

In particular, many owners of owner-occupied structures see having a green building as an added perquisite for attracting the younger-generation workers who are expected to be more green-oriented than prior generations.

[3] FMI's 2008 U.S. Markets *Construction Overview*, p. 13.
[4] *State of Green Business 2008*, 2008 Greener World Media, Inc.; www.greenbiz.com; citing report by SBI.

organic demand will continue to thrive. In situations where the financial viability does not occur, governments are likely to offer incentives and/or put in place specific regulations. Another impetus may be that owners will require buildings to be built more efficiently and with high levels of energy savings because they will maintain ownership longer. Another expectation is that the foreign, multinational businesses that have had sustainable buildings built for them in other parts of the world will demand the same high-performance green buildings and green building services in the U.S. These large firms are seeking the same business advantages for their U.S. buildings that they are realizing in the rest of the world.

High Energy Prices: An additional driver of the demand for improved energy efficiency will be the cost of energy. In the case of owner-occupied structures, building owners will be looking for cost savings in the near term. In the case of spec-built structures, building owners will be looking for lower utility bills and improved comfort of tenants, thus raising the value of the property and allowing higher rents.

Building Codes and Regulations: In the first five months of 2007, more than 100 green building bills were introduced at the state level.[5] Many states have adopted sustainability requirements for all their new government-funded construction projects.[6] Governments have also implemented economic incentives in the form of tax rebates and credits, density bonuses, and other policies such as expedited permitting and approval for green projects.[7]

Building codes are likely to move more toward LEED and force new and retrofit construction to be increasingly energy efficient and increasingly sustainable. Expectations for how the regulations will evolve during the next decade are presented in more detail below in the subsection titled *Environment-Focused Regulations.*

5.3.14 Preplanning and BIM

Preplanning and BIM go hand-in-hand, as it is easy to expect that these new software technologies, especially with their ability to "info-relate" all the involved trades, will provide far superior planning of jobs to that usually performed currently.

Preplanning: With the expectation that the market will be increasingly competitive, it follows that there will also be an increase in the focus on fulfilling the owner's needs and objectives, which is an initial piece in the preplanning process. An additional part of an improved preplanning process will include detailed scheduling, with an expectation of increased usage of building intelligence systems for increasing the energy

Many states have adopted sustainability requirements for all their new government-funded construction projects.

[5] FMI's 2008 *U.S. Markets Construction Overview.*
[6] Ibid.
[7] Ibid.

efficiency of operations. Training for the installers for these new type of buildings is expected to require a tremendous amount of preplanning, especially in the HVAC design and construction process.

BIM: The use of BIM software such as Revit and other three-dimensional (3D) computer-aided design (CAD) software will become standard practice for building design and design of HVAC systems. Owners expect that BIM will provide long-term cost savings and are increasingly requesting BIM functionality. Table 1 lists benefits that BIM solutions provide. Owner expectations are that a BIM-designed building will reduce the estimated 4 percent to 10 percent of original building costs that owners spend each year on managing and maintaining their buildings.

Benefits That BIM Solutions Provide (Scale: 1=strongly disagree; 5=strongly agree*)		
	All Respondents	**BIM Users**
Improved communication and collaboration among project participants	4.2	4.4
Higher-quality project execution and decision-making	4.1	4.2
More comprehensive planning and scheduling	4.0	4.1
Greater assurance of project archival	4.0	4.1
Easier-to-achieve process standardization	3.9	4.1
Higher-quality construction results	3.9	4.0
More reliable compliance with specification and regulations	3.7	3.9
More consistent performance against project budget	3.7	3.8
Greater productivity from labor and assets	3.7	3.8
Broader strategic perspective and innovation	3.6	3.8
Significantly reduced change orders/claims	3.6	3.7
Decreased labor costs	3.5	3.6
Measurable reduced contingencies	3.5	3.5
Other	3.3	3.8
Improved safety performance	3.3	3.3
Competitive advantage in recruiting and staffing	3.2	3.3

Table 1: Benefits that BIM Solutions Provide
**FMI/CMAA Eighth Annual Survey of Owners*

BIM software packages will enable the preplanning process to include the complete preconstruction modeling of the HVAC system. The more advanced software packages will likely enable simulated testing of the entire HVAC system, allowing the owner to test its theoretical operation under many conditions. In some cases, it is expected that the HVAC system will need to be modeled and "tested" before the system will even be sold to the building's owner.

Improved communication and collaboration tops the list of benefits that owners are realizing or expect to realize using BIM technology. By 2018 the benefits of BIM use should be understood and realized throughout the industry. (*FMI/CMAA Eighth Annual Survey of Owners*)

While many in the industry are increasingly aware of BIM's 3D design capabilities, there are also 4D and 5D platforms that include the additional dimensions of costs and time-to-construct. These advanced programs provide immediate estimates for the costs and timing related to desired changes either before construction starts or during the construction process.

BIM tools will be used throughout the construction and commissioning process, further ensuring improved efficiency and proper installations through minimized changes and mistakes, as well as improved operational performance of the building's systems. However, the plans developed through the BIM process will not sit idly after completion of construction. The information about how the building operates, which will be contained within the BIM program, will also be an integral part of a continuous improvement process for the building's operation and the design of future buildings. As the software and hardware systems become more developed, BIM and BIS (Building Intelligence System) will integrate. The monitoring and maintenance knowledge gained through BIS will provide knowledge to improve future building designs.

One of the many hurdles that BIM will have to surmount to reach full potential in the next decade is the question of interoperability. It is projected that $15.8 billion is lost annually by U.S. capital facilities as a result of inadequate interoperability due to the highly fragmented nature of the industry, continued use of antiquated business practices, lack of standardization, and inconsistent application of technology adoption.[8] However, BIM software developers appear to be aware of this problem and striving to build interoperability into the software from the start.

Whereas owners are the current driver for the increased demand for BIM usage, the

BIM tools will be used throughout the construction and commissioning process, further ensuring improved efficiency and proper installations through minimized changes and mistakes, as well as improved operational performance of the building's systems.

[8] National Institute of Standards and Technology. Report: Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry (http://www.bfrl.nist.gov/oae/oae.html).

architectural community is currently the largest user of BIM technology. Many expect that general contractors will take over the lead-user position by 2020, as more general contractors evolve into construction managers and as more owners desire a one-stop, all-in-one service rather than separate companies for design and construction. Potentially slowing the adoption rate is a fear that some have—that BIM will cause a schism in the industry between those who adopt BIM and those who choose not to. Figure 6 shows a gradual increase in the number of BIM users.

Currently, BIM software is estimated to operate at only 30 percent to 50 percent of total capacity, leaving significant opportunities for increased utilization. At full utilization, productivity increases are expected to be 7 percent to 15 percent, while decreasing the time of delivery by 40 percent. Estimates indicate 10 percent to 20 percent acceleration in schedules with BIM.

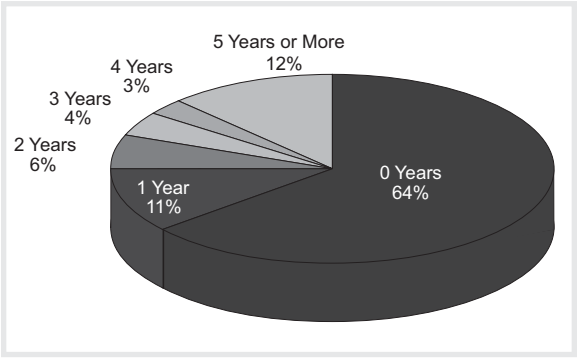

Figure 6: Years Using BIM (FMI/CMAA Eighth Annual Survey of Owners)

According to the results of the FMI/CMAA Eighth Annual Survey of Owners (2007), owners are just beginning to realize the benefits of BIM technology. By 2018, the experience level of current users will mature, and current nonusers will adapt the technology at an increasingly rapid pace.

5.3.15 Prefabrication and Modularization

The growth of prefabrication and modularization applied to nonresidential construction is likely due to labor shortages, and these off-site building methods will play an increasing role in nonresidential construction. Prefabrication can range from its simplest form of modular building assemblies (such as complete wall assemblies) to assemblies of several modular building sections to a completed structure delivered with final assembly done on site. Some expect that a significant number of the prefabricated components will soon be made in offshore locations.

Traditional expectations are that usage of prefabrication for nonresidential construction will be most frequently applied to schools, hotels, and similar types of construction, which in many cases can more easily reuse a single design. An example of this method's viability for construction in the industrial sector is seen in the Swedish company Pharmadule and its successful modularized approach for the biopharmaceutical industry.

Pharmadule builds production facilities for pharmaceutical and biotech companies worldwide. The construction is based on a modular concept that allows it to build the whole facility—the actual building with all the internal components, including piping, HVAC,

and anything else that goes into a complex manufactured building—inside a factory. Instead of construction being completed on a commercial site or in the field, it builds the facilities just as Boeing builds a 747. The results of the in-factory processes are building components referred to as modules. One module is roughly four times the size of a standard shipping container. A complete manufactured building can range from two to three modules for a small building and up to 200 to 300 modules for a large building. The largest project completed at Pharmadule's facilities is a 200,000-square-foot biotech facility constructed for Eli Lilly in Puerto Rico.

On a smaller scale and more specific to HVAC, in consideration of the need for improved efficiency and reduced usage of materials that require significant amounts of energy in their manufacturing, very non-traditional, and as yet unavailable, materials such as highly rigid cardboard that has been coated and/or impregnated with moisture barriers and flame retardants may begin to be introduced into the manufacture of ducting. The cardboard would be made from 100 percent recycled materials. With the advanced manufacturing processes currently in place for cardboard box creation, it may be possible to design systems of ducts to be flat and easily transported to the site, where they are unfolded for installation. The efficient design for transportation would make such a product far more feasible for offshore manufacturing.

5.3.16 Job Site Activities

Increased Efficiency/Productivity: The job site of 2018 will be considerably more efficient than that of today. Labor shortages and the rising cost of materials and fuel, as well as the rising pressure on owners to reduce the time to market, will be primary drivers for this change. Schedule compression will be accomplished with expanded use of BIM, just-in-time procurement practices, and the use of prefabricated building modules. Project management and supervision will become more professional and rigorous to the point that a construction project rivals a modern manufacturing assembly line. Within the decade, the goal to make construction less an art and more of a science using advanced management techniques will be largely accomplished for all commercial construction.

Pharmadule: Biotech Goes Modular

Pharmadule has two fabrication sites, one in Sweden and one in Estonia. Whereas the facility in Sweden was chosen by default, since that was where the founders lived, the choice of Estonia for the second facility was based partially on the comparatively low cost of labor, but more importantly, for high-quality mechanical work for which the country is known. In addition, Estonia is close to Stockholm, where the company is headquartered. By building in only two factories rather than in many locations around the world, Pharmadule has great success training and retaining people in its shops. The

The job site of 2018 will be considerably more efficient than that of today.

workers can be trained more quickly, and, once an employee is trained, he/she is able to stay on for job after job, even though the buildings will end up in various spots across the globe. Compared to the typical approach where a contractor recruits a local work force for each job, trains the workers, and then waits years before being able to use them again, if they are still available, the centralized location of the prefabrication method provides a much more stable and productive work force.

Pharmadule (from an as yet unpublished FMI article for the FMI *Quarterly*)

5.4 B. Residential Market

Introduction

This subsection summarizes the industry's leaders' expectations of how the residential building market will develop during the next 10 years. These expectations are organized into the following contexts:

1. Shifts in the Level of Demand for Residential Buildings
2. Shifts in Where People Will Live in the Future
3. Shifts in How Residences of the Future Will Look and Perform
4. Shifts in How Residences of the Future Will Be Built

5.4.1 Shifts in the Level of Demand for Residential Buildings

The typical homebuyer of 2018 will struggle with an even more difficult decision-making process than he/she has faced in past years. In addition to the usual trade-offs of cost, location, and level of luxuries, the complex issues of IAQ, energy efficiency, carbon footprints, and sustainability are expected to become part of the homebuyer's decision-making process. These factors and others are expected to play influential roles in determining the ultimate level of demand for residential construction 10 years from now.

Projections for residential housing will also be affected by historical housing starts, net changes in vacancy rates, and replacement activities. Housing starts are contingent on household growth trends, which are in turn dependent on changes in birth and mortality rates, social trends, immigration values, economic fluctuations, and age population statistics. Assuming fertility and mortality rates remain constant and migratory patterns continue at a slight year-over-year increase, net household growth could reach an average annual pace of 1.46 million during 2005 through 2015, which is an increase of about 200,000 households per year over the average during the prior 10 years from 1995 through 2005.[9]

[9] "The State of the Nation's Housing, 2007," Joint Center for Housing Studies of Harvard University;

Sustainability and future projections of the residential market take into consideration historical demand patterns in conjunction with several other variables. According to the Joint Center for Housing Studies, Harvard University, long-term sustainable residential growth in demand is expected to reach 19.5 million starts for 2005 through 2014, averaging nearly 1.95 million new units annually. Consideration has been given to year-over-year supply inventories as well as validation that significant construction has occurred in the previous three years and may skew potential annual averages.[10]

Expectations for the demand for residential structures will be split. The demand for SF dwellings will decrease, while the demand for MF housing will increase. Several factors drive this change.

5.4.2 Softening in Demand for Single-Family Dwellings

The volume of demand for SF dwellings from now through the next 10 years is expected to be relatively soft, compared to the past decade. The degree of expected softness ranges from declines in the annual rate of growth for new construction each year to a decline in the actual number of new units constructed each year. Several factors determine the demand for SF dwellings; some are relatively foreseeable, such as *demographic shifts*, the *costs of construction*, and the expected level in the *quality of construction*, and others are not reliably predictable, with the economy being the most significant in this category. Expectations for the foreseeable factors are presented below and are based on a general presumption that the U.S. economy during the next decade will perform adequately, with mild or moderate swings but no great booms nor any frightening declines.

Demographic Shifts: The expectation is that the demand for new SF dwellings will decline due to a two-fold impact from the shift in generations. Since the majority of the generation of baby boomers already will have purchased their second home, further demand for new SF dwellings from this very large subpopulation will decline and will be considerably smaller than seen in recent years. In addition, the smaller population of the succeeding generations will result in an additional reduction in the number of first-time home purchases each year. An additional perspective, and potentially an additional result of this shift in demographics, is that the demand for custom homes, in particular, will decrease.

According to the American Association of Homes and Services for the Aging, by 2026 the population of Americans ages 65 and

The volume of demand for SF dwellings, from now through the next 10 years, is expected to be relatively soft compared to the past decade.

[10] Eric S. Belsky, et al., "Projecting the Underlying Demand for New Housing Units: Inference from the Past, Assumptions about the Future," Joint Center for Housing Studies, Harvard University, November 2007.

older will double to 71.5 million, requiring a significant addition of senior living and assisted-care facilities. Between 2007 and 2015, the number of Americans 85 and older is expected to increase by 40 percent. A leading trend in active senior housing developments is "Forward Living," creating an environment with adaptive technologies that help seniors age comfortably, independently, and safely—within their own home.[11] The trend continues to propel builders to get ahead of the curve in response to profound changes in consumer and lifestyle patterns driven by the retiring population. Comfort and familiarity of surroundings are the primary factors driving this group's purchasing decisions.

While the Forward Living trend is heavily reliant on technological adaptations and innovations, a significant group of retirees is looking to downsize; however, the design of the homes is changing, as is the location. A large group of retirees is looking for homes that are easy to manage and drive the openness of family—large great rooms, central activity centers, and minimal upkeep. Among the most influential factors in active senior living is the affordability factor. Additionally, senior homebuyers are driving the market to provide options—size, location, and amenities.

Costs of New Construction: There is a general expectation that the costs for construction will be significantly higher on a per-square-foot basis and that the resultant increased prices for homes will reduce the number of new dwelling units constructed. The increased costs for new construction are expected to arise from *increased regulatory demands* (dependent on how many and how strong the regulations are), a *low supply of labor* (dependent on the degree or severity of the shortage), and *continued inflation* that impacts commodity and specialty materials.

In contrast, an alternative future expected by some is that there will be an *increase of builder consolidations*, which will benefit from increased efficiencies; in a market of soft demand, this would provide a cost-lowering countereffect to the other costs expected to be on the rise.

Quality of Construction: Expectations for the quality of home construction in the future are mixed. Dependent upon the degree and duration of labor shortages that occur, some expect that a small labor force will result in an increased use of less-trained and less-skilled workers, which will then result in a lowering in the quality of the structures built (primarily cosmetically). Homebuyers tend to be intolerant of low quality and are likely to prefer well-built older homes rather than new ones built with lower-quality standards.

An alternative perspective is that quality, in this case with regard to performance characteristics of a home, will improve. Buyers are, and will continue to be, better informed and increasingly concerned about life-cycle costs and issues such as sustainability and IAQ. In addition, to the extent that more stringent codes are enacted, these would also be likely to further enhance the general quality of the homes.

[11] "Growing Older in America: The Health & Retirement Study," National Institute on Aging, 2007 http://seniorjournal.com/NEWS/Housing/2007/7-12-08-ForwardLiving.htm.

… a greater percentage of the U.S. population will be living in MF housing, such as apartments, condominiums, and retirement communities, …

5.4.3 Increase in Demand for Multifamily Housing

In general, many expect that a greater percentage of the U.S. population will be living in MF housing, such as apartments, condominiums, and retirement communities, than they do today. Driving this trend will be several factors, including *an increased desire for lowering the costs of living/housing (and a related decline in desired size of a home), desire to live closer to work, and an increase in the number of retirees*.

Desire for Lower Cost of Living/Housing: Coupled with an expectation that the cost of energy will be significantly greater in 10 years, many expect that most people will be looking for ways to lower their cost of living related to the energy demands of their housing structure. The size of a home is a fundamental determinant of the amount of energy it will demand, and MF housing typically offers a smaller, and therefore less costly, option to a SF dwelling. In addition, some expect that high energy costs will result in a decline in the average size of new SF dwellings, which could decrease the differential between a private home and a unit in a MF structure, and thereby increase interest in MF housing.

Desire to Live Closer to One's Work: Also coupled with the expectation that the cost of energy will be significantly greater in 10 years, many expect that there will be an increased desire to live closer to one's work as well as shopping and urban recreational opportunities. In addition, traffic conditions of the future are generally expected to be even more congested than today, which will also contribute to a desire to shorten one's commute. Doing so will minimize the costs of transportation as well as travel time; and, since there are more MF than SF residences located in urban areas, most of the people who choose to live in the more urban districts will end up in MF housing (e.g., apartment, condominium, etc.).

Increase in the Number of Retirees: The trend of baby boomers moving into active senior and assisted-living communities has already begun, and this is expected to continue at an increasing rate until the majority of this large generation matures.

The trend of active senior living practices is continuing to pick up momentum as many who reach retirement age are not yet ready to spend their days really retired. Many go

The trend of baby boomers moving into active senior and assisted-living communities has already begun, and this is expected to continue at an increasing rate until the majority of this large generation matures.

into semi-retirement and continue to work part-time. When not working, most are very interested in staying active in one way or another—getting involved in their community, spending increased amounts of time with their family, maintaining a high academic interest, or becoming involved in a wide variety of hobbies.

The increasing desire to remain close to family has encouraged active senior living communities to develop in areas otherwise not traditionally considered for retirement. According to the National Institute on Aging in its *Growing Older in America: The Health & Retirement Study*, in 2002 about 50 percent of retirees resided within 10 miles of one of their children.[12] Thus, housing developments are shifting norms and reflecting generational migratory and residential trends.

Furthermore, many of the anticipated active senior developments are expected to be built in nontraditional retirement areas. Washington, Texas, South Carolina, North Carolina, New Mexico, and even places such as Colorado, Oregon, and Georgia are appealing to more and more baby boomers. In addition, a significant number are choosing to retire in foreign destinations such as Mexico, Thailand, and Costa Rica for their low cost of living and warm climates, a trend that will temper the domestic demand for retirement housing.

5.4.4 Increase in Demand for Renovation, Remodeling, and HVAC Retrofitting

Expectations are that there will be a strong increase in the demand for renovation, remodeling, and HVAC retrofitting of existing residential structures. The forces behind this increase include an expected increase in the cost for new SF dwellings, increased cost of energy, increased amount of government-funded energy-saving incentives and regulations, homeowners' concern for the environment, and an increase in the number of retirees.

Increased Cost of New SF Dwellings: In the event that the regulatory climate becomes more restrictive and labor scarcities increase, the cost of new residential construction will likely increase, and demand for new residential construction may decline. As a result, it is expected that remodeling and updating would be more appealing options for consumers, and demand may be high for renovations and updates that avoid the costs and inconveniences associated with increasingly restrictive regulations.

Increased Cost of Energy: The cost of energy will be a key determinant of the demand for renovation and retrofitting. During the next 10 years, the general expectation is that energy costs will rise faster than will the development of alternative,

Expectations are that there will be a strong increase in the demand for renovation, remodeling, and HVAC retrofitting of existing residential structures.

[12] Ibid.

renewable energy sources. Combined with the aid of likely incentives, the cost savings gained from the renovation and retrofitting work are likely to pay for themselves within a reasonable amount of time. The higher the energy costs, the faster the payback will occur and the higher the demand will be for renovation and retrofitting.

Increase in Government-Funded, Energy-Saving Incentives and Regulations: Governments at all levels—national, state, and local—are expected to provide an array of incentives and regulations aimed at improving the sustainability of existing residences. Incentives will likely include tax savings subsidies and low or zero-rate financing. The extent of government-led initiatives will be a function of the pace of improvement with regard to the level of concern for becoming carbon-neutral (or even carbon-reducing) expressed by world bodies and the American public.

If the burden of regulations is too high, and/or if there is an insufficient level of monitoring for compliance, some expect that a market for "off-code" remodeling efforts could develop. Although expected to be a small percentage of the industry, such activity could result in a regulatory reaction that could add undue regulations onto the industry. Self-monitoring and self-regulating by the industry could reduce the likelihood of off-code work becoming a problem for the industry as a whole.

Homeowners' Concern for the Environment: Even if the economic benefits of renovation and retrofitting do not materialize, it is expected by many that there will be a relatively large number of homeowners and owners of MF properties who, because of their strong personal beliefs regarding climate change and/or a motivation of enlightened self-interest, will make the necessary investment to reduce their personal and professional carbon footprints.

Increased Number of Retirees: A small portion of the large number of retirees are and will continue to buck the trend of moving into senior living retirement housing and simply stay put and make do with what they have. This group, while in the minority, will have influence on the retrofit market as homes continue to age and require functional upgrades.

For some older persons, increased regulations may steer them away from buying a new home or moving to a newer apartment or condominium. Instead, they may choose to stay with the type of home that they are used to rather than deal with a potentially confusing array of new technologies, although this is likely to be a minor factor with baby-boomer retirees who are not as techno-phobic as the prior generations of retirees. Furthermore, retirees are likely to be very interested in minimizing their cost of living and adopting energy-efficient technologies so that their financial resources will more likely last through their extended lives.

5.4.5 Perspective at the Five-Year Horizon

In the five-year horizon, one expectation is that home appreciation will recover very slowly from the losses taken due to the subprime mortgage crisis beginning in 2007 and that this will suppress the demand for new SF housing for several years, with the pace of growth accelerating after this five-year horizon.

Shifts in Where People Will Live in the Future

Expectations Are That Population Growth Will Continue a Southward and Increasingly Urban Migration.

5.4.6 Regional Perspective

Continued Migration from North to South: With the expected high increase in energy costs, the trend of companies and, therefore, their employees to move out of regions that require high amounts of energy for heating and cooling will continue. In addition, each year a greater proportion of the large baby-boomer generation moves into retirement, and, for those who live in the northern states, many will prefer to relocate to a climate that is more comfortable and presents fewer risks during the winter months. For some, however, this desire will be offset by a preference to stay close to other family members and long-established friendships in the area. For others, it may provide the opportunity to move closer to family and long-established but distant friendships. Despite tax incentives to slow the rate that people leave the Snowbelt, this trend will continue for the near future. What the outcome of climate change is currently, or will be in the future, is not well-understood, but one thing that seems to be playing out as predicted is an increase in the variability of weather and an increase in the intensity of its extremes. Examples in the U.S. include the duration and severity of droughts (which can also lead to disastrous firestorms); the duration and severity of rainstorms that bring flooding; and the seasonality, number, and intensity of tornadoes and hurricanes. How the annual weather patterns in the U.S. evolve is likely to have a dramatic effect on the society's migration patterns, accelerating or possibly decelerating the southbound flow. Large changes in weather patterns may cause an exodus from the eastern and southeastern coastlines, the riverside cities and towns in the Midwest, as well as from the fire-prone canyons and forested communities in the urban-suburban "countryside" of the major cities in Southern California and along the Rocky Mountains.

Figure 7 shows U. S. population growth projections to the year 2030.

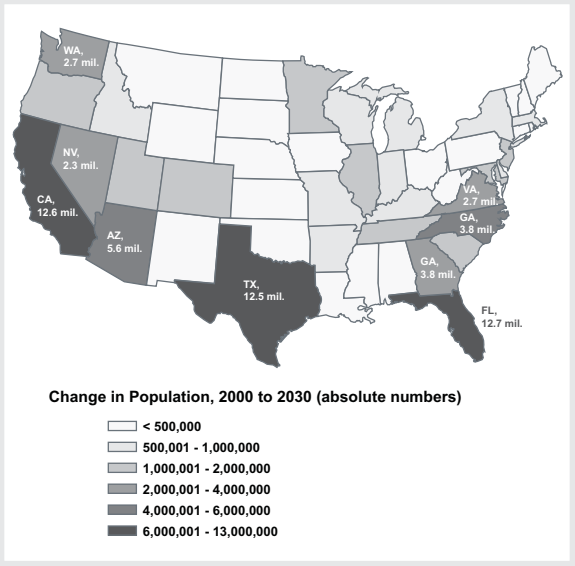

Figure 7: U.S. Population Growth Projections 2000-2030

Despite tax incentives to slow the rate that people leave the Snowbelt, this trend will continue for the near future.

5.4.7 Urban/Suburban/Rural Perspective

Increased Urban Density: As noted, the cost of energy, and therefore transportation, is expected to increase, and these increases will minimize driving and increase the use of mass transit options. Therefore, many expect that there will be a lessening in the interest to live in suburbia and rural locations, and an increase in the interest to live in the more urban, urban-suburban, and town-center districts. People will increasingly want to be closer to their work, shopping, and city-based recreational opportunities.

Reduction in Urban Sprawl: Currently, approximately 80 percent of the U.S. population lives in an urbanized area, and by 2020 it will have risen to 85 percent.[13] A trend toward increasing the density of living has already begun in many communities that are focusing on reducing urban sprawl. In the next 10 years, these sorts of efforts are likely to have taken root in all metropolitan areas. Urban sprawl will have stopped, or slowed dramatically, and a significant proportion of new homes will be built on an in-fill basis in already existing suburbs or within metropolitan city limits.

FMI's 2007 study *State of the Urban In-Fill/High-Density Market in the U.S.* found that urban in-fill/high-density development is becoming a more important strategic market for homebuilders, with expected increases in the number of urban/in-fill projects projected through 2010. The growing trend for urban/in-fill projects is attributed to the 80 million-plus baby boomers and first-time homebuyers who are interested in urban living opportunities that provide housing close to daily living needs. This market condition, along with a shrinking availability of land in certain markets, has stimulated a strong increase in urban in-fill/high-density development.

One potential drawback to the urban in-fill trend is the growing amount of time required for projects to be completed. Nearly half of urban in-fill projects run an average duration of 24 months or longer. The elongated completion schedule is due to additional land regulations, lending requirements related to preleasing, and scheduling and permit applications. In suburban in-fill markets, the trend to build higher-value projects is slower to take hold. The smaller-scale projects can be less risky for the developer in a volatile residential market.

It is expected that the urban in-fill trend will remain strong in western markets, followed by the northeast region, because of favorable government opinion and limited land

The growing trend for urban/in-fill projects is attributed to the 80 million-plus baby boomers and first-time homebuyers who are interested in urban living opportunities that provide housing close to daily living needs.

[13] Web site: www.census.gov/population/www/projections/ppl47.html. The projection was created by using information on mortality, birth rates, and migration patterns established by globalhealthfacts.org. The UN Web site was used to establish a general trend statement.

availability in major metropolitan statistical areas (geographical areas determined by the Census Bureau based on population and interaction). Construction costs will continue to plague the impact of urban in-fill trends. Urban in-fill growth is less predictable in other regions due to the uncertainty around approval processes and market demand.

5.4.8 Energy-Source-Centric Perspective

Hubs of Renewable Energy: An additional perspective, which is held particularly by the social economist Jeremy Rifkin, is that places of work as well as the housing for many of those who work in these places will be located in close proximity to sources of renewable energy such as geothermal and wind, as well as solar to some extent. This concept is part of a more general vision of a "distributed" energy network, a model in which all buildings are constructed with their own ability to produce some or all of the energy demanded by the building. There would continue to be an energy grid system, but the utility and oil companies that are core producers and distributors of energy for our current "centralized" system would have a much smaller role in the creation of energy and have more to do with its distribution.

Besides identifying locations with relatively abundant alternative energy resources and locating new communities there, this concept also envisions that the buildings, in addition to producing some (or all) of their energy needs, will also have significantly improved energy-storage capabilities based on hydrogen storage cells. The flow of energy between a building and the power grid will be controlled by a computer-run program that will regulate the building's demand based on the current real-time cost of the energy. This "smart grid"-based system would reduce the building's demand at times of high energy cost, and, if its intrinsic power system were able to generate a surplus of energy, that surplus could be sold to the grid.

Communities in Europe have already begun to sprout up using this structural format. Countries leading the way in Europe include France, Italy, the United Kingdom, and Portugal. These efforts are a part of the European Union's (EU's) journey toward what is called by some the Third Industrial Revolution. The EU has made a binding commitment that 20 percent of all its energy will be generated by renewable sources by 2020. Along those same lines, China has pledged, in its latest Five-Year Plan, to have renewable energy rise to 15 percent of its energy consumption by 2020.[14]

> … places of work as well as the housing for many of those who work in these places will be located in close proximity to sources of renewable energy such as geothermal and wind, as well as solar to some extent.

[14] "Cross-Cultural Understanding," www.ccun.org News, February 2008, http://www.ccun.org/News/2008/February/19/20n/China,/20EU/20leading/20Third/20Industrial/20Revolution,/20says/20Jereny/20Rifkin.htm. (Note: Rifkin's first name is spelled "Jereny" on this Web site; a search of the Web yielded both Jereny and Jeremy.)

Here at home, according to Rifkin, 23 states in the U.S. have mandated that between 10 percent and 25 percent of their electricity will be generated by renewable sources by 2020, with the ultimate objective to establish zero carbon emissions and sustainable resources.[15] Global investment in renewable energies topped a record $100 billion in 2006 and is expected to leap to approximately $283 billion by 2020.[16]

Shifts in How Residences of the Future Will Look and Perform

Expectations Are That Homes in the Future Will Be Smaller, More Energy-Efficient, and Smarter. The Expected Level of Quality Is Unclear.

5.4.9 Shifts in the Look and Performance of New Residential Structures in General

Energy Demand and Supply: A continually increasing focus will be made on the structure's energy demand and its carbon footprint, with the degree of shift being dependent on the cost of energy and the extent of regulations and their enforcement. The higher utility costs will result in residential structures being designed to consume less energy, which will require the use of higher-efficiency HVAC systems as well as improved windows, insulation, caulking, and sealing.

Current efforts in this direction are seen in General Electric's (GE's) "ecomagination Homebuilder Program." GE claims that a "2,500-square-foot house in Texas built to the *ecomagination* Homebuilder Program specification is designed to lower [carbon dioxide] CO2 emissions by approximately five tons annually, which is equivalent to the CO2 emissions of driving more than 10,000 miles in an average U.S. car, or to the CO2 absorbed by 1.3 acres of a southeastern forest each year." GE's program incorporates high-efficiency appliances and multizoned HVAC systems as well as special framing techniques, such as a continuous air barrier to reduce internal drafts, as well as the use of return air ducts and transfer grilles or jumper ducts to balance pressure so that air circulates easily. For the homeowner, GE estimates these reductions would save $600 to $1,500 annually on utility bills versus an industry-standard average new home. GE guarantees that with this design there will be no more than a three-degree-Fahrenheit temperature differential from the center of any conditioned room within each thermostat zone.

A continually increasing focus will be made on the structure's energy demand and its carbon footprint, with the degree of shift being dependent on the cost of energy and the extent of regulations and their enforcement.

[15] U.S. Department of Energy, "Energy Efficiency and Renewable Energy." (n.d.). *States with Renewable Portfolio Standards*. Retrieved from http://www.eere.energy.gov/states/maps/renewable_portfolio_states.cfm#chart. Sourced from Jeremy Rifkin's "Energy Vision Report: Leading the Way to the Third Industrial Revolution: A New Energy Agenda for the United States in the 21st Century" 2007.
[16] United Nations Environment Programme and New Energy Finance. "Global Trends in Sustainable Energy Investment 2007: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency in OECD and Developing Countries." Retrieved from http://www.unep.org/pdf/SEFI_report-.

Building Intelligence Systems: Residences will follow the trend of building intelligence that has existed for years in nonresidential buildings, with most, if not all, new residences having such systems incorporated in their design by 2018. Currently, some suppliers are already marketing energy-monitoring systems that provide current and historical feedback on a home's indoor energy and water consumption as well as levels of emissions. In addition, these systems can operate in an integrated manner with the audio, lighting, security, and intercom systems. To mitigate the health costs of the large population of aging baby boomers as well as future generations, new government regulations are expected to be developed to require that all residential installations include highly efficient air-cleaning capabilities. Some HVAC manufacturers already have these systems, and others are expected to follow suit.

Quality of Construction: With the expected higher costs of construction and an expected increase in labor outsourcing to remedy the significant shortage in the labor supply, there is concern that the quality of construction, on average, will decline. This will be exacerbated if there is insufficient training. In the opposite direction, however, there is also a strong sentiment that manufacturing of complete residences and the prefabrication/modularization of wall sections, etc., will increase and that, through the more controlled manufactured process, the level of home quality will actually improve. Codes and consumer demand will also support this focus on performance issues.

Energy Production Capabilities: Residential buildings will increasingly produce some of their own needed energy. More residences of all types will include energy-production capabilities, including solar for water heating and, as the technology improves, for PV technologies, biomass, wind energy, and, particularly relevant for HVAC, geothermal heat-exchange systems. Significant interest appears to exist for thermal heat-exchange systems within the HVAC industry.

5.4.10 Shifts in the Look and Performance of New Single-Family Residences

Structure Size: As previously noted, for several reasons, the size of the average new home is expected to be smaller than recent construction and is seen as a reversal of the recent "McMansion" trend. Drivers of the decline in size are expected to be higher construction costs (e.g., materials, labor, and technologies for energy efficiency, as well as an increasing cost of land, particularly in in-fill locations); placement of many new homes on smaller lots, mostly in-fill locations; preference for a home that requires less energy and is less costly to operate; and a simple preference for smaller homes due to a smaller household.

Of particular interest to the HVAC industry will be significant framing improvements and duct designs that will drive energy efficiency and frequently decrease the tonnage requirements for new SF construction.

Structural Changes: Energy-efficient homes will be the standard; they will be tighter and are likely to be constructed using nontraditional materials such as steel and composites. Due to expected shortages in supplies for many traditional materials, some of the nontraditional materials will be materials that are newly developed and not even known today. Of particular interest to the HVAC industry will be significant framing improvements and duct designs that will drive energy efficiency and frequently decrease the tonnage requirements for new SF construction.

Sustainability: In addition to increasing demand for energy efficiency, new SF homes will also be increasingly green and sustainable. Efforts to increase the longevity of homes are historically uncommon in the U.S., although, in Europe and elsewhere, methods and materials have been used for centuries in construction of homes that are expected to last a hundred or more years. Major strides are expected in this area.

According to the FMI 2008 *U.S. Markets Construction Overview*, "Green building is not a passing fad. Sustainable design and development is moving into the mainstream." While the trend toward sustainability has been moving in fits and starts for years, the many factors propelling the trend, such as energy costs, global warming, cleaner air, and quality of life issues have now come together to create the "right time" for going green. The federal government, state governors, city mayors, and concerned citizens across the country have taken up the green banner. By 2018, green building may no longer be a special consideration for a building's design and construction; it will be the norm for all buildings. It is not just an issue for future strategies; it is an issue now.[17]

According to a study done by the National Association of Home Builders (NAHB), 2007 was expected to be an unprecedented year where "more than two-thirds of builders will be building green homes, with only one-third not yet engaged in the marketplace." The residential green market in construction is expected to grow from $7.2 billion in 2005 to between $19 billion and $38 billion by 2010.

The movement is still gaining momentum, and it is projected that complete adoption across the industry is still 5 to 10 years out. In part, this is due to the changing strategy surrounding green and the consistency in program sustainability.[18] Further support for this green growth is shown in a survey by Green Building Media of more than 250 homebuilders that revealed that homebuyers will pay a premium of 11 percent to 25 percent for green-built homes.

At the 2008 Builders Convention, 38 large homebuilders signed a pledge to build units using green technologies in the coming year.[19]

> "Green building is not a passing fad. Sustainable design and development is moving into the mainstream."

[17] FMI 2008 U.S. *Construction Overview.*
[18] McGraw Hill Construction. (2006). *Residential Green Building SmartMarket Report.*
[19] http://www.nbnnews.com/NBN/issues/2008-02-25/Green+Building/index.html.

The Builders Challenge, sponsored by the U.S. Department of Energy (DOE), defines a high-performance home as one that uses at least 30 percent less energy than a typical new home. "Right now, the 30 percent target would meet the 'silver' level in the NAHB National Green Building Program if the energy efficiency were combined with similarly stringent green features in the water and resource efficiency, indoor environmental quality, global impact, and homeowner education categories."[20]

As more homebuilders enlist, the DOE is hoping to spur the construction of 1.3 million high-energy-performance homes by 2030. Accordingly, if the pace of construction is maintained, a "cumulative savings of $1.7 billion in energy costs" and "the carbon equivalent of 606,000 cars off the road annually will be achieved."[21]

Luxuries and Aesthetics: In many situations, the added cost of going green, including design, construction efforts, and installations for these improvements, coupled with an increase in the cost of labor due to low supply, will likely make the homebuyers' trade-offs between the size and location of their home and a host of aesthetic and luxury elements more difficult. In addition, homebuyers as well as homeowner associations (HOAs) will potentially need to deal with a decline in the exterior aesthetics, due to sod-covered "living" roofs, solar panels, and/or large turbine blades, all of which are not currently established architectural norms.

5.4.11 Shifts in the Look and Performance of New Multifamily Residences

Structure Size: Opinions differ regarding the expected size of the average MF unit of the future. If the economy is strong enough, one perspective is that, with the shift away from SF residences, the average square footage of apartments and condominiums will grow and contain even more amenities than offered on average today. Alternatively, if the economy is weak and/or the costs of construction, energy, or land are very high, living units within MF residences are likely to be on average smaller than now.

Structural Changes: As with the construction of SF residences, and potentially even more so for MF structures, the use of prefabrication/modularization is expected to rise with the level of labor shortage. Standardized layouts of apartments and condominiums are very well suited to benefit from the advantages of a mass-production manufacturing process. These MF units will often be multiuse and frequently incorporate

In addition, homebuyers as well as homeowner associations (HOAs) will potentially need to deal with a decline in the exterior aesthetics, due to sod-covered "living" roofs, solar panels, and/or large turbine blades, all of which are not currently established architectural norms.

[20] Ibid.
[21] Ibid.

retail construction and medical facilities in the case of retirement facilities.

Qualitative Differences Between Rental Units and Owner-Occupied Condominiums: With the increased focus on energy efficiency and potentially additional construction costs, a greater number of rental units may be relatively Spartan but with high performance standards. In contrast, a high percentage of condominiums are likely to be relatively upscale, as baby boomers move into the urban high-rise structures built, in part, from the focus on in-fill rather than continued suburban sprawl. These upscale units will also exhibit high performance standards.

Sustainability: Due to economies of scale, MF residential construction will demonstrate the greatest potential for affordability in utilizing green practices. This is because an advantage of building green in bulk is that many of the expenses of green methods can be shared by multiple dwellings. Putting in one big geothermal heating system for 100 MF units, for example, costs a lot less than putting in one system for each of 100 separate homes.

5.4.12 Shifts in the Look and Performance of Existing Residential Structures

Owner-Based Shifts: Increasingly, owners will be incorporating alternative/renewable energy production capabilities and energy-saving appliances into their homes and MF residential structures. The rate of adoption will be heavily dependent on the economics of the improvements. As the costs for these appliances and systems drop, and/or energy costs climb, owners will be increasingly motivated to make such expenditures.

For homeowners, a key consideration will be their expectations for how many years they will be living in the home. The current perspective on the incoming generation of homeowners is that they are likely to be relatively transient, which could make the economic equation more difficult and depress the rate of investment in such things as high-performance HVAC systems.

Economic resistances are likely to be overcome on a state-by-state basis or nationally with government incentives. Oddly, though, the progressive desires of some communities will run into conflicts with state-based building codes, which typically override the local government's interests. There are also potential conflicts with HOA covenants and/or restrictions regarding the exterior aesthetics of the homes in their jurisdiction.

Regulation-Based Shifts: As noted for new SF residential construction, there will be a continually increasing focus on the structure's energy demand and its carbon footprint, with the degree of shift dependent on the cost of energy and the extent of regulations and their enforcement. In many regions, if not nationally, regulations will also be put in place requiring improvements in the energy efficiency of existing residential structures.

Shifts in How Residences of the Future Will Be Built

5.4.13 Drivers of Changes

The drivers of the changes in how residential structures will be built in 2018 include the supply, skills, work ethic, and cost of labor, the availability and costs of material resources; new work processes and technologies such as prefabrication and BIM, and the efforts

towards and regulations regarding green construction practices and sustainability of the built structures.

Materials: Expectations within the HVAC industry are that the annual cost increase for materials used in residential construction will level out to between 7.0 percent and 7.5 percent through 2010 and increase at a more moderate pace in the subsequent years. From the homebuyer's perspective, the full brunt of price increases may be partially offset by the expected increase in income generation of homebuyers. While construction costs will increase, these expected cost increases will drive the development and adoption of more efficient ways to perform the work as well as the development and adoption of new and less-expensive materials.

Manufactured Housing: The manufacturing of complete homes within a factory-like setting is likely to become more common in the U.S. residential market. Whereas one logical driver in addition to cost of such an increase is the anticipated shortage for appropriately skilled labor, there are aspects of the industry and market that will be likely to suppress the rate of penetration for manufactured housing.

Historically, homebuyers and lenders have tended to associate manufactured homes with inferior materials and construction quality. Such perceptions are not particularly valid, as significant improvements have been made throughout the industry. Nonetheless, without a dramatic change in prospective homebuyers' perceptions, acceptance of this method will have a slower growth rate than it likely deserves. Also hindering the potential demand for manufactured homes will be tighter credit requirements, prohibitive zoning requirements, and local covenants.

Beyond reducing the labor required in residential construction, another advantage gained through the manufacturing processes is improved efficiency. As a high volume of manufactured units is produced in a central facility, greater efficiency is possible through coordinated design and manufacturing than would be possible in individual on-site projects.

As home manufacturing increases, so too will the infusion of Toyota-like production methods that are not only highly efficient but result in extremely high product quality. Aspects of homebuilding that were often poorly done in the past, such as air sealing or ductwork installation by undertrained labor, would now be conducted in the vastly more controlled factory settings, with on-site assembly minimized.

According to data from the U.S. Census Bureau and the analysis of costs in this study, typical modular and site-built homes appear to be competing in the sales price range under $150,000, with the competitive range possibly extending as high as $200,000. Competition with manufactured housing occurs most directly in the price range under $100,000. It is in these price ranges that most entry-level site-built housing for first-time buyers is being

The manufacturing of complete homes within a factory-like setting is likely to become more common in the U.S. residential market.

built. There is also no doubt that production of compact, low-cost, site-built housing has been shrinking.[22]

Prefabrication/Modularization: Prefabrication of framing panels and the modularization of HVAC systems are methods that are also expected to aid builders in delivering efficient, high-quality residential projects when full prefabrication is not possible. Modular components are built in the same controlled factory conditions as larger prefabricated structures. These modular components are expected to help save time and labor on job sites, while ensuring consistently high levels of quality by using automated processes to produce significant components of a project off site. Eventually, as construction techniques involving modular components improve, residential construction might even involve robotic construction of modular building components on site as well as in the manufacturing environment.

The usage rate of this method is likely to have particularly strong applicability for MF projects, due to the greater opportunity to make numerous replications of a single floor plan. Already a number of large builders have investments in facilities that will provide more prefabricated materials for the job site.

Preplanning and BIM: Another area of expected improvement that will reduce costs is increased skill at preplanning of the entire project. Development in preplanning will include improved discipline by builders to plan projects before construction has begun as well as the use of sophisticated process and planning tools, such as BIM.

To achieve the highest possible levels of efficiency and quality, designs, tasks, and responsibilities must be clear before the project has started. This will be particularly applicable for prefabricated/manufactured structures. Current advanced planning efforts along these lines include more thorough scrutiny of take-offs by the larger homebuilding companies. Such efforts produce large financial savings from eliminating unnecessary materials across the many applications of a single take-off. In addition, this effort is an example of the first "R" in the three "Rs" of sustainability: reduce, reuse, and recycle.

Like modular building components, BIM can help to reduce project cost by improving project efficiency and quality. BIM takes a step toward eliminating on-site changes and modifications by allowing contractors to simulate the construction and operation of a home before construction begins. BIM could be an increasingly valuable construction tool when used in preconstruction planning to reduce the amount of wasted materials during the construction process.

[22] "Current Trends and a Look to the Future" http://www.manufacturedhousing.org/developer_resources/factory_vs_sitebuilt/index.asp#_Ref421445464.

BIM is expected to be used eventually by most residential builders, but initially builders of MF units will realize the most advantages.

BIM is expected to be used eventually by most residential builders, but initially builders of MF units will realize the most advantages. Even though a single floor plan for a SF dwelling may be used many times, variances in codes, soils, wind loads, etc., will suppress the adoption of this method in the residential market. For SF dwelling construction, there are not as many square feet against which to amortize the expense of BIM as there are in MF structures and nonresidential buildings. Furthermore, the larger homebuilding companies will most likely not take the lead on this development due to perceived risk in early adoption. Smaller firms are more likely to develop this technology for residential construction, with larger builders adopting BIM after they feel it has been proven and refined.

On-Site Building to Become More Complicated: On-site residential construction activity is likely to become more complicated as space for materials and labor becomes more limited, particularly with urban in-fill projects. An increasing number of projects will need to be completed with careful consideration and planning to avoid the overlap of either materials or labor. Many job sites of the future will not have sufficient room to accommodate extra materials or idle work crews.

Beyond small, congested job sites, more stringent regulations are likely to make residential projects even more challenging. The additional requirements imposed by new regulations will add extra steps and complexity to the responsibilities of busy and sometimes less-skilled workers.

5.4.14 Renovation and HVAC Retrofitting

Residential renovation projects on existing buildings are expected to present significant opportunities for HVAC contractors. Already, the HVAC retrofit and service market is larger than the market for new HVAC work, with the growth accelerating for service and renovation. There will be a high level of demand for converting older residential structures to useful, efficient, and environmentally friendly modern housing. These projects will likely require HVAC contractors to conduct duct demolition, new system installation, and the installation of other associated equipment. Renovating and updating older structures will require on-site labor similar to new projects.

The renovation and retrofit market growth is also fueled by the green movement. An example of green-focused retrofitting can be seen in Levittown, New York, which is a historical suburb aiming to reduce its carbon footprint by 20 percent through a three-step, energy-saving approach. More than 5,000 households are signing up for energy audits, overhauling appliances, and using solar to reduce carbon emissions and conserve energy. The city is planning to continue to educate the community and provide services

Historically, the retrofit market has been driven by equipment breakdown (65 percent), home remodeling (30 percent), and energy efficiency (5 percent). With the focus on energy costs, sustainability, and green building, the retrofit market is positioned for significant expansion.

and incentives that will increase awareness of energy-saving opportunities and cost-saving renovations. To realize the complete impact of energy-saving measures in the community, the layout of homes and design of the entire community must adopt the green, environmentally friendly culture. It is expected that many communities across the country will adopt similar initiatives. Historically, the retrofit market has been driven by equipment breakdown (65 percent), home remodeling (30 percent), and energy efficiency (5 percent). With the focus on energy costs, sustainability, and green building, the retrofit market is positioned for significant expansion.

5.5 C. The HVAC Contractor of 2018

Introduction

This section summarizes the future expectations for the HVAC contractor organized into the following contexts:

1. How the HVAC Contractor of 2018 Will Operate
2. Design Tasks of the HVAC Contractor in 2018
3. Fabrication Tasks of the HVAC Contractor in 2018
4. Installation Tasks of the HVAC Contractor in 2018
5. Service, Replacement, Retrofit, and Maintenance Tasks of the HVAC Contractor in 2018
6. Growth of a New Sub-Industry: Environmental/Energy-Optimization Firms

How the HVAC Contractor of 2018 Will Operate

Successful HVAC contractors in 2018 will be efficient, sophisticated, and leaders in the areas related to energy management, green, and sustainability.

5.5.1 HVAC Contractors Will Be Efficient.

The industry will be highly competitive, skilled, and technology-focused. HVAC contractors must become efficient in order to survive in this industry. The need for highly efficient management and construction systems will be required for the HVAC contractor to be profitable, as the work will be very competitive. A more highly skilled and advanced work force will be required for certain HVAC applications. To maintain costs, a focus must be on productivity and efficiency as more skills are required. The contractor will have to be able to do a better job of

managing a more diverse work force than ever before. More effort will be required of the contractor and professional associations to provide the expertise to meet more intensive technical standards.

Figure 8 shows that 81 percent of the respondents to the survey feel that Lean will likely become the norm. Already embraced in manufacturing, Lean practices will be widely accepted and used by successful contractors.

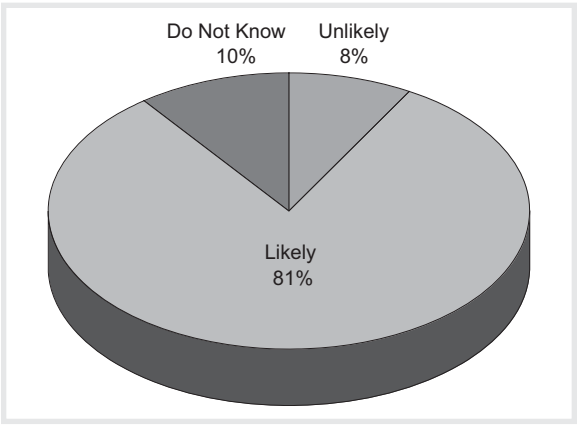

Figure 8: Lean Construction Becomes the Norm within the HVAC Industry.

The Internet, BIM, and labor availability will conspire against the traditional contractor who bids, details, fabricates, and installs the majority of his work. Online plans and specifications, BIM designs that create a bill of material, and regional fabricators and consolidated installers will minimize the value of some customer relationships and eliminate the less-efficient, less-competent contractors. HVAC contractors have accelerated their implementation of technology to support both construction and building service offerings. There is a limited supply of labor, and there has also been a major turnover and loss of expertise due to the retirement within the existing work force. Embedded intelligence within equipment and remote-access technology has enabled the HVAC contractors, both residential and commercial, to support their field labor force from a central location with expertise and remote diagnostics; the value realized has also proven to be attractive to building owners.

BIM skills will likely be a key technology differentiator; learning now will pay off, as the learning curve will become increasingly more difficult. This skill very likely will provide a strong competitive benefit for early adopters.

While BIM continues to demonstrate an additional qualitative value through increasing competitive advantage, it is difficult to identify the best BIM applications in order to define the value added, which has tended to slow adoption rates. Implementation and adoption of BIM is a balance between integration of technology and improved human interaction; implementation links to marketability and new business development.

Another potentially critical area for greatly increased efficiency in HVAC work may be fuel consumption related to the energy consumed, driven by a contractor's fleet of vehicles. Greater use of computer-based technologies for monitoring systems is just one idea that is likely to reduce the number of miles driven as well as the number of gallons consumed.

5.5.2 HVAC Contractors Will Be More Sophisticated.

Due to liability, government requirements, and competitive forces, the HVAC contractor will become more sophisticated. Contractor liability and inherent risks will require qualified and sophisticated contractors and technicians. The government requirements

…almost 90 percent of the respondents believe that they will likely have to add more IT employees.

for LEED and/or green buildings will mean that contractors will need to have the sophistication to be able to properly perform work. It appears that some regulations favor the development of inspectors and certification processes; organizations such as engineering firms and commissioning agents could be well suited to take on this responsibility.

The contractor will become more sophisticated by the use of technology. Contractors will gain better management of materials through online procurement, use automated scheduling systems, process billing information, and perform countless other tasks that require the use of technology. These advances in technology also mean that contractors will find that they require more IT employees on their payroll. Figure 9 shows that almost 90 percent of the respondents believe that they will likely have to add more IT employees.

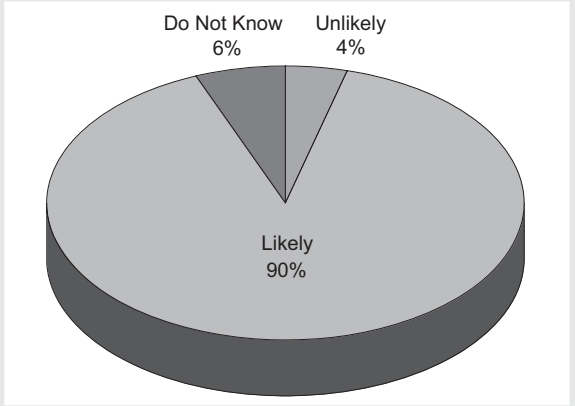

Figure 9: Contractors of 2018 Will Increase IT Staff.

5.5.3 HVAC Contractors Will Be Leaders in Energy/Green/Sustainability.

The industry will experience a demand for greater efficiency and environmental responsibility. This demand will permit HVAC contractors to distinguish themselves from their competition by being leaders in energy/green/sustainability. At a minimum, HVAC contractors will need to understand the new codes and regulations to remain competitive.

More than 58 percent of the respondents believe that it is likely that companies will be extensively recycling ductwork and other equipment, as shown in Figure 10. This is one more potential action that the HVAC contractors can take to support the sustainability movement.

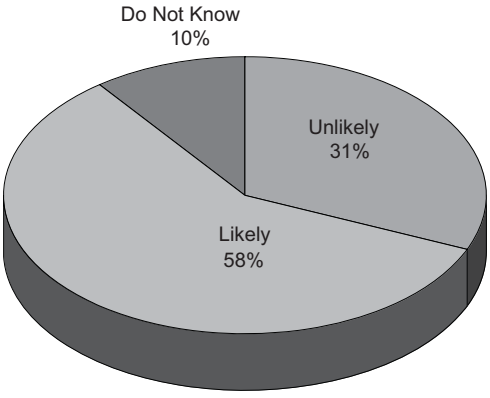

Figure 10: Companies Will Extensively Recycle Ductwork and Other Equipment.

5.5.4 HVAC Contractors Will Be More Segmented.

Based on the market demand and dynamics, it is believed that HVAC firms will evolve into one of the five general types of firms:

- Large, full-service contractors providing design services, full mechanical work, and even MEP packages;
- Installation-only firms focused on labor efficiency, equipment, and duct installation;
- Fabrication firms providing duct either directly to the owner/general contractor or the HVAC contractor;
- Energy/environmental optimization firms focused on energy management, IAQ, commissioning, TAB, and related activities requiring a highly skilled work force; and
- Niche specialties contractors providing support to energy/environmental specialists, residential service, and residential specialty applications.

5.5.5 HVAC Contractors Are Expected to Develop Intelligence as a Core Focus.

In this age of information, those who create and manage information will become the sources that others turn to for answers, but just having information is no longer enough. Intelligence means knowing how to put the information to work. Being proactive in this area means not only mastering HVAC technologies, but also being able to put them all together collaboratively so that BIM design is based on best practices, green design, and building codes. It also means using the most efficient equipment and construction scheduling and developing an ongoing history that is used to schedule maintenance, upgrades, and repairs. Rather than add cost, this intelligent system should reduce cost and labor, and contractors that manage all of this will become the preferred source for the owner.

One of the most difficult challenges is the need for sufficient trained labor. Those contractors who can work from the level of high intelligence and information management will create barriers to entry for the mediocre or less-qualified contractors. They will attract the best workers and follow a continuous improvement culture.

Included in this intelligence focus is cultural intelligence. The mix of workers on a job will be greatly different from 2008. The workforce will be more diverse, reflecting the American population. Acculturation will include consideration of cultural values, multilingual communication skills, and changing dynamics of employees' educational backgrounds. Non-English-speaking personnel will make up the majority of the HVAC work force.

5.5.6 HVAC Contractors Will Think Like Their Customers.

While the current thinking by many is that owners will pay a premium for sustainable construction, by the time 2018 rolls around,

> … just having information is no longer enough. Intelligence means knowing how to put the information to work.

green construction will be standard operating procedure for construction—still important, but not special. Owners are often accused of wanting more for less, and that is not expected to change by 2018.

Building owners want to reduce risk and cost, so contractors must collaborate to not simply take on more risk but reduce it through the process and life cycle of the building. That may also mean driving the technology and design for more efficient systems, not just installing the system that was designed by others, but also designing it. That means being part of the process early, even before the job is awarded. The alternative, and this may also be a strategy for some HVAC contractors, is to be the low-cost provider of installation labor and to compete as a low bidder to whoever serves as the customer. Ultimately, by 2018, those who thrive in the business will work in a highly collaborative manner to create safe, efficient, and low-maintenance buildings.

5.5.7 Contractor Profitability

Although the response was not overwhelming on this point, Figure 11 shows that 52 percent of the respondents from the survey indicated that contractor profits would fall due to "commoditization" of the work performed by the HVAC contractor.

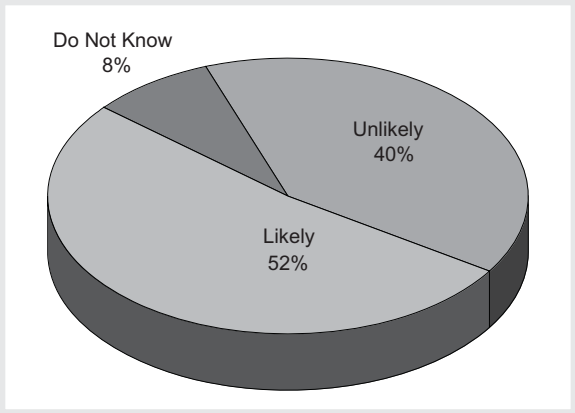

Figure 11: Profitability Will Decline for Most HVAC Contractors Due to Commoditization.

For traditional contractors involved with fabrication and installation of HVAC work and serving as subcontractors to the mechanical, growing or even maintaining their current levels of profit is expected to be difficult.

Design Tasks of the HVAC Contractor in 2018

The design work in 2018 will be more coordinated and accomplished through modeling, will involve outsourcing of HVAC design, and will be changed to include sustainability.

5.5.8 Design Work Will Be More Coordinated and Accomplished Through Modeling.

Particularly for nonresidential buildings, design work will be accomplished through modeling. There will be more reliance on computerization and 3D applications including fully integrated drawings that can be executed anywhere in the world. It will be based on either current technologies or

newer, faster, more accurate technology. CAD is one of the current technologies, and Figure 12 shows that almost 88 percent of the respondents believe that it will likely be used a great deal to help sell jobs.

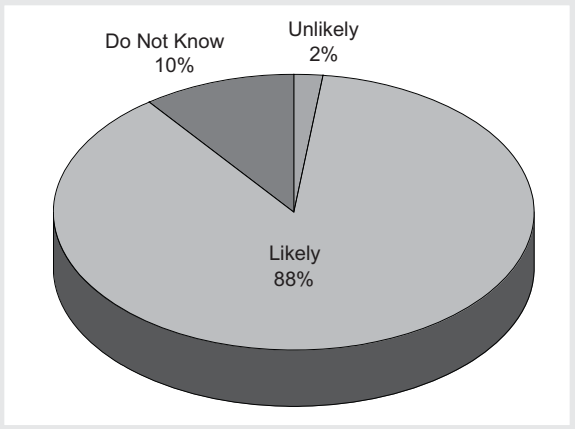

Figure 12: CAD Will Be Used a Great Deal to Help Sell Jobs.

Design work will also be more coordinated. There will be a standardized system, and expectations will be incorporated. Technology will add structure to the coordination between BIM and the trades. New technologies, particularly the unknown but highly anticipated world of nanotechnology, are likely to make profound changes in how air temperature and indoor air environments are modified and controlled, which will require very different design fundamentals and design outcomes.

5.5.9 Design Work Will Involve Outsourcing HVAC Systems.

It will be common to outsource design work to a third-party, independent company. This will include automated work done overseas or outsourcing to wherever there is labor to do the work. It is likely that design work will be treated like a commodity that can be performed or purchased by any firm anywhere in the world. The respondents were varied in their belief that a great deal of outsourcing of design will occur, including HVAC systems. Of the respondents, 65 percent believed that it will be likely, while 29 percent believe that it is unlikely, as shown in Figure 13.

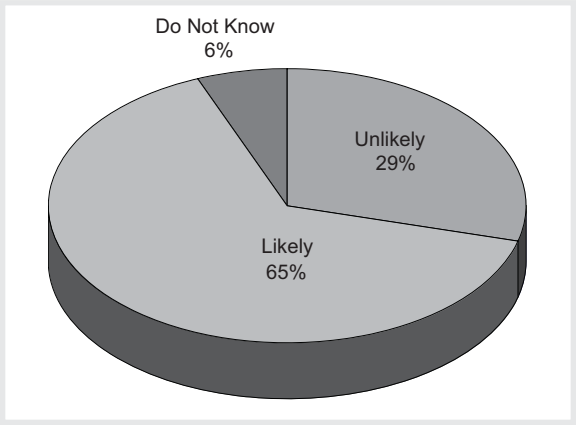

Figure 13: A Great Deal of Outsourcing Design Will Occur, Including HVAC Systems.

Progress in design, such as BIM, will minimize the need for detailing by fabricating and installing contractors and enable the general contractor/construction manager to "shop"

It is likely that design work will be treated like a commodity that can be performed or purchased by any firm anywhere in the world.

the fabrication and installation work as separate packages. Sheet metal shops will increasingly need to specialize in order to gain competitive advantage in these splintered niche markets.

The HVAC contractor will be involved in design work. This involvement will span from a standard practice of a design-team approach to a more integrated approach with mechanical contractors. The involvement could also include a one-stop contractor where design-and-build or design-and-fabrication is performed by one company.

Regardless of the approach to the involvement, it is clear that HVAC contractors will have to do more and more. HVAC contractors are better suited to handle the demands of design-build, and large companies will do a majority of design-build. Figure 14 shows that 88 percent of the respondents feel that it is likely that more progressive HVAC firms will have opted to enter the design market.

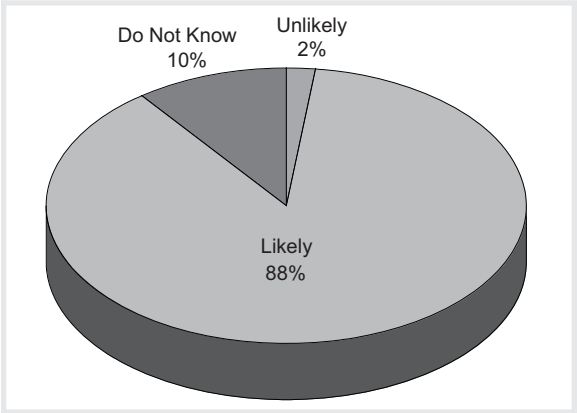

Figure 14: More Progressive HVAC Firms Will Enter the Design Market.

Architecture/engineering (A/E) firms doing HVAC design work may become more of a threat due to BIM and software integration eliminating much of the trade knowledge required to design a constructible project.

Fabrication Tasks of the HVAC Contractor in 2018

It is unclear whether the traditional duct systems will prevail in the market or become a very limited market, but, nonetheless, the fabrication of HVAC systems is expected to change. The procurement and control of materials will be performed online. The way duct is fabricated will change, and HVAC contractors will continue to do less of their own fabrication.

5.5.10 Will Traditional Duct Systems Prevail in the Market?

Respondents from the HVAC Futures Advisory Group are divided on whether traditional ducted systems will have become a very limited market; 48 percent believe that it is unlikely while 44 percent believe that it is likely (Figure 15). Nonetheless, the use of traditional systems will decline, and other systems (under floor, etc.), other materials (fabrics, board products, etc.), and non-ducted designs will increase.

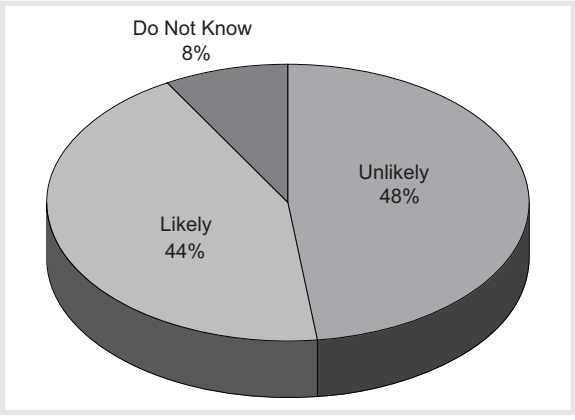

Figure 15: Traditional Ducted Systems Will Have Become a Very Limited Market.

Fewer and fewer sheet metal contractors will do their own fabrication.

5.5.11 Sheet Metal Contractors Will Do Less of Their Own Fabrication.

Fewer and fewer sheet metal contractors will do their own fabrication. Figure 16 shows that more than 87 percent of the HVAC Futures Advisory Group respondents believe that this is likely to occur, which supports the ongoing shift that has been seen for a number of years throughout the industry. Duct fabrication continues to become more and more of a commodity item for the HVAC industry.

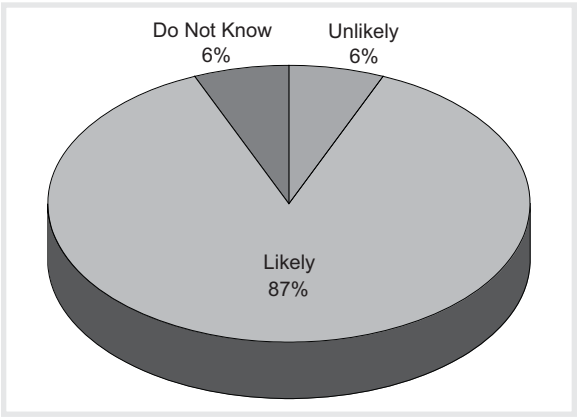

Figure 16: Fewer Sheet Metal Contractors Will Do Their Own Fabrication.

5.5.12 The Way Duct Is Fabricated Will Change.

Duct fabrication will be consolidated by larger firms that are able to accept digital output directly from BIM programs, which can generate a bill of materials without the need for contractor coordination or intervention. Therefore, fewer, larger shops will be doing fabrication. This will lead to less hand fabrication and a few large regional shops. These shops will likely be nonunion without differentiated programs through the union. Another reason for this consolidation is standardization. More often, the ducts will be part of complete assemblies, such as wall assemblies designed to snap together in such a way that leaks are minimized and assembly is simplified. As a result, it will be much more standardized and will be manufactured in large plants, possibly even offshore facilities.

Fabrication may change based upon new materials designed to enhance productivity and support the green movement. The expectation is to see flexible duct, fabrics, high-efficiency fittings, and new products in the market. Perhaps methods will be developed through nanotechnology that will allow duct to be fabricated using recycled materials that still meet fire-rating requirements. Since the duct manufacturing business is not as large as other major manufacturing businesses, changes in technology will come as a derivative of other industry practices. For example, technology used today such as plasma cutting equipment and duct forming lines were actually created in other manufacturing industries first and modified to suit the needs of the HVAC industry. Serious experimentation with alternative materials is expected, but no major shift is anticipated in the next 10 years.

Installation Tasks of the HVAC Contractor in 2018

The way equipment and ductwork are installed will change. In particular, it is expected that manufacturers will become more involved in the installation process, installation will be easier to perform, and the variety of equipment and system types to deal with may increase.

5.5.13 Manufacturers Will Become More Involved.

The first way that the installation of nonresidential HVAC work is expected to change is that more manufacturers will become involved in installing their own equipment. As larger, more complex equipment requires more knowledgeable technicians, they may be employees of the manufacturer rather than the contractor. The manufacturers will also become more involved in the commissioning and service of complicated systems.

5.5.14 Installation Will Be Easier to Perform.

Better modular equipment will be on the market that will require less labor to install. These modular construction techniques will reduce the sophistication at installation. As these become more standardized, the equipment controls will be capable of diagnosing problems with installation during startup. The modular equipment will be less complicated from an equipment perspective and will be prefabricated, dropped into place, and plugged in ("plug-and-play"). This means that manufacturers will create more foolproof installation techniques with systems integration and controls as the highly technical discipline.

5.5.15 The Variety of Equipment and System Types to Deal With Are Expected to Increase.

The last way that installation will change is due to a larger variety of equipment types. The equipment will become specialized. These may include equipment specialized to efficient energy design, based on a specific geography and building design. The equipment may also use embedded intelligence, where commissioning is implemented in steps throughout the installation to a final commissioning at the completion of the installation. This new equipment will have standardized systems, which will have simpler controls and interfaces. This standardization will allow for remote monitoring through central stations for startup and ongoing service.

Duct installation is expected to use prefabricated assemblies, and plug-and-play systems will become more prevalent. The assembly process may use BIM with computer chips installed on each component, which

> The expectation is to see more duct installation using automated layout tools that prefabricate many of the assemblies and spot hangers to improve hanging, connecting, and sealing. Both productivity and performance will be enhanced in the process.

More than 81 percent of the respondents believe that it is likely that differentiation of HVAC work will be based on service and other soft factors.

would minimize interferences and enhance installation efficiency. The expectation is to see more duct installation using automated layout tools that prefabricate many of the assemblies and spot hangers to improve hanging, connecting, and sealing. Both productivity and performance will be enhanced in the process.

Service, Replacement, Retrofit, and Maintenance Tasks of the HVAC Contractor in 2018

The HVAC contractor will be service focused, and the trend will accelerate of retrofit and repair work being more prevalent than new work. How the system is replaced within the residential market will not change much, but the timing of when a system is replaced will change.

5.5.16 The HVAC Contractor Will Be Service Focused.

The contractor of 2018 will have a focus on service due to new technologies that will require specialized service and expertise. Top-quality service will be a differentiator. More than 81 percent of the respondents believe that it is likely that differentiation of HVAC work will be based upon service and other soft factors, as shown in Figure 17.

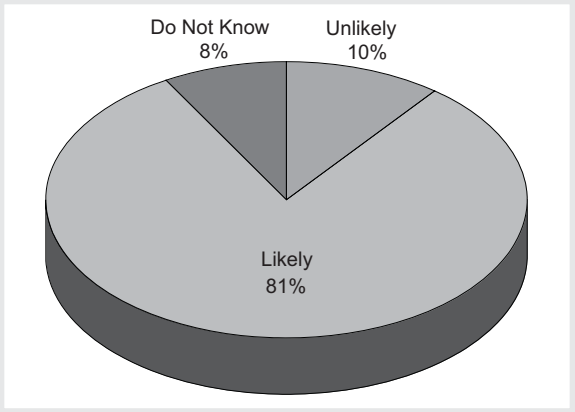

Figure 17: Differentiation of HVAC Work Will Be Based upon Service and Other Soft Factors.

Residential HVAC contractors will also be focused on service, and the way they perform repair work probably will not change appreciably. Figure 18 shows that more than 75 percent of the respondents believe that the residential business model will have changed to be even more service oriented.

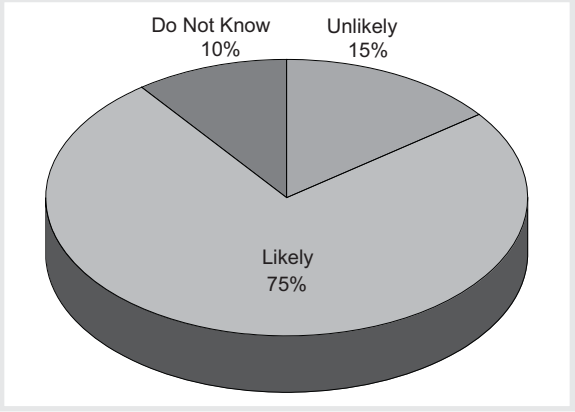

Figure 18: The Residential Business Model Will Have Changed to Be More Oriented Toward Service.

5.5.17 The Trend of HVAC Retrofit and Repair Work Being More Prevalent Than New Work Will Accelerate.

The replacement and service market will flourish as existing equipment ages and new more efficient systems are developed. The respondents agree (90 percent) that it is likely that there will be considerably more retrofit and repair than new work in both the residential and nonresidential markets (Figure 19). Some of the demand for this type of work will very likely be handled by the owners, since the systems are expected to be far simpler and more plug-and-play-based.

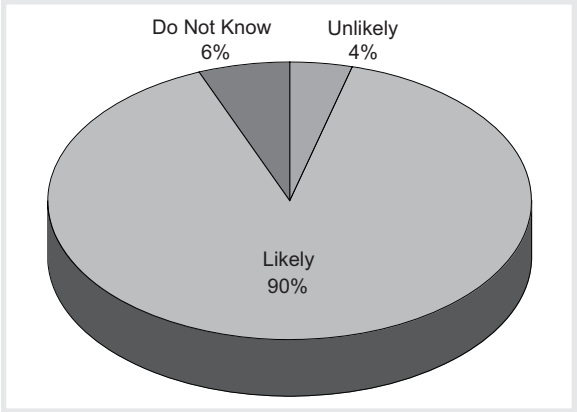

Figure 19: There Will Be Considerably More Retrofit and Repair Than New Work.

5.5.18 Timing for When a System Is Replaced Will Change.

Many systems will be replaced to achieve improved performance rather than due to failure. These systems will often be remotely monitored so that they can be triggered by performance criteria. With continuous performance monitoring, metrics that provide actual performance levels achieved and costs of energy, operation, maintenance and repair, and replacement of systems will be driven not by end-of-life failure, but by operational goals tied to building operation and maintenance. The migration of California standards for residential energy/green standards to other states would increase system replacements in order to assure compliance with the new standards.

Growth of a New Sub-Industry: Environmental/Energy-Optimization Firms

Demand and supply for EMS/BAS (Energy-Maintenance Services/Business-Automation Systems), also referred to as control contractors, are expected to expand rapidly. Many systems are expected to be controlled from a central monitoring site that could be located anywhere in the world. Building owners specify what they want and then outsource the process with the objective of maximizing sustainability-focused efficiencies and minimizing costs. Figure 20 shows that more than 80 percent of the HVAC Futures Advisory Group believes it is likely to expect that control contractors will increase their presence in the nonresidential HVAC industry.

The tasks of building automation and control may very well become a significant industry in itself.

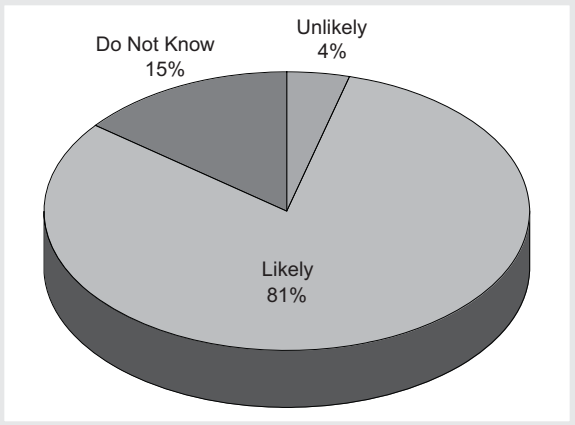

Figure 20: Controls Contractors Will Increase Their Presence in the Nonresidential HVAC Industry.

The tasks of building automation and control may very well become a significant industry in itself, with independent, highly technical facility-management companies operating the systems for owners of nonresidential as well as residential structures. These companies will have a major emphasis on being a "commissioning agent" or "energy-efficiency expert" and are likely to be composed of highly skilled, highly paid problem solvers. One potential model already noted is that the Building Intelligence System will evolve into more of an energy- and environmental-optimization discipline responsible for monitoring, maintaining, and remediating the various building systems that involve energy usage and environmental systems.

5.6 D. Changes in the Business Environment

Introduction

This section summarizes expectations for the future developments of the primary forces that will drive the changes in the construction-based aspects of the HVAC industry. These expectations are organized into the following contexts:

1. Environmentally Focused Regulations of the Future
2. Competitive Environment of 2018
3. The Work Force Environment

Environmentally Focused Regulations of the Future

5.6.1 Introduction

This section summarizes expectations for the future developments of environmentally focused regulations. These expectations are organized into the following contexts:

1. Impacts of the Built Environment on the Natural Environment
2. Impact of Sustainable Environment Construction Activities on the U.S. Economy
3. LEED as a Reference Point for Future Regulations in the U.S.
4. Future Direction of LEED Criteria

To appreciate the basis for the expected increase in environmentally focused regulations, a brief overview of how the built environment affects the natural environment precedes the expectations for how the regulations will impact the U.S. economy and its construction industry.

5.6.2 Impacts of the Built Environment on the Natural Environment

The built environment has a profound impact on our natural environment, economy, health, and productivity. According to the U.S. Green Building Council (USGBC),[23] buildings alone have the following demands and impacts on the natural environment:

Materials Use: Buildings, globally, annually use an estimated three billion tons of raw materials, which equates to roughly 30 percent to 40 percent of all raw material usage each year.[24]

Waste Production: The U.S. Environmental Protection Agency (EPA) has estimated that building-related construction and demolition (C&D) generates between 30 percent and 40 percent of all the waste produced in the U.S., more than 136 million tons of C&D debris in a single year.[25]

Water Use: Buildings in the U.S. are estimated to use about 12 percent of all potable water or 15 trillion gallons per year (in 1995).[26]

Energy Consumption: Buildings consume an estimated 35 percent to 40 percent of the energy used in the U.S. (includes fuel input for production).[27] For electric energy, buildings are estimated to consume between 65 percent and 70 percent of the U.S.'s electrical production.[28]

Greenhouse Gas Emissions: Ultimately, the final concern is the volume of GHGs that are produced in the construction and usage of buildings, which is estimated to represent approximately 30 percent of all the GHGs produced annually in the U.S.

With this magnitude of impact that the built environment has on the natural environment and the current level of general concern regarding global climate change, the need for monitoring, controlling, and reducing the volume of GHGs that the built environment produces seems quite evident. It should be noted that, although many green building programs have been in existence for 10 years or more, the practice of green building is not clearly defined or particularly straightforward. Many gray areas remain regarding the identification and quantification of the true environmental impact for each construction activity.

Buildings consume an estimated 35 percent to 40 percent of the energy used in the U.S. (includes fuel input for production).

[23] U.S. Green Building Council, Green Building Research http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1718.
[24] Lenssen and Roodman, 1995, "Worldwatch Paper 124: A Building Revolution: How Ecology and Health Concerns are Transforming Construction," Worldwatch Institute.
[25] http://www.epa.gov/epaoswer/non-hw/debris/about.htm, and U.S. EPA Characterization of Construction and Demolition Debris in the United States, 1997 Update (U.S. EPA Characterization of Municipal Solid Waste in the United States, 1997 Update. Report No. EP.
[26] U.S. Geological Service, 1995 data.
[27] U.S. Green Building Council, Green Building Research citation of 2003 U.S. DOE Buildings Energy Databook; U.S. Green. Building Council, Green Building Research http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1718
[28] 2003 U.S. DOE Buildings Energy Databook.

5.6.3 Impact of Sustainable Environment Construction Activities on the U.S. Economy

In 2005 the U.S. DOE estimated that the value of construction activities in the U.S. represented approximately 14 percent of the $10 trillion U.S. gross domestic product (GDP) or about $1.4 trillion (includes all commercial, residential, industrial, and infrastructure construction). Considering only commercial and residential building construction, the proportion is almost 10 percent of the GDP, or about $1.0 trillion.[29]

5.6.4 LEED as a Reference Point for Future Regulations in the U.S.

This report includes a focus on the LEED program, as it may be the most reliable reference point and indicator of how environment-focused regulations evolve in the U.S. "LEED currently forms the basis for other sustainability rating systems in the U.S. such as the Environmental Protection Agency's Labs21."[30]

5.6.5 Future Direction of LEED Criteria

Below are the six guiding principles that the USGBC uses to steer its activities.[31] As such, these concepts are strong indicators of the general direction in which future evolutions of LEED criteria are likely to go and the future environment for the building and HVAC industry.

1. **Promote the Triple Bottom Line (Profit People, Planet).** USGBC will pursue robust triple bottom line solutions that clarify and strengthen a healthy and dynamic balance among environmental, social, and economic prosperity.

2. **Establish Leadership.** USGBC will take responsibility for both revolutionary and evolutionary leadership, by championing societal models that achieve a more robust triple bottom line.

3. **Reconcile Humanity with Nature.** USGBC will endeavor to create and restore harmony between human activities and natural systems.

4. **Maintain Integrity.** USGBC will be guided by the precautionary principle in utilizing technical and scientific data to protect, preserve, and restore the health of the global environment, ecosystems, and species.

5. **Ensure Inclusiveness.** USGBC will ensure inclusive, interdisciplinary, democratic decision-making with the objective of building understanding and shared commitments toward a greater common good.

6. **Exhibit Transparency.** USGBC will strive for honesty, openness, and transparency.

The USGBC has been working on the next generation of LEED criteria, which is expected to be released this year (2008). The release of the next generation of criteria for LEED certification, known as LEED 3.0, is

[29] 2006 U.S. DOE Buildings Energy Databook (referenced in - Green Building by the Numbers - January 2008 - http://www.usgbc.org/ShowFile.aspx?DocumentID=3340).
[30] Wikipedia - http://en.wikipedia.org/wiki/Leadership_in_Energy_and_Environmental_Design#LEED_and_carbon_trading.
[31] http://communicate.usgbc.org/usgbc/2006/08.15.06_guiding_principles/guidingPrinciples/index.html

expected to "align the many versions of the LEED green building rating system (new construction, existing buildings, etc.), as well as incorporate recent advances in science and technology."[32] Three major areas of refinements in the expected LEED criteria are making provisions for local climate considerations, making entire building life-cycle assessments, and monetizing the climate-change impact.

The future of IAQ demands are contingent on education and awareness of the various factors that can affect design and facility management strategies. Energy efficiency, IAQ, and indoor air comfort (IAC) are big influencers of new construction and design requirements, particularly in the health care sector. Other commercial buildings are also benefiting from additional attention to IAC and IAQ. New priorities are being placed in the design phase to encourage greater individual control of IAQ and IAC; however, retrofit design and construction is not as greatly influenced, as there are significant cost implications that make a renovation less economically viable. It is the current perception that IAC is a priority over IAQ during the owner's purchasing decision, because IAC is measurable by temperature, sound, humidity, etc., while owners and building users have difficulty quantifying IAQ value. IAQ will continue to gain importance as productivity, comfort, and the increased potential for health risks prevail.

Competitive Environment of 2018

5.6.6 Introduction

This section summarizes expectations for the future developments in the competitive environment. These expectations are organized into the following contexts:

1. Consolidation Activity
2. Expansion of Services
3. Power and Role Shifts
4. New Entrants

5.6.7 Consolidation Activity

Expectations are for continued consolidation, with added large "corporate" builders and fewer small or independent builders. The pace of mergers and acquisitions in the construction industry will continue to shape and mold the appearance of the industry. This is further supported by the majority of survey panelists who expect horizontal and vertical consolidation in the industry to continue for the next decade (Figures 21 and 22). The likelihood of consolidation activity rising is also attributed to the survey participants' belief that HVAC contractors will experience an increased commoditization of services, potentially negatively impacting long-term profitability.

[32] US Green Building Council; West Michigan Chapter Newsletter; September, 2006

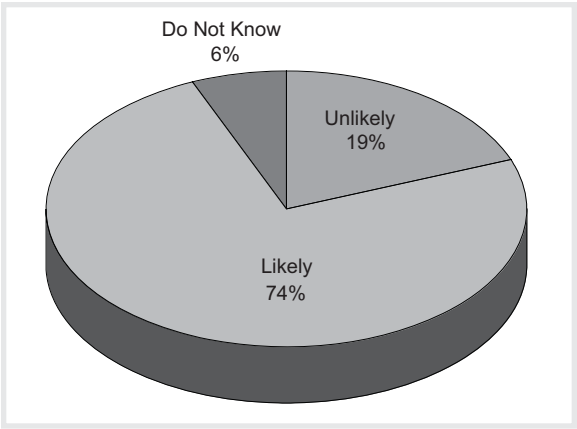

Figure 21: Horizontal Consolidation in the HVAC Industry Is Expected to Continue.

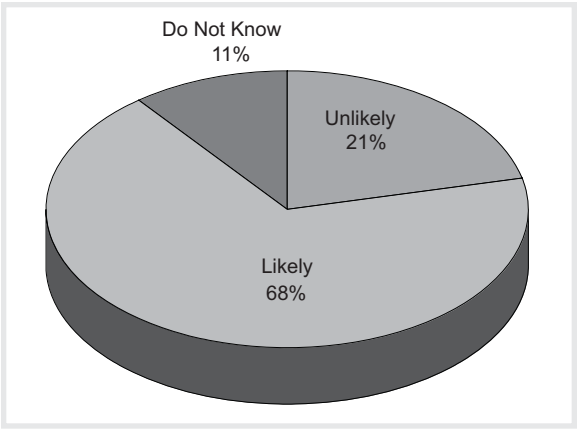

Figure 22: Vertical Integration in the HVAC Market Is Expected to Increase.

Fewer and larger companies will serve the commercial and nonresidential markets for new construction. It is expected that the Emcors, Service Experts, Comfort Systems and similar firms will continue their expansion activities. The continued bifurcation of the U.S. construction market will be reflected in the owners and developers building new construction projects. This will require contractors to follow this lead with the ability to meet the increasingly demanding needs of larger owners.

Expansion of Services

Predictably, fueled by the aging of the contractor owners and continuity/ownership transfer concerns, significant consolidation will occur among HVAC contractors. Input from the participating Advisory Council members supports this projection of continued industry consolidation.

The result will be a group of large, well-capitalized firms that are expanding throughout the U.S. As a result, smaller, independent contractors are faced with increased market competition and additional pressures to remain agile.[33] Additionally, in response to changes, some may choose to specialize the work to gain maximum efficiencies and productivity. With specialization and more advanced systems,

Fewer and larger companies will serve the commercial and nonresidential markets for new construction. It is expected that the Emcors, Service Experts, Comfort Systems, and similar firms will continue their expansion activities.

[33] Global Foresight, Inc., "2006 Report on Industry Trends. Heating, Ventilation & Air Conditioning"

organizations will require highly skilled technicians working in applications such as energy management, controls, etc.

In addition to the expected continuation of consolidation, tomorrow's construction company will be a more corporately oriented builder, displaying a more sophisticated business sense, endearing them to large construction owners. Due to this perceived evolution, all parties will be required to adopt and embrace a more corporate mindset, including design firms and trade contractors.

In the residential market, the largest group of contractors continues to be the establishments with one to four employees, as shown in Figure 23. Should an increase of consolidation occur, that trend will gradually shift to create a divergent composition of a few mega-companies and a large number of small shops. The middle-sized companies will either fall out or become absorbed by larger regional/national firms.

Tomorrow's HVAC contracting landscape will see a number of large contractors with extensive capabilities and small contractors who provide personal service, but have narrowly focused technical capabilities. Despite the anticipated progression of the construction and HVAC industries, there will remain a market for the small, independent contractor or trade contractor that fills a notable need in niche markets with specific customers. In an environment where the project owner demands personal interaction and involvement on a project, often it is

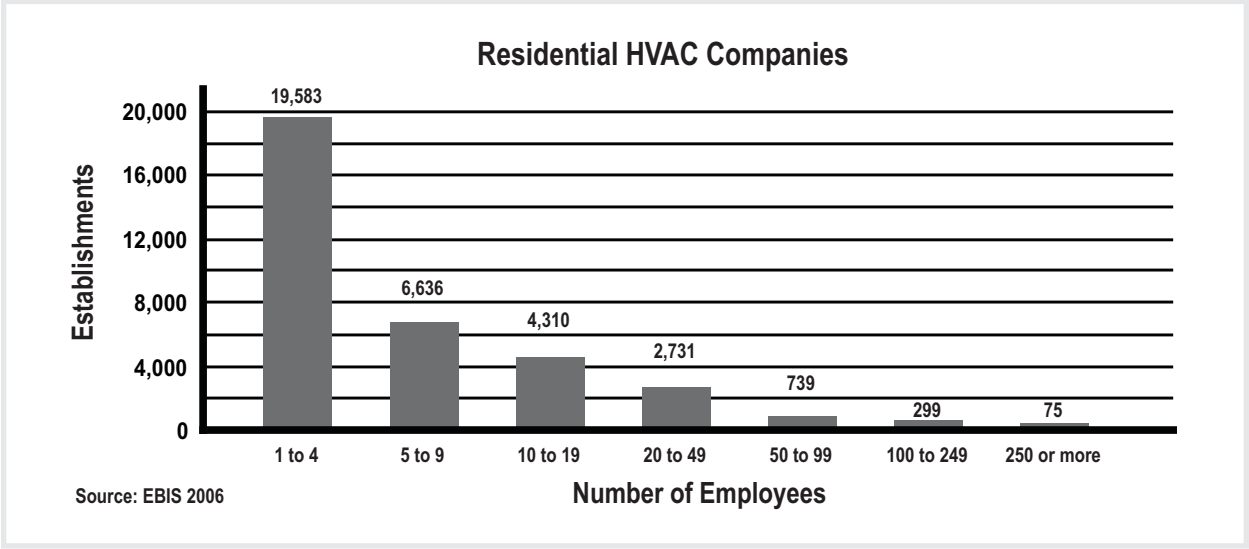

Figure 23: Residential HVAC Establishments (2006)

In an environment where the project owner demands personal interaction and involvement on a project, often it is the smaller, more versatile contractor that succeeds.

the smaller, more versatile contractor that succeeds. What these companies lack in size and resources, they make up for with personal attention, flexibility, and innovation.

Barriers to entry are beginning to surface, particularly on larger, nonresidential work. This consolidation, both horizontal and vertical, has resulted in the formation of more efficient and cost-effective supply chains to support large clients. This restructuring provides cost advantages, while increasing the quality of the delivered building and building services. Contractors who were quick to capture the advantage of changing processes and technology grew their businesses at the expense of those contractors who were hesitant to transition from past practices.

The recent decline in new SF construction has resulted in many contractors expanding into new and unfamiliar markets. These shifts often present unexpected and insurmountable obstacles. In the nonresidential sector, the increased regulations and requirements will likely result in a smaller number of contractors being capable of performing this type of work. In addition to the added technical challenges of nonresidential construction, new technologies, products, and certifications are becoming more commonplace. BIM, green building, LEED certification, etc., all pose as barriers to entry into this and other markets. For the larger, commercially oriented projects, legitimate barriers to entry do in fact exist. Liability issues associated with commissioning, IAQ, and other work serve to keep out the untrained and unqualified competitors. Even with these challenges, however, there are only limited barriers to entry in the residential market.

While there continues to be evidence that domestic contractors will consolidate, there is strong agreement (Figure 24) that dominant offshore contractors will enter the U.S. market in response to growing construction and HVAC opportunities. This changing set of competitors will challenge the smaller domestic contractor to sustain market share.

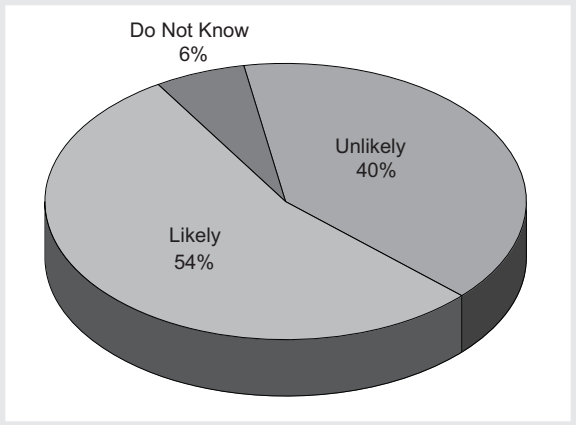

Figure 24: Potential for Offshore Contractors to Enter the U.S. Market Will Increase.

Manufacturer incentives will not encourage a proliferation of new entrants/start-ups. Continued consolidation among the larger, more technically capable contractors will certainly reduce the available number of this type of building contractor and trade contractor. In addition, roughly 60 percent of survey participants agreed that the prospect of significant competition from new start-up contractors supported by manufacturer incentives is minimal. The inherent risk of contracting, coupled with the war for talent the industry faces, will moderate the number of new entrants in the nonresidential market.

Larger contractors will have to expand the scope of their services offered, as opposed to

The integration of HVAC contractors into design and other atypical work will be paramount for sustained success for those firms seeking to maintain the traditional model.

narrowing the scope. Tomorrow's contractors will face an ever-growing pressure to offer more services and possess greater capabilities. Construction owners and general contractors will want to limit the number of partners involved, demanding broader capabilities from their HVAC partners. Nonresidential HVAC contractors will be tasked with taking on more design-build work in order to meet the unique and evolving needs of its customers.

As contractors have consolidated and grown, the ability to consistently provide personal, quality service has become even more challenging. However, this will prove to be an opportunity for those contractors who focus on quality service to distinguish themselves from others. Local owners and developers commonly favor working with local partners, with whom they can develop a relationship for delivery of efficient, productive work environments and high-quality indoor environments.

Existing contractors will need to respond to market forces requiring one-stop shopping. It is expected that tomorrow's HVAC contractor will appear dissimilar to today's version. It will need to be streamlined, proactive, and versatile. The integration of HVAC contractors into design and other atypical work will be paramount for sustained success for those firms seeking to maintain the traditional model.

HVAC contractors will increasingly be tied to both the design and operation phases of the building life cycle. With process integration supported by BIM and like tools, HVAC contractors can leverage their technical expertise to expand their contribution to the building team to include design simulation and equipment selection as well as commissioning of equipment employing embedded intelligence and integration of equipment into the operation and maintenance management systems.

Technologies like CAD and BIM will help to prevent interference and waste as well as improve maintenance after construction. Larger, national contractors will be able to offer end-to-end services. Larger, more vertically integrated contractors and manufacturers will offer a complete analysis of the carbon footprint and provide the needed documentation and advice for increasingly green construction concerns

Larger, more vertically integrated contractors and manufacturers will offer a complete analysis of the carbon footprint and provide the needed documentation and advice for increasingly green construction concerns of owners.

of owners. The need for full service and documentation required by governmental agencies will preclude mid-size to smaller contractors from being cost-effective in this market.

5.6.8 Niche Opportunities

An increased number of local/regional boutique HVAC contractors serving the upscale residential market for custom new homes and major retrofits is expected. The focus on economies of scale and large projects will leave open an underserved niche of well-funded, smaller-scale projects with unusual needs such as custom-built homes seeking cutting-edge self-sufficiency for energy needs. These projects may seek to take full advantage of solar energy systems, passive solar heating, and low-energy cooling concepts. This group may also include more traditional wealthy homeowners who want more control over the project and a closer relationship with the builder.

At the same time, HVAC retrofits and large repair work will be better served by trusted local firms or local branches of larger national firms that are easier to work with and act like smaller specialty firms. While this sector may be the most desirable to work in for new entrants to the market, it will also require the most individual expertise due to the need to be flexible and informed in a number of technologies.

Power and Role Shifts

Larger owners will invest more control in construction managers and program managers to oversee projects and multiproject programs. On large, complex projects requiring a high percentage of project cost for HVAC or special HVAC capabilities, as in industrial work, owners may increasingly contract directly with large HVAC firms. Owners are expected to rely increasingly on construction managers or program managers, whether in-house or more often as outside contractors to manage their programs. In turn, these firms will seek to shift the risk to a flatter organization putting more reliance on the mechanical engineer and specialty contractors. Although BIM is an increasingly collaborative process tool, HVAC contractors will use their knowledge and ability to use BIM to centralize control of the project. This process may also lend itself to greater affiliation with manufacturers linked into the supply chain through BIM applications. For markets where HVAC work is significant relative to project size, this approach will dominate and in time be adopted in other segments.

Many larger general contractors will act as the construction manager, self-performing or buying out subcontractors as they now do; but relationships with subcontractors will become closer, more selective. Most major general contractors have the capability to act as construction managers, and this capacity will grow as they decide to self-perform time-critical or high-profit-margin work. To have greater project control and lower risk, they will form close relationships with a few subcontractors that are reliable, have a sufficient qualified labor force and work as though they were partners in the process. This alignment will likely favor contractors that are able to provide high levels of multitrade collaboration.

For larger nonresidential and retrofit/repair projects, larger HVAC contractors will act as prime contractors and provide design-build services. The owner will push out more risk

HVAC contractors with full in-house engineering and design capabilities will benefit by becoming the prime contractor for owners in this market. Close alignment with manufacturers will further solidify this relationship.

to manufacturers and trade subcontractors. Manufacturers will then require 100 percent of systems to be their equipment in order to provide warranties. Code requirements and changing technology will mean more involvement of HVAC contractors on large renovation projects, especially where the goal is to reduce and manage energy consumption while providing a safe, low-maintenance project. HVAC contractors with full in-house engineering and design capabilities will benefit by becoming the prime contractor for owners in this market. Close alignment with manufacturers will further solidify this relationship. At the same time, in order to offer competitively priced systems and support higher risk in warranties, manufacturers will require even greater loyalty from the contractor.

New Entrants

Big-box stores or other new suppliers will package equipment and labor primarily for residential home repair and retrofit work. Packaged with a home energy audit, these services will address the need for reducing energy usage in the home and finding someone to do the work. The high cost and availability of labor will be an incentive for manufacturers to design units like mini-split and other systems yet to be developed that are easier to install. Big-box stores will help push these units to the consumer as well as packages for home energy audits, installation, and maintenance contracts. Alliances between the big-box stores and HVAC equipment manufacturers will continue to be developed to gain a larger share of the residential market.

Manufacturers trying to build brand will increase their leverage in the market by aligning vertically throughout the distribution channel to the contractor level. In the commercial markets, improved technologies such as 3D CAD and BIM will allow the manufacture and preassembly of major HVAC system components anywhere in the world. These components will be nearly plug-and-play, giving the manufacturer more control and turning what used to be a construction project into an installation task. This vertical alignment will allow the manufacturers to keep systems priced low by sourcing labor and materials anywhere in the world as long as delivery to the site can be made on time and within budget. This also makes it likely that some large owners will contract directly with manufacturers to take advantage of their purchasing power. Such agreements will make it very difficult for traditional HVAC contractors to compete on some work, and they will likely become subs to the manufacturer or, in some cases, be bought out by the manufacturer to do the installation.

Utilities are also particularly well positioned to participate in both the residential and nonresidential HVAC markets.

In the residential market, the expectation is for some manufacturers to become installers through acquisitions of local HVAC residential contractors. The desire is to capitalize on the annuity opportunity and revenue stream through service and retrofit work in an effort to minimize risk and revenue volatility. Utilities are also particularly well positioned to participate in both the residential and nonresidential HVAC markets. Although utilities were burned in the 1990s with their previous market entry, conditions are favorable for market re-entry. One scenario includes the utility actually owning the HVAC equipment through a leaseback arrangement, with ongoing monitoring, maintenance, and retrofitting managed by the utility in close association with the equipment manufacturers.

The Work Force Environment: Expected Gaps in Labor Availability and Skills for the Future of the HVAC Industry and How These May Play Out

5.6.9 Introduction

How will the HVAC work force of 2018 be different from that of today? And how will the work of staffing and managing the crews be different? The answers to these questions will be determined, in general, by the age-old economic dynamic between the demand for labor versus its supply and how these two evolve during the next 10 years. Woven into how the general demand-versus-supply equation shapes the HVAC work force of 2018 is a set of contributing factors and their interrelated dynamics, including skill sets needed compared to skill sets possessed by the available labor.

This section summarizes expectations for the future developments in the labor market. These expectations are organized into the following contexts:

1. Expected Demand for Labor in HVAC
2. Expected Supply for Labor in HVAC
3. Outsourcing and Do-It-Yourself (DIY) as Alternative Solutions to Shortages in Labor
4. The Critical Role of Training
5. Union Presence

Expected Demand for Labor in HVAC

All the currently available projections for the volume of demand for labor in construction and HVAC are based on the assumption of a reasonably performing economy. As such, the available projections do not take into consideration an extended slump in the residential market or the potential effect that the subprime situation will have on the U.S. economy in the long run. No doubt, though, the subprime situation will drive a short-term reduction in the demand for labor in the HVAC trade, especially on the residential side. However, the Bureau of Labor Statistics (BLS) expects that, during economic conditions that cause a decline in the demand

In general, the BLS expects that the demand for HVAC mechanics and installers will grow faster than the industry average.

for construction-related services, there would continue to be a strong demand for technician employment for HVAC service and repair.[34]

In general, the BLS expects that the demand for HVAC mechanics and installers will grow faster than the industry average.[35] The Construction Labor Research Council (CLRC) estimates that the need for new entrants into sheet metal work represents about 5 percent of the new entrants in craft labor needed for the construction industry each year, which during more stable economic conditions equates to between 6,200 and 8,700 net new entrants needed per year.[36]

Expected Supply for Labor in HVAC

For the construction industry in general, and very likely relevant to HVAC as well, the CLRC expects no shortage of people available to perform the desired construction work of the future, but it is likely that there will be a shortage of *adequately trained, skilled, and productive* labor to perform the work.[37] Furthermore, due to regional differences in the demand for construction, shortages will be more severe in some locales than in others.

In general, meeting the demand for labor in the HVAC industry of the future will be dependent upon several sources and related dynamics, including the retirement rate in the current HVAC work force, the rate of entry into the HVAC industry by new generations, the rate of entry into the HVAC industry by immigrants, and the availability and effectiveness of the training needed for HVAC work.

Retirement Rate in the Current HVAC Work Force: The CLRC's analysis of the supply of craft labor in the future indicates that the number of sheet metal workers will be affected relatively mildly by the retirement of workers from the baby-boom generation. The council concludes that the drop in supply due to retirement will not be as large an issue as it will be for crafts such as boilermakers, pipe fitters/plumbers, and bricklayers, as only about 13 percent of sheet metal workers were 50 years old or older in 2003, compared to 20 percent or more for these other three trades.

The effect of retirement is expected to be even less in the residential sector, as the average age of the HVAC worker in this sector is younger than his counterparts in the nonresidential sector. In the near term, the residential sector may feel no shortage of labor whatsoever due to the declining trend in the number of housing starts compared to previous years, peaking in 2005 at 2.1 million and dropping to 1.8 million in 2006 and 1.4 million in 2007.[38] Projections for 2008 are

[34] Global Foresight, Inc.,"2006 Report on Industry Trends; Heating, Ventilation & Air Conditioning." Their report cites the Bureau of Labor Statistics as a source. (http://www.doe.mass.edu/cte/frameworks/trends_ov/hvacr.pdf).
[35] Ibid.
[36] "Craft Labor Supply Outlook 2005–2015," Construction Labor Research Council 2005
[37] Ibid.
[38] U.S. Census; http://www.census.gov/const/startsan.pdf

for 1.2 million starts, which is a level last seen in 1992.[39]

The rate of retirement may also be slowing. In general, people are working later in life—some just to stay active, but others are feeling a financial need to continue working. We are living longer than before, which means there are more years in the traditional retirement phase of life. In addition, there has been an increase in the age requirement for receipt of full Social Security benefits as well as a shift from mostly defined benefit pensions (which facilitate early retirement) to an increased usage of defined contribution plans.[40]

Whereas these factors all apply to some extent to construction, an additional factor of construction work typically being physically demanding is often seen as a limiting factor in terms of how old someone can be and still be effective. This means that people working in the construction trades may choose to work well past the traditional age of retirement, but they may switch to other industries that are not as physically demanding. HVAC work of the future, however, may provide many opportunities that are less physically demanding than now. It is expected that many of the tasks related to the HVAC systems of 2018 will be more technical than physical, enabling many of the more senior craft workers in the industry to remain actively productive many years past the traditional retirement age in the trades.

Rate of Entry into the HVAC Industry: Although the retirement issue may be of less concern for HVAC than for many other crafts in construction, new entrants will still be needed, especially to support the strong potential growth. It is widely known that there will be plenty of competition to attract qualified new entrants between construction and many other industries (as well as between HVAC and the other trades within construction). New entrants to the HVAC industry will need to come from the generation now in high school, immigrants, and possibly nontraditional population groups. Figure 25 shows that almost two-thirds of the HVAC industry leaders in this survey believe it is unlikely that the HVAC industry will become a highly sought-after industry for employment by younger workers, which reinforces another industry challenge.

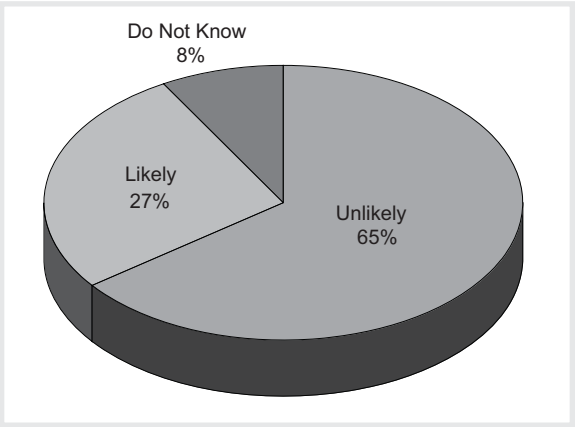

Figure 25: The HVAC Industry Remains Unattractive to the Younger Generation of Workers.

HVAC work of the future, however, may provide many opportunities that are less physically demanding.

[39] Curry, Sheree R. "2008 Housing Forecast for Homebuilders," Housing Giants; Reed Business Information. December 1, 2007.
[40] "Craft Labor Supply Outlook 2005–2015," Construction Labor Research Council, 2005.

Rate of Entry into the HVAC Industry by Immigrants: Immigrant labor will continue to be the fastest-growing segment of the construction labor pool over the next decade. According to the CLRC study, training for this labor pool is uneven across skill sets. Therefore, some skill areas will have even higher rates of labor shortages. The growth rate for Hispanics in the U.S. (23 percent) is almost four times that of whites (6 percent). Whether this population is born in the U.S., naturalized citizens, non-U.S. citizens who are in the U.S. legally (green-card holders), or currently considered illegal immigrants, there will need to be a continued emphasis on bilingual training. Currently, it is believed that most of that training is being conducted in the unionized sector of the labor market, but the need crosses all labor to some degree.

According to the Labor Department's BLS, construction employed the greatest number of foreign-born workers in 2005—about 2.5 million immigrants, or about one out of every eight people coming to this country. Immigration will continue to change the labor force and wages. It is expected that the U.S.'s relative economic strength will attribute to increased global sourcing initiatives.

Outsourcing and DIY as Alternative Solutions to Shortages in Labor

Outsourcing: The labor force is becoming increasingly globalized with more and more U.S. companies locating production in other countries. With the expected increase in prefabrication and modularization, increases in overseas outsourcing are also very likely (see Figure 26). The example of Pharmadule cited earlier is an illustration of how this may play out for a significant share of work. Developing economies' lower cost of labor coupled with available technologies makes global outsourcing extremely feasible. The reliance of the U.S. on global markets is expected to become more integrated through 2020. Despite this outsourcing trend, the impact will be minor as it relates to the HVAC installation, service, and retrofit business. Some impact will likely occur through equipment manufacturing and duct fabrication.

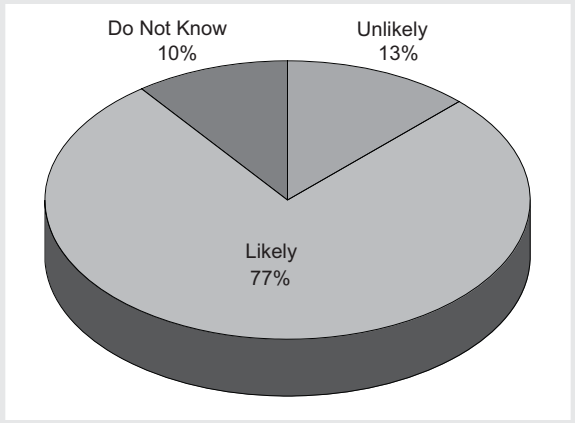

Figure 26: Global Outsourcing Will Prevail Due to Developing Economies' Lower Cost of Labor, Coupled with Available Technologies.

The labor force is becoming increasingly globalized with more and more U.S. companies locating production in other countries.

Simplified Equipment-DIY: In response to a limited labor supply, it is expected that there will be an effort to reduce labor requirements for equipment installation. The simplified products, such as plug-and-play systems, make the installation less labor-intensive. In some cases, even a DIY opportunity may exist for some systems. Manufacturers and/or large distributors may gain a significant share of these expenditures through well-targeted online catalogs and competitive prices.

The Critical Role of Training

As noted above, a shortage of labor in construction really means that there will be a shortage of adequately trained craft workers. As such, training programs will be the leading contributor to increasing labor supply and addressing the changing skill-set requirements within the industry. HVAC work requires a trained work force, with a much higher skilled and advanced work force being required for certain trade-specific activities. This shift provides the industry with the opportunity to change the perception of HVAC laborers to more technical energy-management specialists.

Both the residential and nonresidential sectors will require specific programs addressing the unique characteristics of the HVAC portion of the built environment. The type and technical levels required run the gamut from the residential equipment installer to the energy/environmental systems technician on large, sophisticated nonresidential buildings.

Training Practices and Strategies: Specialized training centers are necessary to meet this labor challenge. Changing skill requirements and available training will drive innovative training practices and strategies as concern mounts. Additionally, increased technology and the desire for quality work will elevate consumer expectations of the industry. These are two areas that highly trained technicians can leverage to gain a foothold in the market. Figure 27 shows factors considered critical to quality training-focused initiatives. Training for installers on new types of technologies and buildings is extremely critical as the trend becomes increasingly adopted in the market. In order to adapt, a tremendous amount of preplanning in the HVAC design and construction process must occur. Individuals will need to be trained on the process and its implications. It is also expected that equipment manufacturers will assume a greater role in technical training.

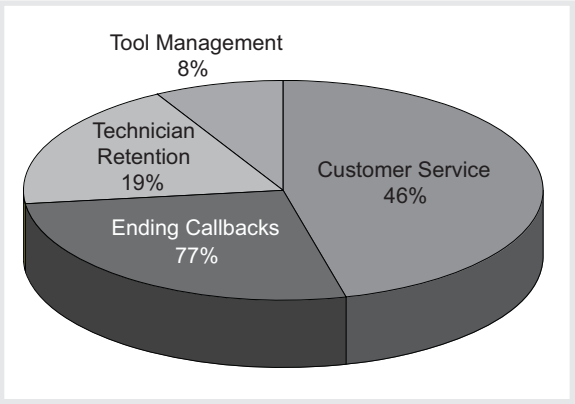

Figure 27: Critical to Quality Training-Focused Initiatives
Source: *Contracting Business*

Training for installers on new types of technologies and buildings is extremely critical.

Training programs will require information to be shared in nonconventional ways. In addition to technical training, training efforts will need to be refocused towards increasing customer-service capabilities and attention to additional elements not previously considered in establishing a competitive advantage. Training skilled labor from the Hispanic pool of labor to meet demands will require instructors with special communication skills not readily available now. Currently, non-English-speaking Hispanic labor adds difficulty for safety and job-site management needs. To attain the desired on-site efficiencies will require training of the Hispanic labor force to speak and write English well enough to understand directions and deal with forms and e-mail. Progressive training centers will need to adapt to the challenge.

Contractors and their labor partners will have to stay "ahead of the curve" to develop craft training and management skills to support this effort. It is suggested that a two-fold system of workers will become evident, each requiring diverse levels of training. One group consists of highly trained and technically skilled workers, while there will be a larger group of workers performing more "commodity" type work who will need to be trained, but to a much lesser extent.

In addition to increased training and preparation efforts, it is projected that further recruiting efforts to improve the level of a skilled work force will be employed in the future. Additionally, it is expected that there will be an increasing focus on retention needs of the industry. A distinction remains between the available work force and the skilled work force, with the potential for a gray market to surface in response to the increased training and skill requirements.

Union Presence

With the multitude of influencing factors shaping the future of the HVAC industry, organized labor is expected to play a critical role. The strength of unions, role in the marketplace, and composition are all elements that will prove to be integral in defining the industry of 2018.

The labor impact will affect union and nonunion firms differently. It is expected that union contractors are in a better leveraged position to absorb some of the labor constraints. It is likely that union contractors with a supply of trained employees would be in a better position to obtain the work and sustain the changing dynamics of the industry. However, concerning the residential market, nonunion construction firms are expected to remain in control in the absence of any labor-management effort to change the situation. It is expected that nonunion contractors will continue to dominate the residential HVAC work in the future.

Strength of Unions: The strength of union influence is perceived to be dependent on the increasing likelihood of union mergers and consolidations. Figure 28 shows that nearly 80 percent of the HVAC Futures Advisory Group believes that consolidation and merger activity will continue to increase through 2018. With consolidations, there is an expectation that the strength of the remaining organizations will increase as they become more effective and gain power in numbers. It is expected that a few aggressive, technology-focused, forward-thinking labor organizations will absorb other unions (formally or informally) and will grow share.

The strength of union influence is perceived to be dependent on the increasing likelihood of union mergers and consolidations. Nearly 80 percent of the HVAC Futures Advisory Group believes that consolidation and merger activity will continue to increase through 2018.

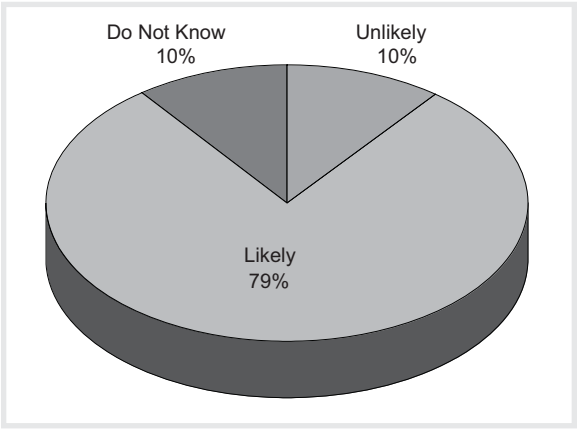

Figure 28: Significant Consolidation Will Occur in Building Trade Unions.

There is also an expectation that union influence will remain limited, due to inefficiencies and image challenges, potentially driving nonunion labor presence in the growth areas of the country. Union presence in the market simply doesn't match where a significant portion of the building is taking place. In addition, should modularization become more prevalent, it will further accentuate the challenge for union labor and contractors; the impact of panelization and modulization creates a disconnect for labor and management using the current model. This will give the prefabricator the advantage in selecting who will perform the on-site assembly of the building components, most likely going to labor they have trained and can control. Subsequently, many believe that the union organizational model is too inflexible. The sheet metal industry in general is believed to have a talented work force and among the more progressive union organizations. There is great opportunity to be highly nimble and simulate what the nonunion work force has achieved by creating a full mechanical work force, which is a one-stop, potentially more-efficient delivery system. However, traditional jurisdictional agreements may be at odds with being responsive to the employer and customer needs.

Table 2 shows the top 10 states for union employment in 2007 and the projected population growth from 2000 to 2030.

Top 10 States by Union Employment as a Percent of Total Employment	
State	% of Employed 2007
New York	25.2
Alaska	23.8
Hawaii	23.4
Washington	20.2
Michigan	19.5
New Jersey	19.2
California	16.7
Minnesota	16.3
Connecticut	15.6
Nevada	15.4

U.S. Department of Labor, Bureau of Labor Statistics, "Union Members in 2007" January 2008, http://www.bls.gov/news.release/union2.nr0.html

Top 10 States by Projected Population Growth	
State	Change: 2000 to 2030 (%)
Nevada	114.3
Arizona	108.8
Florida	79.5
Texas	59.8
Utah	56.1
Idaho	52.2
North Carolina	51.9
Georgia	46.8
Washington	46.3
Oregon	41.3

U.S. Census Bureau, Population Division, Interim State Population Projections, 2005 http://www.census.gov/population/www/projection/projectionsuagesex.html

Table 2: Top Ten States for Union Employment and Projected Population Growth

Mixed perceptions remain as to the strength of union involvement in the long term as a result of increased pressures from nonunion contractors. Many unions will continue to decline in terms of importance with only those adapting to new markets, the new work force, and new skill demands being able to capitalize on the challenges. Few, if any, unions, even in larger cities, will have a strong position without the desire and ability to adapt. It is expected that union labor will continue to decline in the short term and ultimately stabilize at levels well below historical benchmarks. If the union sector does not take in and utilize the new types of workers that make up the work force, then the deterioration of union work is expected and likely to continue. Furthermore, a continued decrease in union strength is anticipated as the dynamics of the industry shift and cause the unions to go through a cycle of reorganization. Figure 29 shows that more than 70 percent of the survey respondents believe that unions will be restructured.

Mixed perceptions remain as to the strength of union involvement in the long term as a result of increased pressures from nonunion contractors.

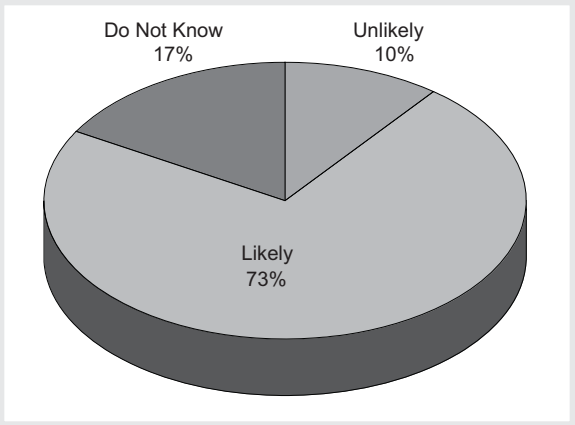

Figure 29: Unions Will Be Restructured.

Some sectors remain more responsive and in need of union organizations. In general, it is expected that nonunion contractors will dominate the residential market as unions consolidate, and unions will continue to lose ground in the residential markets. The cost of union labor will work against growing HVAC market share in this sector, and residential labor rates will be important to retain market share. The obvious residential opportunity seen by the HVAC Futures Advisory Group is in the service and retrofit markets and MF building.

The Role of Unions: The role of unions will be defined by how adaptable to change the organization is; otherwise, the risk is great that unions will be replaced by nonunion labor. Increased use/adoption of new technologies will establish unions that thrive; those that do not will not survive the changing shifts of the market.

It appears that the role of unions remains unclear going forward, as they will still be viable and still be a major source of trained labor, supplying niche markets and niche customers. The role of unions is dependent on what the organizations do to create leverage within the industry. Currently, if no changes are implemented, the unions' role in the marketplace will continue to diminish.

The role of unions in providing a knowledgeable and skilled work force will be more critical than ever, establishing the union's primary role as a recruiting and training organization. The aspects of job security and compensation will become more of a meritocracy and be based on the skill and productivity of the work force. HVAC-certified technicians will be in high demand, and union training centers should leverage the opportunity to attract and train apprentices for certification. The joint labor/management training program and skill certification is a long-standing strength of the skilled trades. Unions and their contractor partners have the opportunity to become a dominant training resource in both areas.

Innovative training programs are necessary to stimulate both current and potential members in unions. The unions will need to adapt their training procedures to deal with

The joint labor/management training program and skill certification is a long-standing strength of the skilled trades. Unions and their contractor partners have the opportunity to become a dominant training resource in both areas.

the new diverse work force and to carefully match skill levels with very specific market demand. Training styles and techniques for a new work force will be a challenge that should be addressed in implementing new recruitment and joint labor/management training programs.

Additionally, unions will need to provide training that is more efficient while creating new areas of content that are required to keep the work force trained. Unions will need to be on the leading edge of training for the new skills and technologies required to meet the market's demand. There should be specialists within the union whose focus will be specific knowledge and skill sets, similar to subject matter experts within the HVAC field. Additionally, content will need to stimulate the younger generation to be challenged and exposed to advancements based on knowledge and performance.

Recruitment initiatives will play a critical role in infusing new topics and ideas into the industry specifically; unions will need to market membership to younger people and instill in potential members a sense of the importance of the skilled tradesman. It will be necessary to change the perception that a college degree is the only way to succeed. For example, union recruitment geared to a more technical, more green, younger worker could successfully fill a void in the market of the future.

The demographic trends will force organized labor to be more diverse in its makeup. A new outlook of responsibility will be needed as roles and influences of the industry diversify. Most importantly, demographic characteristics of the work force are creating a momentum of change. Minority workers are expected to dominate the next generation and, without an effort to change the course, they will likely choose to make their own agreement with employers rather than join a trade union.

It is expected exists that women will become more involved in unions and will also influence the composition of organized labor in 2018. Furthermore, it is believed that unions will remain more appealing to a less-skilled work force if the particular group believes it will receive the training expected to join the highly skilled work force.

Union Crew Mix and Productivity: Crew size and crew composition are also critical areas that impact productivity and ultimately the contractors' ability to get and produce profitable work. Greater flexibility in these areas will help to change the financial model and the existing perceptions regarding organized labor.

Recruitment initiatives will play a critical role in infusing new topics and ideas into the industry specifically; unions will need to market membership to younger people and instill in potential members a sense of the importance of the skilled tradesman.

5.7 E. HVAC Equipment of the Future

Introduction

This section summarizes expectations for the future developments of HVAC equipment. These expectations are organized into the following contexts:

1. Expected Product Developments
2. Improved Life-Cycle Efficiency
3. Trends in Product Supply

Expected Product Developments

Improved Energy Efficiency: High energy prices and greater regulation aimed at sustainability are expected by most to drive the development of higher-quality, longer-lasting, more energy-efficient HVAC systems. Approximately 40 percent of energy use is consumed by buildings across the U.S. Of the total use in North America, 40 percent of the consumption is from the HVAC system. It is expected that new minimum efficiency requirements will be mandated by the U.S. National Appliance Energy Conservation Act in 2008, driving the momentum toward developing net-zero energy-use facilities.[41] Figure 30 shows that three-quarters of the respondents from the HVAC Futures Advisory Group expect it will be likely that breakthrough equipment technology will yield significant energy efficiencies.

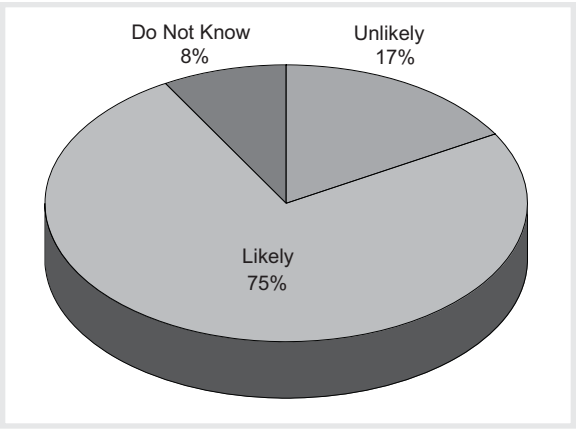

Figure 30: Breakthrough Equipment Technology Is Expected

The following product types and/or product characteristics are expected to experience greater development and/or usage:

1. Geothermal systems in new construction
2. Reduction in unit/housing size
3. Improved insulation
4. Commonplace heat recovery
5. Life cycles of new equipment extending beyond a 12- to 15-year period
6. Replacement of R-22 systems with R-410a
7. Non-ducted HVAC systems
8. Greater modularity and ability for more zones
9. Smaller portable units that increase the flexibility to control specific areas as well as reduce replacement costs

[41] Global Foresight, Inc. 2006 Report on Industry Trends. Heating, Ventilation & Air Conditioning

10. Increasingly complex components (electronically) that are increasingly simple to install, troubleshoot, and service

For new construction, extensive usage of geothermal systems may result in HVAC systems relying much less on electrical energy.

5.7.1 Improved IAQ Management

It is likely that the aging baby-boomer generation will increasingly demand systems that provide higher levels of air quality control as part of their efforts to hold down escalating health care costs. IAQ and IAC will become a critical decision-making factors in purchasing and consumer preferences. Some experts contend that IAQ will be a greater driver than energy costs in the overall green/sustainability movement. Expected improvements related to IAQ include the following:

1. Provision of natural ventilation that is appropriately filtered
2. Air cleanliness
3. Humidification control
4. More creative design and installation method
5. Higher-skilled (technologically) contractors

Improved Life-Cycle Efficiency

The processes involved in the manufacturing and installation of future HVAC systems are also expected to become increasingly efficient. Most HVAC systems for major nonresidential work are expected to be built in a manufacturing facility and then shipped to the job site on a just-in-time basis. Only final assembly tasks will occur on site. The HVAC systems will be integrated with many other systems and will be centrally controlled.

Manufacturing: By building the module in a factory environment, the amount of waste will be significantly reduced. Installation crews will receive the system in modules and be ready to immediately place each component into the system as a finished component. Each module will be complete, including wiring, controls, and piping, all embedded/integrated with the sheet metal ducting. This type of construction will be the next evolutionary stage following what is currently thought of as plug-and-play. These developments will result in the equipment becoming increasingly complex (electronically) but simpler for installation, troubleshooting, and service.

Installation: The HVAC system of the future will require minimal field installation efforts and setup work. The simpler, self-contained modular components will require more efficient, less labor-intensive

Most HVAC systems for major nonresidential work are expected to be built in a manufacturing facility and then shipped to the job site on a just-in-time basis.

installation tasks. While the technical aspects of installation are expected to decline, there is also an expectation that the redundant aspects of installation will increase, with increasingly numerous zones being defined, each requiring additional sensing elements and air management equipment.

Integration: While the installation of the HVAC system itself is expected to become simpler, the HVAC system in larger nonresidential buildings will be networked into a completely integrated super-system. This super-system will manage all the systems in the building and the integration may be complex and require a highly skilled work force. In essence, these integrated systems are building intelligence systems (BIS). Subsystems of the BIS super-system may include the following:

1. Air cooling
2. Air heating
3. Air circulation rate
4. Humidity
5. IAQ/air cleanliness
6. Fresh air ventilation
7. Water-based systems
8. Heat reclaim systems from process and building equipment, etc.
9. Lighting
10. Telephony
11. Computer/IT
12. Security
13. Energy usage/efficiency
14. Energy production

Monitoring and Control: At the design stage, building owners will be able to specify what they want the BIS to monitor and control, in terms of zones as well as subsystems. Setup of the BIS's integrated monitoring and controlling functions is expected to be significantly more sophisticated than traditional HVAC work. Expectations of the monitoring and controlling functions include the following:

1. Monitoring and control functions for all subsystems in the BIS network will be managed in one centralized location.
2. Monitoring and control functions will often be performed remotely (off-premise/off-site) using Internet/Web-based applications over wireless/WiFi technologies.

Commissioning and Trouble-Shooting: The BIS network is expected to have greatly enhanced diagnostic capability compared to what is available today. In addition, while the design and electronics behind these capabilities may be technically complex, it is expected that the efforts to set up and program the diagnostic functions will be relatively easy. The equipment's monitors will be capable of diagnosing any problems in the functional performance of the installation during the start-up phase, immediately able to report any attention-needing failures, as well as sustainability-focused maintenance needs. This capability is particularly well suited for larger nonresidential projects but has similar potential on a much smaller scale with residential applications.

More than 90 percent of the responding HVAC Futures Advisory Group believe it is likely to expect system integration controls will allow contractors to troubleshoot equipment from an off-premises monitoring facility.

Figure 31 shows that more than 90 percent of the responding HVAC Futures Advisory Group believe it is likely to expect system integration controls that will allow contractors to troubleshoot equipment from an off-premises monitoring facility. This potential development is the second highest level of expected likelihood of the 35 potential developments covered in the survey.

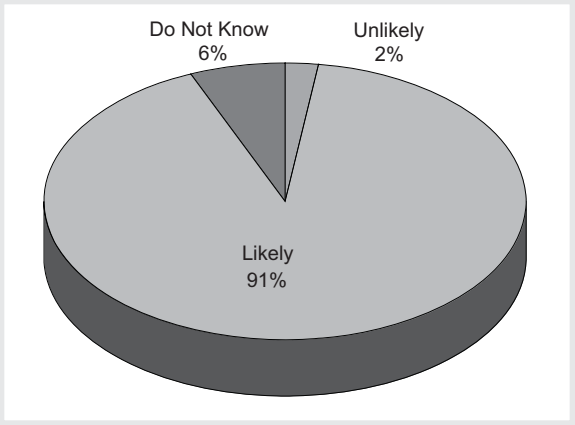

Figure 31: System Integration Controls Will Allow Contractors to Troubleshoot Equipment from an Off-Premises Monitoring Facility.

Maintenance and Service: In many installations, the subsystems will be self-monitored by remote sensors, which are connected to diagnostic equipment that is preprogrammed with the parameters for desired/optimal performance. Monitoring schedules will include constant performance monitoring as well as regularly scheduled routine testing to guide preventive maintenance programs.

When a sensor detects that a function is performing outside of the desired/optimal performance parameters, alarms are triggered, which, in the instances requiring simple adjustments, result in automated, system-controlled readjustments to stabilize the malfunction. More difficult instances will require either off-site manual manipulations within the BIS, or, in more major cases, physical on-premise repairs (e.g., new part, reattach separated components, etc.). With this scenario, the real opportunity lies in the monitoring and control systems versus the traditional model of today.

Expectations are for HVAC service firms to have a greater depth of knowledge surrounding a customer's business needs. This will continue to drive service contracts and long-term relationship development. Additionally, increasing sophistication and compelling value propositions will be required for sales and value pricing. This will be particularly evident in maintenance and service contracts.

Trends in Product Supply

Globalization/International Sourcing/ Imports of HVAC Products: Most expectations are for greater usage of foreign equipment and increases in offshore/

outsourcing fabrications for residential as well as nonresidential activities. As previously noted, the HVAC Futures Advisory Group expects developing economies' lower cost of labor, coupled with available technologies, to make global-design outsourcing feasible.

It is also expected that there will be a major shift of traditional North American HVAC manufacturers using low-cost, country-direct sourcing and/or manufacturing to reduce costs. This potential development was supported by 85 percent of the survey respondents from the HVAC Futures Advisory Group, as shown in Figure 32.

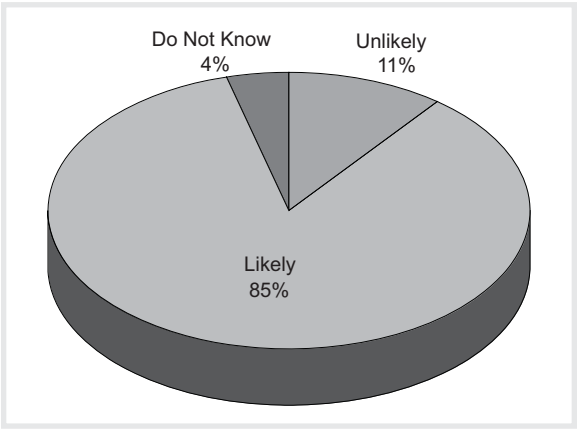

Figure 32: North American HVAC Manufacturers Will Outsource Manufacturing.

Contexts that are expected to increase the impact of globalization in supplying HVAC equipment to the U.S. include the following:

1. Labor-rich foreign markets produce innovative, high-efficiency HVAC systems.

2. The U.S. encounters an acute labor shortage, increases imports of foreign-made systems.

3. Significant regulation in the U.S. would keep consumer demand high, but labor shortages would stimulate increased imports of foreign products.

4. The global economy softens and the presence of foreign manufacturers in the U.S. emerges as they seek to expand their markets.

5. Contractors will gravitate to foreign manufacturers if U.S. manufacturers seek to compete aggressively with contractors.

Supply of Materials: Many expect to see a continued increase in the amount of global pressures for the demand of natural resources and materials. Material costs increases are very likely and are expected to result in new waves of increasingly novel, or alternative, types of materials being introduced into the construction process and HVAC systems. The higher costs and lower availability of traditional materials will result in a quicker pace in the development, introduction and adoption of new materials in the industry.

Figure 33 shows that about half of the respondents in the HVAC Futures Advisory Group believe it is likely to expect that improvements in manufacturing, distribution and value-chain efficiencies will be challenged with shortages of key components (similar to what occurred with expansion valves and compressors) of HVAC equipment.

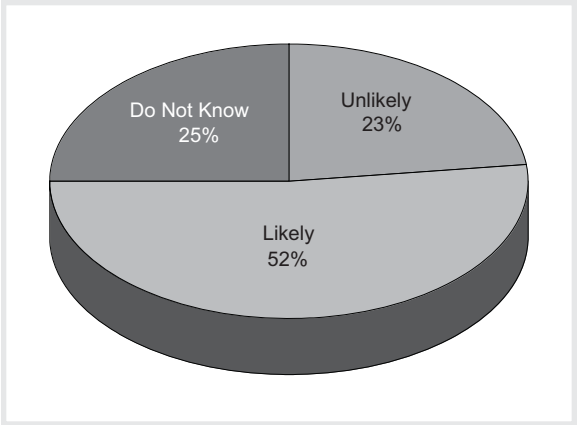

Figure 33: Component Shortages May Impact Manufacturing.

In addition, about half of the HVAC Futures Advisory Group believe it is likely to expect that a manufacturer will emerge worldwide that will create shortages for our domestic manufacturers, which will affect delivery of goods. About one-third believe that this outcome is unlikely. This is shown in Figure 34.

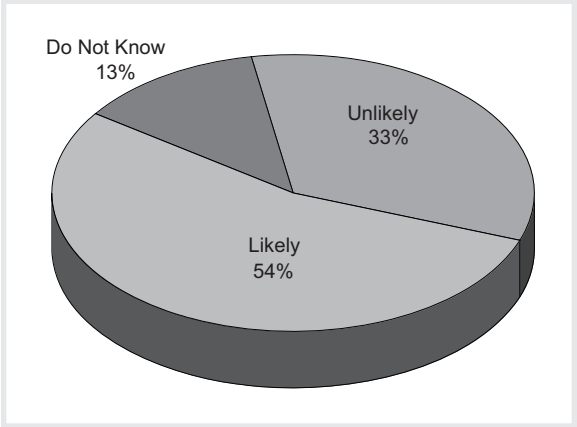

Figure 34: A Worldwide Manufacturer May Impact the Delivery of Product.

6 ACKNOWLEDGEMENTS

FMI would like to acknowledge the New Horizons Identifying Alternative Futures Task Force in appreciation of all efforts and commitment to advancing and educating the HVAC and construction industry through the sponsorship of this study. The Task Force has played an instrumental role in supporting and guiding the study, actively participating in several council meetings, surveys, conventions and reporting. Members of the Task Force and their respective organizations are presented in Table 3.

Name	Company/ Organization
George "Butch" Welsch, Chairman	Welsch Heating & Cooling Company
Jack Baer	Air Comfort Corporation
James M. Boone	New England Sheet Metal Works
Terry Johnston	Lennox Industries
Ronald J. Palmerick	AABCO Sheet Metal Company
William F. Reardon	Sheet Metal Contractors Assoc. of Phil. & Vicinity
Gary L. Schwenk	Bay Area SMACNA Chapter
Howard Stine	Charles E. Jarrell Contracting Company
Frederick L. Streimer	Streimer Sheet Metal Works, Inc.
Dennis Bradshaw	New Horizons Foundation

Table 3: NHF Task Force Personnel

The Task Force and FMI identified a wide range of participant groupings to create a diversified experience and knowledge base. Both the Task Force and FMI provided names of principal thought leaders in a variety of disciplines including the following:

1. Residential and nonresidential HVAC/ sheet metal contractors
2. Manufacturers of HVAC equipment
3. Academia and professors of leading construction programs
4. Trade associations
5. Labor organizations
6. Industrial product service suppliers
7. Homebuilders
8. General contractors and construction managers
9. Architects and engineers
10. Publishers
11. Government

This diversified group of more than 80 individuals, representing various industry stakeholders, contributed more than 40 hours of participation through efforts in establishing and defining a list of influencing factors, providing thoughts in future implications, and completing several in-depth assessments of future scenarios. The listing of those individuals involved on the HVAC Futures Advisory Group is included in Appendix 1.

Further acknowledgements include Art Heimbach, Ph.D., project manager; Alissa

Shelton, senior research analyst; as well as the additional contributing associates of FMI to this study, including John Hughes, Jerry Jackson, Heather Jones, Chuck Jones, and Philip Warner.

7 RESEARCH STUDY METHODOLOGY

The FMI team, with support from the Task Force and the HVAC Futures Advisory Group, gathered industry intelligence through three primary methods: (1) an analysis of secondary data, (2) industry workshops and events, and (3) an online survey and feedback tools. The triangulation of approaches was applied to check the validity and reliability of the findings.

1. **Primary and Secondary Research**
   Industry researchers performed an extensive secondary search using both print and electronic media. Information was collected from academic institutions, industry trade reports, and industry and association publications to supplement the initial findings of the scenarios and potential outcomes. Additional information was obtained through industry conferences, focus groups, and industry interviews. FMI research consultants interviewed HVAC and sheet metal contractors and other industry stakeholders.

2. **Industry Events**
   At the 2007 Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Convention, a focus group was conducted with HVAC and sheet metal contractors and other stakeholders to learn about factors expected to contribute to change in HVAC industry by 2018. Group sessions provided insight for developing several scenarios, and a consensus was reached on the likelihood of certain factors to contribute to the state of the industry within our 10-year horizon. Additional insight was obtained from the NHF annual meeting held in September 2007 in Boston.

3. **Online Survey and Feedback Tools**
   Based on the findings of industry interviews and secondary data, the FMI team collaborated with the NHF Task Force and the HVAC Futures Advisory Group to develop an online survey to evaluate the likelihood that a particular identified trend is expected to prevail. The survey provided an opportunity to include additional implications that impact the future of the industry. Additionally, a survey was introduced to validate the group's suggestions and potential implications. Appendix 2 contains a copy of the online survey instrument.

7.1 Task Force and HVAC Futures Advisory Group Activities

The process and methodology shown in Figure 35 identified issues that are most likely to have the greatest impact on the HVAC industry over the next 10 years through 2018. The study was separated into four tasks involving the HVAC Futures Advisory Group, Task Force and FMI. An overview of the project methodology is highlighted below.

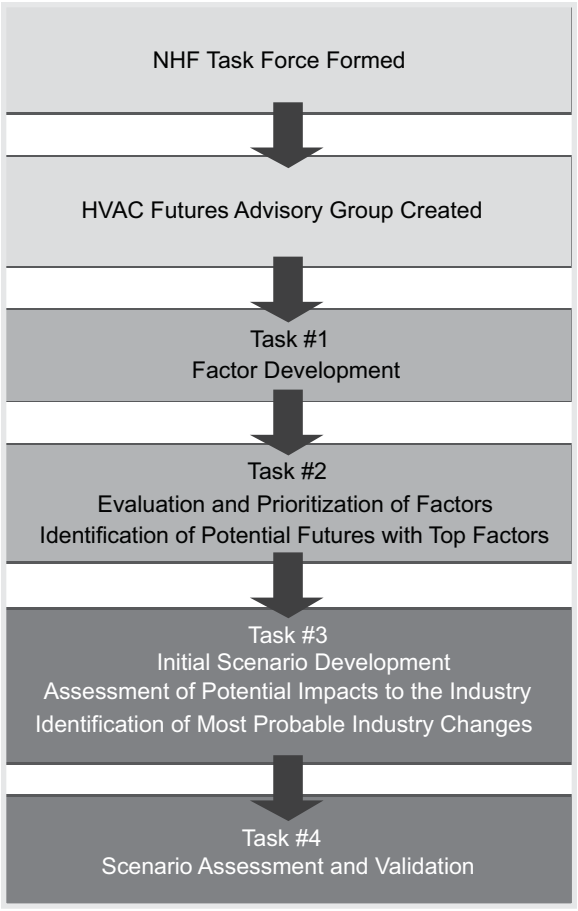

Figure 35: HVAC Futures Study Process and Methodology

7.1.1 Task #1 – Factor Development

Each member of the Task Force was asked to consider and identify a full spectrum of factors and possible changes likely to shape the HVAC industry of 2018 and then to address the resultant effects on the built environment and subsequently the HVAC industry. The term "built environment" refers to an encompassing characteristic of both natural and manmade (sub)urban surroundings (buildings, infrastructure, etc). In this exercise, we considered factors that cross traditional boundaries, for instance, a causal factor that impacts an architect may also impact a manufacturer, but in a different way.

FMI consolidated factors and identified emerging trends, and the documents were sent to the HVAC Futures Advisory Group for review and input as to how the HVAC and sheet metal industries will be shaped by the expected conditions for the key drivers.

FMI developed six major categories of influence that are most likely significant contributors to the shaping of the construction industry of the future. Participants were instructed to consider the unique characteristics of both the residential and nonresidential sectors.

1. **Social Environment.** Sociocultural changes include concepts such as fluctuations in the numbers and distribution of people of different types (demographics) and what people value, including changes in life-style trends, consumer buying patterns, fashion and role models, and major social events. Sociocultural changes also include ethnic/religious factors, ethical issues, changes in ecological/environmental issues, and changes in openness to adopt new technology.

2. **Technological Environment.** Technological environment changes include shifts in information accessibility and communications, changes in competing technology development, changes in the maturity of technology, shifts in consumer buying mechanisms/technology, and changes in management models and innovation potential.

3. **Economic Environment.** Changes in the economic environment consist of shifts in home country and world economic power, vibrancy and health of domestic and global economy, fluctuations in interest and exchange rates, taxation issues, movement in demand seasonality, and changes in international trade/monetary issues and policies.

4. **Political and Regulatory Environment.** The political and regulatory environment consists of changes related to regulatory processes, lobbying, and pressure groups; changes in the home country and international policies and legislation; potential future legislation; changes in war and conflict; amendments to trading policies; requirements in licensing, patent laws, and intellectual property issues; and changes in energy policy.

5. **Competitive Environment.** Changes in the competitive environment include concepts related to the number, size, level of resources, and strategies of existing competitors; changes in entry barriers, brands, brand strengths, and company images; changes in supplier power; changes in buyer power; changes in fixed and variable cost structures and the industry's economies of scale; and changes in ability to differentiate.

6. **Natural Environment.** Changes in the natural environment include climate and weather pattern changes; changes in the frequency of excessive rain, snow, drought, heat, and cold; changes in the frequency of major fires and earthquakes; and changes in energy resources and the availability of natural resources.

The factor-development effort yielded 36 primary factors supported by more than 500 related sub-factors. A summary of leading factors for each environment as developed by the Task Force, HVAC Futures Advisory Group, and FMI is listed in Appendix 3. The identification of trends was integrated into Task #2.

The HVAC and Sheet Metal Industry Futures Study

IDENTIFYING ALTERNATIVE FUTURES

TECHNOLOGICAL ENVIRONMENT

Changes in information and communications, changes in competing technology development, changes in the maturity of technology, changes in consumer buying mechanisms/technology, changes in management models, changes in innovation potential, shown in Figure 36.

POSSIBLE/PROBABLE CHANGES IN THE TECHNOLOGICAL ENVIRONMENT	RESULTANT EFFECTS ON AND/OR CHANGES TO THE BUILT ENVIRONMENT of 2017	RESULTANT EFFECTS ON AND/OR CHANGES TO THE HVAC INDUSTRY of 2017
1. Technical change such as plug-and-play that allows more do-it-yourself installation.	1. Few home owners or business facilities will have capability to install and service 2. With tighter budgets due to energy costs and codes, this impact will diminish	1. Need for specialization will cause less impact to our trade than others 2. Technician diagnostic work to be made easier, specialized training skills will be needed 3. Could result in fewer dollars in replacement / repair work for residential contractors 4. Great opportunity for competitive advantages to surface
2. Wireless technology improvements; Continued adoption of high-speed Internet access.	3. Owners, A/E 's will [illegible] communication wi[illegible] 4. This technology [illegible] versatility with [illegible] overall system [illegible] 5. Better [illegible] costs	5. Increased usage of wireless technology in controls – residential and commercial
3. System integration in controls becomes less costly.	6. [illegible]	6. Sheet metal contractors will become primary HVAC contractor – including controls 7. New technician skill sets needed. Manufacturers (commercial) can monopolize service sector
4. Mini -Split technology, dominant in rest of world, begins to take off in North America.	8. [illegible] will become [illegible] [illegible] world's markets is small – uninterested in efficiency or IAQ	8. The technology needs to be cost - justified to American/business market (buy-in) before success can be measured
5. Building Information Modeling (BIM) requirements and application use	10.	9. Co-generation will be deployed in commercial applications, but not in residential due to cost and complexity.
6. One central computer will control several manufacturers' equipment	11. It is critical to good IAQ	10. There will be more open protocols in controls.
7. There will only be small, incremental improvements in heat-transfer technology.	12. This will require significant resources dedicated to research and improvement	11. More emphasis on the air delivery, greater efficiency required. 12. Active noise control will be deployed in commercial and residential applications.

Figure 36: Effects on Built Environment and HVAC Industry Resulting from Changes in the Technological EnvironmentTask #2 – Evaluation and Prioritization of Factors

Task #2 involved both the Task Force and the HVAC Futures Advisory Group and focused on reviewing the extensive listing of primary factors and scoring each one regarding its expected effect on the industry (see Figure 37). The Task Force and Advisory Group looked at (1) the expected amount of change that is likely to be seen in the factor itself and (2) the degree of responsiveness that the HVAC industry is likely to have to each unit of change in the factor. The outcome of the task enabled a prioritization of the ideas and factors submitted as significant shapers of the built environment and projected a view of HVAC industry operation for the next 10 years. An online survey tool was used to collect the data. (See Appendix 2.)

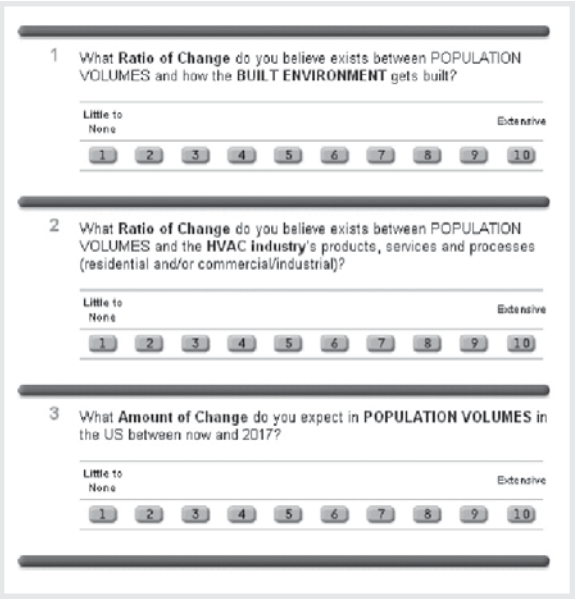

Figure 37: Sample Survey Questions

Scoring on these two measures was done using a 10-point scale, where a rating of one indicated a large change would occur, but it would be of little relevance. The rating of a 10 demonstrated strong agreement that a small change would create a significant impact. Additionally, on questions relating to the amount of change, a rating of 1 would indicate little change and 10 a great level of change. Each participant considered the following four metrics:

1. **The Ratio of Change Relative to the Built Environment.** Identifying the strength of the relationship between a factor—how it will change—and how the built environment is built, including types and availability of inputs, processes employed, and demand cycles.

2. **The Ratio of Change Relative to the HVAC Industry.** This rating gauges the strength of the relationship between a factor and the HVAC industry. The

question asks about the ratio of change in the factor to changes in the HVAC industry and how the change would impact the industry.

3. **Scope of Change.** Scope of change refers to the amount of change that the factor will undergo over the course of the next 10 years. Several factors had the potential for interrelatedness, and the scope of change was contingent on additional variables.

4. **Level of Personal Interest in the Factor.** The level of personal interest in the factor is an indication of how likely one is to obtain additional knowledge of the factor and then synthesize the understanding of the possible changes. It is expected that participants with an interest in the topic are more likely to provide depth and insight.

Each pair of scores was multiplied together, evaluating the level of change and the impact to both the HVAC industry and the built environment, resulting in a Net Effect Estimate for each factor. The factors were then ranked by the metric, and the 15 top-priority factors shown in Table 4 were chosen to be included in the remaining planning efforts.

15 Top-Priority Factors	
SOC	Consumer/client values and preferences
	Distribution of age and wealth
	Consumer/client buying behaviors
TECH	Improvements in wireless technology
	Improvements and/or cost reductions in system integration of controls
	Adoption and application of high-speed Internet access
	Adoption and application of building information modeling
ECON	Demand and demand cycles
ECON/SOC	Availability and cost of human resources
ECON/NAT	Availability and cost of energy resources
	Availability and cost of raw materials
POL	Performance-focused codes and regulations, etc.
COMP	Set of competitors
	Rate of innovation adoption by contractors in the HVAC industry
	Consolidation and cost-saving efforts

Table 4: 15 Top-Priority Factors Likely to Shape the HVAC Industry

7.1.2 Task #3 – Initial Scenario Development

Scenario development stems from a process of consolidating factor prioritization efforts, survey valuations, and supplemental knowledge of the industry. To supplement the initial findings, FMI sought out the opinions of the leading thinkers in long-range strategic planning in general, as well as for the 15 primary factors developed in Task #2. FMI also sought group involvement from industry leaders through a special session held at the 2007 SMACNA Convention. Through this research, the particular dimensions were identified as (1) being potentially the top determinants that will shape the HVAC industry during the next 10 years, (2) being predominantly independent of one another, and (3) having a great deal of uncertainty regarding what outcome they may have as well as what effects may occur if there is great change in the status quo.

Integrating the various inputs, FMI collected and consolidated the suggested implications and established four potential planning scenarios that may serve to describe the HVAC and construction industry in 2018 and beyond. The integrated responses for each planning scenario were distributed to the HVAC Futures Advisory Group to help resolve contradictions as well as suggest strategies to be taken before 2018. At the conclusion of this task, FMI asked each member of the Advisory Group to complete an online survey to provide industry opinions regarding the likelihood of the scenarios occurring throughout the HVAC industry during the next 10 years. The identification of potential implications and assessment provided both qualitative and quantitative validation of the initial scenarios.

Members of the HVAC Futures Advisory Group were assigned one of four planning scenarios with an equivalent distribution of members assessing each of the scenarios. Each planning scenario was explored, evaluated, and reported on by members of the Advisory Group. Reviewers of each scenario were selected based on the interests they identified in the survey as well as their profession and the sector in which they work.

In the development of an HVAC scenario, two key factors were identified as drivers for change—level of labor supply in the U.S. and the extent and severity of government regulations related to environmental issues. The impact of the drivers of change assumptions varied across the scenarios. Using a matrix format and two alternative, but equally plausible, outcomes for each of these dimensions, four potential general frameworks were created (see Figure 38). The set of four scenarios created for this study include *Mixed Bag, On the Edge, Trapped, and Tense Balance*. The complete scenario descriptions are included as Appendix 4.

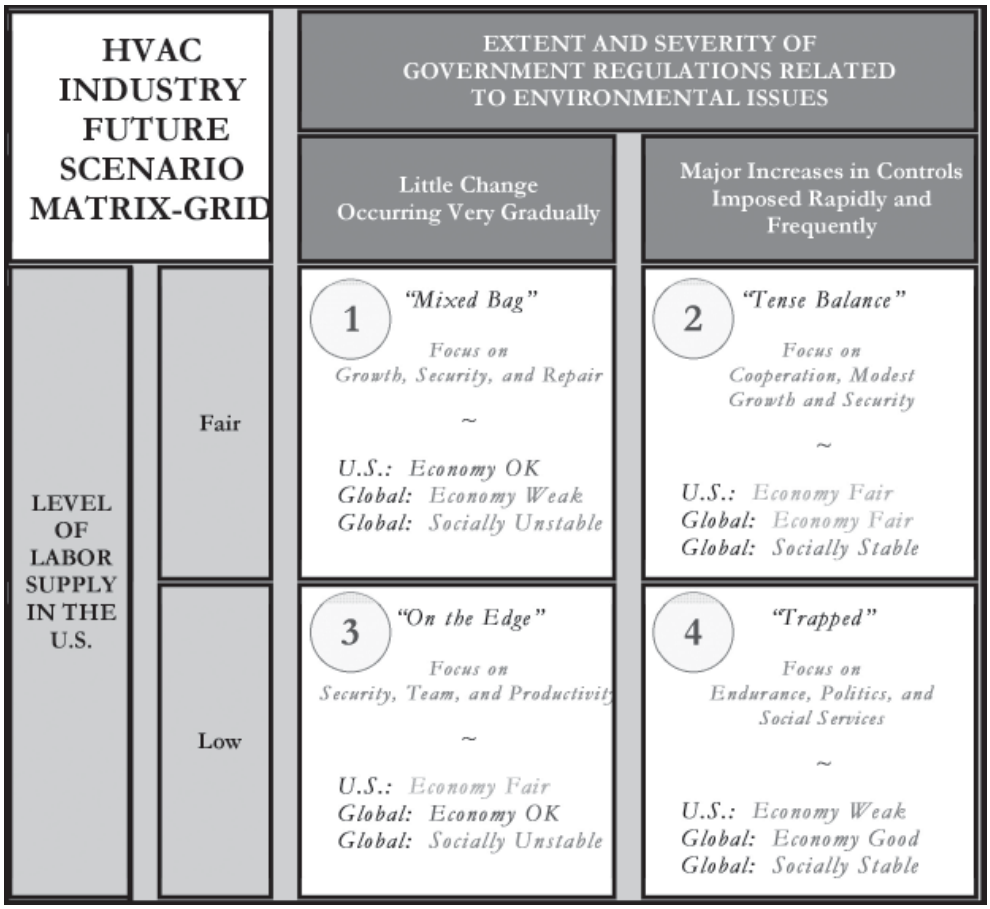

Figure 38: HVAC Industry Future Scenario Matrix-Grid

Each of the planning scenarios for the U.S. in 2018 is considered to have a reasonable potential for actually occurring.[42] Global pressures will add complexity to the scenarios for the U.S. FMI added to these planning scenarios the pieces of information gathered about the potential directions that each of the top-priority factors might take in the next 10 years.

Task #3 required HVAC Futures Advisory Group members to (1) put themselves into the world of 2018 as described by the assigned planning scenarios, (2) propose what will be different about the HVAC industry within a specific context, and (3) suggest what the greatest challenges might be for maintaining a viable business operation within the specified industry sector given the

[42] Patrice Hill, "Economy to struggle as baby boomers retire," Washington Times, July 10, 2007). Key sources cited in the article include Federal Reserve Chairman Ben S. Bernanke; Arthur Rolnick, senior vice president of the Federal Reserve Bank of Minneapolis; Harry S. Dent Jr., president of the H. S. Dent Foundation, an investment research group; Thomas Stinson, Minnesota State economist; Laura Rossman, publisher of the Alliance's Momentum newsletter; Richard Berner, chief U.S. economist with Morgan Stanley; Ronald D. Lee, University of California professor of economics and demography, director of UC Berkeley's Center for the Demography and Economics of Aging, and co-editor of the book *Demographic Change and Fiscal Policy*.

conditions. Each planning scenario included a set of several planning-guiding questions designed to stimulate thinking and provide some structure to the scope of the scenario.

The online survey (Appendix 2) was structured into three sections. Section 1 addressed identifying implications and the impact on the residential, nonresidential, and HVAC segments. It contained six open-ended questions designed to challenge the elements of the scenario and include suggestions for potential changes. Section 2 posed a series of 35 implications identified in Task #2 as potential influencers of the HVAC industry of 2018. Respondents were instructed to consider the likelihood the implication would occur within the constraints and conditions of the proposed scenario, ranking on a four-point scale, one as extremely unlikely and four as extremely likely. This section was analyzed within each scenario and across all four planning scenarios to identify the likelihood to occur regardless of other dependent variables. Section 3 included a series of open-ended questions relating to implications for the industry.

7.1.3 Task #4 – Scenario Assessment and Validation

The fourth and final task was designed to seek feedback and validation in the completion of the scenarios. Task #4 formed the basis for fulfilling two primary goals of the study: (1) identification of trends and drivers shaping the HVAC industry in 2018 and (2) presentation of a set of potential futures that will enable the HVAC and sheet metal industry to position itself to capitalize on future trends. This task established a validation process of potential and foreseeable implications expected to shape the future of the HVAC industry initiated through dynamic strategic conversation. This feedback provided an opportunity to test ideas and develop options for strategic responses.

In this task, FMI collected and consolidated the suggested implications for each planning scenario, as provided by the HVAC Futures Task Force, noting when contradictory or common expectations occurred and when unique expectations were found. The integrated responses for each planning scenario were distributed to the Task Force for members to provide guidance and resolve contradictions as well as suggest strategies to take advantage of the potential positive conditions in the scenario.

8 GLOSSARY

A / E – Architects / Engineering; describes a sector of the building design industry

BIM – Building Information Modeling; process of generating and managing a building information model throughout the lifecycle of a building

BIS – Building Information Systems

BLS – Bureau of Labor Statistics

CAD – Computer-Aided Design

CADD – Computer-Aided Drawing (Design)

CAFE – Corporate Average Fuel Economy

C & D – Construction and Demolition

CLRC – Construction Labor Research Council

CMAA – Construction Management Association of America

CPI – Consumer Price Index

DIY – Do-It-Yourself; construction work done by the householder without the aid of paid professionals

DOE – Department of Energy

EMS/BAS – Energy-Maintenance Services/ Business-Automation Systems

EPA – U.S. Environmental Protection Agency

EU – European Union

GDP – U.S. Gross Domestic Product

GE – General Electric

GHGs – Greenhouse gases

HOAs – Homeowner Associations

HVAC – Heating, Ventilation and Air Conditioning

IAC – Indoor Air Controls; Indoor Air Comfort

IAQ – Indoor Air Quality

IT – Information Technology

LEAN – Principles and practices addressing the end-to-end design and construction process. The approach aims to manage and improve construction processes with minimum cost and maximum value by considering customer needs.

LEED – Leadership in Energy and Environmental Design; a standard for Green Building design practices and evaluations

MEP – Mechanical Electrical Plumbing; describes a sector of the building design industry

MF – Multifamily

mpg – miles per gallon

NAHB – National Association of Home Builders

NHF – New Horizons Foundation; a sheet metal industry initiative, in partnership with SMACNA

NRCI – Nonresidential Construction Index

PM – Project Manager

PV Energy – Photovoltaic Energy

NRCI – FMI's Non-Residential Construction Index

SBI – Sustainable Business Institute

SF – Single-Family

SMACNA – Sheet Metal and Air Conditioning Contractors National Association

TAB – Testing, Adjusting and Balancing; certification process for HVAC systems within the construction industry

U.S. – United States

USGBC – U.S. Green Building Council; organization that promotes sustainability in how buildings are designed, built and operated; developed LEED rating system

3D – Three-Dimensional

9 APPENDIX 1 – STAKEHOLDERS PROVIDING INPUT

Last Name	First Name	Organization	City	State
Adolfs	Mr. Tony	Chicagoland Sheet Metal Contractors Association	Bellwood	IL
Alexander	Mr. Paul	Straus Systems	Stafford	TX
Anders	Mr. Jude	Shoreline Concepts, LLC	Glendale	WI
Andis	Mr. Gary	National Energy Management Institute	Alexandria	VA
Arnold, Jr.	Mr. Frank	Prudential Heating & Air Conditioning	Louisville	KY
Baer	Mr. Jack	Air Comfort Corp.	Broadview	IL
Barbour	Mr. Scott	Copeland Corporation	Sidney	OH
Biedermann	Mr. Rob	J. B. Henderson Construction Co., Inc.	Albuquerque	NM
Boniface	Mr. Thomas	Independent Sheet Metal Company	Hawthorne	NJ
Boniface	Mr. Andrew	Bonland Industries, Inc.	Bronx	NY
Boone	Mr. James	New England Sheet Metal Works	Fresno	CA
Boynton	Mr. Rex P.	North American Technician Excellence	Arlington	VA
Bradshaw	Mr. Dennis	New Horizons Foundation	Chantilly	VA
Bratcher	Mr. Dave	Bratcher Heating and Air Conditioning	Normal	IL
Burke	Mr. John	TCS Heating & Air Conditioning	Philadelphia	PA
Campbell	Mr. Mike	Campbell & Company	Pasco	WA
Corrigan	Mr. Mike	Lyon Sheet Metal Works	St. Louis	MO
Cramer	Mr. Matthew	Dee Cramer, Inc.	Holly	MI
DeMusis	Mr. Thomas	Wm. J. Donovan Co., Inc.	Philadelphia	PA
Dighe	Mr. Atul	5 Big Questions	Bowie	MD
Dills	Mr. Nathan	Midwest Fabricator, LLC	Oklahoma City	OK
Earls	Mr. Garry	St. Louis County	St. Louis	MO
Edinger	Mr. George	C & R Mechanical Company	Bridgeton	MO
Edwards	Ms. Dana	National Heating & Ventilating Co.	Albuquerque	NM
Elrod	Mr. Dave	DPR Construction, Inc.	Phoenix	AZ
Gillespie	Mr. Phil	Sheet Metal Contractors Association of Central Indiana, Inc.	Indianapolis	IN
Goldkamp	Mr. Jack	Design Aire Inc.	St. Louis	MO
Goodhue	Mr. Thomas J.	Columbia Chapter SMACNA	Portland	OR
Grau	Mr. John	NECA	Bethesda	MD

Last Name	First Name	Organization	City	State
Hall	Mr. John	BNP Media – ACHR News	Troy	MI
Hamilton	Mr. John	International Certification Board	Woodbury	MN
Harpring	Mr. Kevin	Harpring Inc. Industrial Sheet Metal	Louisville	KY
Harris	Mr. David	National Institute of Building Sciences	Washington	DC
Harrison, PE	Mr. Michael	The Harrison Group, Ltd.	Annapolis	MD
Hart	Mr. Bill	PHY Inc. Consulting Engineers	Philadelphia	PA
Hermanson	Mr. Rick	Hermanson Company, LLP	Kent	WA
Hill	Mr. Ed	HVAC, Inc.	Bristol	TN
Hogan	Mr. Dennis D.	S/M Contractors of Iowa, Inc.	West Des Moines	IA
Hoppe	Mr. Mitchell	Melrose Metal Products, Inc.	Fremont	CA
Howard, III	Mr. Eli P.	SMACNA	Chantilly	VA
Howell, P.E.	Mr. Gregory A.	Lean Construction Institute	Louisville	CO
Insetta	Mr. Michael	Construction Round Table of New Jersey / Merck & Co., Inc.	Lebanon	NJ
Johnson	Mr. Bryan	Capital Engineering Consultants, Inc.	Rancho Cordova	CA
Johnston	Mr. Terry	Lennox Commercial	Richardson	TX
Kimball	Mr. Russell	Evergreen State Heat & AC	Everett	WA
Kowalczyk	Mr. Rich	Fulcrum Management Group, Inc.	Slanesville	WV
Larkin	Mr. Keith	DPR Construction, Inc.	Phoenix	AZ
Lawton, P.E.	Mr. Wayne M.	X-nth, Inc.	Milwaukee	WI
Lueken	Mr. John	SMACNA – St. Louis Chapter	Saint Louis	MO
Mamayek	Mr. Michael	Illingworth Corporation	Milwaukee	WI
McCoy	Mr. David M.	New Mexico Sheet Metal Contractors Association	Albuquerque	NM
Miller	Mr. Christopher	Miller Sheetmetal, Inc.	Bremerton	WA
Monek	Mr. Chris	Associated General Contractors	Arlington	VA
Murphy	Mr. Mike	BNP Media – ACHR News	Troy	MI
Murphy	Mr. Pat	Murphy Construction	St. Louis	MO
Nigro	Mr. Joe	SMWIA	Washington	DC
Novak	Mr. Randy	Novak Heating & Air Conditioning, Inc.	West Des Moines	IA
O'Dorisio	Mr. J. Kevin	SMACNA – Los Angeles Chapter	Santa Fe Springs	CA
Palmerick	Mr. Ron	AABCO Sheet Metal Company	Ridgewood	NY
Radomski	Mr. Philip	Frank V. Radomski & Sons, Inc.	Colmar	PA
Rajotte	Mr. Karl	Estimation, Inc.	Linthicum Heights	MD
Reardon	Mr. William	Sheet Metal Contractors Association of Philidelphia & Vicinity	Conshohocken	PA

Last Name	First Name	Organization	City	State
Rodgers	Mr. Ron	New Horizons Foundation	Peoria	AZ
Roeckle	Mr. Roland	Hunter Roberts Construction Group	New York	NY
Rosenstein	Dr. Irving (Irv)	Temple University School of Labor Education	Philadelphia	PA
Russell	Mr. Steve	Brasfield & Gorrie	Birmingham	AL
Schwenk	Mr. Gary	SMACNA, Bay Area Chapter	Oakland	CA
Seeber	Mr. Ronald L.	Cornell University	Marcellus	NY
Shipley, P.E.	Mr. David	Marbek	Ottawa, Ontario	CN
Siebert	Mr. Mark	Productive Service Solutions, Inc.	Mishawaka	IN
Sievers	Mr. Donald	Associated Sheet Metal, Inc.	Jackson	MO
Skaer	Mr. Mark	ACHR News	Troy	MI
Smith	Mr. Matthew	Smith Heating and Air Conditioning	Stockton	CA
Stalknecht	Mr. Paul	Air Conditioning Contractors of America	Arlington	VA
Stevenson	Dr. Dave	Stevenson Company	Louisville	KY
Stine	Mr. Howard	Charles E. Jarrell Contracting Company	Earth City	MO
Streimer	Mr. Frederick L.	Streimer Sheet Metal Works, Inc.	Portland	OR
Tommelein	Ms. Iris	University of California	Berkeley	CA
Tubbs	Mr. Michael L.	Korte Construction Company	Highland	IL
Weil	Mr. Mike	Contracting Business	Cleveland	OH
Welsch	Mr. Butch	Welsch Heating & Cooling Company	St. Louis	MO
Weston, PE	Mr. David A.	Weston & Associates Mechanical Engineers, Inc.	Carmichael	CA
Wiezel, Ph. D.	Dr. Avi	Arizona State University	Tempe	AZ
Wimer	Mr. John	National Center for Energy Management and Building Technologies	Alexandria	VA
Woods	Mr. James	Buildings Diagnostics Research Institute	Chevy Chase	MD
Yeager	Mr. Raymond	Ductmate Industries	Charleroi	PA
Zahner	Mr. Robert	A. Zahner Company	Kansas City	MO
Zimmermann	Mr. David C.	Sheet Metal Workers	St. Louis	MO

10 APPENDIX 2 – ONLINE SURVEY (TASK #2)

The outcome of Task #2 is to enable a prioritization of the vast list of ideas and factors submitted as significant shapers of how the built environment is built and how the HVAC industry operates during the next 10 years.

Throughout the survey, participants were presented with each of the proposed factors and asked to score each one on four separate ratings:

1. **Ratio of Change Relative to the Built Environment**
2. **Ratio of Change Relative to the HVAC Industry**
3. **Scope of Change**
4. **Level of Personal Interest in the Factor**

The scale for each of the ratings was a 1 to 10 scale, where 1 represented a large change in the factor with little or no impact and 10 represented a small change in the factor with an enormous impact.

1. **RATIO OF CHANGE RELATIVE TO BUILT ENVIRONMENT**
   This rating is about the strength of the relationship between a factor and how the **BUILT ENVIRONMENT** gets built. This question asks for your belief about the ratio of change in the factor to changes in how buildings, in general, are built. This can be in terms of impact on

a. The *types and availabilities of inputs* (e.g., materials, manpower, financing, etc.)

b. The *types of processes employed* (e.g., types of companies involved, location of assembly, etc.)

c. The *demands and desires of the consumers and clients* (e.g., types and functions of the buildings, features of the buildings, location of the buildings, etc.).

QUESTION FORMAT

What **Ratio of Change** do you believe exists between **FACTOR X** and how the **BUILT ENVIRONMENT** gets built?

Little to None Extensive

1 2 3 4 5 6 7 8 9 10

2. **RATIO OF CHANGE RELATIVE TO THE HVAC INDUSTRY**
   This rating is about the strength of the relationship between a factor and the HVAC industry. This question asks for your belief about the ratio of change in the factor to changes in the HVAC industry. This can be in terms of impact on:

a. The *demand for HVAC functions*

b. The *types and availabilities of inputs*

c. The *methods and mechanisms that will be installed to deliver the desired functions*

d. The *work processes that will be required to install the necessary equipment*

e. The *types of companies in the HVAC industry*

f. The *profitability of companies in the HVAC industry*

QUESTION FORMAT

What **Ratio of Change** do you believe exists between **FACTOR X** and how the **HVAC industry's** products, services, and processes (residential and/or commercial/industrial)?

Little to None Extensive

1 2 3 4 5 6 7 8 9 10

3. **SCOPE OF CHANGE**
   Scope of change refers to **the amount of change** that you believe **THE FACTOR will undergo** over the course of the next 10 years. These ratings also use a 10-point scale. A rating of 1 means that you believe a factor will change very little, if at all, over the next 10 years. A rating of 10 means that you believe a factor will change extensively over the next 10 years.

QUESTION FORMAT

What **Amount of Change** do you expect in **FACTOR X** in the U.S. between now and 2017?

Little to None Extensive

1 2 3 4 5 6 7 8 9 10

4. **LEVEL OF PERSONAL INTEREST IN THE FACTOR**
   The level of personal interest in the factor refers to how much you are interested in reviewing material regarding the future of the factor and then synthesizing your understanding of the possible changes in the factor with how you think those changes will impact how the built environment gets built and how the HVAC industry operates. These scores will help us sort and then assign the factors to appropriate HVAC Futures Advisory Group members for Task #3, the drafting of scenarios of what the future of the HVAC industry may look like relative to the potential outcomes of a particular pair of factors.

QUESTION FORMAT

At what level do you rate the amount of **interest** you have in the changes expected to occur in the HVAC industry due to the changes in **FACTOR X** in the U.S.?

Little to None Extensive

1 2 3 4 5 6 7 8 9 10

Identifying Alternative Futures

There are six major factor categories, with each category containing the list of major factors that were submitted by the Advisory Group members.

1. Sociocultural: There are five major factors to score.
2. Technological: There are 12 major factors to score.
3. Economic: There are six major factors to score.
4. Political: There are four major factors to score.
5. Competitive: There are seven major factors to score.
6. Natural: There are two major factors to score.

Sociocultural

1. **CHANGES IN POPULATION VOLUMES**
   This includes change in the overall POPULATION GROWTH (current estimate of a 15 percent increase—304 million to 350 million—from now through 2017), the comparative change in the U.S. vs. other Western countries, change in the distribution of ETHNICITies and cultures in the U.S. (including the growth in the Hispanic and other populations, the needs and work values of these new immigrants, and their potential to be included in organized labor).

2. **CHANGES IN THE DISTRIBUTION OF AGE AND WEALTH**
   This includes changes in the size of the middle class, the purchasing power and expected demands on the wealth of the baby-boom generation, the aging of the baby-boom generation, and the sizes of the generations following the baby boom, as well as pension-related issues.

3. **CHANGES IN THE GEOGRAPHIC DISTRIBUTION OF OUR POPULATION**
   This includes the expected final destinations of immigrants; the movement of people from north to south and east to west; and trends regarding living in large versus small towns, rural versus urban, etc.

4. **CHANGES IN CONSUMER/CLIENT VALUES AND PREFERENCES**
   This includes consumer and commercial/industrial customer awareness of and interest in issues such as (1) indoor air quality remedies via central-ducted systems, (2) global warming and its potential impacts, (3) energy efficiency and concepts such as building footprints, AND (4) being "green" and the sustainability of buildings.

5. **CHANGES IN CONSUMER/CLIENT BUYING BEHAVIORS**
   This includes consumer and commercial/industrial customer use of the Internet for research and/or purchase, the involvement of women in making decisions regarding purchases of residential HVAC system, and the extent that consumers will be brand-savvy, brand-conscious and brand-loyal (or not).

If you believe there are additional major changes in the socio-cultural environment that will have a major impact on the HVAC industry in the coming years, please describe.

Please add any comments regarding the changes in the sociocultural environment that will have a major impact on the HVAC industry in the coming years.

Technological

1. **RATE OF INNOVATION ADOPTION BY CONTRACTORS IN THE HVAC INDUSTRY**

2. **INNOVATIONS THAT MAKE DO-IT-YOURSELF INSTALLATION MORE FEASIBLE**
   This includes plug-and-play technologies and any other similar innovations.

3. **IMPROVEMENTS IN WIRELESS TECHNOLOGY**

4. **IMPROVEMENTS AND/OR COST REDUCTIONS IN SYSTEM INTEGRATION OF CONTROLS**

This includes more open architecture, open protocols, etc., in the software of products.

5. **ADOPTION OF MINI-SPLIT TECHNOLOGY AND DUCTLESS SYSTEMS**

6. **IMPROVEMENTS IN HEAT-TRANSFER TECHNOLOGY**

7. **TECHNOLOGY THAT WILL LIMIT THE DEMAND PLACED ON THE POWER GRID AT ANY ONE TIME**

8. **IMPROVEMENTS IN NOISE-CONTROL TECHNOLOGY**

9. **ADOPTION AND APPLICATION OF HIGH-SPEED INTERNET ACCESS**

10. **ADOPTION AND APPLICATION OF SYSTEM REQUIREMENTS**
    This includes requirements that reduce the profitability for dealers and decrease the interest big-box retailers would have in becoming a major factor in residential HVAC sales.

11. **ADOPTION AND APPLICATION OF EQUIPMENT REDESIGN**
    This includes the general capability for equipment to become more efficient as well as advancements in equipment manufacturing technologies and the additional investment in research and development associated with new equipment and the phase-out/disposal of old equipment.

12. **ADOPTION AND APPLICATION OF BUILDING INFORMATION MODELING (BIM)**

If you believe there are additional major changes in the technological environment that will have a major impact on the HVAC industry in the coming years, please describe them.

Please add any comments regarding the changes in the technological environment that will have a major impact on the HVAC industry in the coming years.

Economic

1. **CHANGES IN THE AVAILABILITY AND COST OF FINANCIAL RESOURCES**

2. **CHANGES IN THE AVAILABILITY AND COST OF RAW MATERIALS**
   This includes changes in the supply and costs of the materials used to manufacture the equipment that is installed in HVAC systems.

3. **CHANGES IN THE AVAILABILITY AND COST OF ENERGY RESOURCES**
   This includes changes in the supply and costs of fossil fuels, hydroelectric energy, nuclear energy, solar energy, etc.

4. **CHANGES IN THE AVAILABILITY AND COST OF HUMAN RESOURCES**
   This includes changes in the supply and costs of skilled and unskilled labor as well as professional-level employees.

5. **CHANGES IN DEMAND AND DEMAND CYCLES**
   This includes expected changes in the volume of demand (driven by need as well as financial ability) for HVAC equipment and services, their cyclicality, and changes in what services are expected, primarily in the commercial, industrial, and governmental sectors.

6. **IMPROVEMENT IN MANUFACTURING, DISTRIBUTION, AND VALUE-CHAIN EFFICIENCIES**
   This includes expected changes in the efficiency of delivering the HVAC functions and utilities that clients/consumers want, including shifts in the production of various components to countries with lower wage costs. Such improvements would provide increases in value.

If you believe there are additional major changes in the economic environment that will have a major impact on the HVAC industry in the coming years, please describe them.

Please add any comments regarding the changes in the economic environment that will have a major impact on the HVAC industry in the coming years.

Political and Regulatory

1. **CHANGES IN LEGISLATION, REGULATIONS, AND CAUSES OF RISK-BASED LIABILITIES**
   This includes all major risk-related matters that can lead to large litigation claims and cause significant levels of liabilities that can quickly cause firms to become worthless.

2. **CHANGES IN PERFORMANCE-FOCUSED CODES AND REGULATIONS, ETC.**
   This includes changes in national, regional, state, and local requirements and standards regarding efficiency, air quality, greenness, etc.

3. **CHANGES IN ORGANIZED LABOR**
   This includes changes in the number and characteristics of participants in the movement, the influence unions have, mergers of labor organizations, jurisdictional matters, etc.

4. **CHANGES IN GLOBAL ISSUES**
   This includes issues related to the wars, conflicts, and terrorism.

If you believe there are additional major changes in the political environment that will have a major impact on the HVAC industry in the coming years, please describe them.

Please add any comments regarding the changes in the political environment that will have a major impact on the HVAC industry in the coming years.

Competitive

1. **CHANGES RELATED TO CONSOLIDATION AND COST-SAVING EFFORTS**
   This includes vertical as well as horizontal consolidation at all levels, extent of use of low-cost country-direct sourcing and manufacturing, the extent of outsourcing the design of HVAC systems, and the disintermediation of distributors.

2. **CHANGES IN THE SET OF COMPETITORS**
   This includes the extent that Asian, European, and other foreign-based firms enter the North American market, the role that "Big-Box" suppliers develop; and changes in the proportion of (1) industrial/fabrication contractors that serve niche markets, (2) "duct installation only" firms, (3) firms that serve higher-end markets, and (4) smaller firms.

3. **CHANGES IN BARRIERS-TO-ENTRY AND DIFFERENTIATION STRATEGIES**
   This includes competitive advantages derived by rapid availability of products and supplies, control systems, level of indoor air quality as well as levels of leadership knowledge and expertise in the contractor firms.

4. **CHANGES IN SALES METHODS AND STRATEGIES**
   This includes expected changes in commissioning strategies, financing options, contracting methods, etc.

5. **CHANGES IN MARKET PERCEPTIONS OF HVAC CONTRACTORS**
   This includes how consumers/clients perceive the contractors in the HVAC industry as well as how various factions in the industry perceive each other.

6. **CHANGES IN DELIVERY STRUCTURE AND PROCESSES**
   This includes changes in the roles, value-add, and relative amount of control that general contractors, engineers, construction managers, and HVAC contractors have in projects.

7. **CHANGES IN VOLUME OF DEMAND FOR TRADITIONAL HVAC SERVICES**
   This includes changes in the percent of work that is outsourced as well as potential opportunities in other markets.

If you believe there are additional major changes in the competitive environment that will have a major impact on the HVAC industry in the coming years, please describe them.

Please add any comments regarding the changes in the competitive environment that will have a major impact on the HVAC industry in the coming years.

Natural

1. **CHANGES IN OUR PLANET'S CLIMATE**
   This includes the expected extent of changes, changes in sea level, levels of humidity, range of temperatures, wind speeds, and rainfall experienced in different regions and the frequency of weather-related natural disasters, such as tropical cyclones (hurricanes), tornadoes, blizzards, floods, dust storms, wildfires, erosion, etc.

2. **CHANGES IN NON-CLIMATE-BASED NATURAL DISASTERS**
   This includes expected changes in the frequency of earthquakes, tsunamis, volcanic eruptions, and other geothermal-related events.

If you believe there are additional major changes in the natural environment that will have a major impact on the HVAC industry in the coming years, please describe them.

Please add any comments regarding the changes in the natural environment that will have a major impact on the HVAC industry in the coming years.

Respondent discipline distribution for Task #2 as completed by the HVAC Futures

Advisory Group and the Task Force is represented below.

Industry Sector	Number
HVAC/Sheet Metal Contractor	10
Trade Association	9
A/E	8
Academia	3
Labor Organization	3
General Contractor	2
Industrial Product Service Supplier	2
Construction Manager	1
Government	1
HVAC/Equipment Manufacturing	1
Other	1
TOTAL	**41**

11 APPENDIX 3 – METHODOLOGY, FACTOR DEVELOPMENT IMPACT SURVEY (TASK #1)

Sociocultural Environment	
Changes in population volumes	■ Demographics – population growth ■ Demographics – ethnicity ■ Immigrant values
Changes in the distribution of age and wealth	■ Income distribution ■ Distribution of wealth and financial relationships ■ Aging of U.S. population ■ Effects on competition ■ Effects on how things get built ■ Income security
Changes in the geographic distribution of population	■ Geography

Changes in consumer/client values and preferences	■ Consumer awareness ■ Consumer preferences ■ Environmental sustainability
Changes in consumer/client buying behaviors	
Technology Environment	
Rate of innovation and adoption by contractors in the HVAC industry	■ Adoption rates
Innovations that make do-it-yourself installations more feasible	■ Innovations and self-installation
Improvements in wireless technology	■ Wireless technology
Improvements and/or cost reductions in system integration of controls	■ System integration
Adoption of mini-split technology and ductless systems	■ Mini-split technology ■ Ductless systems
Improvements in heat-transfer technology	
Technology that will limit the demand placed on the power grid at any one time	■ Demand and the power grid ■ Flexible design technology
Adoption and application of high-speed Internet access	
Adoption and application of equipment redesign	■ Advancements in equipment capabilities ■ Changes in manufacturing technologies
Adoption and application of Building Information Modeling (BIM)	
Economic Environment	
Changes in the availability and cost of financial resources	
Changes in the availability and cost of raw materials	
Changes in the availability and cost of energy resources	■ Access to energy resources ■ Availability of energy resources ■ Global influence of energy resource demands
Changes in demand and demand cycles	
Improvement in manufacturing, distribution, and value-chain efficiencies	
Political and Regulatory Environment	

Changes in legislation, regulations, and causes of risk-based liabilities	■ Impact of risk allocation and protection ■ Litigation
Changes in performance-focused codes and regulations, etc.	■ Regional and national codes ■ Increasing standards and regulations
Changes in organized labor	■ Number and characteristics of participants in labor unions ■ Influence of unions ■ Mergers of labor organizations ■ Jurisdictional matters
Changes in global issues	■ Conflict, war, terrorism
Competitive Environment	
Changes related to consolidation and cost-saving efforts	■ Vertical and horizontal consolidations ■ Direct sourcing and manufacturing
Changes in the set of competitors	■ Shift of industry positions ■ New competitors
Changes in barriers to entry and differentiation strategies	■ Differentiation strategies ■ Barriers to entry
Changes in sales methods and strategies	■ Sales methods ■ Strategies to build relationships
Changes in market perceptions of HVAC contractors	
Changes in delivery structure and processes	
Changes in volume of demand for traditional HVAC services	
Natural Environment	
Changes in our planet's climate	
Non-climate-based natural disasters	■ Natural disasters ■ Personal health environment

Respondent discipline distribution for Task #1 as completed by the HVAC Futures Advisory Group and the Task Force is represented below.

Industry Sector	Number
HVAC/Sheet Metal Contractor	10
Trade Association	9
A/E	8
Academia	3
Labor Organization	3
General Contractor	2
Industrial Product Service Supplier	2
Construction Manager	1
Government	1
HVAC/Equipment Manufacturing	1
Other	1
TOTAL	**41**

12 APPENDIX 4 – SCENARIO PLANNING OVERVIEW (TASK #3)

Scenario planning is a methodology employed by researchers and planners to identify and play out the unknown future based on a set of current knowns. The technique presents a framework for a situational analysis in order to provide alternative views of future conditions likely to influence a current system. The objective is to prepare for likely changes.

Scenario planning employs six key steps:

1. Identify assumptions/drivers for change.
2. Bring drivers together into a viable framework.
3. Define initial and potential scenarios.
4. Establish the most viable and likely two or three scenarios.
5. Validate the scenarios and implications.
6. Assess implications and impact.

Scenarios are developed by bringing the drivers together and integrating fact-based changes. A scenario, as defined by Mats Lindgren and Hans Bandhold, is a coherent and plausible description of a possible future state of the universe, created specifically for the HVAC industry.[43] The scenarios address given influences and unknowns to demonstrate a potential view of the future through the consideration of perceptions and imagination. A scenario is not intended to be a forecast, but rather a tool, used in conjunction with external information that will project a potential view of the industry. By utilizing a probability matrix, scenario planning can be instrumental in defining the most likely outcomes.

The goal of a scenario is to provide a "scene" and motivation to stretch our thinking of how the HVAC industry will have evolved within the proposed developments. (The scenario logic is meant to push and provoke thinking. The center of the grid can be thought of as today, t = 0, with the future unfolding as an unpredictable trajectory into the quadrants.)

Scenarios perform several roles in this study. The primary and central role is to provide a standard, methodical framework to consider an alternative view. In this context, the scenarios are created from external factors

[43] Lindgren, Mats, and Bandhold, Hans. Scenario Planning: The link between future and strategy. Palgrave/Macmillan. 2003. p. 21.

that establish baselines that are important to the industry and create a context for importance. An additional role of scenarios is to provide qualitative measurements of the future that define the probability and level of agreement that identify the likelihood of occurrence. Last, scenarios serve as an extension of thinking to communicate potential consequences of change in the key driving dimensions.

Planning Scenario #1 for the Year 2018

"Mixed Bag"

LOW Regulations & FAIR Labor Supply

U.S. ECONOMY: Okay GLOBAL ECONOMY: Weak GLOBAL SOCIAL: Unstable

OVERVIEW[44]

It was eight years ago, back in 2010, when the U.S. had its first "domestic" act of terrorism since 9-11; not a single year has gone by since then that we have not experienced at least one major terrorist attack here on our own soil. The amount of social turbulence across the globe really started to escalate back around 2010. Many people blame the increase in global violence on the "take whatever I can get" attitude of the increasingly millions of people each year who are being made homeless by the greater frequency of cataclysmic hurricanes and tornadoes coupled with the concomitant decline in food and potable water reserves. However, an equal number of people blame the social chaos in general, and the attacks on the U.S. specifically, on the neo-cold-war attitudes that developed between the U.S. and the numerous countries that are outraged by the lack of federal leadership for reducing the greenhouse gases (GHGs) that those countries believe are the root cause for the exceptionally dangerous weather systems that have been disproportionately occurring in their countries.

Periodic efforts by the U.S. House and Senate to pass bills that would have established higher requirements for vehicle fuel efficiency have progressed slowly, with the current Corporate Average Fuel Economy (CAFE) standard only now up to 31.5 miles per gallon (mpg). As a reference, the CAFE was raised periodically, starting at 18 mpg in 1978 (the first year of the standard), to 27.5 mpg in 1985, and staying at that level until 2009, when the standard was raised to 31.5, where it currently stands, despite the efforts in the late 2000s to have it raised to 35 mpg. Gas at the pump in the U.S. has reached $7.50 a gallon (current dollars), which has suppressed the amount of driving and the related emissions, but has also added to the cost of living directly as well as through the transfer cost of transportation for most goods and products.

The U.S. economy is in relatively good shape currently due to the low level of emphasis on controlling carbon emissions coupled with a sufficient work force that was achieved by

[44] NOTE: Not all aspects of a real world can be included in a scenario. Attempts have been made to include the most relevant issues as defined by the Top 15 Driving Factors that were prioritized through Task #2. We hope the descriptions are full enough to work with. If you feel a vital aspect is missing, you can make reference to it in your responses to the questions that follow the scenario.

the reformed immigration polices. Achieving the reforms of the immigration laws in the late 2000s was very divisive, but the resultant strength of the economy soothed most of the ire held by those who wanted to severely cut back on the inflow of illegal as well as legal immigrants. With many European and Asian countries' economies struggling due to their having taken more aggressive policies towards climate change issues, the U.S. has been able to attract high-quality immigrant workers as well as benefit from the strong dollar and lower-than-normal prices for imported goods. The U.S. work force is now composed of a very appropriate mix of educated, skilled, and unskilled workers. Most of the new immigrants during the past 10 years have been relatively young, which provides the added benefit of a long duration in the labor market. Slightly more than 50 percent of the construction labor force is Hispanic. The boost in population has also served to increase total consumer expenditures above what it would have been otherwise, further benefiting the economy. Labor wages are just a bit on the low side, as the desire to work in the U.S. is high and has produced intermittent surpluses in the work force.

Efforts to slow the departure of older workers from the work force have been slow to occur. Many baby boomers have wanted to prolong their careers out of love of the job, but far more are interested out of necessity because they had not prepared adequately for retirement. And even though these baby boomers desire to work past retirement age, most employers have not been interested in hiring folks in their 60s and 70s. With the erratic nature of the economy, companies have been in no position to reverse their mandatory retirement policies and early retirement programs, which force the most skilled and experienced workers to leave the work force. Whereas most universities and government offices stopped forcing workers to retire unless they have safety-related jobs such as firefighting and policing, the vast majority of private-sector companies took several years before they were willing to bite the bullets of providing wage and benefit enticements to keep the most productive workers on staff. Private corporations continue to take their cue from the retirement ages set by Social Security and Medicare, and changes in these areas of government policy have not been able to be made. Proposals in Congress to switch to private retirement savings accounts that are funded by workers themselves to ease the potentially onerous tax burden on the smaller work force of the future have gone nowhere. Net-net however, it turns out that the number of employees needed each year, and particularly in starting positions or physically demanding positions, has been far greater than could be expected to be available from the older generation even if the policies and incentives were in place.

The cost of oil (now just over $200 a barrel most of the time) and the concerns about further contributions of heat and pollution to the atmosphere have led to a considerable amount of attention away from oil, with a great majority of our energy needs being met by nuclear power and clean coal. Initial tests of nano-based solar-voltaic panels and nano-based lighting systems show great promise for reducing the need for non-renewable energy sources. The nano-based solar-voltaic panels are a potential driver of decentralized energy production, with every structure being capable of producing some portion of its needed energy, and, when its production exceeds its needs, the energy can either be stored in hydrogen-based energy cells or sold to the

centralized utility, which will be losing its kingpin position in the system. Two building products just introduced this year are self-regulating wall systems and windows. The walls can produce their own radiant heat and the windows are self-cooling.

The impact on the world of China's growth has been significant, but not as much as it might have been had the costs of reversing the environmental damage caused by the initial years of their uncontrolled growth not been so tremendous. The continued growth of the Chinese population has driven many significant global developments. The Chinese population, now at 1.9 billion and roughly 20 percent of the entire planet, increases each year by approximately 20 million people, a number that exceeds the total population of individual countries such as Belgium, Greece, Cambodia, or Ecuador. Annual population growth in China actually exceeds the current population of Ohio, Illinois, or Pennsylvania. The climate in much of the populated area of China is very hot and humid during at least six months of the year. The energy demands related to the population size, their need for conditioned air, and to support their commercial efforts has been staggering, and, to offset it, China focused its controlled economy of developing alternative energy sources (particularly hydrogen-based energy storage and production systems) and the most efficient and reliable appliances, including air conditioning and air filtration systems. China is positioned to become the world leader in the manufacture of renewable energy "engines" and ultra-efficient electrical devices.

Planning Scenario #2 for the Year 2018

"Tense Balance"

MANY Regulations & FAIR Labor Supply

U.S. ECONOMY: Fair
GLOBAL ECONOMY: Fair
GLOBAL SOCIAL: Stable

OVERVIEW[45]

Since the mid-2000s, the U.S. economy has been performing unevenly, but generally okay, with annual growth rates ranging from 2.5 to 3.0 percent (compared to about 4.0 percent during the late 1990s). Suppressing the growth has been a continual tightening of a wide swath of regulations aimed at reducing the U.S.'s contribution to what some people believe to be climate change brought on by humans' activities, an increased frequency of natural disasters hitting U.S. cities, the ongoing needs of rebuilding decayed elements of our infrastructure, and the huge medical and welfare expenses of the now mostly retired but insufficiently prepared to take care of themselves baby boomers. All these causes of economic difficulty have also created unfortunate echo-effects. Insurance rates have gone off the charts due the high annual costs for the damages from the extreme weather conditions and the exceptional volume of medical expenses needed by the vast number of tragically unprepared boomers. Keeping the economy from being

[45] NOTE: Not all aspects of a real world can be included in a scenario. Attempts have been made to include the most relevant issues as defined by the Top 15 Driving Factors that were prioritized through Task #2. We hope the descriptions are full enough to work with. If you feel a vital aspect is missing, you can make reference to it in your responses to the questions that follow the scenario.

in any worse shape has been the stable supply of labor, the relatively stable social conditions across the globe (low levels of terrorism), and a generally healthy global economy.

Within a year after former Vice President Al Gore's winning of the 2007 Nobel Peace Prize for his documentary about global climate change, several pieces of anti-pollution and reduced-energy-usage legislation were passed in a very emotional and knee-jerk-like fashion. Whereas numerous past attempts by the U.S. House and Senate to pass bills establishing higher requirements for vehicle fuel efficiency had failed, in 2008 the regulations for the CAFE standard were dramatically revamped, requiring annual improvements in CAFE of 2 mpg each year for the next 10 years. This legislation resulted in an increase from the 27.5 mpg standard that had been in place since 1985, to the 47.5 mpg standard that we have today. With gas at the pump in the U.S. having reached $7.50 a gallon (current dollars), the better average amount of gas mileage has helped keep the increases in the cost of transportation below the average rate of increase for the Consumer Price Index (CPI).

In addition to changes in the CAFE regulations, a wide array of legislation was passed requiring much greater energy efficiency of all HVAC equipment, computers, manufacturing equipment, and household appliances. Investments and incentive programs were established to encourage the development of alternative energy sources that produce little or no climate-affecting emissions. These efforts have resulted in the initial stages of a distributed energy system; just about every new building is fitted with one or more energy producing capabilities (e.g., solar, geo, etc.) as well as high-efficiency hydrogen-based storage cells that hold energy produced in excess of the building's demand.

The changes in CAFE did have dramatic effects on the auto industry in the U.S. The automobile manufacturers in Europe and Asia, who had been developing highly fuel-efficient cars for their domestic markets, were able to shift production to meet the new regulations. Within two years after the regulations first went up, Chrysler was totally out of business. Ford and General Motors had far greater ownership of several foreign automobile manufacturing operations and were able to bring in cars to meet the regulations but lost billions of dollars by not being able to use much of their domestic production capacity. A great amount of skilled labor was put into the labor market from the widespread decline of the automobile industry. This labor pool benefited many other industries that were feeling a tight labor supply even though the immigration laws had been reformed to allow a greater number of immigrants than in prior years.

Efforts to slow the departure of older workers from the work force have been slow to occur. Many baby boomers have wanted to prolong their careers out of love of the job, but far more are interested out of necessity because they had not prepared adequately for retirement. Moreover, even though these baby boomers desire to work past retirement age, most employers have not been interested in hiring folks in their 60s and 70s. With the erratic nature of the economy, companies have been in no position to reverse their mandatory retirement policies and early retirement programs, which force the most skilled and experienced workers to leave the work force. Whereas most universities and

government offices stopped forcing workers to retire unless they have safety-related jobs such as firefighting and policing, the vast majority of private-sector companies took several years before they were willing to bite the bullets of providing wage and benefit enticements to keep the most productive workers on staff. Private corporations continue to take their cue from the retirement ages set by Social Security and Medicare, and changes in these areas of government policy have not been able to be made. Proposals in Congress to switch to private retirement savings accounts that are funded by workers themselves to ease the potentially onerous tax burden on the smaller work force of the future have gone nowhere.

Achieving the reforms of the immigration laws in the late 2000s was very divisive, but the resultant strength of the economy soothed most of the ire held by those who wanted to severely cut back on the inflow of illegal as well as legal immigrants. The U.S. work force is now composed of a very appropriate mix of educated, skilled, and unskilled workers. Most of the new immigrants during the past 10 years have been relatively young, which provides the added benefit of a long duration in the labor market. Slightly more than 50 percent of the construction labor force is Hispanic. Labor wages have barely kept up with inflation.

Terrorism has declined over the past decade, which has enabled countries across the planet to focus their economic engines on repairing decayed infrastructures, developing new technologies, and attending to emergency social conditions, which have been in greater demand in many countries that have been struck by the more frequent and more powerful weather storms, extended droughts, losses in productive land, and extensive wild fires. New technologies have focused particularly on the development of alternative energy sources and improved energy efficiency. Two building products just introduced this year are self-regulating wall systems and windows. The walls can produce their own radiant heat and the windows are self-cooling.

The impact on the world of China's growth has been significant, but not as much as it might have been had the costs of reversing the environmental damage caused by the initial years of their uncontrolled growth not been so tremendous. The continued growth of the Chinese population has driven many significant global developments. The Chinese population, now at 1.9 billion and roughly 20 percent of the entire planet, increases each year by approximately 20 million people, a number that exceeds the total population of individual countries such as Belgium, Greece, Cambodia, or Ecuador. The climate in much of the populated area of China is very hot and humid during at least six months of the year. The energy demands related to the population size, their need for conditioned air, and to support their commercial efforts has been staggering, and, to offset it, China focused its controlled economy of developing cost-effective nano-based solar panels (photovoltaic), hydrogen-based energy systems, and the most efficient and reliable appliances, including air conditioning and air filtration systems. China is positioned to become the world leader in the manufacture of renewable energy "engines" and ultra-efficient electrical devices.

Planning Scenario #3 for the Year 2018

"On the Edge"

LOW Regulations & LOW Labor Supply

U.S. ECONOMY: Fair
GLOBAL ECONOMY: Okay
GLOBAL SOCIAL: Unstable

OVERVIEW[46]

Since the mid-2000s, the U.S. economy has been performing erratically, with annual growth rates ranging from 2.0 to 2.5 percent (compared to about 4.0 percent during the late 1990s). Suppressing the growth has been the continually declining labor force and the reoccurrence of terrorist activities on domestic soil. The minimal change in regulations related to supposed global-warming-related emissions and a comparatively stronger economic performance in Europe and Asia have been keeping the economy from being in even worse shape.

The labor force has been severely lacking for a decade, which has been due to (1) the large number of aging baby-boom workers who have moved into retirement, (2) the fact that the pool of native workers available to fuel economic activity and growth has been insufficient to fill the void, and (3) the drop in immigration caused by a strong backlash against illegal aliens that occurred in the late 2000s. At that time, many economists, including Federal Reserve Chairman Ben S. Bernanke, argued strongly for reforms that would have replaced the hodgepodge of legal and illegal migration with a system that focused on attracting immigrants who had the relatively high education and skill levels needed by our economy. When a Senate immigration bill for such a system was defeated in 2007 and was swiftly followed by the successful passage of bills that resulted in a significant reduction in the influx of illegal immigrants, the issue became even more polarized. Sadly, even though virtually all parties realized that an increase in immigration is drastically needed to replace the retired boomers, the bitter feelings and staunch inflexibilities have kept any sort of reforms from being passed. The net effect has been an ongoing net shortage of approximately 3.0 million immigrants per year needed to overcome the problems caused by aging and to enable the economy to stay close to its average growth rate in the mid-2000s of about 3.0 percent. The absence of these people not only reduces the volume of GDP possible to produce, but also results in a lower level of consumer consumption that would otherwise occur.

Efforts to slow the departure of older workers from the work force have been slow to occur. Many baby boomers have wanted to prolong their careers out of love of the job, but far more are interested out of necessity because they had not prepared adequately for retirement. Moreover, even though these baby boomers desire to work past retirement age, most employers have not

[46] NOTE: Not all aspects of a real world can be included in a scenario. Attempts have been made to include the most relevant issues as defined by the Top 15 Driving Factors that were prioritized through Task #2. We hope the descriptions are full enough to work with. If you feel a vital aspect is missing, you can make reference to it in your responses to the questions that follow the scenario.

been interested in hiring folks in their 60s and 70s. With the erratic nature of the economy, companies have been in no position to reverse their mandatory retirement policies and early retirement programs, which force the most skilled and experienced workers to leave the work force. Whereas most universities and government offices stopped forcing workers to retire unless they have safety-related jobs such as firefighting and policing, the vast majority of private sector companies took several years before they were willing to bite the bullets of providing wage and benefits enticements to keep the most productive workers on staff. Private corporations continue to take their cue from the retirement ages set by Social Security and Medicare, and changes in these areas of government policy have not been able to be made. Proposals in Congress to switch to private retirement savings accounts that are funded by workers themselves to ease the potentially onerous tax burden on the smaller work force of the future have gone nowhere. Net-net however, it turns out that the number of employees needed each year, and particularly in starting positions or physically demanding positions, has been far greater than could be expected to be available from the older generation even if the policies and incentives were in place.

It was eight years ago, back in 2010, when the U.S. had its first "domestic" act of terrorism since 9-11; not a single year has gone by since that we have not experienced at least one major terrorist attack here on our own soil. The amount of social turbulence across the globe started to escalate in 2010. Many people blame the increase in global violence on the "take whatever I can get" attitude of the increasingly millions of people each year who are being made homeless by the greater frequency of hurricanes and tornadoes coupled with the concomitant decline in food and potable water reserves. However, an equal number of people blame the social chaos in general, and the attacks on the U.S. specifically, on the neo-cold-war attitudes that developed between the U.S. and the numerous developing countries that are outraged by the lack of federal leadership for reducing the GHGs that those countries believe are the root cause for the destructive weather systems that have disproportionately occurred on their countries.

All efforts by the United Nations and other globally oriented multicountry-based organizations have been unable to construct a mutually agreeable plan to reduce GHGs. The continuing disagreements between rich and poor countries have resulted in annual increases in GHG emissions since 2008, when at the that time the desired goal was to reduce, by 2020, such emissions to levels equal to 60 percent to 75 percent of the levels in 1990. Periodic efforts by the U.S. House and Senate to pass bills that would establish higher requirements for vehicle fuel efficiency have progressed slowly, with the current CAFE standard only now up to 31.5 mpg. As a reference, the CAFE was raised periodically, starting at 18 mpg in 1978 (the first year of the standard), to 27.5 mpg in 1985, and staying at that level until 2009, when the standard was raised to 31.5, where it currently stands, despite the efforts in the late 2000s to have it raised to 35 mpg. Gas at the pump in the U.S. has reached $7.50 a gallon (current dollars), which has suppressed the amount of driving and the related emissions, but has also added to the cost of living directly as well as through the transfer cost of transportation for most goods and products.

Now, with the all-too-regular terrorist acts on American soil, the increased rate of natural disasters hitting U.S. cities, the ongoing needs of rebuilding decayed elements of our infrastructure, and the huge medical and welfare expenses of the now mostly retired but insufficiently prepared to take care of themselves baby boomers, the U.S. economy has been lucky to not be in worse shape. Two forces helping to keep the economy from recession have been (1) the comparatively strong European and Asian economies and (2) improvements in labor productivity.

When the U.S. tightened its immigration regulations, Japan and China, and to a lesser extent Europe (countries that also suffer from the aging population issue), instead took an open-arms approach to the people who could no longer find a feasible way into the U.S. These countries have been more able to increase their production levels, and at the same time benefit from increased domestic demand for consumer products. The U.S. has been able to benefit from this through increased demand for many of our goods and services, especially given the favorable exchange rates the European and Asian countries are able to have in these conditions.

In the absence of a sufficient number of new immigrants, fewer U.S. workers have been called upon to support a growing number of retirees. The imbalance has been partially met through even greater productivity than was seen in previous generations. Investments have been focused in this area, further improving the worker's output per hour that had grown strongly in late 1990s through the 2000s due to the computer, Internet, and digital applications. Thankfully, strong flows of investment from abroad have occurred to support this development. The previously relied upon source for investment had been the investment funds available from the baby boomers, but as they spent down this savings other sources were needed.

Planning Scenario #4 for the Year 2018

"Trapped"

MANY Regulations & LOW Labor Supply

U.S. ECONOMY: Weak
GLOBAL ECONOMY: Good
GLOBAL SOCIAL: Stable

OVERVIEW[47]

Since the mid-2000s, the U.S. economy has been performing poorly, with annual growth rates ranging from 1.0 to 2.0 percent (compared to about 4.0 percent during the late 1990s). Suppressing the growth has been the continually declining labor force, strong regulations related to environmental concerns, and the reoccurrence of terrorist activities on domestic soil. Keeping the economy from being in even worse shape has been the comparatively stronger economic performance in Europe and Asia and their associated demand for comparatively less expensive high-quality products.

[47] NOTE: Not all aspects of a real world can be included in a scenario. Attempts have been made to include the most relevant issues as defined by the Top 15 Driving Factors that were prioritized through Task #2. We hope the descriptions are full enough to work with. If you feel a vital aspect is missing, you can make reference to it in your responses to the questions that follow the scenario.

The labor force has been severely lacking for a decade, which has been due to (1) the large number of aging baby-boom workers who have moved into retirement, (2) the fact that the pool of native workers available to fuel economic activity and growth has been insufficient to fill the void, and (3) the drop in immigration caused by a strong backlash against illegal aliens that occurred in the late 2000s. At that time, many economists, including Federal Reserve Chairman Ben S. Bernanke, argued strongly for reforms that would have replaced the hodgepodge of legal and illegal migration with a system that focused on attracting immigrants who had the relatively high education and skill levels needed by our economy. When a Senate immigration bill for such a system was defeated in 2007 and was swiftly followed by the successful passage of bills that resulted in a significant reduction in the influx of illegal immigrants, the issue became even more polarized. Sadly, even though virtually all parties realized that an increase in immigration is drastically needed to replace the retired boomers, the bitter feelings and staunch inflexibilities have kept any sort of reforms from being passed. The net effect, according to Fed Chairman Bernanke, has been an ongoing net shortage of approximately 3.0 million immigrants per year that would have overcome the problems caused by aging and enabled the economy to stay close to its average growth rate in the mid-2000s of about 3.0 percent. The absence of these people not only reduces the volume of GDP possible to produce, but also results in a lower level of consumer consumption that would otherwise occur. Net-net however, it turns out that the number of employees needed each year, and particularly in starting positions or physically demanding positions, has been far greater than could be expected to be available from the older generation even if the policies and incentives were in place.

When the U.S. tightened its immigration regulations, Japan and China, and to a lesser extent Europe (countries that also suffer from the aging population issue), instead took an open-arms approach to the people who could no longer find a feasible way into the U.S. These countries have been more able to increase their production levels, and at the same time benefit from increased domestic demand for consumer products. The U.S. has been able to benefit from this through increased demand for many of our goods and services, especially given the favorable exchange rates these countries are able to have in these conditions.

In the absence of a sufficient number of new immigrants, fewer U.S. workers have been called upon to support a growing number of retirees. The imbalance has been partially met through even greater productivity than was seen in previous generations. Investments have been focused in this area, further improving the worker's output per hour that had grown strongly in late 1990s through the 2000s due to the computer, Internet, and digital applications. Thankfully, strong flows of investment from abroad have occurred to support this development. The previously relied upon source for investment had been the investment funds available from the baby-boom generation, but as they spent down this savings other sources were needed.

Further complicating the domestic labor situation has been our inability to develop human capital. There have been an increasing number of shortages of the highly educated and skilled workers needed to create and man

the technologies of the future. Employers report shortages of skilled workers in areas that were dominated by the baby-boom workers, such as nuclear, aerospace, and petroleum engineering. The workers that are needed should have at least a college education to land the best jobs and fuel technological advances, but high school dropout rates have continued to increase and are now consistently at 13 percent. The resources necessary for improvements in the system have not been available due to the slow economy and more urgent demands for funds to meet the increasing needs for (1) higher levels of national security, (2) social and material relief for the people and communities that have been struck by terrorist attacks or devastating weather storms, and (3) repairing the critical elements in the nation's infrastructure.

Within a year after former Vice President Al Gore's winning of a the 2007 Nobel Peace Prize for his documentary about global climate change, several pieces of anti-pollution and reduced-energy-usage legislation were passed in a very emotional and knee-jerk-like fashion. Whereas numerous past attempts by the U.S. House and Senate to pass bills establishing higher requirements for vehicle fuel efficiency had failed, in 2008 the regulations for the CAFE standard were dramatically revamped, requiring annual improvements in CAFE of 2 mpg each year for the next 10 years. This legislation resulted in an increase from the 27.5 mpg standard that had been in place since 1985, to the 47.5 mpg standard that we have today. With gas at the pump in the U.S. having reached $7.50 a gallon (current dollars), the better average amount of gas mileage has helped keep the increases in the cost of transportation below the average rate of increase for the CPI.

In addition to changes in the CAFE regulations, a wide array of legislation was passed requiring much greater energy efficiency of all HVAC equipment, computers, manufacturing equipment, and household appliances. Investments and incentive programs were established to encourage the development of alternative energy sources that produce little or no climate-affecting emissions. These efforts have resulted in the initial stages of a distributed energy system; just about every new building is fitted with one or more energy producing capabilities (e.g., solar, geo, etc.) as well as high-efficiency hydrogen-based storage cells that hold energy produced in excess of the building's demand.

These emergency-based priorities of national repairs and medical health have siphoned away the financial as well as physical and mental resources that would otherwise be allocated to a vast range of wealth-producing activities. As such, the pace of technological development has slowed considerably; nanotechnology has not gone much beyond medical applications, and the much-promised radical advancements in biological development have not really happened at all. On the brighter side, there have been continued improvements in the areas of energy conservation and energy production. The cost of oil (now just over $200 a barrel most of the time) and the concerns about further contributions of heat and pollution to the atmosphere have led to a considerable amount of attention away from oil, with a great majority of our energy needs being met by nuclear power and clean coal. Initial tests of nano-based solar-voltaic panels and nano-based lighting systems show great promise for

reducing the need for non-renewable energy sources. The nano-based solar-voltaic panels are a potential driver of decentralized energy production, with every structure being capable of producing some portion of its needed energy, and, when its production exceeds its needs, the energy can either be stored in hydrogen fuel cells or sold to the centralized utility, which will be losing its kingpin position in the system.

DEVELOPMENTS SPECIFIC TO CONSTRUCTION AND THE HVAC INDUSTRY

This section contains a listing of additional circumstances that are particularly relevant to construction and the HVAC industry. Many of these ideas are drawn from the inputs the HVAC Futures Advisory Group provided in Tasks #1 and #2. Others are taken from the research results relevant to the items in the list of 15 top-priority factors.

MIXED BAG	TENSE BALANCE	ON THE EDGE	TRAPPED
"GREEN" ORIENTED REGULATORY ENVIRONMENT			
LOW	**MANY**	**LOW**	**MANY**
LABOR SUPPLY SITUATION			
FAIR	**FAIR**	**LOW**	**LOW**
U.S. ECONOMY STATUS			
OKAY	**FAIR**	**FAIR**	**WEAK**
GLOBAL ECONOMY STATUS			
WEAK	**FAIR**	**OKAY**	**GOOD**
GLOBAL SOCIAL CONDITION			
UNSTABLE	**STABLE**	**UNSTABLE**	**STABLE**
DEMAND, PURCHASE METHODS, AND PURCHASE DECISION-MAKING			
Consumers and commercial customers will continue to use the Internet for research and/ or purchase. The Internet provides all needed information, and consumers and commercial customers become more educated about system performance criteria and product capabilities. Internet sales will be a leading factor for all businesses.	Consumers and commercial customers will continue to use the Internet for research and/or purchase. The Internet provides all needed information, and consumers and commercial customers become more educated about system performance criteria and product capabilities. Internet sales will be a leading factor for all businesses.	Consumers and commercial customers will continue to use the Internet for research and/ or purchase. The Internet provides all needed information, and consumers and commercial customers become more educated about system performance criteria and product capabilities. Internet sales will be a leading factor for all businesses.	Consumers and commercial customers will continue to use the Internet for research and/ or purchase. The Internet provides all needed information and consumers and commercial customers become more educated about system performance criteria and product capabilities. Internet sales will be a leading factor for all businesses.
The high cost of medical care for the aging boomer generation has led to strictly enforced government regulations for IAQ in all buildings, including older existing structures.	The high cost of medical care for the aging boomer generation has led to strictly enforced government regulations for IAQ in all buildings, including older existing structures.	The high cost of medical care for the aging boomer generation has led to strictly enforced government regulations for IAQ in all buildings, including older existing structures.	The high cost of medical care for the aging boomer generation has led to strictly enforced government regulations for IAQ in all buildings, including older existing structures.

MIXED BAG	TENSE BALANCE	ON THE EDGE	TRAPPED
Confidence is expected from all brands; quality level expected to be "zero-defect." Poor manufacturers are driven out of the industry.	**Confidence is expected from all brands; quality level expected to be "zero-defect." Poor manufacturers are driven out of the industry.**		
The desire/want/need for "green" and sustainability is high along with expectations for high-energy efficiency and excellent air quality.	**The desire/want/need for energy efficiency, "green," and sustainability has become the norm due to government support through tax breaks and tax penalties that make the outcomes cost-competitive.**	**The desire/want/need for "green" and sustainability fades due to greater concerns about energy consumption and air quality.**	**The desire/want/need for energy efficiency, "green," and sustainability has become the norm due to government support through tax breaks and tax penalties that make the outcomes cost-competitive.**
Price slips as a concern with greater emphasis put on performance features and overall product quality. People are willing to invest for a better future.	**Reasonable price is also expected, with quality being an equally important decision-making factor.**	**Reasonable price is also very important, with overall product quality being a third-tier decision-making factor. For single-family dwellings, the payback time is longer.**	**Pressure for low price is extreme, but overall product quality needs to be good enough to meet the sustainability regulations.**
DEVELOPMENTS SPECIFIC TO RESIDENTIAL BUILDINGS AND SYSTEMS			
The ratio of new construction in single-family dwelling to multifamily dwelling residential buildings (put-in-place dollars) has shifted from about 7:1 in 2006 to 5:1, due to the combined forces of	**The ratio of new construction in single-family dwelling to multifamily dwelling residential buildings (put-in-place dollars) has shifted from about 7:1 in 2006 to 3:1, due to the combined forces of**	**The ratio of new construction in single-family dwelling to multifamily dwelling residential buildings (put-in-place dollars) has shifted from about 7:1 in 2006 to 5:1, due to the combined forces of**	**The ratio of new construction in single-family dwelling to multifamily dwelling residential buildings (put-in-place dollars) has shifted from about 7:1 in 2006 to 3:1, due to the combined forces of**

MIXED BAG	TENSE BALANCE	ON THE EDGE	TRAPPED
(1) The close-knit extended family and community orientation of the large Hispanic population (approximately 20% of the total U.S. population).	(1) The close-knit extended family and community orientation of the large Hispanic population (approximately 20% of the total U.S. population).	(1) The close-knit extended family and community orientation of the large Hispanic population (approximately 20% of the total U.S. population).	(1) The close-knit extended family and community orientation of the large Hispanic population (approximately 20% of the total U.S. population).
(2) The populace moving to homes that require less energy for heating and cooling.	(2) The populace moving to homes that require less energy for heating and cooling.	(2) The populace moving to homes that require less energy for heating and cooling.	(2) The populace moving to homes that require less energy for heating and cooling.
(3) The populace moving to homes that minimize the distances needed to travel on a daily basis.	(3) The populace moving to homes that minimize the distances needed to travel on a daily basis.	(3) The populace moving to homes that minimize the distances needed to travel on a daily basis.	(3) The populace moving to homes that minimize the distances needed to travel on a daily basis.
(4) The populace moving to homes in the larger cities due to their being the centers of health care and culture.	(4) The populace moving to homes in the larger cities due to their being the centers of health care and culture.	(4) The populace moving to homes in the larger cities due to their being the centers of health care and culture.	(4) The populace moving to homes in the larger cities due to their being the centers of health care and culture.
Housing starts are about average. Due to fair level of labor supply, labor rates are moderate to low, which, combined, mostly off sets the increasing cost of materials.	**Housing starts are a little below average. Although there is a fair level of labor supply and labor rates are moderate to low, the increasing cost of materials and energy and the added efforts to meet the regulations for "green"/sustainability methods lead to suppression in demand.**	**Housing starts are at some of the lowest levels since early 2012. Due to low labor supply, labor rates are very high, which, combined with the high cost of materials, has suppressed the demand for building private homes and some nonresidential buildings.**	**Housing starts are at some of the lowest levels since early 2001. Due to low labor supply, labor rates are very high, which, combined with the high cost of materials, energy, and activities required to meet the environmental regulations, has strongly suppressed the demand for building private homes and some nonresidential buildings.**
The average size of a new single-family dwelling has declined by 10%.	**The average size of a new single-family dwelling has declined by 20%.**	**The average size of a new single-family dwelling has declined by 20%.**	**The average size of a new single-family dwelling has declined by 25%.**

MIXED BAG	TENSE BALANCE	ON THE EDGE	TRAPPED
(1) High cost of land in general.	(1) High cost of land in general.	(1) High cost of land in general.	(1) High cost of land in general.
(2) High cost of energy for heating and cooling.	(2) High cost of energy for heating and cooling.	(2) High cost of energy for heating and cooling.	(2) High cost of energy for heating and cooling.
(3) High cost of materials due to global demand.	(3) High cost of materials due to global demand.	(3) High cost of materials due to global demand.	(3) High cost of materials due to global demand.
		(4) High cost of labor	**(4) High cost of labor.**
Just like the Intelligent Buildings in the nonresidential market, there are now more Smart Homes, with similarly integrated systems. About 50% of new homes are "smart."	**Smart Homes, similar to Intelligent Buildings in the nonresidential market, are now mandated, meaning that 100% of all residential construction is "smart."**	**Just like the Intelligent Buildings in the nonresidential market, there are now more Smart Homes, with similarly integrated systems. About 25% of new homes are "smart."**	**Smart Homes, similar to Intelligent Buildings in the nonresidential market, are now mandated, meaning that 100% of all residential construction is "smart."**
To save on cost of transportation (high due to energy costs), there is considerably more telecommuting.	To save on cost of transportation (high due to energy costs), there is considerably more telecommuting.	To save on cost of transportation (high due to energy costs), there is considerably more telecommuting.	To save on cost of transportation (high due to energy costs), there is considerably more telecommuting.
Younger generation decision-making is not necessarily based on economics; more so on carbon footprint.	Younger generation decision-making is not necessarily based on economics; more so on carbon footprint.	Younger generation decision-making is not necessarily based on economics; more so on carbon footprint.	Younger generation decision-making is not based on economics; more so on carbon footprint.
Consumers will be more brand-savvy and more brand-conscious, but not brand-loyal.	Consumers will be more brand-savvy and more brand-conscious, but not brand-loyal.	Consumers will be more brand-savvy and more brand-conscious, but not brand-loyal.	Consumers will be more brand-savvy and more brand-conscious, but not brand-loyal.

MIXED BAG	TENSE BALANCE	ON THE EDGE	TRAPPED
DEVELOPMENTS SPECIFIC TO NONRESIDENTIAL BUILDINGS AND SYSTEMS			
Energy efficiency of buildings and cost-effective maintenance have become increasingly important to owners. Intelligent Building Systems are in about 70% of all new nonresidential buildings. Except for the manufacturing sector, where the wireless systems used in office and retail structures cannot be used since these industrial plants tend to be highly reflective, meaning radio waves can be scattered and prone to interferences. About 40% of these buildings are "intelligent."	**Intelligent Building Systems are mandatory for 100% of all new nonresidential buildings.**	**Energy efficiency of buildings and cost-effective maintenance have become increasingly important to owners. Intelligent Building Systems are in about 70% of all new nonresidential buildings. Except for the manufacturing sector, where the wireless systems used in office and retail structures cannot be used since these industrial plants tend to be highly reflective, meaning radio waves can be scattered and prone to interferences. About 40% of these buildings are "intelligent."**	**Intelligent Building Systems are mandatory for 100% of all new nonresidential buildings.**
Nonresidential customers develop their systems online and place orders for materials via the Internet.	Nonresidential customers develop their systems online and place orders for materials via the Internet.	Nonresidential customers develop their systems online and place orders for materials via the Internet.	Nonresidential customers develop their systems online and place orders for materials via the Internet.
CONSTRUCTION PROCESSES, MATERIALS, AND PRODUCTS			
The LEED program continues to exist and is designed into approximately 40% of residential and nonresidential projects.	**The LEED program has become a government-regulated and mandated program. 100% of all new construction is required to meet at least the minimal LEED certification level.**	**The LEED program continues to exist and is designed into approximately 40% of residential and nonresidential projects.**	**The LEED program has become a government-regulated and mandated program. 100% of all new construction is required to meet at least the minimal LEED certification level.**
Modular construction has become the norm for almost all types of buildings.	Modular construction has become the norm for almost all types of buildings.	Modular construction has become the norm for almost all types of buildings.	Modular construction has become the norm for almost all types of buildings.

MIXED BAG	TENSE BALANCE	ON THE EDGE	TRAPPED
Construction materials costs continue to heat up. Estimators predict annual inflation of 9 to 10% for new construction material costs.	Construction materials costs continue to heat up. Estimators predict annual inflation of 9 to 10% for new construction material costs.	Construction materials costs continue to heat up. Estimators predict annual inflation of 9 to 10% for new construction material costs.	Construction materials costs continue to heat up. Estimators predict annual inflation of 9 to 10% for new construction material costs.
At first, Building Information Modeling (BIM) was used for cost reduction, enabling the user to offer lower contract prices to owners, but now it is used by almost all contractors and has virtually become a requirement.	At first, Building Information Modeling (BIM) was used for cost reduction, enabling the user to offer lower contract prices to owners, but now it is used by almost all contractors and has virtually become a requirement.	At first, Building Information Modeling (BIM) was used for cost reduction, enabling the user to offer lower contract prices to owners, but now it is used by almost all contractors and has virtually become a requirement.	At first, Building Information Modeling (BIM) was used for cost reduction, enabling the user to offer lower contract prices to owners, but now it is used by almost all contractors and has virtually become a requirement.
BIM is a key part in constructing effective intelligent buildings.	BIM is a key part in constructing effective intelligent buildings.	BIM is a key part in constructing effective intelligent buildings.	BIM is a key part in constructing effective intelligent buildings.
LABOR FORCE			
Due to several factors, the skills required of HVAC professionals now include greater abstract thinking, computer usage, online research, systems integrations, and flexibility to change. The factors include	Due to several factors, the skills required of HVAC professionals now include greater abstract thinking, computer usage, online research, systems integrations, and flexibility to change. The factors include	Due to several factors, the skills required of HVAC professionals now include greater abstract thinking, computer usage, online research, systems integrations, and flexibility to change. The factors include	Due to several factors, the skills required of HVAC professionals now include greater abstract thinking, computer usage, online research, systems integrations, and flexibility to change. The factors include
(1) Increasing number of intelligent buildings, nonresidential and residential (integration into security systems, sensor networks, etc.)	(1) Increasing number of intelligent buildings, nonresidential and residential (integration into security systems, sensor networks, etc.).	(1) Increasing number of intelligent buildings, nonresidential and residential (integration into security systems, sensor networks, etc.).	(1) Increasing number of intelligent buildings, nonresidential and residential (integration into security systems, sensor networks, etc.).

MIXED BAG	TENSE BALANCE	ON THE EDGE	TRAPPED
(2) Rapid change in technology.	(2) Rapid change in technology.	(2) Rapid change in technology.	(2) Rapid change in technology.
(3) Concerns about disease control have led to the integration of filtration and sanitation devices into most HVAC systems for schools, public buildings, etc.	(3) Concerns about disease control have led to the integration of filtration and sanitation devices into most HVAC systems for schools, public buildings, etc.	(3) Concerns about disease control have led to the integration of filtration and sanitation devices into most HVAC systems for schools, public buildings, etc.	(3) Concerns about disease control have led to the integration of filtration and sanitation devices into most HVAC systems for schools, public buildings, etc.
(4) Continued usage of high-speed Internet access for guidance during installation and repair.	(4) Continued usage of high-speed Internet access for guidance during installation and repair.	(4) Continued usage of high-speed Internet access for guidance during installation and repair.	(4) Continued usage of high-speed Internet access for guidance during installation and repair.
(5) System diagnostics initially conducted over the Internet.	(5) System diagnostics initially conducted over the Internet.	(5) System diagnostics initially conducted over the Internet.	(5) System diagnostics initially conducted over the Internet.
The competitive aspect of service has become increasingly important, and, most of the time, techs are now very professional and are coached on how to make a very good first impression.	The competitive aspect of service has become increasingly important, and, most of the time, techs are now very professional and are coached on how to make a very good first impression.	The competitive aspect of service has become increasingly important, and, most of the time, techs are now very professional and are coached on how to make a very good first impression.	The competitive aspect of service has become increasingly important, and, most of the time, techs are now very professional and are coached on how to make a very good first impression.
COMPETITIVE LANDSCAPE			
Due to slow rate of new-process adoption in the industry, back in 2010 Toyota and Panasonic formed a joint venture in the U.S. to start building single-family dwellings and smaller office/commercial buildings. Toyota has been building homes in Japan since the mid-2000s, and Panasonic was a natural fit for handling the electrical and HVAC specialties. With their leadership in LEAN principles, they have developed a long list of highly satisfied clients and customers.	Due to slow rate of new-process adoption in the industry, back in 2010 Toyota and Panasonic formed a joint venture in the U.S. to start building single-family dwellings and smaller office/commercial buildings. Toyota has been building homes in Japan since the mid-2000s, and Panasonic was a natural fit for handling the electrical and HVAC specialties. With their leadership in LEAN principles, they have developed a long list of highly satisfied clients and customers.	Due to slow rate of new-process adoption in the industry, back in 2010 Toyota and Panasonic formed a joint venture in the U.S. to start building single-family dwellings and smaller office/commercial buildings. Toyota has been building homes in Japan since the mid-2000s, and Panasonic was a natural fit for handling the electrical and HVAC specialties. With their leadership in LEAN principles, they have developed a long list of highly satisfied clients and customers.	Due to slow rate of new-process adoption in the industry, back in 2010 Toyota and Panasonic formed a joint venture in the U.S. to start building single-family dwellings and smaller office/commercial buildings. Toyota has been building homes in Japan since the mid-2000s, and Panasonic was a natural fit for handling the electrical and HVAC specialties. With their leadership in LEAN principles, they have developed a long list of highly satisfied clients and customers.

13 APPENDIX 5 – SURVEY INSTRUMENT (TASK #3)

IMPLICATIONS FOR THE BUILDING AND HVAC INDUSTRY BASED ON

PLANNING SCENARIO #1 – "Mixed Bag"

LOW Regulations & FAIR Labor Supply

U.S. ECONOMY: Okay
GLOBAL ECONOMY: Weak
GLOBAL SOCIAL: Unstable

This section contains a series of questions regarding your thoughts about the implications that the above Planning Scenario has for the HVAC Industry.

1. You might want to let the reading "stew" for a day or so before going on to responding to the questions.
2. Be sure to honestly accept that **THERE ARE NO WRONG ANSWERS.**
3. Feel free to call or email Alissa or Art at FMI if you need any clarifications.
4. **YOU DO NOT HAVE TO ANSWER ALL THE QUESTIONS**
   a. If you do not have an opinion or idea regarding a question, it is quite all right to leave it blank.
5. After you have given your first effort to formally respond to the questions, you might again wait a day or so and then come back to them to see if you have more to add (most of the time people do, but it is OK if you don't).
6. When you are adequately satisfied with your answers, simply email a copy of your responses to Alissa. Please submit your opinions and contributions by **November 30, 2007.**

SECTION 1

Each question in this section focuses on the implications you foresee in the specific sectors of the HVAC industry given the macro conditions described in the "Mixed Bag" Planning Scenario where the following are identified:

1. Little in government regulations, in response to concerns related to climate change
2. A fair supply of labor
3. A generally "okay" U.S. economic condition
4. A weak global economy
5. An increase in social instability and terrorist activity

For each of the construction sectors presented in Section 1, please write in up to two highly important implications that you believe have a very good chance to occur given the context of Planning Scenario #1. There are six two-part questions in this section.

1. **Impact on Building in General – RESIDENTIAL**

Based on the scenario of **low environmental regulations** and a **fair supply of labor**, please write in up to two highly important implications you see for residential building in the year 2018 (*aspects to consider include demand, demographics, size, location, materials, labor, industry consolidation, role of construction manager/general contractor, and any other aspects that you feel are appropriate*).

2. **Impact on Building in General – NONRESIDENTIAL**
   Based on the scenario of **low environmental regulations** and a **fair supply of labor**, please write in up to two highly important implications you see for nonresidential building in the year 2018 (*aspects to consider include demand, demographics, size, location, materials, labor, industry consolidation, role of construction manager/general contractor, and any other aspects that you feel are appropriate*).

3. **Impact on HVAC Work – RESIDENTIAL**
   Based on the scenario of **low environmental regulations** and a **fair supply of labor**, please write in up to two highly important implications you see for future residential HVAC work **related to the type of work performed** (*such as system configuration, new technology, BIM, system efficiency, codes and regulations, labor intensity, labor availability and sources, and other factors that you deem to be appropriate*).

4. **Impact on HVAC Work – NONRESIDENTIAL**
   Based on the scenario of **low environmental regulations** and a **fair supply of labor**, please write in up to two highly important implications you see for future nonresidential HVAC work **related to the type of work performed** (*such as system configuration, new technology, BIM, system efficiency, codes and regulations, labor intensity, labor availability and sources, and other factors that you deem to be appropriate*).

5. **Impact on HVAC Work – Who Will Be Doing The Work – (RESIDENTIAL AND NONRESIDENTIAL)**
   Based on the scenario of **low environmental regulations** and a **fair supply of labor**, please write in up to two highly important implications you see for future residential and nonresidential HVAC work **related to who will be doing the work—design, fabrication, installation, etc.** (*consolidation of contractors, mechanicals/general contractors/utilities/ others performing the work, contract types, labor structure, role of service, and other factors that you deem to be appropriate*).

6. **Impact on HVAC Contractor (RESIDENTIAL AND NONRESIDENTIAL)**
   Based on the scenario of **low environmental regulations** and a **fair supply of labor**, please write in up to two highly important implications you see for future residential and nonresidential **HVAC contractors** (*type of work performed, size of business, ownership of firm, profitability, risks, labor availability, business threats, competitive position, customer loyalty, supply sources, and other factors that you deem to be appropriate*).

SECTION 2

Below is a series of potential implications for the HVAC industry that were submitted in the Future Visioning Task #2. For each implication statement, please indicate how likely you think that implication will occur under the conditions of Planning Scenario #1 – **low environmental regulations and a fair supply of labor.**

Use

- "**1**" to indicate that you think an implication is **Extremely Unlikely** to occur in the world described in the scenario,
- "**2**" to indicate that you think an implication is **Somewhat Unlikely** to occur in the world described in the scenario,
- "**3**" to indicate that you think an implication is **Somewhat Likely** to occur in the world described in the scenario,
- "**4**" to indicate that you think an implication is **Extremely Likely** to occur in the world described in the scenario, and
- "**5**" to indicate that you feel you are not able (**Do Not Know**) to make a judgment regarding the likelihood of the implication occurring given the conditions of the U.S. as described in the scenario.

	Extremely Unlikely	Somewhat Unlikely	Somewhat Likely	Extremely Likely	Do not Know
1. There will be extensive horizontal consolidation of HVAC competitors.	1	2	3	4	5
2. There will be extensive formal vertical consolidation of HVAC suppliers and manufacturers.	1	2	3	4	5
3. Manufacturers will have acquired most distributors in order to get better and closer access to the markets.	1	2	3	4	5
4. There will be a major shift of traditional North American HVAC manufacturers using low-cost country-direct sourcing and/or manufacturing to reduce costs.	1	2	3	4	5

	Extremely Unlikely	Somewhat Unlikely	Somewhat Likely	Extremely Likely	Do not Know
5. The sheet metal contractor will typically be a sub to the general contractor on commercial work.	1	2	3	4	5
6. Added competition from new contractors given incentives from manufacturers will create new start-up companies.	1	2	3	4	5
7. The HVAC industry will become a highly sought-after industry for employment by younger workers.	1	2	3	4	5
8. Differentiation of HVAC work will be based upon service and other soft factors.	1	2	3	4	5
9. There will be a significant demand on the technical side of the sheet-metal business – Service – Tab – Commissioning – Certifications.	1	2	3	4	5
10. CADD design will be used a great deal to help sell jobs.	1	2	3	4	5
11. A great deal of outsourcing of design will occur, including HVAC systems.	1	2	3	4	5
12. Fewer and fewer sheet metal contractors will do their own fabrication.	1	2	3	4	5
13. More progressive HVAC firms will have opted to enterthe design market.	1	2	3	4	5
14. Companies will be extensively recycling ductwork and other equipment.	1	2	3	4	5
15. Big Box stores will have become major players in HVAC equipment sales and installation.	1	2	3	4	5
16. Big Box stores will have become major distributors of plug-and-play DIY mini-split appliances.	1	2	3	4	5

	Extremely Unlikely	Somewhat Unlikely	Somewhat Likely	Extremely Likely	Do not Know
17. The residential business model will have changed to be much more oriented towards service.	1	2	3	4	5
18. Residential units will be brought into the repair shop instead of serviced in home at high per-hour costs.	1	2	3	4	5
19. Breakthrough equipment technology will yield significant energy efficiencies.	1	2	3	4	5
20. System integration controls will allow contractors to troubleshoot equipment from an off-premises monitoring facility.	1	2	3	4	5
21. There will be considerably more retrofit and repair than new work.	1	2	3	4	5
22. Control contractors will increase their presences in the nonresidential HVAC industry.	1	2	3	4	5
23. Utilities and other third parties will own and service the equipment; homeowners will lease the equipment.	1	2	3	4	5
24. Unions will go through a typical business cycle of reorganization.	1	2	3	4	5
25. Improvements in manufacturing, distribution, and value-chain efficiencies will be challenged with shortages of key components (similar to what occurred with expansion valves and compressors recently).	1	2	3	4	5
26. Significant consolidation will occur within building trade unions.	1	2	3	4	5
27. Lean construction will become the norm within the HVAC industry.	1	2	3	4	5

	Extremely Unlikely	Somewhat Unlikely	Somewhat Likely	Extremely Likely	Do not Know
28. Dominant offshore competitors will enter the HVAC contracting market.	1	2	3	4	5
29. A manufacturer will emerge worldwide that will create shortages for our domestic manufacturers, which will affect delivery of goods.	1	2	3	4	5
30. Profitability will decline for most HVAC contractors due to commoditization.	1	2	3	4	5
31. Developing economies' lower cost of labor coupled with available technologies will make global outsourcing feasible.	1	2	3	4	5
32. Contractors will find that they require more IT employees on their payrolls.	1	2	3	4	5
33. Traditional ducted systems will have become a very limited market.	1	2	3	4	5
34. The glut of HVAC firms exiting the business will considerably lower the value of the contractors' business.	1	2	3	4	5
35. New energy legislation will create a windfall for the HVAC manufacturer and contractors.	1	2	3	4	5

SECTION 3

Please provide your thoughts to any of the questions below that you have an opinion about. Given the conditions stated in the Planning Scenario #1 of **low environmental regulations** and a **fair supply of labor**. . .

1. What will be the role of unions in this setting and how would you describe the range of people who are the current members?

2. What conditions stand out as good opportunities for significant transformations that people in the HVAC industry are particularly well suited to take advantage of?

3. What will have changed in how design services are performed?

4. What will have changed in how duct is fabricated?

5. What will have changed in how the equipment installation is performed?

6. What will have changed in how ducts will be installed?

7. What will have changed in how systems are controlled and monitored?

8. What will have changed in how systems are serviced and maintained?

9. What will have changed in how systems are replaced?

Respondent discipline for Task #3 as completed by the HVAC Futures Advisory Group and the Task Force is represented below.

Industry Sector	Number	Composition (%)
HVAC/Sheet Metal Contractor	15	28
A/E	5	15
Trade Association	8	13
General Contractor	4	8
Academia	3	6
Industrial Product Service Supplier	3	6
HVAC Equipment Manufacturer	2	4
Labor Organization	2	4
Construction Manager	1	2
Government	1	2
Homebuilder	1	2
Publisher	1	2
Other	5	9
TOTAL	**53**	**100%**