

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

THE 2022 HVAC AND SHEET METAL INDUSTRY FUTURES STUDY UPDATE

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2022 NEW HORIZONS FOUNDATION FUTURES STUDY TASK FORCE

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TABLE OF CONTENTS

Executive Summary	1
Introduction	3
Study Goals	3
Survey Data Collection and Methodology	3
Approach, Limitations, and Uncertainties	6
Comparative Historical Trends in Prior Futures Studies	6
2016 Study Findings and 2022 Outcomes	8
2022 Emerging Future Scenario Trends and Impact Areas	9
Potential Disruptive Activities	9
Prefabrication and Modularization Advancements	9
Widespread Adoption of Lean Principles	10
Skilled Craft and Flexible Labor Sourcing/Organized Labor Future Engagement	12
Software Challenges within the AEC Industry	14
The Future of Supply Chains	15
Managing Risk & Profitability Growth	17
Connected Construction for Collaboration	18
Mega Projects	20
Industry Structure and Consolidation	22
Big Data, KPI Analytics, Benchmarking	23
Autonomous Tools	24
BIM Driven Layout Tools	25
Internet of Things “IoT”	26
Customer Energy Cost Reduction Requirements/Carbon Footprint	28
Economic/Legislative/Pandemic Megatrends	29
Appendices	32
Appendix A: Prefabrication and Modularization Advancements	32
Appendix B: Managing Risk & Profitability Growth	34
Appendix C: Mega Projects	35
Appendix D: Customer Energy Cost Reduction Requirements/Carbon Footprint	37
Endnotes	42
New Horizons Foundation Contributors	44

EXECUTIVE SUMMARY

In this New Horizons Foundation 2022 HVAC and Sheet Metal Industry Futures Study Update, Maxim Consulting Group accomplished the following primary objectives:

- Understand the drivers of potential future scenarios in HVAC/Sheet Metal and Mechanical contracting and the construction industry in general.
- Seek to confirm the previous study assertions and actual outcomes:
 - Identify the comparative historical trends in prior futures studies that have continued since 2008 and provide a 2022 update.
 - Provide a 2022 update on the four specific trend scenarios put forth in the 2016 study update.
- Forecast potential industry trend scenarios.
- Provide directional information that contractors can operationalize.

Extensive research included a quantitative survey with participant responses exceeding 4% of SMACNA membership, with data collected on the actual and perceived future impacts and trends for the industry and contractors.

We found that the continuing long-term trends identified in the 2008 Futures Study have become significantly more impactful and will continue for the next five years. These were:

- “Solutions-First” Approach to Buying Construction Services
- Energy Costs
- Prefabrication and Modular Building
- National Demand for HVAC Services and Construction

- BIM Technology Penetration and Maturing
- Vertical Integration

The prior 2016 Futures Study presented the following four potential scenarios to have occurred over the last several years.

- **An ultra-high technology and ultra-high efficiency market:** We have observed a continued acceptance of new technologies as systems have familiar interfaces, and users have been conditioned by the technology available. Building automation will continue, but there will be slow adoption of HVAC contractors as data monitors. Additionally, tax incentives will continue to support continued government support to drive efficiency.
- **A market defined by highly-varied customer needs:** Highly varied customer needs continue to be the norm, although there is more alignment within specific verticals (data centers, hospitals, commercial, etc.). Serial buyers of construction demand performance from proven project teams.
- **A market characterized by general economic decline with increasing efficiency mandates:** Wage pressure due to extended inflation will be strong in 2022 and 2023, with most economists predicting a mild recession in 2024, provided the Fed does not increase the rate too sharply to slow the economy. Inflation significantly affects material and equipment prices, but supply chain issues and availability will return to normal lead times by 2025. Efficiency will be driven by the legislative agenda for massive decarbonization, and the fuels used for heating and cooling will require new skill sets and expertise from contractors.
- **A low-tech market that changes little from the present one:** A general slow move toward more fuel cell technologies and applications. Regulatory changes will keep pace with technological capabilities to improve efficiency

- **Large buyers of construction services:**
Large buyers of construction services will require improvements in anticipation of forthcoming legislative regulations.

This 2022 Futures Study has identified the following Emerging Future Scenario Trends and Impact Areas. Understanding these trends and the impacts enables contractors to see possibilities and opportunities for growth.

- Prefabrication and Modularization Advancements
- Widespread Adoption of Lean Principles
- Skilled Craft and Flexible Labor Sourcing/
Organized Labor Future Engagement
- Software Challenges with the AEC Industry
- The Future of Supply Chains
- Managing Risk & Profitability Growth
- Connected Construction for Collaboration
- Mega Projects
- Industry Structure and Consolidation
- Big Data, KPI Analytics, Benchmarking
- Autonomous Tools
- Internet of Things “IoT”
- Customer Energy Cost Reduction
Requirements/Carbon Footprint
- Economic/Legislative/Pandemic Megatrends

Finally, actionable recommendations are provided for contractors to operationalize these trends.

INTRODUCTION

In this 2022 Update to the HVAC and Sheet Metal Industry Futures Study, Maxim Consulting Group validated the findings from the 2008, 2012, and 2016 studies and identified the likely trends and impacts in the next five to ten years.

Most recently, HVAC/Sheet Metal and Mechanical contractors have faced challenges on many fronts. In addition to having a more challenging time recruiting competent labor, contractors are paying more to entice them. The U.S. Chamber of Commerce Commercial Construction Index report finds that 56% of contractors indicate a high level of anxiety over the skill levels of their employees, up six points from the previous quarter and twenty points year-over-year.¹

Almost all (95%) contractors face at least one product shortfall, up from 93% in the previous quarter and 24 percentage points (71%) from a year earlier.² The product most in limited supply among contractors is steel (27%), followed by metal roofing (19%).³

The prior HVAC and Sheet Metal Industry Futures Study (2016 Update) is available here:

<https://www.newhorizonsfoundation.org/project/the-hvac-and-sheet-metal-industry-futures-study-update-2016/>

Study Goals

The New Horizons 2022 Futures Study aims to understand the drivers of potential future scenarios in HVAC/Sheet Metal and Mechanical contracting and the construction industry in general. Specifically, the objectives were to:

- Seek to confirm the previous study assertions and actual outcomes:
- Identify the comparative historical trends in prior futures studies that have continued since 2008 and provide a 2022 update.

- Provide a 2022 update on the four specific trend scenarios put forth in the 2016 study update.
- Forecast potential industry trend scenarios.
- Provide directional information that contractors can operationalize.

Maxim Consulting Group accomplished these goals by performing a four-phase strategy:

- Researching and analyzing possible trends
- Evaluating past studies for long-term common trending themes
- Determining the relatively recent pandemic's lasting implications
- Presenting likely scenarios given current industry influential developments

Survey Data Collection and Methodology

Using a quantitative survey with participant responses from SMACNA members, data was collected on the actual and perceived future impacts and trends for the industry and contractors. Membership responses were diverse in both location (*Figure 1* and *Figure 2*) and revenue size (*Figure 3*).

Figure 1: Survey Participant Distribution

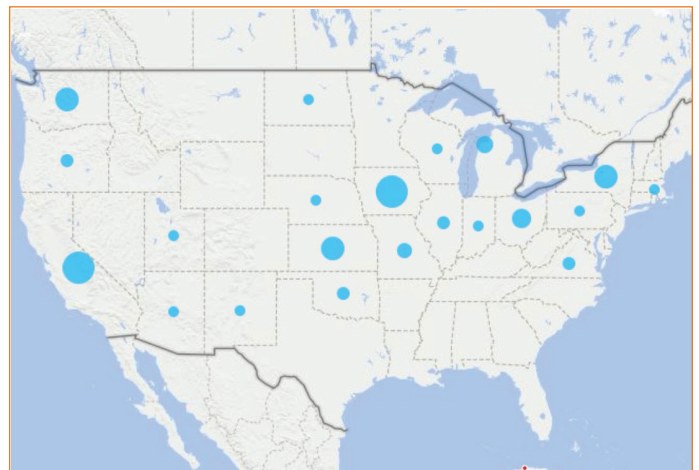
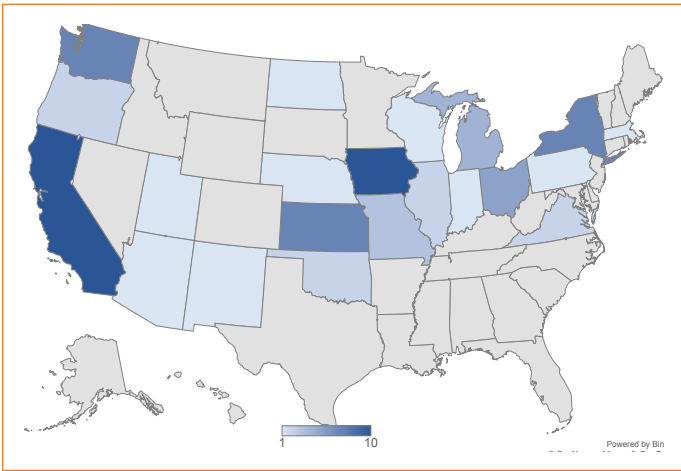
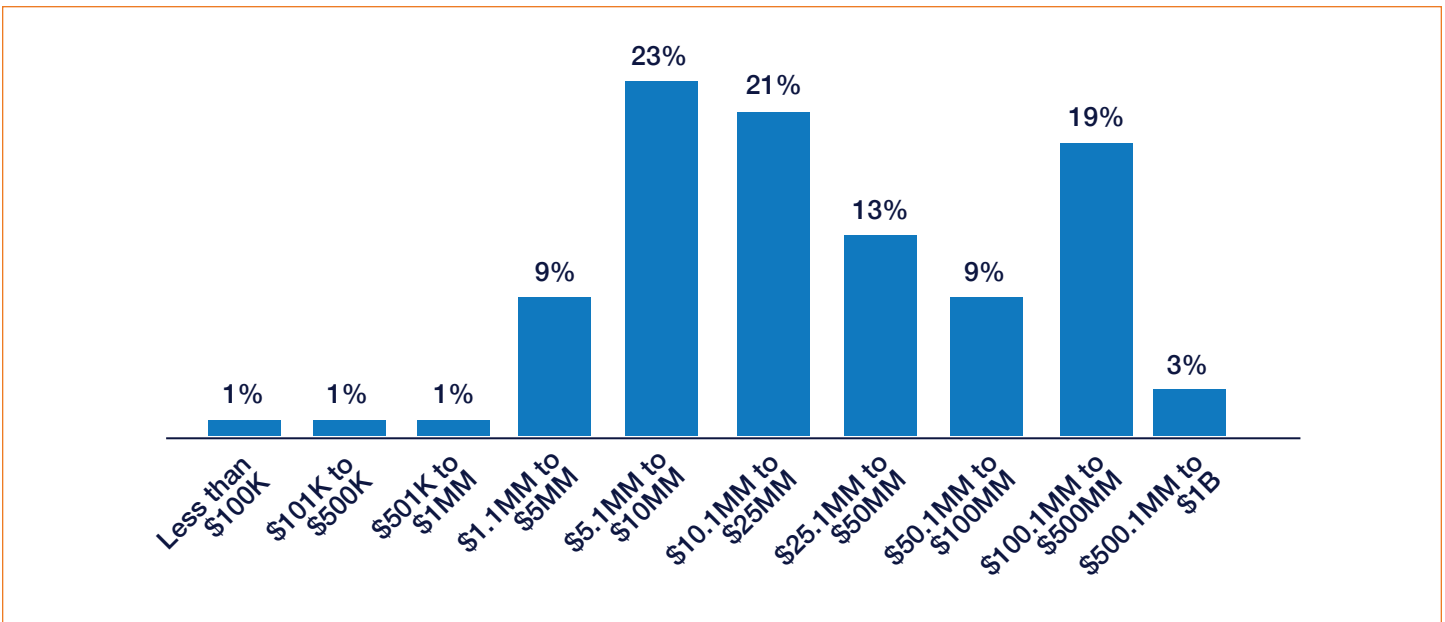


Figure 2: Survey Participant Count Per State



Additionally, Maxim Consulting Group has done research independently and in collaboration with industry trade groups to gain an understanding of the difficulties, challenges, and opportunities confronting HVAC/Sheet Metal and Mechanical contractors and the construction industry in the upcoming years. Based on this knowledge, we offered updates to the prior study’s conclusions and 2022 outcome results and presented in this study trends, impacts, and potential implications and opportunities for HVAC/Sheet Metal and Mechanical contractors in the coming years. These trends emerged as the ones that would have the most bearing on the future of HVAC/Sheet Metal and Mechanical contractors and the industry.

Figure 3: Survey Participant by Revenue Size



The survey focused on potential areas and the contractor perspective by gathering data on impacts on the job site, project management, overall business operations, and other items identified by the participants. As seen

in *Figure 4*, participants indicated the impacts in each area from 4 (High) to 1 (Low). This format allowed the responses to quantify the relative magnitude of the impact within each area.

Figure 4: Survey Participant Ranking

Impact Area	Survey Participant Rank 4 (Highest) – 1 (Lowest)
Organized Labor Future Engagement	4
Supply Chain Issues	4
Profitability Growth	4
Risk	4
Management/ Leadership Attraction	4
Skilled Craft & Flexible Labor Sourcing	4
The Advent of COVID-driven Factors	3
Cashflow Impact of Project Requirements	3
Work Profitability Mix	3
Increase in Warehouse Space	3
Facility Service and Maintenance	3
Customer Carbon Footprint Reduction	3
Customer Energy Cost Reduction	3
Smart Buildings	3
Customer Increased Requirements	3
Autonomous Tools	3
Big Data, KPI Analytics, Benchmarking	3
Widespread Adoption of Lean Principles	3
Increased Remote Workforce	3
Industry Consolidation & Mergers	2
Integrated Project Delivery (IPD)	2
A Decline in Office Space	2
Facility Monitoring by HVAC Contractor	2
Outsourced Facility Management	2
Procurement: Aggregate Purchasing	2
Design Delegation/ Outsourcing	2
Data Islands on Disparate Systems	2
Diversity, Equity & Inclusion (DEI) Issues	2
Mega Projects	1
3-D Printing	1

Approach, Limitations, and Uncertainties

The analysis was conducted as follows. Initially, we utilized probable future scenarios to assess changes in significant factors and their effects on HVAC, Sheet Metal, and Mechanical contractors. Using this information, we analyzed changes in demand and their consequences on investment, supply chain and customer costs, employment supply, labor intensity, and value chain impacts. We utilized region-specific pricing and labor assumptions and anticipated technological learning curves over time, if possible.

We acknowledge the limits of the future possibilities, as with any transition scenario. First, while certain factors are examined at the sector level, the scenarios may not always give sufficient information to examine how different types of activity would be impacted, necessitating summarization to obtain the required sectoral granularity. Second, the models underlying the future possibilities may not account for crucial sector dynamics or limits.

Our approach consists mainly of an examination of first-order impacts. Numerous uncertainties might influence the size of the results reported here. While some of these factors may result in less favorable results than those estimated in this study, others show that the shift will undoubtedly incur extra costs and impacts. Similarly, the costs associated with governmental regulation may exceed those stated here.

These implications are not predictions but critical decision points and elements to consider when developing future business plans. Each of the 2022 Emerging Future Scenario Trends also includes Potential Implications and Contractor Opportunities for HVAC/Sheet Metal and Mechanical contractors to operationalize the conclusions reached in the report.

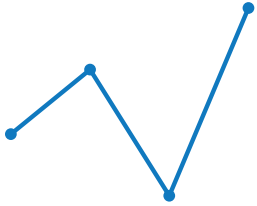
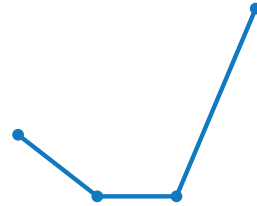
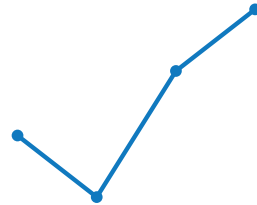
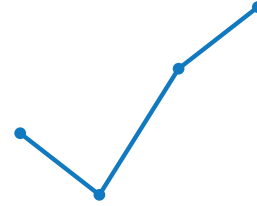
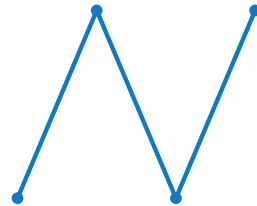
COMPARATIVE HISTORICAL TRENDS IN PRIOR FUTURES STUDIES

We assessed the prior studies, and while many of the trends may potentially continue, there are indications of new trends emerging with longer-lasting and more impactful effects on HVAC/Sheet Metal and Mechanical contractors. We have charted the prior stated continuous trend impacts of the 2008, 2012, and 2016 studies and included the observed 2022 outcome and how the future will likely evolve. While the prior studies have reviewed the potential impact drivers, they did not consider any disruptive factors which would heavily influence HVAC/Sheet Metal and Mechanical contractors. The chart below in *Table 1* shows the historical factors put forth in prior studies and the likely influence relative to the other factors in the next five years. A factor with a rising line indicates a more significant impact, and a declining line indicates a less impactful factor.

Table 1: Comparative 2008-2022 Trend Impact & Outcome

Prior Studies Trends	2008-2022 Trend Relative Impact	2022 Outcome & Likely Future
<p>“Solutions-First” Approach to Buying Construction Services</p>		<p>“Solutions-First” will continue to be a price-driven market with select verticals understanding the value of a collaborative approach to reduce the overall lifecycle cost of the facility.</p>

THE 2022 HVAC AND SHEET METAL INDUSTRY FUTURES STUDY UPDATE

Prior Studies Trends	2008-2022 Trend Relative Impact	2022 Outcome & Likely Future
Energy Costs		<p>Energy costs have significantly increased in all areas, in contrast to the forecasted likely future in the 2016 study. Oil prices will likely stabilize, but the current Presidential Administration’s halt on pipeline projects will pressure natural gas prices.</p>
Prefabrication and Modular Building		<p>Prefabrication and modularization will continue to be at the forefront of the industry for the foreseeable future. Faced with labor shortages, compressed schedules, and price constraints, contractors will be compelled to innovate and deliver more with the same or fewer resources.</p>
National Demand for HVAC Services and Construction		<p>Increased government programs through targeted budget funding to promote home ownership, followed by commercial, healthcare, and other support facilities, will contribute to the expansion of the building sector. In addition, increasing building activities, infrastructural changes, and HVAC replacement and upgrades are among the primary factors contributing to the growth of the nation’s HVAC services and construction markets.</p>
BIM Technology Penetration and Maturing		<p>BIM will remain the go-to collaboration tool for trade coordination with REVIT as the market leader for the foreseeable future, with BIM’s full capabilities predicted to be widely adopted. It will continue to evolve with the addition of 4D (Schedule) and 5D (Cost). The use of BIM Models for facility management has been irregular but will continue to evolve.</p>
Vertical Integration		<p>Consolidation for scale is more likely than broad-based adoption of a vertical integration strategy. Large-scale failures like Kattera will yield lessons learned and provide pause. Supply chain issues resulting from COVID make it seem more likely for sector consolidation than contractors pursuing vertical integration.</p>

2016 STUDY FINDINGS AND 2022 OUTCOMES

2016 Research Finding	2022 Outcome & Likely Future
<p>An ultra-high technology and ultra-high efficiency market</p>	<ul style="list-style-type: none"> ■ Continued acceptance of new technology ■ User interface importance (ease of use) ■ Smart buildings that recognize user preferences and adapt the space accordingly ■ Continued government support for energy efficiency ■ Tax incentives to fund adoption ■ Adoption rates increase to drive R&D into new technology ■ Businesses continue to run equipment to failure ■ Slow adoption of HVAC contractors as a data monitor ■ Increase automation of alerts to drive maintenance needs ■ Continued demand for energy efficiency
<p>A market defined by highly-varied customer needs</p>	<ul style="list-style-type: none"> ■ Highly varied customer needs continue to be the norm, although there is more alignment within specific verticals (data centers, hospitals, commercial, etc.) ■ Traveling with key customers continues as serial buyers of construction demand performance from proven project teams, including partnering with other local contractors in a distant customer market ■ Technology offerings consolidate from point use solutions to workflow and collaboration across multiple business functions, trades, and stakeholders (Owner, Engineer, Architect, General, Sub Trades, etc.)
<p>A market defined by general economic decline with increasing efficiency mandates</p>	<ul style="list-style-type: none"> ■ Wage pressure due to inflation will be strong in 2022 and 2023, with most economists predicting a mild recession in 2024, provided the fed does not pump the brakes too hard with interest rates to slow the economy. ■ Material and equipment inflation prices largely stick, but supply chain issues settle, and availability returns to normal lead times. ■ The legislative agenda for massive decarbonization continues changing the types of products installed and the fuels used for heating and cooling, requiring new skill sets and expertise
<p>A low-tech market that changes little from the present one</p>	<ul style="list-style-type: none"> ■ A move toward more fuel cell technologies ■ Regulatory changes keep pace with technological capabilities to achieve the required efficiency improvements ■ Large buyers of construction services demand improvements ahead of legislative requirements

2022 EMERGING FUTURE SCENARIO TRENDS AND IMPACT AREAS

Understanding these trends and impacts enables contractors to see possibilities and opportunities for growth.

- Prefabrication and Modularization Advancements
- Widespread Adoption of Lean Principles
- Skilled Craft and Flexible Labor Sourcing/Organized Labor Future Engagement
- Software Challenges with the AEC Industry
- The Future of Supply Chains
- Managing Risk & Profitability Growth
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Potential Disruptive Activities

Some potential disruptive activities could change various fundamental components of the HVAC/Sheet Metal and Mechanical contractor business, including ductless mini split systems.

Additionally, significant external factors discussed later in this study include economic recession, prolonged

pandemic activity, supply chain challenges, and increasing energy costs.

Prefabrication and Modularization Advancements

Prefabrication and modularization will continue to be at the forefront of the industry for the foreseeable future. Faced with workforce shortages, schedule compression, and pricing pressures, prefabrication and modularization provide a meaningful way to combat these industry issues. Serial buyers of construction services such as large mission-critical operations, hotel chains, and the like are pushing the envelope on what prefabrication and modularization can accomplish. For example, large data center owners realize the benefits of having the contractors design the systems and facilities in the most constructive way possible to maximize the opportunity to prefabricate. The traditional section design consultants and architects are becoming second fiddle, with the contractors taking the lead in the process on behalf of the owner.

Similarly, hotel chains are building entire hotel rooms in a modular fashion and stacking them like building blocks to build hotels. This approach to prefabrication and modularization is substantially changing the contractor’s role. Companies must learn how to manage the process at an entirely new level.

Another trend that will continue in the prefabrication and modularization space is the push to stabilize the process. Contractors are working hard to build out their standard product libraries at the component, assembly, and system levels. The purpose is to accelerate the throughput of the detailing process, standardize products so companies can procure at the company level, not just on individual projects, and standardize the manufacturing and installation processes. Stabilizing the process at this level sounds easy but is time-consuming and challenging to accomplish. Contractors need to continue this pursuit and integrate technology solutions that assist in the process. REVIT plug-ins, custom-designed software plug-ins, material requirements planning software, and

similar technologies are helping companies integrate the design-detail-procure-manufacture-install workflow.

See [Appendix A: Prefabrication and Modularization Advancements](#) for additional information.

Potential Implications and Contractor Opportunities

Basic prefabrication capabilities are no longer enough. Contractors do not necessarily have the facility to fabricate but need the capability to manage the design process or risk becoming an install-only player. To work on large, sophisticated projects with serial construction buyers, contractors must learn to facilitate and manage the design process from end to end. The result should be a constructive design with a bill of materials that can be manufactured by the contractor or procured through a third party. This trend will continue to push down into smaller and smaller projects.

The amount of information contractors must manage can be overwhelming. Technology supporting integrated workflows is becoming vital. Technology solutions such as those mentioned above will be critical to ensure information drops are minimized, and costly mistakes are not made.

Some contractor shops may be faced with economic challenges. By managing the design process and procuring a constructive bill of materials through a third-party, fixed costs and value-added to the owner can be reduced. On the flip side, companies with extensive manufacturing capabilities may have the capacity to increase their sales to third parties, thereby increasing utilization and improving the economics of the shop by spreading fixed costs across more manufacturing hours.

Larger and medium-sized contractors that rely on traditional procurement channels, such as design-bid-build, should assess the impact of changes in procurement processes. Design for Manufacturing and Assembly (DFMA) encourages early trade partner onboarding.

If DFMA models result in Owners and Buyers selecting multi-trade fabrication businesses, this may negatively

impact straight line contractors. Have you developed a strategy for linking your business with other upstream buyers? Are you required to examine the available market space?

The next generation of buyers desires to transfer field-based risk to the manufacturing center. In addition, they are seeking greater QA/QC guarantees, supply chain procedures, sourcing efforts, and greater technological integration (BIM/VDC/Purchasing/Production Management/Productivity). Can or will you invest in these demands?

All sizes and types of contractors should evaluate their business plan or strategy against the future of their market, area, and specialty.

Widespread Adoption of Lean Principles

Lean construction will continue to be a large part of the future of construction. Contractors will need to learn and adapt lean tools to their businesses. Lean tools have been mainstreamed in almost every other industry for years, and early attempts to introduce lean concepts to construction were met with resistance. Field implementation through the trades has been impeded by terminology and jargon that an increasingly impatient workforce cannot (or will not commit to) translate to work practices.

Still, the tools and principles are being adapted to make lean a long-term and impactful topic in construction. Contractors are learning that each project is unique, which is the very reason to create consistent systems and processes to execute the work. Lean thinking proves that standardization is necessary, creates efficiency, and allows contractors to develop the workforce more quickly and systematically.

Contractors will need to learn and continue to use lean tools internally, such as value stream mapping, swim lane processes, and desk-level instructions. Additionally, tools such as workplace organization (what is known as 5S), problem resolution boards, versatility matrices, and rapid improvement teams should become mainstream. These tools systematically engage the organization and employees to improve

the business, define career paths, and identify skills gaps. Deploying these tools results in higher employee engagement and improved business results.

Working externally with owners and general contractors, mechanical and sheet metal contractors will continue to see trends such as pull planning, multi-trade prefabrication, and the creation of centers of expertise.

- Pull planning has been out in the industry for years and has been used successfully by general contractors to hold the various stakeholders accountable for the pull plan. Also, subcontractors often fail by sending untrained people into pull planning meetings without understanding what should be taking place, what expectations should be established, and how the process should be run.
- Multi-trade prefabrication will also continue to evolve out of necessity to make project schedules on time and because of the advent of appropriate risk-sharing in contracts. It makes sense on many projects to complete multi-trade prefabrication for cost and schedule benefits. Contractors will need to figure out how to lead these efforts and bring them to General Contractors and owners alike as a value-add service and a unique differentiator.
- Centers of expertise are also beginning to emerge and will continue to do so. This is not new in the sheet metal space, where manufacturers have figured out how to do mass customization. The fire protection contractors (sprinkler fitters) have also pivoted to a regional model with a distribution network. It is anticipated that piping and plumbing will also see similar trends. This could be good news for smaller companies without prefabrication facilities, which could threaten larger companies that have invested heavily in prefabrication capabilities but will likely remain a sourcing alternative and those with manufacturing capability closest to the

job site remaining cost competitive due to transportation costs.

Lean construction is here to stay. It must be emphasized that field leaders should be trained and well-prepared for the challenges ahead. In addition, to integrate the movement of workers from the field to the shop with labor reporting adjustments that allocate time to the appropriate group: Field or Shop. Similarly, sheet metal contractors have typically made equipment acquisitions based on the acceleration of a particular operation rather than eliminating process bottlenecks. At some point, the throughput is connected to the activity with the lowest critical path performance or the waste between phases. As with pull planning field training, training on value streams focuses on what accelerates throughput, not on a machine or a single person.

Potential Implications and Contractor Opportunities

Many of these principles are sound and have worked in many other industries. They simply needed to be adapted to construction. Still, a highly fragmented industry, and there is a high variance in processes across companies. Contractors need to be proactive in their pursuit of training to add lean tools, capabilities, and knowledge to their portfolio at both field and management levels to remain competitive going forward.

- Ensure that all levels of operations leaders, field and office, have access to formal training, particularly in *basic* lean principles, short interval scheduling, and pull planning—all in a translated curriculum that makes sense to the person performing the work.
- Identify subject matter experts or learners within the company who can serve as mentors and advocates for best practices in lean processes and implementation.
- Work with local associations, industry groups (SMACNA, AGC, MCAA, NECA), and local training centers to devote resources to education and training.

- Look for a Community of Practice in the LCI (Lean Construction Institute) and put key people in contact with other practitioners.
- Executive leadership must be engaged and participate in the process. Attend pull planning sessions and witness what works and what doesn't work.
- Utilize SMACNA and New Horizons Foundation materials on lean processes and shop improvement processes.

https://www.newhorizonsfoundation.org/category/project-execution/lean-quality/?post_type=project

<https://store.smacna.org/-searchResults?searchParameters=Lean>

Skilled Craft and Flexible Labor Sourcing/Organized Labor Future Engagement

Most HVAC/Sheet Metal and Mechanical contractors take ample labor supply for granted. Their careers have covered a period of rapidly increasing global labor pools, which is now coming to an end. In the 1950s, the fastest labor force expansion in modern history occurred due to the convergence of three transient occurrences: the coming of age of the baby boomer generation, women's entry into the workforce, and the relatively peaceful cold war. Nonetheless, demographic shifts and technical and societal developments indicate that the labor market will drastically change in the future decade.

The outdated notion that construction occupations are not desirable careers and consist primarily of manual work is changing. A decade-long trend of labor shortages in the business will last until at least 2030. Career prospects for new entrants are driven by the simultaneous pressures of labor shortages and the social urge to diversify the workforce. Modern technology and innovation have altered the nature of construction work and continue to do so. From project managers and planners to operators and engineers, design managers, and senior positions, the HVAC/Sheet

Metal and Mechanical construction business offers a multitude of exciting positions, and the demand for skilled labor continues to rise. In reality, there are millions of high-skilled trade jobs but insufficient employees to fill them.

The traditional apprentice is changing. Contractors need field apprentices and people to fill manufacturing positions and advanced building modeling programs requiring substantial IT skills. Many contractors have turned to internship programs to help fill the manufacturing and IT roles, giving people an opportunity to try out the position.

It cannot be lost that apprenticeship and internship programs are competing with the open market, and many companies are paying very well, further dwindling the available pool of candidates. The traditional career path to executive positions for contractors starts in the field, gaining a deep understanding of the technical issues and installation means and methods and progressing through management. Many contractors are concerned that the quality of apprentices is declining, and the organization's future leadership may not come from traditional channels. Not only is the quantity of apprentices inadequate, but the quality of candidates can be improved, generating the pipeline for future leaders. Apprentices that work for companies where the culture is to promote from within are often provided a roadmap to an executive-level position. Those contractors stand the best chance of long-term employment with their apprentices.

Never has it been more crucial for the construction business to prioritize diversity and inclusion. Although the construction sector is more accessible to newcomers than in the past, minority groups continue to be underrepresented in the workforce. The industry will become even more proactive in attracting and retaining people from all backgrounds and walks of life and making the construction business a welcoming environment for everyone.

Creating a diverse staff helps businesses develop and promote minorities; thus, the time has come for this industry to embrace inclusion. Here are the reasons why

diversity and inclusion are essential for the construction industry's future, as well as suggestions for how the sector may begin to apply these values more effectively.

Potential Implications and Contractor Opportunities

HVAC/Sheet Metal and Mechanical contractors are becoming a more diverse and inclusive sector for its long-term success and profitability. A competitive advantage can be gained by supporting underrepresented persons. Here are some reasons why diversity and inclusion are crucial in the construction industry:

- Contractors in the construction industry may address labor shortages by building a diverse staff. As construction needs grow in the future, contractors will hire more workers. Supporting and employing a diverse workforce can lead to a competitive advantage.
- Diversifying the workforce will boost employee satisfaction and a sense of belonging. The journey to inclusion is one of valuing all. In an inclusive organization, people are more engaged, productive, and likely to remain with an organization if they sense they have a role within it.
- Employing individuals from underrepresented groups enables managers to locate qualified candidates. Limiting prejudice expands their applicant pool. Veterans, for instance, might come to the workplace with leadership training and team-building skills. With more skilled employees, a business may be more productive. In fact, a diverse company is 1.3 times more productive than one that lacks inclusiveness.⁴
- While progress is being made in the building business, there is always space for improvement. Here are a few ways to increase diversity among HVAC/Sheet Metal and Mechanical contractors:
 - Minorities frequently confront more significant impediments to educational possibilities. Employers should provide

real-world experiences to aid in skill development. For instance, a corporation may join a community college to teach students about the construction industry.

- Partner with local unions and training centers to offer classes to new pre-apprentices or helpers who may not have a construction background.
- Partner with local diversity and inclusion organizations that work with minority groups to place candidates with companies and the local union support.
- Make accommodations for persons of diverse backgrounds. Offering a language training program to non-native English-speaking staff is an example. Consider training existing managers in language-based barriers and alternative communication methods. When describing projects, managers may also employ graphics. Improving team communication is vital for ensuring employee safety.
- Have one of the existing employees or managers assist those in need of a GED (equivalency degree) with math or training necessary to improve test scores and apprenticeship candidacy.
- Implement programs like the Heavy Metal Summer Experience to attract new candidates (a SMACNA sponsored initiative). <https://hmse.org/>.

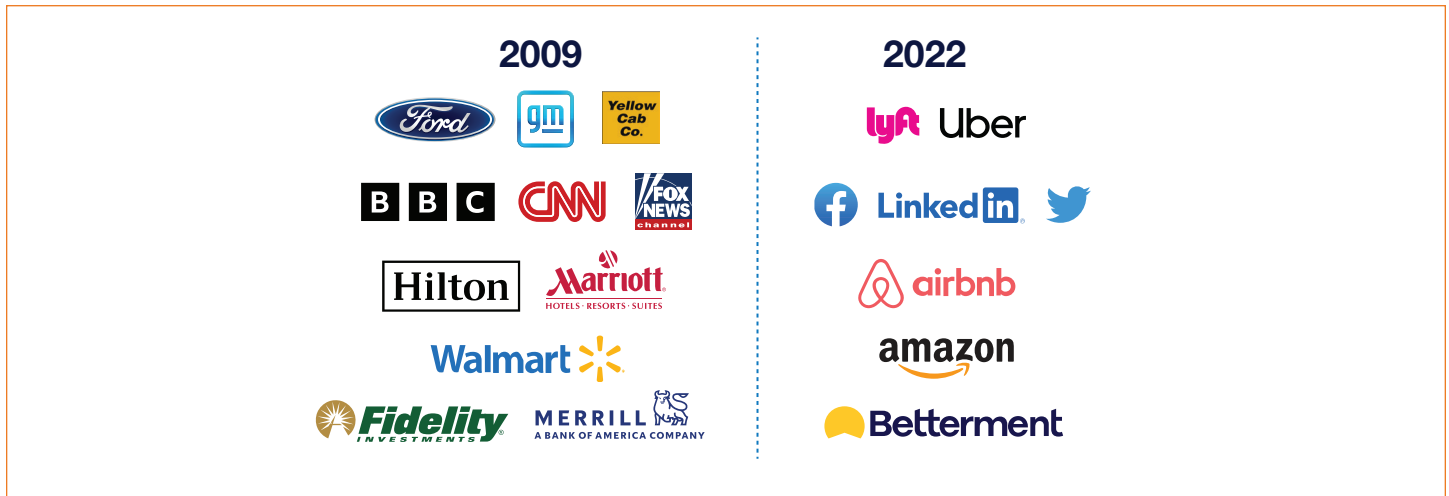
By collaborating, contractors may shift perception to the strong culture that already exists in the business, where people's well-being and organizational culture drive revenue. It will also help shift the needle toward equal representation of women and minorities in senior and governing positions, which will usher in a new era for the business.

Software Challenges within the AEC Industry

The construction industry is the second largest in the world, behind medical/healthcare. It is also the last major industry to be disrupted by software. Marc

Andreessen wrote an article in 2011 published in the Wall Street Journal describing what he saw as software companies changing the world.⁵ Looking around the landscape post-pandemic, it would be difficult to argue his observations were incorrect. *Figure 5* illustrates the fundamental point.

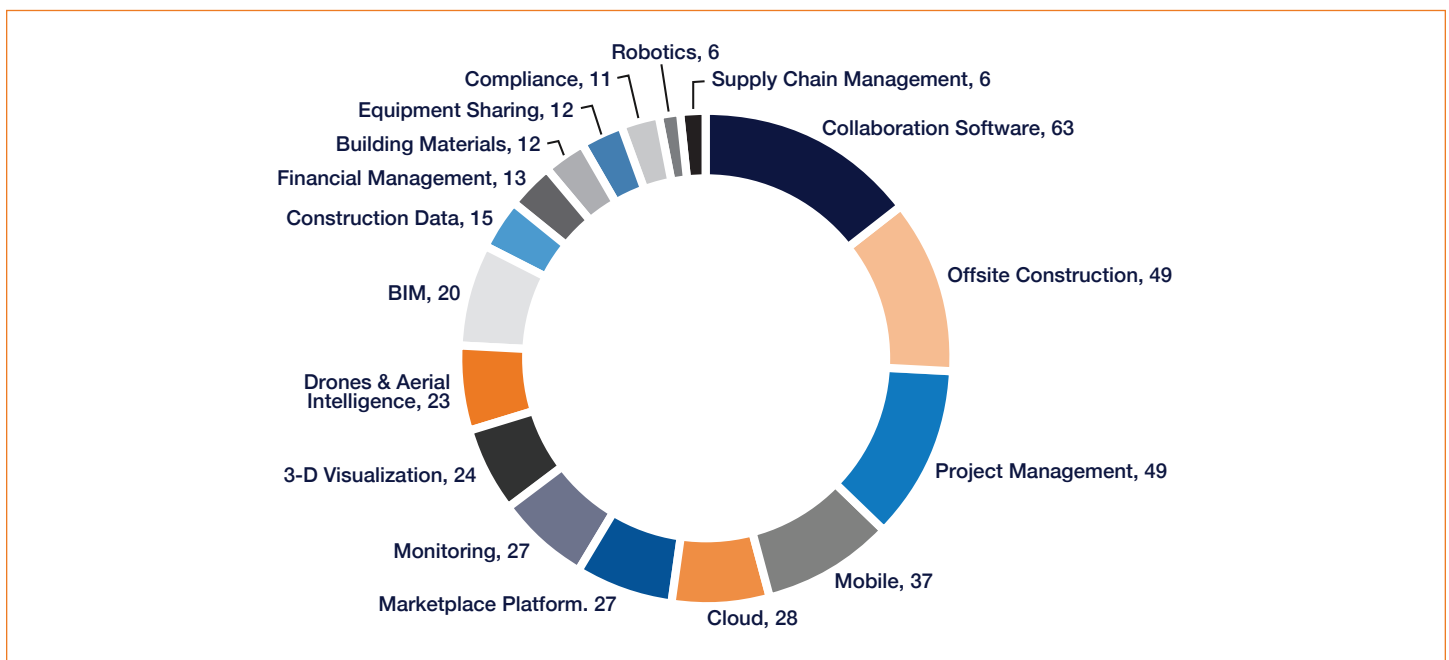
Figure 5: The Slow Pace of Fast Change



One of the points made by Andreessen was that software companies would capture vast amounts of consumer spending. Uber is a classic example. They do not own a single cab, yet they have completely

disrupted the taxicab industry as a software company. The argument is that software companies will likely have similar impacts on construction. A look at *Figure 6* shows us where these startups are focused.

Figure 6: Where Startups are Focused



The investments run the gamut across virtually every aspect of construction. While some aspects of the construction process will be more challenging to address with software than others, the fact is that technology in the next five years will make a considerable change in construction. The industry will be moving from collecting data to running analytics on that data that points to actionable management decisions. Artificial Intelligence is here and is being used for design, project management, supply chain, and other workflows. There have been heavy investments into products like Disperse, Open Space, Autodesk Build, and Versatile Natures, to name a few. These are intentional pursuits with companies going after specific industry sub-segments to solve problems and create a new profitable business.

Potential Implications and Contractor Opportunities

It should be noted that many contractors do not have the IT capacity (internally or externally) to develop solutions.

- The focus for the contractor should be placed on what increases profitability for the company.
- Contractors need to have a proactive process to evaluate the available software solutions. It is no longer reasonable to expect your IT personnel to evaluate options. A cross-functional team with a budget should be established to investigate, test, and ultimately deploy software solutions that fit your specific business needs.
- Engage professionals with the experience to design an overall strategy and then a plan to execute it in phases. Each phase should provide immediately drive profitability for the company.
- Plan on training, initially, during follow-up, and for subsequently hired new employees. Most software adoption fails because of poor implementation and scheduling. We're too busy working on the regular business to deploy changes successfully.

<https://www.newhorizonsfoundation.org/project/organizational-adoption-of-new-technologies-best-practices-for-smacna-contractors/>

The Future of Supply Chains

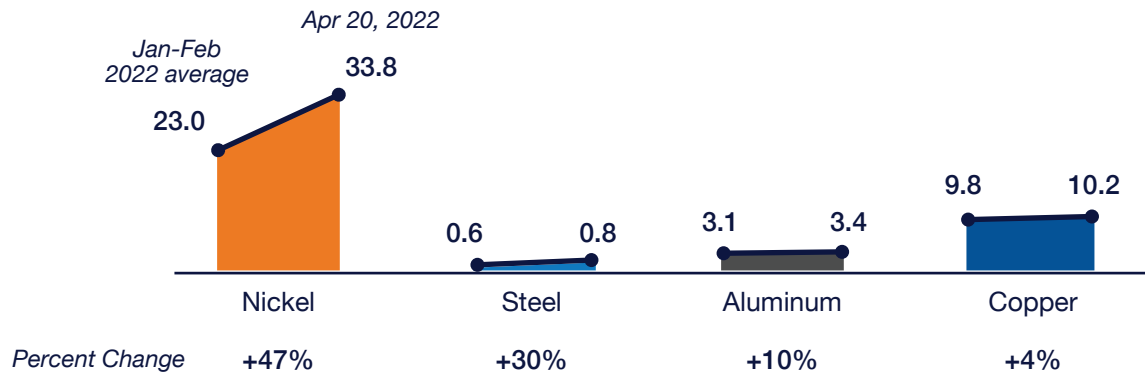
The competition for essential supplies, equipment, and goods intensifies. Before February 2022, all types of industrial materials were in high demand. In particular, commodities were soaring. Many reached ten-year highs, but with some price volatility.

The Russian invasion of Ukraine then accelerated the price increases of dozens of commodities that Russia and Ukraine export (coal, copper, steel, aluminum, nickel), with the two countries combined market shares ranging between 10 and 50%.

These materials are vital to several industries. Due to the risks to rare commodities and price increases, automakers are especially worried; they anticipate 15 to 25% spot-price hikes due to price increases in essential materials such as aluminum, copper, and steel. These are harsh blows for manufacturers to bear. Car purchasers would also find it challenging to pay much higher prices.

Recently, the prices of several of these commodities appear to have stabilized. However, further modifications may be forthcoming. Indeed, certain minerals, such as nickel, steel, and aluminum, are a temporary inconvenience. For others, the war has caused or exposed a supply vacuum, likely resulting in much higher prices. And for yet others, such as auto-making metals, buyers and sellers are seeking a new global equilibrium. Over time, equilibrium will likely be reached, but prices may be higher than they are currently.

Key commodity prices from Jan-Feb average to April 20, 2022, \$ thousand per ton



Estimated cost of materials for key commodities used,¹ \$ thousand per ton

■ Aluminum ■ Steel ■ Copper ■ Nickel

A New Supply Chain Situation

Supply chain managers have begun to change their attention from maximizing “just in time” delivery to storing and planning for “just in case” situations as international trade renegotiations, COVID-19 lockdowns, and conflicts continued to trouble contractors. Most managers reported that they had raised levels of crucial product inventory, while a lesser proportion had shifted to dual sourcing of raw materials and supplies.⁶

The crisis in Ukraine and ensuing sanctions provide executives with more reasons to evaluate their sourcing capabilities. Eighty percent of respondents to our upcoming study of supply-chain leaders, the latest in a series, stated they have implemented “dual sourcing” as of March 2022, up from 55% a few months earlier. In light of the war, dual sourcing is expected to grow significantly over the next five years. Russian exports account for around 2% of the yearly world trade volume of \$19 trillion, but a substantially larger proportion of several vital commodities, such as basic metals and energy supplies. Finding alternative sources of raw materials will be particularly difficult for enterprises whose supply is currently concentrated.

As a result, supply chains are being reconstructed once more as part of a long path towards flexibility. As for spending switches from commodities to services, it is feasible that some of the strain on supply chains may be lifted, but not all. As stress increases, nearshoring (especially in the high-tech and construction industries) and onshoring are preferred sourcing methods.

Potential Implications and Contractor Opportunities

The recovery from the pandemic has had minimal effect on the HVAC industry’s supply chain concerns. Many of the same obstacles persist, and each new disruption brought on by pandemics, wars, and labor shortages has triggered a cascade of setbacks. The coronavirus pandemic continues to impede the flow of commodities, with a 2022 incident in China generating significant complications. The war between Russia and Ukraine also hampers commercial networks and will continue to present challenges to contractors. As a result, HVAC/Sheet Metal and Mechanical contractors will continue to experience delays in acquiring some components and equipment and greater uncertainty over the coming years.

Contractors should consider purchasing inventory and supplies immediately. Numerous HVAC/Sheet Metal and Mechanical contractors are currently acquiring additional secure storage facilities and equipment to house their surplus goods. This may appear to be an unnecessary investment with additional holding costs, but when consistent price rises become the norm, the concept becomes more reasonable.

Given the ideas of increasing inventory (to address supply chain) and the necessary space for kitting, assembly, and aggregation of components or multi-trade fabrication, a combination of future trends – supply chain and prefabrication – may be included in the company’s space plan.

No one knows exactly when the supply chain concerns will be resolved, but they eventually will, but trending indicates stabilization toward 2030. It is unlikely that supply chains would increase in a straight line, and the final resolution might take years. The planning of sales inventory activities by contractors should be improved by monitoring and projecting client demand and evaluating choices to meet the need in advance. Contractors with the most effective supply chain management will be the most profitable.

Managing Risk & Profitability Growth

Many leading contractors manage project risk by implementing systematic risk analysis and a standardized framework to manage risk and guarantee target profitability.

Research on the future of construction project risk indicates that many general contractors and clients expect to understand how contractors manage risk and risk mitigation. Most contractors effectively will be handling risk by using a simple procedure shown below:

- Risk identification: Identify everything that might go wrong with a project in collaboration with stakeholders.
- Risk assessment: Using a sliding scale, determine the impact the risk would have on the project if it were to occur. Prioritize the most significant threats.

- Risk mitigation entails developing plans to reduce the likelihood of occurrence. Then, create processes that define what you will do in the event of danger.
- Monitoring risks: Assess your project frequently and scan the horizon for any threats.

To utilize this framework, the project manager needs to organize meetings with the project’s stakeholders (the architect, owner, contractors, and subcontractors) to outline the risks unique to this project.

Particular hazards are common to all projects (e.g., the unpredictability of the weather), while others are unique to each building. For example, there may be a mechanical design element that has never been constructed. Consequently, you must analyze the potential issues and how they might be resolved.

Technological innovation and digital solutions are streamlining construction operations and project administration. Among other dangers, we detect positive benefits on productivity, quality, and safety. According to most analysts, the industry will undergo significant technical changes in the next three to five years to adapt to new government laws and standards.

Employment, sustainability, and quality are the three primary areas in which regulatory changes may impact your productivity in the next few years. The government response to COVID-19 resulted in several regulatory adjustments for contracting companies.

If compliance management systems are unconnected and manual, it can be challenging to align all aspects of your organization to new standards as quickly as required. In the next five years, the most lucrative businesses will build and employ an online system that makes it easier to:

- Avoid penalties and damage to your reputation for noncompliance.
- Translate legislation and regulations into standard operating procedures.
- Adapt quicker than the competitors to capitalize on possibilities.

- Audit and monitor risk more precisely.

See [Appendix B: Managing Risk & Profitability Growth](#) for additional information.

Potential Implications and Contractor Opportunities

Over the coming years, the most profitable HVAC/Sheet Metal and Mechanical contractors will be dedicated to strengthening their company’s risk management and recognize the need to get the basics right. Transparent and consistent risk procedures and controls, a risk culture, and accurate risk reporting are the biggest drivers of profitability. The level of risk management can vary substantially across projects in different markets, and these elements can be critical.

Many contractors resist using risk management methodologies primarily because they believe they do not have underlying solid data, which might hinder the ability to develop reliable, accurate risk assessments. Selecting the projects your company can successfully deliver is a significant step for most companies and stay within your expertise. Contractors must emphasize a risk avoidance strategy and a collective understanding of granular risk and the strategies employed to prevent it – at both the project and enterprise levels.

Risk processes and controls are only as effective as their operators. Similarly, the HVAC/Sheet Metal and Mechanical industry has made safety second nature, and businesses must include risk management in their most basic processes. This means establishing a clearly defined risk culture where employees feel comfortable voicing concerns and bringing up issues. This will only be successful if the signals from the top are unified and constant and if leaders are viewed as taking forceful action to remedy any deficiencies. Having the proper tone at the top and continuous communication and reinforcement across the business is essential. Formal training in risk management is missing in most contracts for owners and contractors.

Create a unified risk management process that incorporates enterprise, portfolio, and project risk management. Without integration, it is difficult, if not

impossible, to determine the effects of many events and occurrences. Nevertheless, risk management appears to have a way to go before it is taken as seriously as other activities. Hence, integrated risk management is very significant.

Action items:

- Create a written risk assessment/bid analysis template to be prepared before starting any estimate. Include a thorough review of contract risks and prepare bid qualifications.
- Implement a formal contract review process and use the same template developed for estimating. Contracts issued to subcontractors by general or mechanical contractors often differ from the Owner agreements embedded in the bid documents.
- As discussed above, develop a risk register and include it in the Turnover Meeting, the handoff from Estimating to Operations. *Note: in smaller companies, where the estimator and PM may be the model (also termed “Eat what you Kill”), it is still essential to complete the checklists and develop a risk register to be reviewed by the Manager or Owner as the case may be.*

https://www.newhorizonsfoundation.org/category/business-management/new-market-entry/?post_type=project

Connected Construction for Collaboration

The sheer amount of information flowing through contractors’ offices is simply overwhelming. Everything from BIM model iterations, design changes, emails, schedule updates, and submittals add up to a lot of information to process and manage. The volume of information is only increasing, and the complexity of the information will require collaboration tools. There is a need for a common data environment where companies can have one source of truth and eliminate all the back and forth.⁷

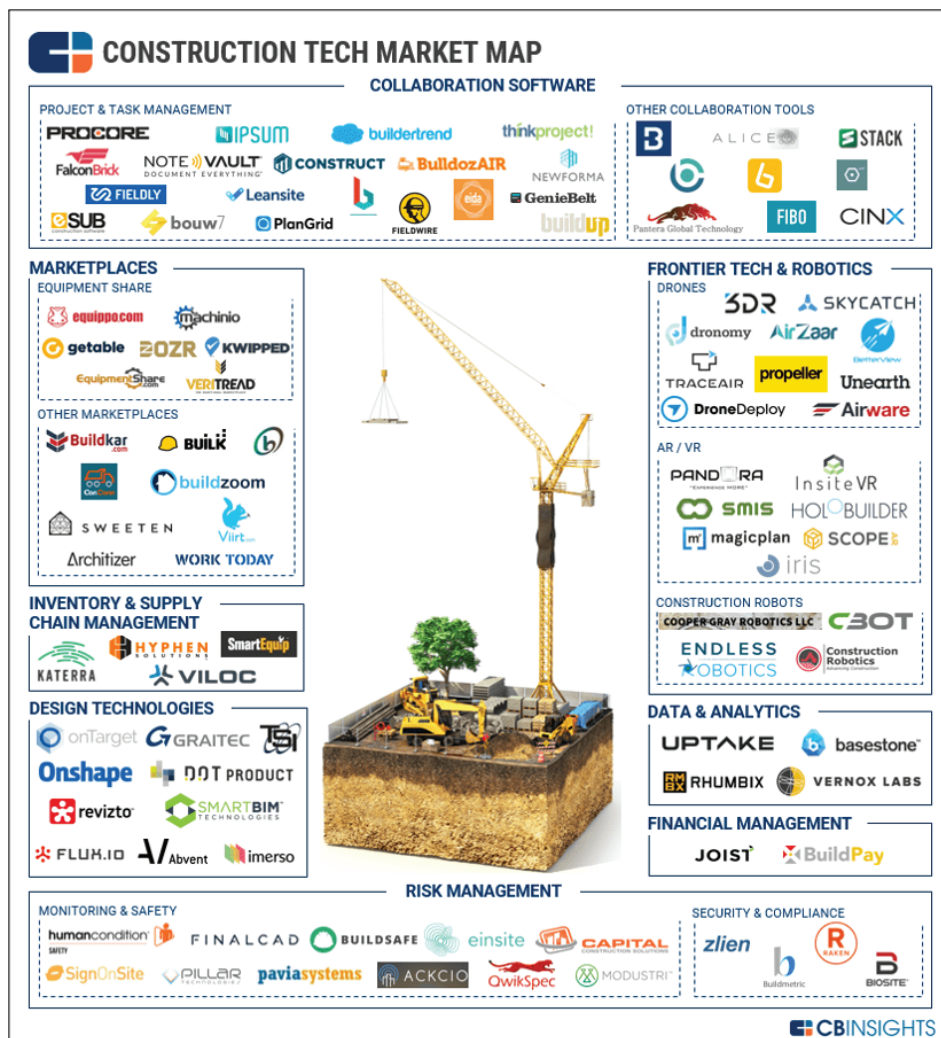
Historically, the HVAC/Sheet Metal and Mechanical contracting business was far from interconnected.

Contractors are all too aware of the effects of unconnected processes and data. On most construction sites today, there is a lack of communication and coordination between the various teams. Frequently, contractors and trade experts must deal with obsolete data and designs riddled with mistakes and omissions. This is because data is lost between each step of a project due to the usage of nonintegrated software.

Data silos, unconnected teams, and a lack of insight into real-time information have a negative impact on project performance, resulting in costly delays, rework, and waste. In 2018, the construction sector in the United States wasted \$177 billion due to inadequate data and communication.⁸

The challenge with creating a connected collaboration environment is the sheer volume of technology investment and the number of applications being introduced in the industry. Contractors simply cannot keep up with all the latest and greatest apps and point use solutions. It is nearly impossible to decipher which solutions to use and integrate them into your organization. Trying to integrate with changing players on each project makes the likelihood of full integration arguably impossible. *Figure 7* from CB Information Services illustrates just some of the latest technologies coming to market.⁹

Figure 7: CBInsights Construction Technology Map



Fortunately, the industry is beginning to see products and solutions coming to market that allow for the interconnectivity and interoperability of point use solutions. The intent is to have an enterprise approach to connecting all the technology solutions for improved collaboration and communication.

Potential Implications and Contractor Opportunities

Contractors should focus on acquiring technology; its success and suitability are determined by its implementation and utilization. Primary technology investments should be made to improve data access and productivity. Software tools should be introduced to maximize use, how decisions are made, and who makes them.

Companies should continue to invest in mobile devices. However, when it comes to investments in applications and software, end users are removed from the purchasing process, and utilization suffers as a result. Even though most contractors provide PMs and field superintendents with mobile devices to make it easier, the potential of these devices for gaining access to data and enhancing productivity appears to be untapped. In fact, we see a small percentage of contractors utilizing mobile applications to access project data and communicate, other than for sending emails, text messages, time reporting, or making phone calls.

After a contractor acquires technology, its success and suitability are determined by its implementation and utilization. Companies often do not properly implement a product; even though the technology investment is primarily made to improve data access and productivity, low end-user adoption calls into question the tactics involved in deploying it to teams, as well as how decisions are made and who makes them.

Companies should be spending on mobile devices, but when it comes to investments in applications and software, end users are removed from the purchasing process, and utilization suffers as a result. Even though most provide project managers and field superintendents with mobile devices to aid in this quest, the potential of these devices for gaining access

to data and enhancing productivity appears to be untapped.

Actions needed:

- Create training programs for new and experienced foremen and use classroom, remote and hands-on sessions to improve utilization. This can be an excellent opportunity for an intern, for example, to engage with foremen at the site and contribute valuable work while gaining key exposure to the company's key personnel.
- Ensure area foremen or superintendents are equally trained and capable of demonstrating the use of the tools with foremen.
- Make technology a part of each routine foreman's meeting to invite questions and increase team awareness.
- Where the size of the company warrants, put someone in operations in charge of operations technology. At the very least, identify a subject matter expert – the go-to person – within the company for foremen to obtain help from.
- Adopt software and tools that can show a bottom-line impact on financial results or human results. Not all software pays off. Some are the price of admission and will be demanded by employees or customers.

<https://www.newhorizonsfoundation.org/project/organizational-adoption-of-new-technologies-best-practices-for-smacna-contractors/>

Mega Projects

Mega projects are necessary for the continued existence of cities, nations, and individuals. The problem is that these programs usually deviate from their budgets, schedules, or both.

Large investments in infrastructure may also have a transformative influence on the economy. All businesses make substantial contributions to the

nation's gross domestic product. Consider the significant growth of Amazon, Google, Meta (Facebook), Microsoft, Apple, and many auto manufacturers leading the way. These mega projects have been successful, yet numerous of them are being prolonged. Unsurprisingly, many projects are behind time and drastically over budget, and firms are increasingly paying additional costs to prevent this from happening.

Overoptimism and Overcomplexity

Sometimes, costs and timescales are routinely underestimated to justify a project, while benefits are routinely exaggerated. Many project managers competing for financing manipulate the figures until they fall below what is considered affordable, so disclosing the actual cost would make a project unappealing. Such endeavors are doomed to failure from the beginning.

This frequently occurs when large projects span state or national boundaries and include a combination of corporate and government funding. A new railway, for instance, may consist of three national governments, multiple municipal governments, varying environmental and health regulations, varying degrees of skills and salary expectations, and dozens of private contractors, suppliers, and end-users. Before commencing a project, these complication-causing factors are sometimes not thoroughly analyzed or priced to the greatest extent. A single problem can forever halt the process. In one instance, for example, it took two nations a decade to resolve the diplomatic issues that permitted them to construct a hydroelectric dam.

Comparing the project under consideration to similar initiatives that have already been completed is a valuable reality check. This technique, known as "reference-class forecasting," combats confirmation bias by compelling decision-makers to evaluate situations that may not necessarily support the recommended course of action. For instance, if a city wishes to construct a 10-kilometer metro line with four stops, it should examine the cost and time dynamics of similar projects in other cities.

Mega Project Detail Execution Will Continue to Drive Performance

Having provided an unrealistically low project budget, there is a tendency to cut costs to preserve cost assumptions and safeguard the engineering and construction firms' (usually narrow) profit margins. From design and planning to construction, project execution is plagued by challenges such as insufficient design, lack of scope clarity, ill-advised shortcuts, and even mathematical mistakes in scheduling and risk assessment. A McKinsey assessment of 48 failed mega projects revealed that poor execution was responsible for 73% of cost and time overruns; the remainder was attributable to politics, such as the formation of new governments or legislation. In part, poor execution is a result of the complexity of many projects, in which ostensibly ordinary concerns can become big headaches. For instance, if steel is not delivered on schedule to the construction site, the delay might halt the entire project if one of the specialty trades has an issue. These delays tend to reverberate across the entire project system, so a boost in productivity will not compensate for them.

Another difficulty is low production. During the previous two decades, the manufacturing sector's productivity has roughly doubled, whereas construction productivity has stayed steady or even deteriorated. In many areas, however, wages have continued to climb faster than inflation, resulting in greater expenses for the same outcomes. Studies by McKinsey indicate that delivering infrastructure more effectively can cut its total cost by 15%. Preparation in advance pays for itself many times over. Gains in approval, engineering, procurement, and construction may provide savings of up to 25% on new projects without sacrificing quality.

See [Appendix C: Mega Projects](#) for additional information.

Potential Implications and Contractor Opportunities

These mega projects will continue to highlight any lagging productivity performance of these contractors;

thus, it is essential to pay close attention to personnel and management to preserve performance.

There are three reasons why most project development companies and project sponsors are hesitant to invest much in early engineering and design. Initially, they frequently lack the financial resources to invest considerably in design and engineering. Second, they are anxious to begin building and breaking ground. Lastly, they are concerned that the design will be altered after construction starts, rendering the upfront design costs futile.

Without a trained and well-resourced network of project managers, counselors, and controllers, projects will not provide the highest potential return on investment. Our experience suggests that if project developers or project sponsors invest 3 to 5% of the project's capital cost on early-stage engineering and design, the project is more likely to be delivered on time and under budget. This is because the design phase frequently raises issues that must be fixed prior to construction, saving HVAC/Sheet Metal and Mechanical contractors time and money. These mega projects will continue to drive revenue for the next five years.

Opportunities and Threats exist arising from mega projects. When these projects arrive in a market, they disrupt the standard labor supply. Overtime, pirating and attraction pay disrupt both large and small local contractors. The opportunity may be to strive to be involved. Even a smaller contractor may be able to carve off a segment of one of these mega projects and insulate the company from labor predators. The threat may be to ignore the market reality and be faced with meeting a competitor's offers of elevated pay, guaranteed work weeks, and other benefits. In summary, mega projects affect everyone.

Industry Structure and Consolidation

The construction industry is on the verge of a major upheaval that will permanently alter how buildings are purchased, planned, constructed, and installed. The use of technological forces in the building sector drives contractor profitability. The construction business

has the lowest digitalization index, a measurement of technology adoption, compared to all other major industries. Therefore, the benefits for success are substantial, and successful contractors recognize that investing in technology for themselves and their clients will increase profitability.

The normalized cost of construction has outpaced the consumer price index by a substantial margin, resulting in an increase in the price of buildings. This may be observed in big cities by comparing the average pay to the average cost of housing or by observing the increasing commuting times. This tendency must reverse to be sustainable.

There are several examples of new entrants to the construction industry whose sole objective is to boost cost-efficiency and challenge the status quo. The trend of technology upsetting traditional businesses with high costs and low productivity is not new, and the benefits can be enormous. It is believed that the HVAC/Sheet Metal and Mechanical construction business will be the final significant industry to benefit and be impacted by these technology companies. External investments into these companies undeniably indicate that change is imminent and approaching. Plan Grid was acquired for \$875 million; Procore went public in 2021 and was valued at \$11 billion; Building Connected was acquired for \$275 million.

In 2020, most contractors prioritized reducing risk and conserving cash to retain liquidity. The M&A transaction volumes for 2021 were over 160% higher than the prior year and 10% higher than for 2019. During the first eight months of 2021, the US engineering and construction industry's M&A activity increased, with deals totaling \$16 billion. At this rate, the sector should have surpassed \$20 billion in transaction value by the end of the year.

Potential Implications and Contractor Opportunities

To obtain quicker access to new digital capabilities and solutions, HVAC/Sheet Metal and Mechanical contractors can acquire companies with experience using these new technologies. This M&A activity is a

step in the right direction and is expected to accelerate in 2022. In the coming decade, contractors will acquire other companies to drive company valuation, diversify customers and markets, increase financial capabilities, reduce competition, lower tax liabilities, and leverage existing technology. Additionally, revenue synergy is driven by a complementary revenue source like a new market, geographic expansion, or a product/service that offers diversification.

For companies contemplating a sale as an exit strategy, read the New Horizons Foundation studies: https://www.newhorizonsfoundation.org/category/business-management/exit-transitions/?post_type=project.

For companies looking to grow through acquisition, read the New Horizons Foundation study “the Risk of New Market Entry”: https://www.newhorizonsfoundation.org/category/business-management/new-market-entry/?post_type=project.

Finally, be in touch with the market. Suppose you are a straight-line sheet metal contractor, and your largest mechanical customer goes into the sheet metal business or buys a competitor of yours. What’s the impact on your business? Acquisitions will affect the marketplace. This is true of your owners and general contractors as well.

Big Data, KPI Analytics, Benchmarking

Any organization that knows how to sustain continuous performance and scale expansion understands data use’s significance. Monitoring data through key metrics provides firms with the information necessary to achieve effective transformation. Occasionally, organizations experience sudden success due to a stroke of luck. Still, the chance of this happening is rare. Without the informational tools and collected data to sustain the weight of operations over the long term, the company will not benefit from any profitable guidance. Using data, truly successful organizations understand how their efforts convert to wins or losses, and your company will also benefit.

Analyze to Enhance Your Enterprise

Regardless of company conditions, tracking external and internal data is essential. Customers and clients supply sales numbers, location, audience segmentation, and marketing metrics. These indicators show external performance that will impact decision-making. How much did the new advertising campaign cost, and how much new business did it generate? Where does the demographic target reside?

Determine how well teams utilize time and resources internally. Should you invest in more efficient instruments to save time and aggravation in the long run? Does the team possess the necessary competence to proceed? How much money and time are used for an ROI of X? Need additional resources, personnel, or expertise? What could simplify the procedure or enhance teamwork? What money does X hours of work generate?

Knowing “how” and “why” enables contractors to make informed judgments.

How can I establish KPI goals and benchmarks?

How do you select a KPI objective that is realistic and achievable? Perform an examination of historical data and monitor the development over time. How did the business perform historically? What has changed throughout the years? What variations in advertisements/investment/popularity impact the metrics? What resources do you now possess, what is required to achieve the objective, and is it possible to do so within the allotted time frame?

For instance, one of the most prevalent KPIs is revenue, yet just marking a target does not provide much insight. Consider when developing and gathering information:

- Profits by month, quarter, and year, historical and present period
- ROI is determined by comparing the budget spent on campaigns/resources to the profit generated.
- Investment in personnel/equipment/services

If historical data indicated that income was low during the summer months and that large advertising spending had no influence on sales throughout the season, future summer planning might differ. New website content increased traffic to a specific landing page by 30% and produced leads. The average yearly profit trajectory demonstrates an overall growth of 3% yearly. This information will be used to distribute resources by season or recruit additional people to improve performance. KPI objectives are excellent suggestions for staying on track, not strict goals whose failure spells death. Due to the unpredictability of business, staying on top of data allows firms to adjust to new discoveries readily.

Continue Using Data and Insights

There is no definitive conclusion to data analytics. Continue using information from your ERP (Enterprise Resource Planning) system and exploiting data; you will have a comprehensive understanding of your firm for improved decision-making, expansion, and success.

Potential Implications and Contractor Opportunities

Benchmarking is the examination of business processes in comparison to those of a peer organization. It may be a helpful tool for some, but only with careful thought. Benchmarking is a different process that needs additional analysis and viewpoint for comparison. Best practices in an industry are not a universal norm, but they are good samples of what other firms measure and find beneficial. Comparisons can provide fresh insights that contrast with the internal performance of your firm, leading to improved planning and calibration. Benchmarking is not appropriate for many businesses, but it provides additional analytics for those who adopt the method.

Use KPIs pertaining to production metrics on the shop floor or comparable factors in the field. The capacity to extract the appropriate data from the ERP system assists in order, work without defect, inches of cut speed per minute, pounds per hour formed, warehousing expenditure over time, service revenue per truck, collections data measures, etc.

Autonomous Tools

The world is approaching an autonomous era. Industrial robots have been used in the industrial industry for decades, and today they are being utilized everywhere in construction. The construction sector is going to be the next to face an automated revolution. When most people hear the words “automation and robotics,” it is likely that industrial automation is implied. Industrial automation refers to the automation of physical operations using physical robots and specialized control systems. This is exemplified by a manufacturing sheet metal prefabrication shop with robotic cutting prefabrication with a high degree of autonomy.

In contrast, when individuals discuss automation in general, they often refer to software automation. On computers, software automation is used to execute jobs traditionally performed by humans. There are a variety of software automation branches, kinds, and trends, including test automation, robotic process automation, Intelligent Automation, and others.

Construction, specifically with HVAC/Sheet Metal and Mechanical contractors, is an ideal application for autonomous equipment. Most tasks are repetitive, physical, precise, and time-sensitive and often do not demand original or creative thought. Manufacturers are automating these tasks first, and the industry is moving to embrace this innovation to remain competitive completely.

Automation has already made significant strides in the construction business, even though firms are sometimes sluggish to adopt new technologies. While the sheet metal contracting industry may not be at the forefront of robotics, autonomous construction equipment is more prevalent than many believe.

According to research, 12% of construction businesses are only beginning to use robotics.¹⁰ Another 4% indicated that they employed these technologies in every project.¹¹ These numbers are hardly spectacular, but they suggest that automated technology is gaining momentum, and we see this trend continuing to accelerate over the next five years.

Here are examples of how autonomous tooling and processes are being used by mechanical and sheet metal contractors:

- BIM Models and enabling software and hardware allow automating hanger layout, fabrication, and installation. Models are harvested, hangers are cut and pre-assembled using automated saws and computer sorts and gages, labels are printed, and points data is transmitted to the field. According to one contractor, this automated process reduces hanger labor on plumbing and piping systems by up to 70%. The savings are significant given that hanger labor can amount to 25% of rough-in labor.
- A similar process allows spools to be sent digitally to the shop, where a Watts-Mueller robotically-controlled head rotates the pipe and cuts, bevels, and preps the pieces to weld-ready status.
- A ductwork coil line is fitted with a tap cutting head to permit taps in rectangular duct to be cut during the fabrication of the duct segment, eliminating a step in assembly.
- A spiral manufacturer uses the light gage cutting equivalent of the Watts-Mueller system on spiral-formed duct, cutting in all taps and takeoffs.

This pattern is beginning to alter HVAC/Sheet Metal and Mechanical contractors' processes as the technology becomes affordable. The primary driver for contractors in this sector is the following areas.

BIM Driven Layout Tools

With breakthroughs in generative design, software algorithms, and robotic building, our existing procedures will undergo significant change over the next three to ten years. Computers and machines will do ever-increasingly complex tasks in the future.

Instead of Building Information Modeling (BIM), Building Information Optimization will become

prevalent. Instead of physically sketching walls, doors, and columns for what we believe to be a good design, we will provide the computer "rules" directing it to provide us with the ideal building footprint, structural load capacity, and thermal performance. Things that took months will be accomplished in a day. While this has significantly contributed to process transformation and lower risk, many contractors are holding back with implementations.

The majority of businesses now using BIM software concentrate on data collection. They manually design structures, manually input data, and manually print data. This system generally works; however, it is not particularly efficient. In addition, the majority of companies do not execute this procedure effectively. Most businesses use their BIM software as if it were a CAD tool. Over the next five years, trends indicate widespread adoption of BIM's full capabilities. If a tool does not exist or if the software has limitations, the capability exists for companies to design their own additional functionality. This functionality has existed with tools such as REVIT's Dynamo – this is an integral product for companies with leading profitability and will continue to extend their gains.

Instead of collecting and reporting data in the future, software companies are now introducing capabilities for connecting to utilize prior design data to guide designs. Additionally, companies such as Dusty Robotics allow the model to be printed directly on the work surface in full, 1:1 scale. This mitigates conversion errors, creating a "what you see is what you get" layout result. Exactly what the customer is looking for.

Artificial Intelligence for Contracts Automation and Clause Correction

Identify clauses including contract price, waivers of consequential damages, releases of subrogation, indemnification and insurance responsibilities, etc. This is an excellent risk analysis tool for general contractors and subcontractors. Existing products such as Document Crunch can perform automated text reviews of contracts and identify over 40 clauses to rapidly assess risk and save time and money on contract analysis for negotiations and other purposes.

Document Crunch, and products like it, provide insight, explanation, and automated example contract terms and language to aid in contract discussions and writing. This is also an excellent tool for training your staff to compare manually written contracts to software-generated ones.

Potential Implications and Contractor Opportunities

- Standardize BIM solutions and parts or families of items and create assemblies that are common or can be used in all applications, with minor adaptations. This is the first step in standardizing the manufacturing of products.
- Invest in layout tools and technology that speeds up or automates field layout and installation of inserts, hangers, and supports.
- Invest in equipment based on the throughput of the process. Buying equipment that doesn't eliminate a bottleneck may not pay off.
- Challenge your staff to be creative in adopting new methods or tooling. For example, one contractor reported pre-fabricating louver damper assemblies and associated controls and wiring to the shop, reducing all work above waist level and reducing field hours by 90%. To date, no other contractor has replicated this approach, creating a sustainable advantage.

Internet of Things “IoT”

The Internet of Things (IoT) refers to the interconnection of physical devices, cars, buildings, and other entities integrated with electronics, software, sensors, actuators, and network connections to gather and share data. The variety of applications is extensive. When you examine the idea of connecting any device, system, or location to the Internet to know what is occurring at any given time, it becomes immediately apparent that the only limitation of IoT applications is our creativity.

Although many do not consider the construction business to be technologically savvy, the IoT in

construction is closer than we believe. It is something that many contractors can accomplish. In reality, one or more of your teams is probably already utilizing a smart (i.e., networked) construction site.

The building industry is experiencing trouble with productivity. Many projects run late and over budget, and the industry is slower than others to adapt to change, costing businesses billions. Large projects (including mega projects) take up to 20% longer to complete than anticipated and are up to 80% over budget.¹²

The IoT dramatically impacts the construction industry. The advancement of digital technology promotes the interconnection of places, the improvement of safety, the reduction of accidents, and the enhancement of work processes. Analyzing data gathered from IoT sensors enhances the intelligence and efficiency of building sites.

Numerous industries have already seen the benefits of the IoT, but the construction industry will soon feel its full impact. It is well-timed: construction firms have increased in size and expanded their operations geographically, and in terms of the projects they undertake since the beginning of the current decade. They must concurrently manage projects in several locations while optimizing asset lifecycle management and sticking to tighter deadlines to minimize delays and unnecessary costs.

In light of increased competitiveness and the need to protect the environment, all of this needs more robust project management. Digital technologies will continue to provide the means for advancement. Employing digital solutions such as sensors on workers' clothes and hardhats, “wearables” can check for hazardous chemicals on the construction site, and sensors can monitor and alarm if employees enter a dangerous location. The IoT has the potential to minimize all forms of building accidents drastically.

New products and software in IoT will continue to drive project management and significantly reduce costs. The networking of construction sites with sensors, CCTV cameras, and even drones provide real-time reporting so that decisions can be made regarding the

present condition of a construction project and any necessary course adjustments to keep it on schedule. On-material sensors and RFID tags can support automated operations, enabling proactive material ordering and equipment maintenance. Similarly, sensors on on-site equipment monitor consumption levels and can signal potential problems for preventative maintenance. Traditionally, construction sites that ran out of supplies or required equipment repair caused costly delays.

And herein lies the central point for the future of IoT: The ultimate value of the IoT resides in data that organizations can use for continuous improvement. Technology will continue to provide rapid, iterative, intelligent insights from data that will result in substantial economic benefits.

Artificial intelligence (AI) and machine learning (ML) are positioned to play a much more significant role in the construction sector over the next decade due to their ability to exploit data and convert it into operational value.

AI and ML have the potential to not only alter the way construction businesses execute projects but also have a significant influence on the working conditions of construction site staff. They enhance your ability to evaluate schedules and provide more precise information on the amount of personnel and other resources required for projects, allowing you to reduce waste, save money, and increase the efficacy of your initiatives. Using AI and ML, construction organizations may examine data on stock levels, schedules, and even project-specific information such as weather or other disturbances to become better informed and avoid future errors or problems experienced on previous projects.

In addition to the potential presented by the IoT, the increased use of digitization in the building planning process and on the construction site enables companies to collect data that paper could not. In construction projects, the implementation of advanced analytics will increase efficiency, timeliness, and risk management through the insights gathered.

Potential Implications and Contractor Opportunities

The construction industry is primed for digital change, and organizations that do not engage swiftly risk falling behind. The construction sector is under-digitized, with enterprises unable to grasp the growth and efficiency possibilities of AI, IoT, and other digital tools. However, contractors acknowledge the necessity and promise of digital technology: Ninety-five percent of construction organizations polled by KPMG think emerging technologies, such as IoT, will fundamentally alter their sector, and 72% say the adoption of new technologies, such as IoT deployments, is part of their strategic plan or vision. PwC claims that 98% of industrial enterprises expect digital solutions such as IoT-enabled predictive maintenance or augmented reality to enhance productivity by up to 12%.

The IoT consists of various applications in hundreds of industries. When appliances, machines, devices, and systems can connect to the internet and communicate with each other, the possibilities are endless. While these technologies are slowly creeping into various projects, they are not in high demand but will continue increasing in use as customers recognize the long-term benefits. The only limiting factor in making the IoT in HVAC/Sheet Metal and Mechanical contractors more profitable will be the imagination of contractors.

As more technological advances come to light, IoT will find its spot in construction. Even with the availability of innovative technology that can connect to the internet or intelligent tools and equipment, many businesses continue to employ traditional methods. The IoT may reduce costs and improve efficiency in the building business, implementing technology such as variable and occupancy controls embedded into building systems. Many HVAC/Sheet Metal and Mechanical contractors will begin to use the IoT in the future to remain competitive. Within five years, it will be required to remain competitive on projects.

See NHF White paper on IoT: <https://www.newhorizonsfoundation.org/project/white-paper-internet-of-things-iot-implications-and-strategies-for-sheet-metal-and-hvac-contractors/>

Customer Energy Cost Reduction Requirements/Carbon Footprint

Conversations and initiatives on climate change, carbon emissions and footprints, greenhouse gas, and net-zero energy are widespread and will not diminish in the coming decade. The vast majority of the climate research emphasizes that the agreed-upon necessary steps for the major nations and governments to prevent future consequences are still realizable, and the building sector has a major role to play. While a vocal minority of elected political officials may dispute the actual impact of any climate change, a long list of federal, state, and local government initiatives have been announced and are being implemented regulating the design, construction, and operation of the inventory of new and existing public and private buildings.

The research on building carbon emissions and Green House Gas (GHG) supports the impact buildings have on producing both. GHG from buildings contributed 21% of global greenhouse gas (GHG) emissions in 2019, including both direct emissions from the manufacture of construction materials and indirect emissions from the offsite generation of power and heat.¹³ Private developers, the US government, and many state and local governments have supported various initiatives to reduce emissions and energy costs by supporting efficiency upgrades in public and private facilities. Most agree that no path exists to reach net-zero emissions without deep retrofits of existing buildings. Not only must all categories of existing buildings be retrofitted, but new structures must also be constructed using currently available and rapidly evolving emission mitigation systems.¹⁴

Industry experts and construction leaders understand the magnitude of economic transformation that a net-zero transition would entail and the difficulty of the substantial short-term risks of uncoordinated action. We conclude that the change would be universal, significant, and front-loaded, with varied consequences on industries, regions, and communities while creating substantial contractor opportunities for capital spending on physical assets and technological innovation to reduce operating costs. The contractors with the most skilled workforce will be best prepared for the net-zero

movement driving down GHG emissions. These firms already see the profit potential with far more on the horizon as net-zero market share.

Many forward-thinking building owners are strongly committed to net-zero building emissions by 2030. HVAC/Sheet Metal and Mechanical contractors of a like mind and commitment now have a golden opportunity to assist net-zero building owners to deeply slash the size of their carbon footprint, if not eliminate it altogether, while profiting handsomely.

Contractors should be able to describe energy advantages and lifetime benefits to each client's system and how it contributes to a net-zero goal for the community, state, and nation. Recently, a greatly heightened media coverage has focused on eliminating building carbon, battling climate change, and slashing energy consumption levels. In addition, a growing list of regulatory initiatives driven by code groups, local building officials, consumer groups, and government benchmarking rules for lease negotiators has pushed building owners to address their carbon issues. It is not unusual for commercial and residential property owners to feature the environmental impact of their properties. Further, building owners are very aware of the need to address public tenant demands for low carbon, energy-efficient buildings with healthy IAQ. All these factors motivate owners and governments to act to slash carbon to reach net-zero, and that can pay off for HVAC/Sheet Metal and Mechanical contractors with the technical and market knowledge to capitalize.

See [Appendix D: Customer Energy Cost Reduction Requirements/Carbon Footprint](#) for additional information.

Potential Implications and Contractor Opportunities

Over time, contractors and other business enterprises would need to adjust their business models as conditions change and opportunities arise; integrate climate-related cost, bidding, and budgeting factors into the decision-making processes for strategy, finance, and capital planning, among others; and consider leading action with others in their industry

or ecosystem of investors, supply chains, customers, and regulators.

While awareness of the need to minimize energy use is relatively recent, the corresponding technology has continuously evolved for several years. Consequently, significant reductions are achievable soon with existing technologies based on well-established research.

Indoor air quality can be maintained at the highest possible level by teams who regularly inspect a building's various systems and replace filters, humidifiers, and purifiers according to their replacement schedules. Contractors can also ensure that a building's systems are operating efficiently. Contractor technicians that care about a building's health may be one of the strongest advantages for building stronger client relationships for a variety of reasons, including energy efficiency, building comfort, and tenant health and satisfaction.

Over the next five years, leading contractors will utilize technology, which plays a significant part in advancing HVAC energy efficiencies, such as programmable systems driven by software and remote monitoring, which can keep commercial buildings at ideal levels of comfort and energy consumption.

Supply chain shortages are impacting everyone's HVAC maintenance and replacement plans; multifamily, commercial, and individual homes are all suffering the effects of a supply chain where waiting for parts and units is the new norm, and no one knows when supply will become less tight.

Given that the HVAC industry is expanding while supplies are decreasing, it is only reasonable to evaluate how best to position contractors to increase revenues. Energy efficiency is among the most essential objectives. Emerging trends place energy efficiency at the forefront of the next level of innovation more than ever before. Decarbonization and technology are in the lead by providing monitoring, service contracts, and early warning intervention before systems fail.

At best, a conventional HVAC/Sheet Metal and Mechanical contractor may arm themselves with a commitment to be in this sector, to educate and

promote their unique capacity to perform, and, at the top level, to assemble the team to carry out the project. Many participants are already present, including automation specialists, experts in smarts and components, new entrants, and engineering-centric organizations. The exception, or the call to action, is perceived as an extraordinary service partner, a trusted adviser close to the current building inventory, and may earn market share through proximity.

Past illustrations of how energy efficiency has impacted SMACNA contractors are easy to find. Electrical contractors would note that the shift to LED lighting greatly impacted electrical systems' cost and sale prices. Pay attention to the shifting sands of the future, and be prepared to alter your path.

Economic/Legislative/Pandemic Megatrends

In several nations, inflation has surged. According to McKinsey's Global Economics Intelligence executive summary, US inflationary pressure expectations are the worst in modern years.

In the United States, inflation surged to 8.5% due mostly to rising energy prices. The US economy declined by -0.4% in the first quarter of 2022, with experts attributing the decline to sharp rises in US imports and a reduction in US manufacturing production.¹⁵ The invasion of Ukraine by Russia has exacerbated supply chain disruptions and production constraints in both developed and developing countries.

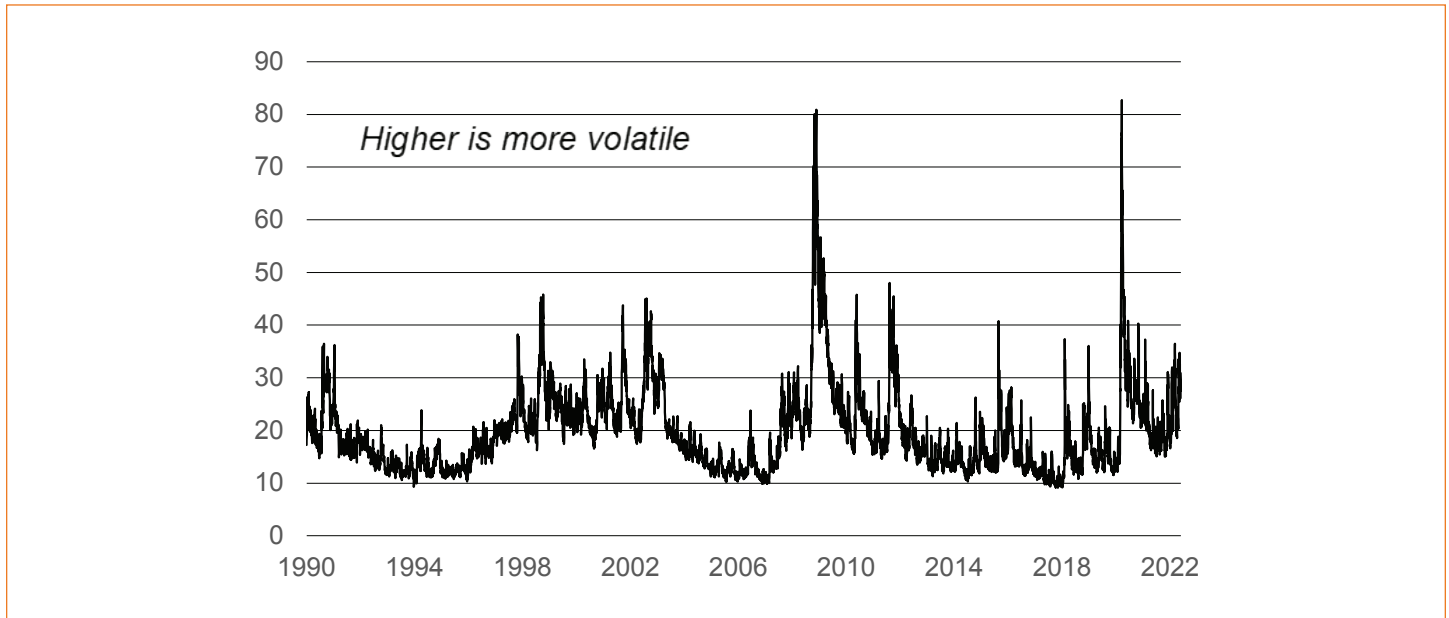
The invasion of Ukraine and US political leadership economic development policies have heightened economic instability, and the economic outlook will continue to be challenging over the next five years. Recent monthly statistics reveal, however, that the foundations of the economy are healthy and that overall demand remains robust. Labor and material shortages constrain contractor services. However, the Federal Reserve seeks to maintain a balance between controlling inflation and stifling economic development. Rising energy prices mainly drive inflation, so rate hikes cannot be anticipated

to have a major effect on it. Given these challenging circumstances, the composite leading indicators suggest a downturn in the US economy.

The US Volatility Index (VIX) had increased, although not nearly as much as in March 2020, when the COVID-19 pandemic broke out. This is consistent with past results that economic volatility

is unexpectedly low during war and conflict, possibly because an increase in government spending makes it simpler to anticipate a portion of company earnings.¹⁶ However, over time, this conflict may prove to be unique due to its implications on energy; fluctuations in energy supplies and pricing can have profound consequences on the US economy.

Figure 8: US Volatility Index (VIX)



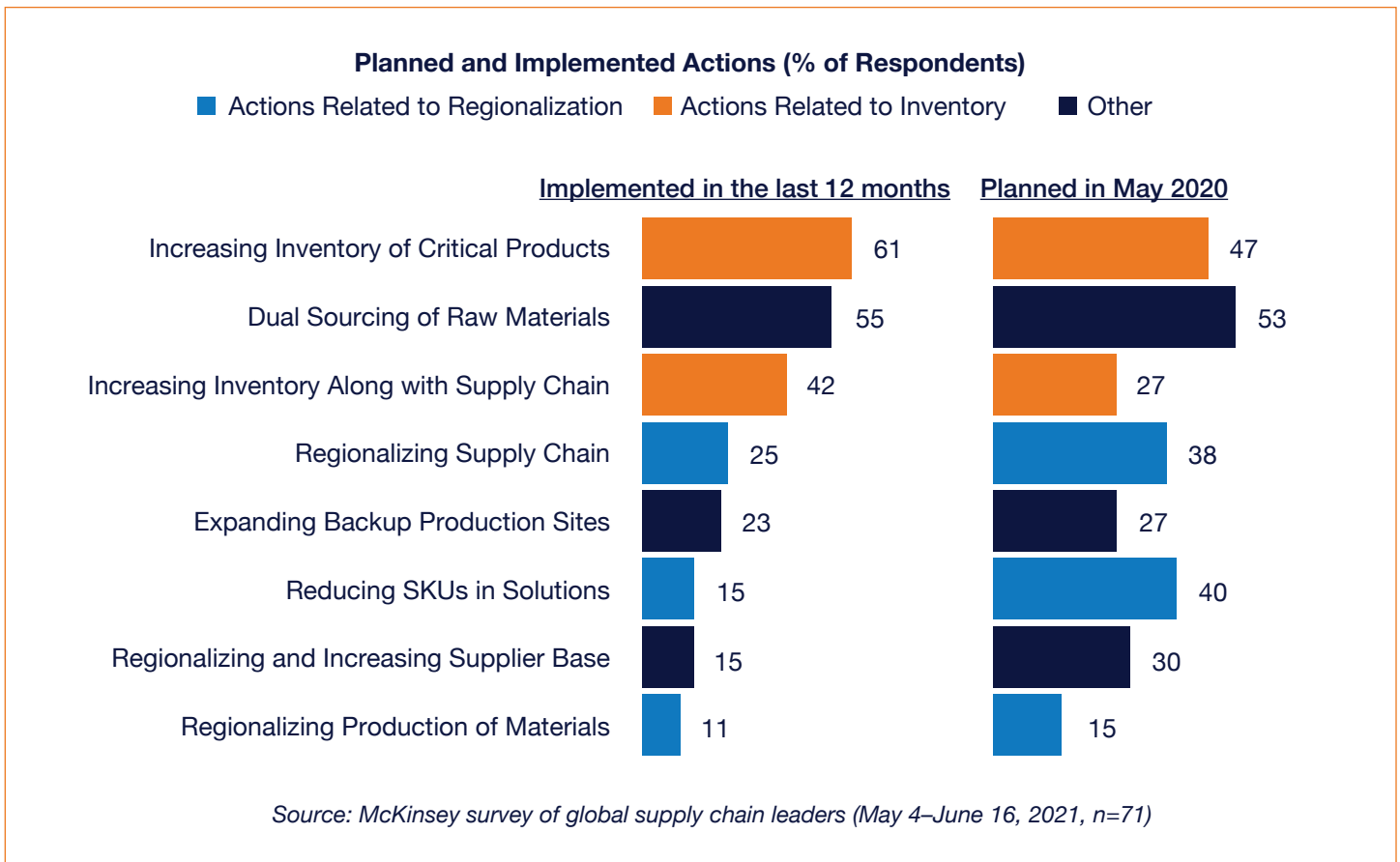
Companies have only partially remedied the coronavirus pandemic-exposed flaws in global supply networks. In light of increased obstacles, completing the project is much more necessary.

In a 2020 poll of top supply-chain executives across sectors and regions, 93% of respondents said they planned to make their supply networks more flexible, agile, and robust.¹⁷ The following year, McKinsey conducted a survey with a similarly large sample of supply chain leaders. This time, respondents were asked to describe the actions they have taken to strengthen their supply chains over the past year, how these improvements compare to the plans they had drafted

earlier in the crisis, and how they anticipate their supply chains to continue to evolve over the coming months and years.

As seen in *Figure 9*, most firms intend to employ numerous strategies to strengthen supply-chain resilience, such as expanding their inventories of essential products, components, and materials, diversifying their supplier bases, and localizing or regionalizing their supply and production networks. In reality, companies were far more likely to increase inventories and significantly less likely to implement nearshoring or regionalization sourcing strategies (with the raw-material supply).

Figure 9: Planned and Implemented Sourcing Strategies



Potential Implications and Contractor Opportunities

The key is to be flexible and respond to changing economic conditions, including having the relationships to flex up and down with your labor demand and create multiple alternate channels for materials.

The HVAC/Sheet Metal and Mechanical construction business is lagging relative to the general market and responds to existing trends. The message is clear: There are leadership changes, economic cycles, wars, and pandemics, and they are disruptive. If there is a takeaway, it is how contractors respond. More essential is if they have tried their idea and approach and are willing to make adjustments. Our fortitude will be tested, and your business must endure adversity and thrive.

In summary, stress test your business plan or your longer-term strategy. Get a few of your team in a room and ask, “What’s the worst thing that could happen?” and “what would we do if it happened?”

APPENDICES

Appendix A: Prefabrication and Modularization Advancements

The industry trends of workforce shortages, schedule compression, pricing pressure, and a highly competitive environment will likely continue well into the future. Industry consolidation will help combat some of these issues. Still, it will take years, if not decades, to come to fruition, and low barriers to entry will extend the timeline and complexity to reduce overall capacity. Companies seeking a meaningful strategic advantage must innovate in a meaningful way that is difficult for competitors to imitate. For years, prefabrication and modularization have been a critical response to the industry trends cited above. The industry has been told for years that delivering materials and equipment directly to the job site is the most efficient. Research

suggests to us that perhaps it is not the most effective nor the most efficient method. Contractors are forced to move from using prefabrication/modularization selectively to using it on all projects regardless of size and complexity. Contractors are beginning to realize the benefits of bringing all products through a single logistics facility for kitting, packaging, and prefabrication despite double handling costs, regardless of project size or complexity. Advanced prefabrication is the institutionalization of a process that all projects follow to conform to the variability of scope, products, etc., in each project.

The manufacturing world would refer to what contractors do in the prefabrication arena as Project Engineer to Order. The process of engineering to order is the most complex manufacturing cycle and involves the most steps, as shown in *Figure 10*.

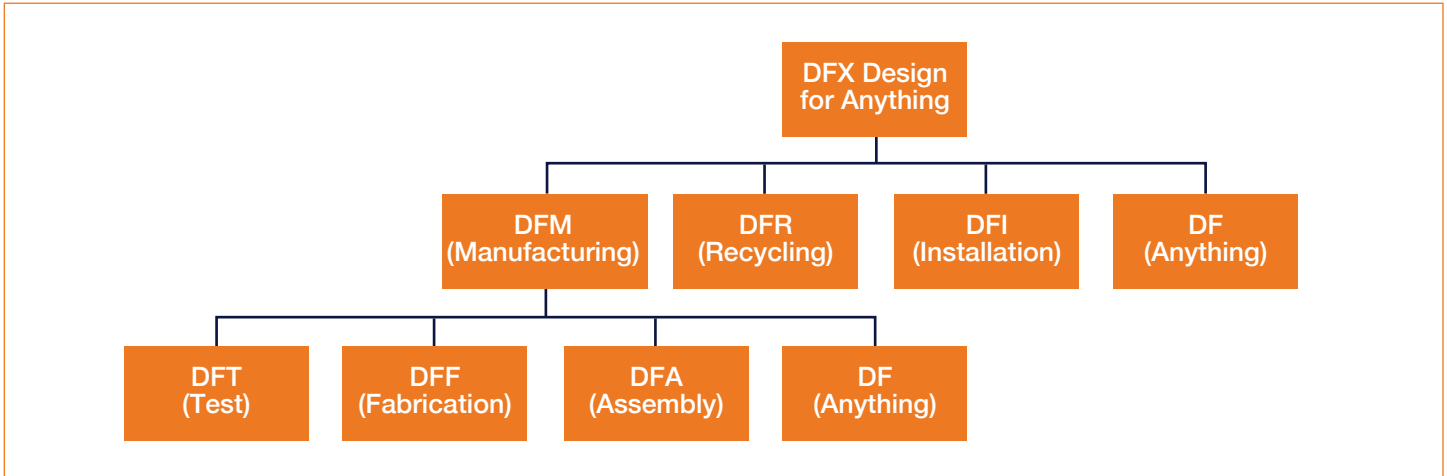
Figure 10: Engineering Cycles

Project ETO Delivery Lead Time						Project Engineer-to-Order
Design	Purchase	Manufacture Fabrication	Assemble	Ship	Installation	
ETO Delivery Lead Time						Engineer-to-Order
Design	Purchase	Manufacture Fabrication	Assemble	Ship		
MTO Delivery Lead Time						Make-to-Order
	Inventory	Manufacture Fabrication	Assemble	Ship		
ATO Delivery Lead Time						Assemble-to-Order
	Manufacture	Inventory	Assemble	Ship		
MTS Delivery Lead Time						Make-to-Stock
	Manufacture	Inventory	Assemble	Ship		

As stated, Project Engineer to Order contains the most work steps and is the most complex engineering cycle. As a result, contractors are turning to what is known

as DfX (Design for Anything). See *Figure 11* below for details on Design for Anything.

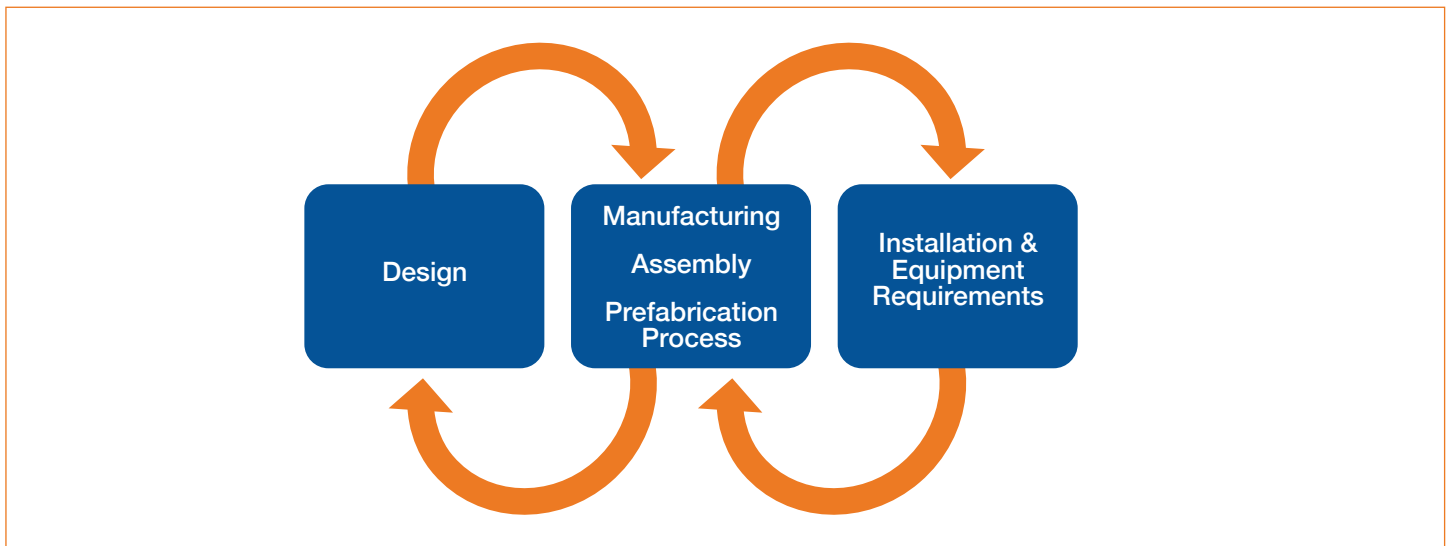
Figure 11: Design for Anything



DfX is a manufacturing principle. For contractors, the utility is to unpack DfX and move to what is known as DFMAI (Design for Manufacturing, Assembly, and Installation). Essentially, contractors are reversing the typical concept of designing it (the project), detailing it, prefab it, and sending it to the field to install it.

The problem is typical that the field is not involved in the design and detailing process, so critical installation constraints are missed, and the field may find they have a product that cannot be properly installed. What needs to happen in DFMAI is to reverse the cycle, as shown in *Figure 12*.

Figure 12: Reversing the Prefabrication Cycle to Support Installation Constraints



The field identifies the problematic issues in the installation process and then works with the Prefabrication/Manufacturing group to identify products that overcome the installation constraints. Then those products are integrated into the design and detailing process. The end game is that the design process is no longer the constraint in throughput. The design and detailing group uses pre-engineered products at the component, assembly, and system level in 70-80% of the installation use cases. The products can be integrated into REVIT or whatever detailing software is used. The manufacturing bill of materials details are passed on to the manufacturer who orders and builds the products, and the field receives those for installation. The overall process creates consistency and reduces variability in the construction process.

As contractors embrace the advanced prefabrication workflow described above, they will likely find themselves without software to support the workflow. Few mainstream ERP (Enterprise Resource Planning) software programs contain an MRP (Material Requirements Planning) module. Contractors may use everything from Quickbooks, Peachtree, Foundations, Viewpoint, Spectrum, Coins, Sage Timberline, Dynamics, Oracle, SAP, or anything in between, and only a few of those listed have MRP capabilities. An MRP manages the workflow from design and detailing to procurement, manufacturing, shipping, logistics, and ultimately installation. An MRP is a production planning, scheduling, and inventory control system used to manage the prefabrication process. An MRP can dramatically improve visibility and tracking if properly implemented. Our research suggests that over 94% of contractors that prefabricate have little or no data on their productivity in the shop, cannot express to the field where their prefabrication order is in the overall process, and cannot provide accurate lead times or delivery dates.

It is not necessary for a contractor to move from no MRP to a full-blown MRP implementation. Some steps can (and should) be taken based on the level of sophistication. The options are as follows:

- Use collaboration software such as Planview. This product allows companies to create

projects, assign responsibilities for tasks, see a master schedule, track time, and basically create a custom workflow, ticketing, and prefabrication process flow that is enabled and tracked through the software.

- Use an MRP “Light” such as Manufacton. This product helps manage off-site production and on-site installation. The capabilities continue to evolve, and products such as this may be well suited for those that are well established in prefabrication but seeking improvements in tracking and visibility.
- Use an MRP such as Oracle Net Suite. This will require a complete ERP and MRP implementation but will allow for seamless integration between the construction and manufacturing businesses.

Implementing an MRP solution that suits the degree of prefabrication a contractor utilizes is a critical next step to advancing the organization. Contractors looking to go to “the next level” will be required to implement an MRP solution that matches their capabilities.

Appendix B: Managing Risk & Profitability Growth

Every project presents its own set of risks. Variables ranging from the construction site’s location to the training level of new employees can affect the evolution of construction hazards. For successful risk management, high-impact, high-probability risks should be addressed first, followed by low-impact, low-probability risks. To develop an effective risk management strategy, the organization identifies five sources of risk that must be taken into account:

- **Safety:** Any construction site dangers or hazards can result in worker injuries.
- **Financial:** Factors affecting your cash flow, such as a lack of sales, economic issues, unanticipated cost increases, and competition from other businesses.

- **Legal:** The possibility of contractual conflicts with clients or potential legal exposure in other areas.
- **Project:** Poor resource management, underestimation of time, absence of appropriate procedures, or misunderstanding of project deliverables are examples of project risks.
- **Environmental:** Floods, earthquakes, and other natural disasters destroy building sites and make them impossible to work.

A sixth and very real risk management decision point is project selection. The above list assumes the project is being undertaken. Pursuing new types of work, new customers, or new geographies should be in its own risk assessment category.

Every project manager is aware that construction work is fraught with unpredictability. However, when time is limited, undertaking a thorough risk assessment may not always appear to be the most efficient use of resources. In addition, studies emphasize the following advantages of risk analysis in building projects:

- Aids in assessing and determining project viability
- Can reduce losses
- Identifies project hazards and estimates the possible cost associated with each.
- Determines if you will make a sufficient profit on a specific project.
- Maintains premiums at an appropriate level
- Limits claims for professional indemnity
- Protects the integrity and reputation of your firm

Appendix C: Mega Projects

Electric Vehicles and Battery Manufacturing Facilities

Electric cars will continue to transform the auto industry by boosting the growth of battery production facilities and decreasing the cost of generating revenue. Some automakers will produce their own batteries for electric vehicles, while others rely on suppliers. Whether or not to create batteries is a question for some automobile manufacturers. In actuality, it depends on the most effective component for business expansion. Batteries will remain the focus in the immediate term since supply (including raw materials) appears to be tightening, and costs must continue to decline.

Given the fast sales curve for electric vehicles, battery purchase will become a crucial competitive flashpoint, driving increased income possibilities for battery manufacturers and incentivizing them to expand their manufacturing facilities over time.

Data Centers and Mega-warehouses

Dodge Data & Analytics anticipates more record-breaking years for warehouse construction activity, with \$52.8 billion in construction starts (+13% increase). Since 2018, this activity has more than doubled. Since then, Amazon has invested \$9.7 billion to cover the United States with its colossal fulfillment centers. Two Amazon warehouses that broke ground this year in Massachusetts and New York provide a sense of the size of these structures. The \$3.77 billion Amazon North Andover Fulfillment Center in Massachusetts costs \$466 million, while the 2.6 million-square-foot Amazon warehouse/distribution center in New York costs \$410 million.

While there will be pauses in some mega-warehouses, such as Amazon's recent development pause to execute a new capacity and distribution strategy, the overall trend over the next five years will be continued growth in total warehouse space.

Over the next five years, data centers and warehouses will continue to be two of the most active development categories. In the future, new high-tech campus buildings from Apple, Google, and Amazon will undoubtedly generate further enthusiasm for comparable expansions.

As businesses continue to gather enormous amounts of data on their computers, the building of data centers, in particular, is expanding. Microsoft is breaking ground on a multibillion-dollar makeover of its existing Redmond, WA campus, joining Apple, Google, and other industry titans are extending their “home” facilities. Firms like Marriott and General Electric are also anticipated to break ground on new headquarters. As more businesses continue to expand their facilities, many are likely to install the necessary infrastructure to support their operations.

Healthcare-related Facilities

There is a nearly 10% rise in building spending on healthcare facilities reaching \$33 billion annually. There are several mega projects worth at least \$1 billion. On the Ohio State University campus, the \$1.2 billion Wexner Hospital Tower houses the construction of the world’s biggest hospital. In May of 2021, construction began on the \$900 million Michigan Medicine Tower at the University of Michigan.¹⁸

The Mayo Clinic is contemplating a \$6 billion expansion of its Rochester, Minnesota, main campus. Beck’s Hospital Review cites the \$3.75 billion University of California Davis hospital in Sacramento; the \$2 billion that Massachusetts General Brigham will spend on multiple facilities in and around Boston; the \$1.74 billion renovation of Seattle’s Harborview Medical Center; and the \$1.6 billion harbor UCLA medical center in West Carson, California as other impressively sized projects.

Airports

The President signed the American Rescue Plan Act of 2021 into law in March 2021 and included \$8 billion to be awarded as economic assistance to eligible U.S. airports.¹⁹ The FAA has created Airport Rescue

Grants for the distribution of this cash. The FAA will provide grants to all airports within the national system, including all commercial service airports, relief airports, and certain public-owned general aviation airports.

These grants will give economic help to airports affected by the COVID-19 outbreak around the nation. To help the economic revival of the national airport system, the FAA wants to execute this initiative swiftly, and this represents a significant opportunity for contractors to participate in projects.

K-12 Education

Construction of public kindergarten through grade 12. One of the largest individual building categories is contingent on enrollment growth, age of existing facilities, and local environment for the bond issues that generally support a substantial portion of the development costs. Since these building projects are frequently equipped with the most advanced lighting, security, voice data video, and climate control systems, the bidding process is often quite competitive. According to National Center for Education Statistics projections, increases in public school enrollment through 2029 will be most prevalent in the sunbelt and western states, according to Dodge Data Analytics. Among the largest public school projects to break ground in 2021 was the \$344 million Lowell High School in Lowell, Massachusetts.

Additionally, there is a significant school expansion development in Texas and the midwest to support companies relocating and residents migrating to lower income tax states. Examples are Toyota, Caterpillar, Hewlett Packard, Oracle, and many venture capital firms (which will inject funding into new companies).

Appendix D: Customer Energy Cost Reduction Requirements/Carbon Footprint

Scientific consensus and the majority of research support the conclusion that the window for reaching US climate change targets is rapidly closing.²⁰ The vast majority of the climate research emphasizes that the agreed-upon necessary steps for the major nations and governments to prevent future consequences are still realizable, and the building sector has a significant role. While a vocal minority of elected political officials may dispute the actual impact of any climate change, a long list of federal, state, and local government initiatives have been announced and are being implemented regulating the design, construction, and operation of the inventory of new and existing public and private buildings. These initiatives come from private building owners, developers, and contracting firms managing the project construction.

While most governments have primarily focused on limiting Green House Gas (GHG) emissions, reducing carbon footprint, and lowering energy consumption (and costs) for energy are priorities. The research on building carbon emissions and GHG supports the impact buildings have on producing both. GHG from buildings contributed 21% of global greenhouse gas (GHG) emissions in 2019, including both direct emissions from the manufacture of construction materials and indirect emissions from the offsite generation of power and heat.²¹

Private developers, the US government, and many state and local governments have supported various initiatives to reduce emissions and energy costs by supporting efficiency upgrades in public and private facilities. Generally, this has been through support for job-creating retrofit tax incentives, direct grant programs, and incentives to produce sustainable buildings. These emission and efficiency enhancements include wider use of heat pumps and induction technology and adopting more modern energy codes for new buildings. The United States has also enacted legislation, program funding, and revised regulations

to invest in new technologies to reduce emissions associated with construction, including for high-performance private and public buildings.²²

Building Changes

Countless nations, environmentally concerned corporations, educational institutions, nonprofit foundations, and the United Nations have challenged the United States to have net-zero emission buildings before 2050. However, meeting these goals within the present decade is a more challenging goal. Private owners, developers, and many general contractors across the country are already challenging the industry to meet this goal. Most agree that no path exists to reach net-zero emissions without deep retrofits of existing buildings. Not only must all categories of existing buildings be retrofitted, but new structures must also be constructed using currently available and rapidly evolving emission mitigation systems.²³

Although in 2020, around \$164 billion was spent on decarbonizing buildings, financing constraints will impede advancing decarbonization to scale. Governments will need to continue aggressively implementing building energy regulations to limit emissions from existing and new structures.

According to the growing research on emission reduction, so-called “sufficiency” measures, as opposed to short-term efficiency gains, will be an essential component of reducing building-related emissions. These include emphasizing the design of buildings with shared space and the ability to adjust their size to meet the changing needs of occupants, repurposing unused buildings to reduce the use of virgin materials, and utilizing the thermal mass of buildings to reduce thermal energy requirements. According to the research, these sufficient measures might account for 17% of the potential GHG reduction in buildings by 2050 on a global scale.

The report estimates that high-performance buildings will be the standard rather than the exception of those built by 2050. More could be done to reduce emissions if the real estate, development, and construction

sectors embraced a higher and more expeditious rate of renovation and quality-driven building retrofit effort. However, for that to occur, it is critical to accelerate knowledge of related construction and engineering skills to reduce the costs and remove constraints to achieve high-efficiency building at scale sooner, not later.

Unfortunately, the policymakers are struggling to act, and the net-zero challenge remains unclear: greenhouse gas emissions continue unabated and are not offset by removals. More noticeable is that the world is not sufficiently motivated, convinced, or economically and technologically equipped to complete the net-zero transition quickly. In addition, most of the most promising and generous national and international pledges have yet to be supported by comprehensive government spending and financial assistance plans or carried out on a significant scale. Even if all net-zero commitments and national climate pledges were met, research indicates that warming would not be limited to 1.5°C above preindustrial levels, thereby increasing the likelihood of triggering most of the catastrophic effects of climate change. One growing probability is that the risk of negative biotic feedback loops is irreversible.

The solution to the goal-setting net-zero crisis cannot be separated from pursuing economic growth, corporate and public investments, technological development, and equitable burden-sharing. With so many nations lagging in economic growth while overproducing GHG emissions, implementation will not be simple. It will require a committed and aggressive involvement by the international economic community to offset the short-term hazards of poorly planned or disorganized action with longer-term investments to offset the consequences of inadequate or delayed response. Indeed, a more chaotic shift, as seen in the Russian attack on Ukraine and Russia cutting off energy to regional nations, are perfect examples. This short-term policy shift has impacted energy supply and access and boosted energy and food costs, particularly for people and areas with lower incomes. This rapid policy shift appears to also have repercussions on the nation's economy, producing a reaction that could hinder the policy enthusiasm for needed change to add to more aggressive net-zero initiatives.

Achieving net-zero emissions in nations known for slow, incremental change would require a fundamental transformation to much of the global economy, as it would necessitate significant changes to the seven energy and land-use systems that produce the world's emissions: electricity, industry, transportation, buildings, agriculture, forestry, and other land use, and waste. Nine essential prerequisites (including physical building blocks, economic and cultural transformations, governance, institutions, and commitment) must be met amidst numerous economic and political obstacles to bring about these changes. These obstacles should not come as a surprise.

This necessitates resolving many complicated concerns, such as financing public and private facility net-zero transformations, the optimal mix of technologies that should be incentivized and deployed to reduce emissions while slashing a building's carbon budget, minimizing costs, and meeting needed performance standards. Add to that list of concerns the infrastructure and supply chain bottlenecks likely to occur. A number of physical restrictions, such as the availability of natural resources or the expansion of manufacturing capacity, could slow the transition. What amounts of public and private construction-related expenditures on physical assets would be required throughout the transition? Who would cover the changeover costs, and will governments support what is needed now to prevent future disasters? How will the change affect the markets and operations of businesses? What will the implications be for employees and consumers? And how may customers be urged to make the required modifications to their consumption and spending patterns to facilitate the transition? If past is prologue, optimism for a broad-based positive environmental impact response is not as encouraging outside the building sector due to a more impressive industry record on efficiency and GHG.

While many governments and corporations are boosting their public relations and budgetary climate action commitments, substantial obstacles stand in the way. Industry experts and construction leaders understand the magnitude of economic transformation that a net-zero transition would entail and the difficulty of the substantial short-term risks of

uncoordinated action. We conclude that the change would be universal, large, and front-loaded, with varied consequences on industries, regions, and communities while creating substantial contractor opportunities for capital spending on physical assets and technological innovation to reduce operating costs. The contractors with the most skilled workforce will be best prepared for the net-zero movement driving down GHG emissions. These firms already see the profit potential with far more on the horizon as net-zero market share.

For the net-zero movement to grow to scale and impact the majority of the industry, policymakers would need to act together with unity, resolve, and ingenuity and extend their planning and investment horizons even as they take immediate actions to manage risks and capture opportunities. Businesses need to define market goals, execute, and evolve to stay on top of the effort for decarbonization. It will also be important to develop offsetting plans for scope 1 and 2 emissions and potentially expand those plans to include scope three emissions, depending on the nature of their operations.²⁴

HVAC/Sheet Metal and Mechanical Contractors Are a Key Component of the Solution

Most major policy issues threatening the stability and economic health of many complex nations and the world appear beyond the typical person's comprehension and abilities. Most citizens believe they cannot do much about them or impact their trajectory or destiny. However, members of the HVAC, and IAQ industry, due to their unique markets – residential, commercial, industrial, and public sectors – can influence powerful clients' corporations and public sector decision-makers to thoughtfully, significantly, and expeditiously reduce carbon emissions, a fundamental cause to local, state, and national carbon emissions as well as limit the growing crisis of global warming.

Most scientific and engineering studies support this conclusion, as most national and international decision-makers are by now aware. According to a McKinsey research report, “The United States

could reduce greenhouse gas (GHG) emissions by 3.0 to 4.5 gigatons of CO₂e by 2030” using proven approaches and high-potential emerging and existing technologies²⁵ – technologies that are available now, accessible, and highly familiar to HVAC/Sheet Metal and Mechanical contractors and many sophisticated contractor clients.

Reports have found that facility-focused improvements could reduce greenhouse gas emissions by as much as 870 megatons by 2030. Adopting a national policy option of retrofitting buildings with more efficient HVAC equipment could lower emissions by 45 megatons per year.

The National Renewable Energy Laboratory (NREL), located within the Department of Energy (DOE), has studied this issue extensively over decades and has recently reported on the policy value and limitations of executive orders and temporary regulations, which include:

- The current Presidential Executive Order cannot be met with current construction practices.
- The Industrialization of Construction is part of the answer.

Many forward-thinking building owners are strongly committed to net-zero building emissions by 2030. HVAC/Sheet Metal and Mechanical contractors of a like mind and commitment now have a golden opportunity to assist net-zero building owners to deeply slash the size of their carbon footprint, if not eliminate it altogether, while profiting handsomely. Beyond lucrative new construction, contractors can play an instrumental role in substantial carbon reductions through upgrades to a facility maintenance effort and ongoing ethics. While too often overlooked, maintenance has always offered to play a highly significant role in energy and carbon reductions and financial savings. It is the responsibility of the owner and his contractors to maintain the building system infrastructure. We all know that the HVAC system is often the highest energy expense component and the one involved in shaping the carbon output.

Responsible contractors with building owner clients should take the first opportunity to assess their client’s mechanical system’s age, performance, and other vital components. Typically, owners faced with a defective component or HVAC system would rather “fix what is broken” or prioritize using the lowest cost components and systems when replacing older units to minimize expenses. When assisting clients, consider the business case for the total cost throughout a product’s lifetime; a greater initial cost often translates to cheaper costs over time. Contractors must be able to explain the distinction between initial cost and lifespan cost to building owners. Value engineering and life cycle cost analysis are part of federal bidding. First, costs are rarely indicative of even mid-life or long-term operational and repair costs.

Regular maintenance, beyond its positive impact on system life and health, also influences the quantity of energy consumed to operate the HVAC system. Much more is involved when a mechanical/HVAC system underperforms. When mechanical systems demand more energy, power plants must generate more electricity. Most power plants require millions of gallons of fresh water to be cooled, and more energy production increases carbon emissions. As defined earlier in the report, the quantity of carbon required to power a building’s systems is its “carbon footprint.” It is one approach to quantifying the environmental impact represented by each structure. Not only has the importance of each system’s carbon footprint rapidly increased in recent years but owner concern has also spiked, creating major opportunities for HVAC/Sheet Metal and Mechanical contractors that know how to boost operational efficiency while slashing carbon emissions.

Contractors should familiarize themselves and their marketing team with all issues surrounding the concept and impact of each facility’s carbon footprint to better sell net-zero pathways to each owner. This would also often include providing the owner with high efficiency, comprehensive indoor air quality system. Contractors should be able to describe energy advantages and lifetime benefits to each client’s system and how it contributes to a net-zero goal for the community, state, and nation. Recently, a greatly

heightened media coverage has focused on eliminating building carbon, battling climate change, and slashing energy consumption levels. In addition, a growing list of regulatory initiatives driven by code groups, local building officials, consumer groups, and government benchmarking rules for lease negotiators has pushed building owners to address their carbon issues. It is not unusual for commercial and residential property owners to feature the environmental impact of their properties. Further, building owners are very aware of the need to address public tenant demands for low carbon, energy-efficient buildings with healthy IAQ. All these factors motivate owners and governments to act to slash carbon to reach net-zero, and that can pay off for HVAC/Sheet Metal and Mechanical contractors with the technical and market knowledge to capitalize.

Financial institutions also have a pivotal role in supporting large-scale, necessary capital reallocation, as part of their business plan. This needs to occur even as they manage their risks and opportunities. Governments and multilateral institutions could use existing and need to develop new policy, regulatory, and fiscal tools to expand incentives and support vulnerable stakeholders for a successful, measurable response. The pace and scale of the expeditious transition meant that many of today’s institutions would require reform. New ones must be created to disseminate best practices, establish standards and tracking mechanisms, and drive large-scale capital deployment.

A significantly expanded tax incentive policy mix and program spending menu will be needed to transform into a net-zero emissions environment in construction. The cost of retrofitting or constructing large-scale physical assets for the net-zero transition will be historic, far beyond the recent infrastructure plan. It represents a substantial scale-up of spending relative to today’s levels, but with proper incentives, building owners and construction contractors have proven they will respond. History demonstrates adequate incentives, and program grants drive action in a short time frame. Net-zero buildings will result from capital that will be spent very differently relative to today’s construction financing. For example, capital is reallocated away from high-emissions assets

and toward low-emissions ones. Therefore, raising capital at this scale will be challenging for those less economically rewarding investments without a new incentive structure to reward building owners. While some of this spending would quickly yield a return, other investments will yield environmental advantages without bottom-line impact. These include addressing technological uncertainty of investment, managing risk/return trade-offs, driving capital flows to developing countries, and ensuring the availability of this capital exists in the sectors and geographies in which emissions reduction is most needed.

This raises the question: How to incentivize the best and achieve and pay for the hoped-for low carbon economy and building inventory transition? Who provides the financing (public versus private actors and the mix of financing sources provided by countries), how capital is raised (debt versus equity, through taxes on businesses or consumers), and various combinations of these factors are among the factors to consider? For instance, public money may be generated by increasing company taxes, carbon taxes, tariffs on cross-border carbon imports, consumer taxes, or by giving tax cuts and tax incentives in conjunction with governments incurring new debt.

In determining the appropriate strategy for funding the transition to a low-carbon or carbon-neutral community, stakeholders will need to evaluate the following three factors:

First, whatever strategy would generate money at the required rate and scale and motivate its deployment?

Second, funding might effectively include equity principles, including how much equity would be required based on past emissions and who can afford to pay.

Third, what are the larger effects of various funding strategies? The latter is particularly significant since it may substantially impact the socioeconomic effects of a transition to net-zero emissions.

Let's examine these three elements in further depth:

First, ways of finance; most crucially, capitalization is required. The most prevalent strategy is to increase or charge taxes on customers or assess fees based on their shopping behavior. This should, or at least has the potential to, reduce spending on essentials or discretionary items in other sectors of the economy if it is not balanced by tax cuts or fiscal stimulus elsewhere. This might impact company revenues for selected industries, employment, and overall economic growth.

Second, if not well controlled, the source of finance might worsen existing inequities. For instance, it may be difficult for developing nations to raise the necessary funds for the changeover.

Thirdly, the funding choice might impact the transition rate to net-zero emissions. Certain technology, such as an electric vehicle (EV) charging infrastructure, may need large-scale public funding to accomplish the adoption rate required to achieve net-zero emissions. The options presented here do not factor in these considerations. Our focus is on sizing the magnitude of the policy need, scope, and odds of success utilizing the policy levers available to key players and nations. However, the questions surrounding the big issues, such as "who pays," "how they pay," and "when they pay," are unavoidable as stakeholders seek to embark on the economic transformation needed for the net-zero transition. And most importantly, how to move expeditiously with results stakeholders can appreciate. Governments, corporations, and institutions must navigate all these hazardous pathways to net-zero GHG by keeping the likely consequences mentioned above the front of mind.

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