Supply Chain Profile
Project 1A New Construction
Market Characterization

Massachusetts Energy Efficiency Programs'
Large Commercial & Industrial Evaluation

Prepared for: Massachusetts Energy Efficiency Program Administrators
Submitted to: National Grid

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1. Executive Summary

This report provides the results of the in-depth interviews with architects, design engineers and construction managers for Project 1A New Construction Supply Chain Profile, a Market Characterization project completed as part of the evaluation of the large commercial and industrial (C&I) programs operated by the Massachusetts program administrators (PA's).

This research addressed the following goals:

1. Characterize the design, engineering, and construction management firms involved with recent large commercial construction projects in Massachusetts.
2. Characterize the design and specification practices with regard to energy efficiency.
3. Assess changes in design and specification practices as a result of contact with the program.
4. Assess awareness and participation in new construction programs offered by the PA's.

The research is qualitative and is designed to provide richness and depth from the conversations between senior Massachusetts-based members of the evaluation team and the interviewees.

KEMA completed in-depth interviews with 31 architects, 11 mechanical engineers and 9 construction managers. The interviews were conducted by telephone between February 15 and April 22, 2011. The interviews averaged roughly 45 minutes in length, with a range of 25 minutes to 70 minutes.

A large percentage of projects completed by the firms represented by those interviewed, were greater than 75,000 square feet based on the Dodge Player Database. However it should be noted that the statements made by the individuals are not necessarily indicative of the projects of that size because the interviewee may or may not have been a part of the design team for those very large projects.

Table 1-1 Overview of Survey Respondents

Characteristics	Architects	Engineers	Const. Managers
No. of Firms Interviewed	31	11	9
Avg. No. of FTEs in Mass. per firm	34	42	150
Range of Services	Architecture, Planning, Green Building Consulting, Interior Design	Mechanical, Electrical, Plumbing, Fire Protection	Construction Management, Land Development, Bldg Owner/Operator
Avg. % of Projects Mass. Based	68%	51%	77%
No. of Projects > 10,000 sf (2005 – 2010)	290	207	65
% of Projects > 75,000 sf	43%	33%	52%
% of Projects > 100,000 sf	32%	27%	45%
Total Est. Value of Projects	$6,190,028,000	$4,703,949,000	$1,688,569,000
Firm Experience with Incentive Programs	21 of 31 respondents said their firms' projects had received support from the programs at some level	10 of 11 respondents said their firms' projects had received support from the programs at some level	8 of 9 respondents said their firms' projects had received support from the programs at some level

1.1 Key Findings

The list below summarizes the key findings from the 51 interviews completed for this market characterization effort.

Demand for energy efficiency design and equipment has been increasing. Examples of each include:

- Increased awareness of energy costs and savings from energy efficiency measures
- Market-driven green building rating systems such as LEED and MA-Collaborative for High Performance Schools (MA-CHPS)
- A quick succession of energy code changes
- The adoption of the energy "Stretch" code by 70+ Massachusetts municipalities
- The mandate for 20% more efficiency in new construction for state buildings (Executive Order 484)
- Rapid advancement and greater availability of energy efficient technologies

Building professionals in the commercial sector continue to face barriers in energy-efficient design and specifying energy efficient equipment. Building professionals recognize the importance to their businesses of promoting energy efficiency, but continue to face obstacles in delivery. The principal barriers include:

- First costs of energy efficient equipment (owners tend to focus on up-front costs).
- Extreme diversity in construction decision-making structures and the decision making criteria among the various customer segments in the commercial sector.
- Reluctance of designers and contractors to change established procedures and specifications.
- Lack of awareness of the relationship between fundamental construction decisions such as building siting and subsequent opportunities to effectuate energy savings.

Additional challenges that architects, engineers, and construction managers face when trying to incorporate energy efficient equipment are:

- Convincing their clients to use unproven technologies
- Resistance from owners who need to train personnel to understand and operate more complicated systems
- Coordinating more sophisticated equipment and more sophisticated controls
- Lead times, product availability and constructability

Some building professionals are well-informed on PA program offerings and are comfortable in using those programs. Most, however, have only modest knowledge of the programs and report that they have experienced problems in accessing program services. Many of the architects interviewed are unaware of how new construction programs work. They tend to rely on mechanical engineers or other consultants to pursue incentives, although most are interested in learning about new construction incentive programs. Other possible causes for lower market penetration include:

- The time it takes to coordinate and apply for the incentives is a deterrent in this market where consultants need to reduce fees as much as possible and aren't able to budget for the extra time it takes to participate in the program.
- The point at which the design teams engage the utilities in the project is inconsistent; therefore, there are mixed results on the perceived helpfulness of the programs.

Recent changes to the Massachusetts Energy Codes have pushed building professionals to reconsider their approaches to energy-efficient design.

- Equipment technologies seem to be keeping adequate pace with code updates and stricter energy efficiency requirements. Although equipment selection was noted as a challenge, there were no complaints that it was impossible.
- The recent rapid pace of code changes is causing some concern in that consultants find themselves with a constant learning curve which ultimately costs them time and money.
- It is believed that due to the adoption of the Stretch Code there is some spillover effect in communities that have not adopted that Code. Engineers and architects tend to design to match the higher standard. There is evidence that this spillover effect crosses state lines as well.

In regard to specific energy efficient equipment, trends and technologies, a wide range of responses was reported.

<u>Lighting</u>

- Architects, engineers, and construction managers expressed strong interest in LED fixtures; almost all mentioned that LED's are still too expensive to fit out more than just a portion of a building project – with the exception of parking fixtures.

- The use of occupancy sensors is becoming standard practice for engineers, but daylight dimming systems, at a cost premium, do not get into nearly as many projects.
- There is an inherent struggle for lighting designers to try to minimize lighting power densities while adequately addressing the lighting desires of the architects.
- Market penetration of efficient fixtures has increased to the point that in some cases it is actually cheaper to install the more efficient fixtures.
- There appears to be high market penetration of high performance T-5 and T-8 pendant, direct/indirect fixtures; however, based on survey responses, designers and construction managers do not demonstrate consistent knowledge of the types of fixtures and lamps that are considered to be high efficiency.

HVAC

- Variable air volume HVAC systems are becoming common practice in the design and construction market.
- Evaporative condensing units, chilled beams and cogeneration systems are gaining wider acceptance and recognition.
- The benefits of incorporating advanced controls, monitors and sensors are being recognized. These systems are being more widely used although some engineers are wary of these technologies because they are seen as more problematic than helpful.
- The use of variable frequency drives is widely recognized as an energy efficiency best practice.

Building Shell

- While it is generally agreed that increasing wall and roof insulation is desirable, there are fundamental disagreements among architects and construction managers about what constitutes an efficient wall or roof assembly.
- Low-e glass, thermal barriers, and shading devices are common in practice.
- Code has had a significant effect on the way wall assemblies are designed and constructed.
- There is lack of understanding and agreement on proper design strategies among architects and construction managers for high performance building envelopes.

Building Simulation Modeling

- Opportunities to fully engage design teams in the Comprehensive Design Assistance (CDA) program are lost when building simulation models and incremental system cost information cannot be obtained quickly enough to affect efficient equipment and measure selection.
- Buildings that are not required to be modeled due to a LEED certification process, government mandate, or participation in utility incentive programs generally do not get modeled.

Building Commissioning

- Building commissioning is regarded very favorably by architects and engineering firms and is viewed as necessary for complex buildings like bio-technology laboratories, medical facilities, large institutional buildings, and schools.
- Because the value of the commissioning process is difficult to quantify, Owners who do not work in facility management, do not readily understand its value. One architect noted that Owners view commissioning as a luxury. This effect appears to be exacerbated by the fact that one cannot predict the impact of commissioning on operations, which makes the cost of commissioning difficult to justify.

In general, market actors have thoroughly embraced high performance T5 and T8 lamps and electronic ballasts, and they are specifying far more lighting controls. All three types of market actors expressed enthusiasm for LED lamps and the associated savings they offer. It will be important for PA's to monitor the LED market to ensure that when new LED products are accepted into new construction programs and the information is quickly communicated to the market.

In regard to HVAC and motors, variable frequency drives (VFDs) were mentioned very often as superior efficiency measures. Engineers and construction managers seek high efficiency boilers and opportunities for co-generation systems. Two engineers mentioned that they like to specify compressors with frictionless magnetic bearings (for chillers).

With recent updates in the Massachusetts Building Code and adoption of the Stretch Code in 70+ municipalities, architects and engineers from all types and sizes of firms have to re-evaluate their design strategies. Rather than swapping out one piece of equipment for one that is incrementally more efficient, they are determining whether they can downsize or even eliminate equipment. They are pairing non-condensing boilers for the peak heating season with condensing boilers for shoulder season loads. They are asking for independent reviews of lighting layouts and watts/SF calculations three times before finalizing designs. Innovation, evaluation and re-design are critical tools in reaching the next efficiency threshold.

1.2 Recommendations

The LCIEC Team has developed a list of recommendations intended to help improve the functionality and overall success of the programs. The recommendations are based on the in-depth interviews with architects, design engineers and construction managers.

To address the more significant challenges in energy efficient design and construction and to continue to improve program effectiveness, we recommend:

- Address the First-Cost Barrier – Consider alternative incentive approaches such as tiered incentives for higher levels of efficiency. Consider expanding financial or technical assistance offerings for life cycle cost analysis to demonstrate the longer term value of accepting higher first costs.
- Improve the value of technical assistance offerings by being consistently engaged with project design teams. The impact of the utility intervention is not fully realized because information about incentives and alternative technologies choice is not delivered on time to design teams. Modeling firms need to quickly upgrade models and turnaround results to customers. For program implementers or technical TA's to become an integral a part of the design team, architects and engineers will need to be reminded of the value of keeping implementers/TA's up to speed on design changes so that they may provide value to design decisions.
- Assist architects and engineers in understanding appropriate high performance building envelope design strategies for the Massachusetts climate. Effective envelope design is critical to achieving long term electrical and thermal savings in buildings. KEMA recommends enhancing current program offerings to fully address the knowledge gap on high efficiency envelope design in the market. We suggest a two pronged approach to advance high performance envelope design: 1) Convene a working group consisting of stakeholders such as Massachusetts DOER, the Massachusetts Board of Building Regulations and Standards and the Massachusetts Net Zero Energy Building Task Force and representatives from the architect, contractor, and building science community to study the challenges associated with high performance building envelope

design, and 2) based on input from the working group, commission a study of advanced building envelope designs beyond what is required by code and provide examples of appropriate, high performance designs for Massachusetts. Note that the Boston Society of Architects has previously been commissioned by the Massachusetts Board of Building Regulations and Standards to provide sample details of envelope design that *meet* code.

- Continue to build upon educational seminars, similar to Advanced Building seminars, to provide education and programmatic support on integrated design and whole building performance. Address siting and envelope issues such as climate-responsive design, building orientation, massing, building-integrated lighting controls (e.g. sunshades), programming of space needs vis-a-vis thermal comfort, insulation, and facade treatments. The goal is to achieve deep savings; therefore we recommend that the new construction programs take a leading position on building performance by embracing a program that researches and promotes whole building design practices for the Massachusetts region. This cutting edge program would help define the conversation on building design. We suggest partnerships with the Massachusetts Department of Energy Resources, Boston Society of Architects, graduate schools of architecture, building science and engineering programs, and for-profit and not-for-profit architectural/engineering entities (e.g. Association of Energy Engineers and Massachusetts-Chapter of the USGBC) for both short term and longer term needs.
- Streamline the application process by reducing the amount of paperwork that is required for participation. Aim to minimize the time architects and engineers have to spend on completing the applications. Otherwise, provide compensation directly to the design team which will help offset their costs for participating.
- Establish contacts within the top 25 architects, design engineers and construction management firms who can provide regular updates regarding project plans and timing, and industry trends. Instill the mantra that participation in the incentive programs during the early stages of design will help them maximize the potential building performance levels.

2. Introduction

This report provides the results of the in-depth interviews with architects, design engineers and construction managers for Project 1A New Construction Supply Chain Profile, a Market Characterization completed as part of the evaluation of the large commercial and industrial (C&I) programs operated by the Massachusetts program administrators (PA's). In this section we provide a review the study objectives, summarize the research approach, and describe the organization of the remainder of the report.

2.1 Evaluation Objectives

The overarching objective of the LCIEC Market Characterization study as defined by the Request for Proposal is the following:

> **"To define the attributes of a specific market area in enough detail that the program planners and administrators can use the information for improving program implementation."**

The principal research objectives of the Characterization's Supply Chain Profile are provided in Table 2-1.

Table 2-1 Research Objectives

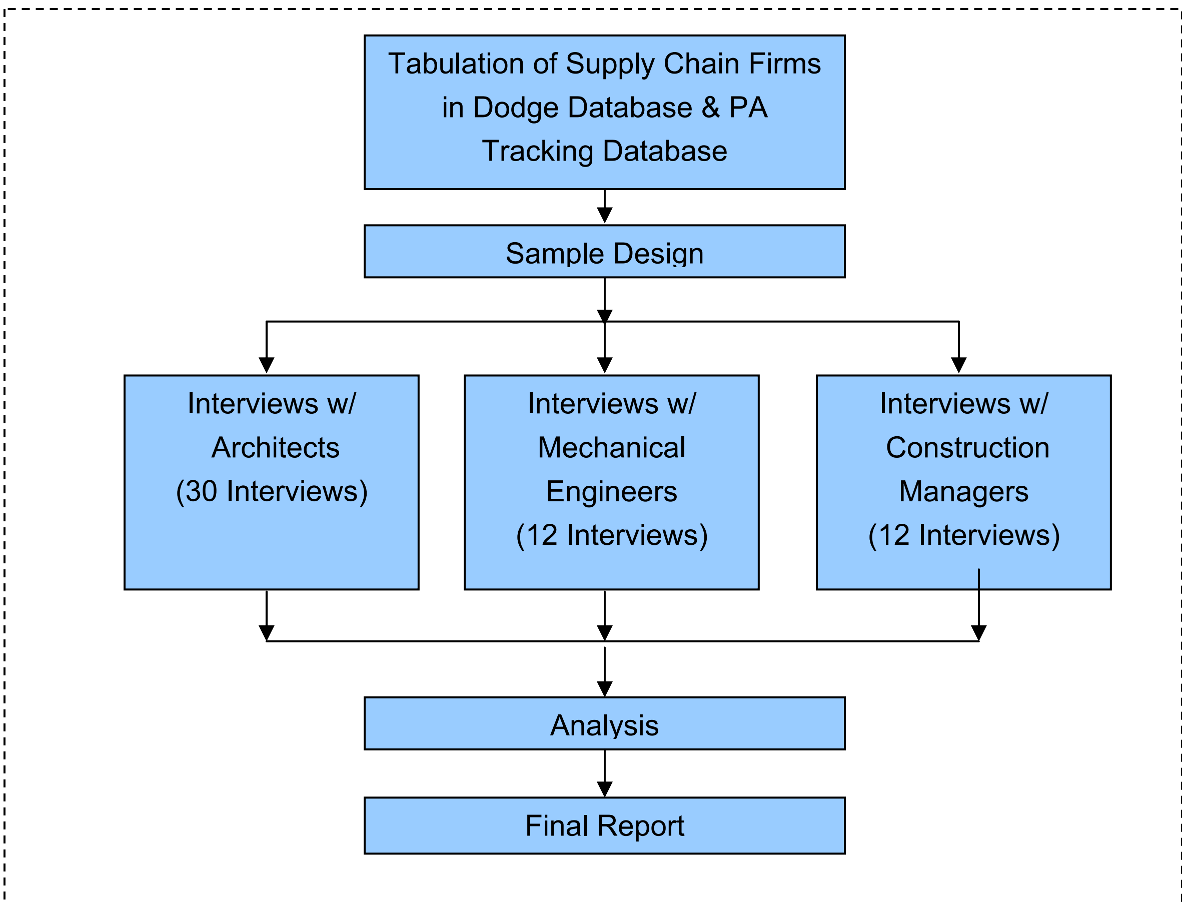
#	Primary Objective
1	Develop a comprehensive characterization of the design, engineering, and construction management firms involved with recent large commercial construction projects in Massachusetts.
2	Characterize the design and specification practices of the key firms in this group with regard to energy efficiency.
3	Assess the degree to which these firms report changing their design and specification practices as a result of contact with the program.
4	Examine the degree to which key design and construction management firms have participated in the PA programs.

2.2 Overview of Approach

This section provides a high level synopsis of the Project 1A Team's approach to characterizing the new construction supply chain in Massachusetts. Figure 2-1 depicts the research plan that was developed and implemented in accordance with the RFP and additional information that was subsequently provided by the PAs and EEAC Consultants.

The research provided herein is qualitative. It is designed to provide richness and depth from the conversations between senior Massachusetts-based members of KEMA's Sustainable Buildings and Operations (SBO) practice and the interviewees. KEMA's SBO division provides green building consulting and sustainable building portfolio services. Our team regularly interacts with owners, architects, engineers, and construction teams. The qualitative results do not necessarily apply to the entire population of architects, design engineers and construction managers active in the Massachusetts new construction marketplace.

Figure 2-1. Supply Chain Profile Research Plan



2.3 Organization of Report

The remainder of the report is organized as follows:

- **Section 3. Approach** provides a detailed description of the sample design and data collection activities.
- **Section 4. Results** presents the findings of the in-depth interviews with 31 architects, 11 design engineers and 9 construction managers.
- **Section 5. Conclusions and Recommendations** presents conclusions based on the in-depth interviews with architects, design engineers and construction managers. The LCIEC Team offers recommendations to further engage these firms in the new construction programs offered by the PAs.
- **Appendix A. Supply Chain Interview Guide**

3. Approach

The LCIEC Team addressed the objectives (Table 2-1) of the Supply Chain Profile using in-depth interviews with architects, engineers and construction managers active in the Massachusetts non-residential new construction market. Prior to the in-depth interviews, the LCIEC Team examined the F. W. Dodge Players Database for non-residential construction projects in Massachusetts and developed a sample based on these data.

In this section we describe the following:

- **Tabulation of Firms.** Tabulations of the mentions of architects, design engineers, and construction managers in the Dodge Players database in the last five years (September 2005 through September 2010) in Massachusetts' non-residential construction market place.
- **Sample Design.** Description of the sampling approach to the interviews with architects, design engineers and construction managers.
- **Data Collection.** Description of the approach to the interviews with architects, design engineers and construction managers.

3.1 Tabulation of Firms

The study commenced with three initial steps:

1. Tabulations of mentions of architects, design engineers, and construction managers in the Dodge Players database for the most recent years.
2. Tabulations of mentions of architects and general contractors in PA program records.
3. Comparison of the list of architects, design engineers, and construction managers listed in the Players database to the list developed from PA program records.[1]

[1] The Evaluation Team did not perform a comparison of new construction supply chain firms in the Dodge and PA tracking databases because the PA tracking databases did not include any information on the construction firms, architects or engineers associated with the participant projects. On October 21, 2010, The Evaluation Team submitted a data request for Project 1A – Market Characterization's Project 2: Commercial New Construction Customer Quantitative Profile. We requested participant-level program tracking data on participating new construction projects for the most recent years. In the preferred data format, all available information on the projects including project description, address, actors associated with the project (including the owner, construction firm, architect, and engineer), and the energy efficiency measures committed through the program was requested. The tracking data contained the majority of fields requested in the preferred data format. Information on market actors associated with each project was not included.

3.1.1 Dodge Players Database

The project team acquired and analyzed the entire F. W. Dodge Players Database for non-residential construction projects for the Commonwealth of Massachusetts for the years 1996 through 2009. The Dodge Players database contains retrospective information on commercial and industrial construction projects that, according to Dodge, have begun construction. Dodge attempts to compile data on the following:

- Identification of the owner and project principals
- Identification of the architect and general contractor
- Principal uses
- Building size
- Estimated project costs

The data are developed by field reporters employed by McGraw Hill who rely on contacts throughout the new construction industry to identify potential new projects and who regularly visit construction permitting offices to identify newly permitted building projects. The field reporters also make follow-up contacts with project managers to collect information on the status of the construction and the businesses that are involved with the construction.

The Players Database is designed to furnish information on the market actors associated with individual new construction projects, including owners, architects, engineers, construction managers and other market actors. The database contains a unique identifier for each project and a unique identifier for each firm (market actor). Estimated project costs are recorded for every project in the database.

The Players Database contains contact information on the main contact person at the firm including name, address, telephone, fax, and email. The contact field generally remains static. There is the chance that some contact names were no longer valid at the time of the study. Nonetheless, this contact information was used to identify and reach potential respondents in this study.

The database supported the creation of the lists of the owners, architects, engineers, construction managers, and other market actors, active in the commercial and industrial construction market in Massachusetts in a specified period, ranked in terms of total project value or total number of projects.

The Evaluation Team created and reviewed the lists of design engineers, architects, and construction managers and the lists of construction projects these firms were associated with from the Dodge data. Table 3-1 presents the tabulations of the mentions of architects, design engineers, and construction managers in the Dodge Players database in the last five years (September 2005 through September 2010) in Massachusetts' non-residential construction market.

The table is organized according to our sample design strategy described in Section 3.2 Sample Design. The populations of architects, engineers and construction managers were segmented based on the size of the firm (in terms of total construction value) and whether the majority of the firm's work (at least 75 percent of the firm's total construction value) was conducted for public or private clients. The purpose of the latter segmentation is to support analysis of the effect of differences between private sector construction processes and public sector construction delivery processes on the adoption of energy efficiency practices and participation in the PAs' new construction programs.

The percent of total construction value (% Total Value) in Table 3-1 exceeds 100 percent because several projects have more than one firm from the same category of market actor listed as a market actor (e.g. two architectural firms worked on the same project). In these cases the project value is counted for each market actor listed for the project.

Table 3-1 Dodge Data Market Actors, September 2005 – September 2010

Stratum[2]	Group[3]	Private or Public >=75%[4]	Architects		Mechanical Engineers		Construction Managers	
			# Firms	% Total Value[5]	# Firms	% Total Value[6]	# Firms	% Total Value[7]
1	Top 10	Private Sector	7	18.7%	4	24.9%	10	25.1%
2	Top 10	Public Sector	0	0.0%	0	0.0%	0	0.0%
3	Top 10	Assorted	3	8.1%	6	39.0%	0	0.0%
4	Top 11-25	Private Sector	9	12.7%	5	6.4%	11	12.8%
5	Top 11-25	Public Sector	5	6.7%	4	5.8%	1	1.1%
6	Top 11-25	Assorted	1	1.3%	6	7.0%	3	3.9%
7	Others	Private Sector	536	40.1%	176	14.0%	664	54.1%
8	Others	Public Sector	158	16.8%	45	3.9%	144	13.8%
9	Others	Assorted	48	11.1%	16	3.9%	24	5.7%
TOTAL			**767**	**115.5%**	**262**	**104.9%**	**857**	**116.5%**

2 Sample design stratum.

3 Market actors were ranked in terms of the total construction value in the MA non-residential construction market in the last five years to form three major groups: Top 10 actors, Top 11-25 actors, and the others.

4 Based on their share of projects in private or public sector, each firm was classified as being mostly private, or mostly public, or neither. A firm was classified to be mostly private if its share of private projects in terms of project value is at least 75 percent. Similarly, a firm was classified to be mostly public if its share of public projects in terms of project value is at least 75 percent.

5 % Total value exceeds 100% because there are projects for which more than one architecture firm is listed and the value of the project is counted for all firms involved.

6 Ibid.

7 Ibid.

Key findings from the tabulation include:

- The 10 largest firms in terms of total project value account for 27 percent, 64 percent and 25 percent of total project value for architects, design engineers and construction managers, respectively.
- The Top 25 architectural and construction management firms accounted for nearly half of the total project value. Among engineers, the Top 25 firms accounted for 83 percent of total project value.
    - Top 25 Architects = 48% of total project value.
    - Top 25 Design Engineers = 83% of total project value.
    - Top 25 Construction Managers = 43% of total project value.
- The majority of firms focused on private sector construction during the previous five years.
    - Architects = 552 of 767 firms (72% of total project value).
    - Design Engineers = 185 of 262 firms (45% of total project value).
    - Construction Managers = 685 of 857 firms (92% of total project value).
- Public sector construction was the focus for:
    - Architects = 163 of 767 firms (24% of total project value).
    - Design Engineers = 49 of 262 firms (1% of total project value).
    - Construction Managers = 145 of 857 firms (15% of total project value).

3.2 Sample Design

This section presents the sample design for the in-depth interviews with architects, design engineers, and construction management firms. Given the in-depth interviewing approach required to obtain the data needed for this analysis, resources were not available for the kind of large samples needed to support statistical analysis of survey results. The LCIEC Team employed a systematic approach to the sample design to ensure a representative sample of firms active in the Massachusetts new construction market place.

3.2.1 Preparation of the Sample Frame

Preparation of the sample frame included four steps:

1. **Tabulations of Architects, Engineers, and Construction Management Firms.** The first step in the sample design was the tabulations of the mentions of architects, engineers, and construction managers in the Dodge Players database in the last five years (September 2005 through September 2010) in Massachusetts non-residential construction market. The project team used these fields to identify market actors and assess activity levels.
2. **Identification of Large Projects.** The second step was to restrict the sample frame only to supply chain actors that were involved in at least one large nonresidential project in the last 5 years. For the purpose of this study, a project is considered to be large if the construction area is 10,000 square feet or larger. Since the construction square footage is not populated for all projects in the Dodge database, total project value was used as a proxy for the project size. Any project that had a value of $1 million or more was considered to be large.[8]
3. **Rankings of Construction Firms.** The architects, engineers, and construction management firms were then ranked in terms of the total construction value in the MA non-residential construction market in the last five years to form three major groups: Top 10 actors, Top 11-25 actors, and the others.
4. **Private vs. Public Projects.** Based on their share of projects in private or public sector, each firm was classified as being mostly private, or mostly public, or neither. A firm was classified to be mostly private if its share of private projects in terms of the firm's overall project value is at least 75 percent. Similarly, a firm was classified to be mostly public if its share of public projects in terms of the firm's overall project value is at least 75 percent.

[8] Project value is populated for every project in the Dodge database. Project team estimated that a building approximately costs $100 per square foot. Therefore, a 10,000 square foot building would be expected to cost about $1 Million.

3.2.2 Sample Selection

The work plan recommended interviewing samples of 30 architects, 12 mechanical engineers and 12 general contractors, each divided more or less evenly between participants and non-participants in the PA programs. However, the PA program tracking databases did not contain records of supply chain actors. Therefore, the sample was developed using the Dodge project records only. Following the development of the sample frames, samples were selected for each market actor group.

The sample frame and target number of completes for architects is shown in Table 3-2. We targeted six completed interviews with the Top 10 group (Strata 1 through 3) and another six completed interviews with the Top 11-25 group (Strata 4 through 6). We anticipated the need to contact all firms (census) in the Top 25 to achieve the desired target completes. The sample for Stratum 7 through 9 was selected using probability proportional to size (PPS) sampling technique, where firms with greater construction value have a higher probability of selection. Stratum 7 had a target of 10 completed interviews and Strata 8 and 9, each had targets of four completed interviews.

Table 3-2 Sample of Architects

Stratum	Group	Private or Public >=75%	# Firms	% Total Value[9]	Target Completes
1	Top 10	Private Sector	7	18.7%	4
2	Top 10	Public Sector	0	0.0%	0
3	Top 10	Assorted	3	8.1%	2
4	Top 11-25	Private Sector	9	12.7%	3
5	Top 11-25	Public Sector	5	6.7%	2
6	Top 11-25	Assorted	1	1.3%	1
7	Others	Private Sector	536	40.1%	10
8	Others	Public Sector	158	16.8%	4
9	Others	Assorted	48	11.1%	4
TOTAL			**767**	**115.5%**	**30**

[9] % Total value exceeds 100% because there are projects for which more than one architecture firm is listed and the value of the project is counted for all firms involved.

Table 3-3 presents the sample frame and target number of interview completes for construction management firms. We targeted three interviews from the 10 construction management firms in Stratum 1. Stratum 4 contains 11 out of 15 construction management firms in the Top 11-25 group, with a target of two completed interviews. We anticipated the need to contact all firms (census) in Strata 1 and 4 to achieve the desired target completes. The sample for Stratum 7 through 9 was selected using PPS sampling technique. Stratum 7 had a target of five completed interviews and the remaining two interviews were targeted in Strata 8 and 9.

Table 3-3 Sample of Construction Managers

Stratum	Group	Private or Public >=75%	# Firms	% Total Value[10]	Target Completes
1	Top 10	Private Sector	10	25.1%	3
2	Top 10	Public Sector	0	0.0%	0
3	Top 10	Assorted	0	0.0%	0
4	Top 11-25	Private Sector	11	12.8%	2
5	Top 11-25	Public Sector	1	1.1%	0
6	Top 11-25	Assorted	3	3.9%	0
7	Others	Private Sector	664	54.1%	5
8	Others	Public Sector	144	13.8%	1
9	Others	Assorted	24	5.7%	1
TOTAL			**857**	**116.5%**	**12**

[10] % Total value exceeds 100% because there are projects for which more than one general contractor firm is listed and the value of the project is counted for all firms involved.

The sample frame and target number of completes for design engineers is shown in Table 3-4. We targeted five completed interviews with the Top 10 group (Strata 1 through 3) and three completed interviews with the Top 11-25 group. We anticipated the need to contact all firms (census) in the Top 25 to achieve the desired target completes. The sample for Stratum 7 through 9 was selected using probability proportional to size (PPS) sampling technique, where firms with higher construction value have a greater likelihood of being selected. Stratum 7 had a target of two completed interviews and Strata 8 and 9, each had a target of one completed interview.

Table 3-4 Sample of Design Engineers

Stratum	Group	Private or Public >=75%	# Firms	% Total Value[11]	Sample Size	Target Completes
1	Top 10	Private Sector	4	24.9%	4	2
2	Top 10	Public Sector	0	0.0%	0	0
3	Top 10	Assorted	6	39.0%	6	3
4	Top 11-25	Private Sector	5	6.4%	5	1
5	Top 11-25	Public Sector	4	5.8%	4	1
6	Top 11-25	Assorted	6	7.0%	6	1
7	Others	Private Sector	176	14.0%	20	2
8	Others	Public Sector	45	3.9%	10	1
9	Others	Assorted	16	3.9%	10	1
TOTAL			**262**	**104.9%**	**65**	**12**

3.3 Data Collection

Senior Massachusetts-based members of KEMA's Sustainable Buildings and Operations (SBO) practice conducted the in-depth interviews. Some interviews with smaller firms were completed by other KEMA staff under the direct supervision of the SBO team. KEMA's SBO division provides green building consulting and sustainable building portfolio services. The interviewers were able to use their professional familiarity with issues of energy efficiency in commercial

[11] % Total value exceeds 100% because there are projects for which more than one engineering firm is listed and the value of the project is counted for all firms involved.

building design and operation to elicit important details and resolve inconsistencies in the answers they received from respondents.

The interview guide is provided in Appendix A. The primary objectives of the interview were to gain information and understanding of the respondents':

- Current design and specification practices.
- Recent changes in design and installation practices.
- Perceptions of changes in customer demand for energy efficient design and equipment.
- Perceptions of drivers of those changes.
- Views on the business value of energy efficiency to chain and franchise customers.
- Views on the influence of the program on designers and construction managers.

Table 3-5 presents a summary of the key research topics covered in the interview. All topics may not have been covered in each interview. The focus of each interview was guided by the experience, areas of interest and availability of the interviewees.

Table 3-5 In-depth Interview Research Topics

Key Research Topics	Architects	Mechanical Engineers	Construction Managers
General Company Information			
Services Provided	√	√	√
Specialization in Particular Building Types	√	√	√
Changes in Demand for Energy Efficiency			
Importance of Energy Efficiency	√	√	√
Reasons for Interest in Energy Efficiency	√	√	√
Objections to Energy Efficiency	√	√	√
Identification of Decision Makers	√	√	√
Changes in Design/Construction Practices			
Practices: Lighting Fixtures/Controls	√	√	√
Practices: HVAC Systems/Controls	√	√	√
Practices: Building Envelope Systems	√	√	√
Building Simulation Modeling to Inform Design	√	√	
Value of Building Commissioning	√	√	
Energy Codes			
Awareness of Code Changes	√	√	√
Effect of Code Changes on Design/Construction	√	√	√
Promotion of Efficient Design/Construction Practices			
Marketing of Energy Efficient Design	√	√	√
Importance of Offering Energy Efficient Design	√	√	√
Challenges to Delivery of Energy Efficient Design	√	√	√
Chain and Franchise Trends			
Uptake of Energy Efficiency by Chains & Franchises	√	√	√
Program Awareness			
Familiarity with Program Incentives	√	√	√
Importance of Program Incentives	√	√	√
Program Effectiveness	√	√	√
Program Influence on Design/Construction Practices	√	√	√
Recommended Changes to Program	√	√	√

To increase study participation rates, KEMA emailed an advanced letter to each sampled firm with an available email address in the Dodge Database. The advanced letter included:

- A description of the study
- An overview of the topics to be covered in the interview
- Estimated length of the interview (30 minutes)
- Contact name and telephone number for National Grid Project Manager to confirm the legitimacy of the study

Participation rates were also improved via assistance received from the PAs' implementation staff. On several occasions KEMA received additional contact information from the PA implementation staff for firms that were not responding to KEMA initial recruitment attempts.

As shown in Table 3-6 KEMA completed in-depth interviews with 31 architects, 11 design engineers and 9 construction managers. The interviews were conducted by telephone between February 15 and April 22, 2011. The interviews averaged roughly 45 minutes in length, with a range of 25 minutes to 70 minutes. Tables 3-7, 3-8, and 3-9 provide a summary of the characteristics of the firms interviewed.

Table 3-6 Completed Interviews

Stratum[12]	Group[13]	Private or Public >=75%[14]	Architects		Design Engineers		Construction Managers	
			Target	Achieved	Target	Achieved	Target	Achieved
1	Top 10	Private Sector	4	4	2	2	3	3
2	Top 10	Public Sector	0	0	0	1	0	1
3	Top 10	Assorted	2	2	3	3	0	0
4	Top 11-25	Private Sector	3	3	1	1	2	0
5	Top 11-25	Public Sector	2	3	1	0	0	0
6	Top 11-25	Assorted	1	0	1	2	0	0
7	Others	Private Sector	10	10	2	0	5	3
8	Others	Public Sector	4	5	1	1	1	0
9	Others	Assorted	4	4	1	1	1	2
TOTAL			**30**	**31**	**12**	**11**	**12**	**9**

12 Sample design stratum.

13 Market actors were ranked in terms of the total construction value in the MA non-residential construction market in the last five years to form three major groups: Top 10 actors, Top 11-25 actors, and the others.

14 Based on their share of projects in private or public sector, each firm was classified as being mostly private, or mostly public, or neither. A firm was classified to be mostly private if its share of private projects in terms of project value is at least 75 percent. Similarly, a firm was classified to be mostly public if its share of public projects in terms of project value is at least 75 percent.

Table 3-7 Overview of Architects Interviewed

Characteristics	Architects Top 10	Architects Top 11-25	Architects Others
No. of Firms Interviewed	6	6	19
Avg. No. of FTEs in Mass. per firm	84 (Low being 35, High being 180)	90 (Low being 20, High being 300)	23 (Low being 1, High being 100)
Range of Services	Mainly architecture, although one firm also does mech., elec., and green bldg consulting	Architecture, planning and interior design (one firm provided services in all disciplines)	8 out of 19 provided both architecture and engineering services
Geographic Reach	U.S. mainly, (one firm worked internationally)	Northeast mainly (one firm worked internationally)	Varied responses from Boston/Metro only to international
Avg. % of Projects Mass. Based	61%	62% (Low being 4%)	73% (Low being 5%)
Project Type Specialization	All sectors covered	Primary secondary ed., higher ed., multi-family, retail, hotels	Office, healthcare, primary, secondary, and higher ed., multi-family, and retail
No. of Projects > 10,000 sf	80	91	119
Total Est. Value of Projects	$3,563,597,000	$1,591,138,000	$1,035,293,000
Experience with Incentive Programs	4 of 6 respondents said their firms' projects had received support from the programs at some level	4 of 6 respondents said their firms' projects had received support from the programs at some level	13 of 19 respondents said their firms' projects had received support from the programs at some level

Table 3-8 Overview of Engineers Interviewed

Characteristics	Engineers Top 10	Engineers Top 11-25	Engineers Others
No. of Firms Interviewed	6	3	2
Avg. No. of FTEs in Mass. per firm	57 (Low being 32, High being 90)	30	16
Range of Services	Mainly mechanical, electrical and plumbing Add'l services mentioned included civil engineering, LEED consulting and fire protection	Mechanical, electrical and fire protection	Mechanical, electrical, plumbing and fire protection
Geographic Reach	Northeast, nationally, and internationally	Northeast mainly	One northeast, one international
Avg. % of Projects Mass. Based	45%	70%	80% for the firm who works mainly in the northeast, 5% for the firm doing international work
Project Type Specialization	Office, Healthcare, Primary, Secondary, Higher Ed., Multi-family, Hotels	Office, Healthcare, Higher Ed., Data Centers	Data centers
No. of Projects > 10,000 sf	179	24	4
Total Est. Value of Projects	$4,318,477,000	$361,442,000	$24,030,000
Experience with Incentive Programs	6 of 6 respondents said their firms' projects had received support from the programs at some level	2 of 3 respondents said their firms' projects had received support from the programs at some level	2 of 2 respondents said their firms' projects had received support from the programs at some level

Table 3-9 Overview of Construction Management Firms Interviewed

Characteristics	Const. Managers Top 10	Const. Managers Top 11-25	Const. Managers Others
No. of Firms Interviewed	4	0	5
Avg. No. of FTEs in Mass. per firm	200 (Low being 25, High being 350)	-	109 (Low being 50, High being 250)
Range of Services	Construction Management	-	Construction Management, Land Development, Bldg owner/operator
Geographic Reach	3 respondents on do work in Mass., 1 respondent does work internationally	-	Two respondents said Mass. only, three said northeast mainly
Avg. % of Projects Mass. Based	3 respondents said 90-100%., the respondent who conducts work internationally estimated 1%	-	82%
Project Type Specialization	Office, Healthcare, Primary, Secondary, Higher Ed., and Laboratories	-	Commercial Office Space
No. of Projects > 10,000 sf	31	-	34
Total Est. Value of Projects	$1,272,202,000	-	$416,367,000
Experience with Incentive Programs	4 of 4 respondents said their firms' projects had received support from the programs at some level	-	4 of 5 respondents said their firms' projects had received support from the programs at some level

It was decided on April 11, 2011 by KEMA and the Program Administrator, Project Manager to no longer attempt to complete interviews. To maximize interview participation rates in future evaluation studies of this type, we recommend the following:

- Establish a group of trade allies and continue to build relationships with key points of contact within the top 25 architectural, engineering, and construction management firms.
- Maintain a database of key contacts within these firms, understanding who it is that typically manages the incentive program applications, and who the green building champions are in their respective firms as these folks typically take an interest in this subject.
- Advertise the upcoming interviews and the importance of participant feedback to the trade allies and targeted firms.
- Collect feedback from program participants upon release of incentive monies.

4. Results

This section presents the key findings from the in-depth interviews with 31 architects, 11 design engineers, and 9 construction management firms.

Key findings are organized into five sections:

- **Demand for Energy Efficiency and Related Building Owner Decision Making.** This section investigates customer demand for energy efficient design and equipment. We investigate changes in demand over the past three years, what may be driving change, and who is driving the change.
- **Design/ Construction Practices.** If demand for design and installation energy efficient equipment is changing, how are new construction market actors changing their design and specification practices? Architects, engineers, and construction managers describe efficient designs/technologies for lighting, HVAC, and envelope systems and estimate their frequency of specification and installation of efficient equipment. This section also covers the use of building simulation software to inform designs and the value of the process of building commissioning.
- **Energy Codes.** Massachusetts recently implemented its 7th edition of the building code (January 1, 2009), closely followed by the 8th edition (July 1, 2010). This section investigates the respondents' views on the effect that building codes have had on design practices.
- **Promotion of Efficient Design Practices.** This section examines the level of promotion and specific activities undertaken by firms to encourage customers to select energy efficient designs and equipment. Also addressed is whether greenhouse gases (GHG's) and GHG targets drive decisions about lighting, HVAC, and envelope selection.
- **Program Awareness.** This section assesses program awareness among firms and the effectiveness and influence of new construction incentive programs on the design, specification, and/or construction processes. It also presents customer suggestions for improvements to the new construction programs.

4.1 Demand for Energy Efficiency and Related Decision Making

This section assesses the importance of energy efficiency in the decision making process during the design of a new building, who has the greatest influence over those decisions and what the key factors are that drive those decisions. Understanding these factors provides a base to help the PA's determine whom to target with program marketing and educational materials, and what topics to focus on in promotional or educational materials.

Key findings regarding changes in the demand for energy efficiency and the decision making process are:

Energy efficiency is important to clients. On a scale of 1 through 5 (1 = not at all important and 5= very important),

- Architects generally rated importance of energy efficiency at 4 and above (23 out of 31 responses) for their clients,
- Engineers rated efficiency at 4 or above (9 out of 11 responses), and
- All construction firms (9 out of 9) reported energy efficiency at a 5, or very important, for their clients.

Although most interviewees indicated that energy efficiency is an important consideration, it is clear that their primary objective is to design and construct buildings that meet client needs. In addition to energy efficiency, key considerations include functionality, cost, aesthetics, and durability of design.

Building owners have increased their demands for energy efficiency in design and equipment specification since 2008. In cases where survey participants didn't see an increase in demand, they indicated energy efficiency was already a strong priority for their clients and remained a strong priority between 2008 and 2011.

Among clients for the respondents' services, the principal motivation for seeking energy-efficient designs and equipment is to lower utility bills. Other drivers that surfaced during interviews include:

- Adherence to state mandated energy efficiency levels for state-owned buildings (Executive Order 484 [15]– new construction must be 20% more efficient than code and must be LEED Silver certified).
- Qualification for additional financial reimbursement incentives from the state for K-12 schools construction (an additional 2% of total project costs for green building certification goes to municipalities).
- Adherence to voluntary environmental guidelines (e.g. American College and University Presidents' Climate Commitment).
- The clients' desires to lower their environmental impact.
- The firms' desire to lower impact because it aligns with their core values or it is important to public perception of their firm.
- Maintenance of the owners' "thermal comfort".

Clients' principal objection to using energy efficient equipment or design is higher first capital costs. However, first costs are not the only objection. The respondents reported that more sophisticated clients, such as colleges and universities, biotechnology firms, and laboratory facilities raise additional concerns that "higher service type [equipment] requires more mechanics, more controls and more oversight to run them properly as opposed to just starting them up and running the system." In other words, this client type considers the total cost of ownership beyond first costs and fuel expenses. For some clients, who may operate their facilities on a 24/7 basis, the need for equipment reliability and ease of maintenance is paramount. Furthermore, they don't want to be "guinea pigs" for new technologies, and they cannot afford to be "embarrassed" by a system failure.

While it is perceived that energy efficient equipment can be more sophisticated and difficult to operate, this indicates a need and an opportunity to educate this customer segment on the

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[15] On April 18, 2007, Governor Patrick signed Executive Order 484 - Leading By Example: Clean Energy and Efficient Buildings. The order directs that for state facilities, all new construction and major renovation over 20,000 square feet must meet MassLEED Plus requirements. All new construction under 20,000 square feet must meet MassLEED Plus, achieve 20% above the Mass Energy Code, or meet the Advanced Buildings energy criteria. The MassLEED Plus standard is the same as LEED for New Construction but imposes additional prerequisites on Massachusetts projects:

- 20% more efficient than Mass. energy code baseline
- Reduction of outdoor water consumption by 50% and indoor water consumption by 20% relative to standard baseline projections.
- Conformance with at least 1 of 4 smart growth criteria from LEED's Sustainable Sites category.

overall benefits. Once the benefits are understood, these are the types of owners who are able to accept longer payback periods and accept newer technologies. Developers and commercial building owners are less likely to accept newer technologies because they have a greater sensitivity to higher first costs, especially when the efficiency benefit cannot be captured in a higher selling or leasing prices.

There is no consistent set of influential parties for new building construction. Although there are identifiable groups of influencers for most market segments, relative influence of different groups varies greatly from one market segment to another. We learned that who participates in the decision making process depends on many factors including: the private versus public financing of the project, the level of complexity of the building project, and decision-making hierarchies (or lack thereof) among owners and developers. As one architect wryly quipped about who has the most influence, "It depends…for 10 projects there could be 10 different answers."

Many respondents reported that, while the "Owner" such as a Board of Trustees, CEO, or CFO is the ultimate decision-maker, there is often an intermediary whose input and access to the Owner significantly impacts the degree to which the Owner incorporates energy efficiency into a project. The intermediary could be the Owner's construction manager, director of architectural or capital planning, facilities director, or a facilities engineer. While this is true for private commercial and institutional Owners, decision-making for developers often lies with the president or CFO of their own companies.

For K-12 customers, influential parties vary depending on the local political landscape. For some, the mayor holds the most sway on a school project, but for other respondents, school building committees, facility managers, and planning departments have more say in when and where energy efficiency makes it into a project.

4.2 Design / Construction Practices

This section examines current design and construction practices with specific attention to efficient designs and equipment selection for lighting, HVAC, and envelope systems. Also included are findings from the interviews with architects and engineers on the use of building simulation software to inform designs and the value of the building commissioning process.

Key findings regarding current design and construction practices are organized as follows:

- Current Lighting System Practices

- Current HVAC System Practices
- Current Building Envelope Practices
- Building Simulation Modeling
- Building Commissioning

In general, market actors have thoroughly embraced high performance T5 and T8 lamps and electronic ballasts, and they are specifying far more lighting controls. All three types of market actors expressed enthusiasm for LED lamps and the associated savings they offer. It will be important for PA's to monitor the LED market to ensure that when new LED products are accepted into new construction programs, the information is quickly communicated to the market.

In regard to HVAC and motors, variable frequency drives (VFDs) were mentioned very often as superior efficiency measures. Engineers and construction managers seek high efficiency boilers and opportunities for co-generation systems. Two engineers mentioned that they like to specify compressors with frictionless magnetic bearings (for chillers).

With recent updates in the Massachusetts Building Code and adoption of the Stretch Code in 70+ municipalities, architects and engineers from all types and sizes of firms are having to re-evaluate their design strategies. Rather than swapping out one piece of equipment for one that is incrementally more efficient, they' re determining whether they can downsize or even eliminate equipment. They are pairing non-condensing boilers for the peak heating season with condensing boilers for shoulder season loads. They are asking for independent reviews of lighting layouts and watts/SF calculations three times before finalizing designs. Innovation, evaluation and re-design are critical tools in reaching the next efficiency threshold.

4.2.1 Current Lighting System Practices

Those market actors interviewed were asked to describe the technologies that represent best practices for lighting in three particular space types: offices, retail spaces not including high bay spaces, and high bay spaces. Their responses are captured in Table 4-1. Responses for office space were consistent across market actors; responses varied for retail space, and responses for high bay space showed very little consistency among respondents. The latter variation is a potential indication of a lack of understanding of what constitutes high efficiency lighting design for high bay space.

Table 4-1 Summary of Respondent Identified Best Practices: Lighting

Types of Spaces	High Efficiency Lighting Fixtures and Controls
Office Space	▪ Most respondents with some level of familiarity with lighting design offered the following lighting fixtures and controls for office spaces: o High performance T-8's or T-5 direct/indirect pendant fixtures o LED's for task lighting and accent lighting o Occupancy sensors and daylight dimming controls
Retail Spaces, not Including High Bay Spaces	▪ Respondents were less clear about high efficiency fixtures for retail spaces – also described as spaces that include display lighting. Market actors reported a wide range of lamp types, such as: o Fluorescent T8 and T5's for general lighting o Spot lighting using metal halides, halogens, CFL's, and LED's o More lighting is controlled through energy management systems o Occupancy sensors for non-public spaces
High Bay Spaces	▪ All three types of market actors provided a wide-range of lighting fixtures they consider as energy efficient for high bay applications; including: o T8 High Performance high bay fixtures o T5 High Output high bay fixtures o Pendant-mounted fixtures - HID's not fluorescents o CFL's for high spaces o LED's for interior and exterior lighting applications

Architects and engineers consistently believe they specify high efficiency fixtures and lighting controls. All respondents indicated that the demand for efficient lighting had either stayed the same or increased since 2008 - largely driven by code changes, desire for energy efficiency or both. Additionally, 32 out of 51 total respondents indicated that their success rate is quite high – 80% or more of the time they are able to achieve high efficiency installations.

Many designers and construction managers seemed to lack a systematic strategy for evaluating the efficiency of lighting designs. In other words, market actors stated that certain fixtures, controls, and layouts are "efficient" but were unable to articulate the method by which efficiency was measured and deemed to have been achieved.

Architects, engineers and construction managers have consistent understandings of high efficiency lighting for office space. Those market actors interviewed consistently identified specification of high performance T-8's or T-5 direct/indirect pendant fixtures as best practice for office space lighting. Respondents indicated the new construction energy efficiency incentive programs have influenced the specification practices for uniform spaces such as offices, with standard ceiling heights and acoustical ceiling tile finishes.

Descriptions of efficient lighting design for high bay spaces were more mixed - most likely reflecting the fact that high bay spaces can be very utilitarian, such as warehouses, or have considerable aesthetic requirements, such as theaters and auditoriums.

Respondents are far less clear about what constitutes high efficiency lighting design in more varied spaces. It was difficult for respondents to define energy efficient lighting for spaces such as retail stores where color temperature, color rendering, light intensity, and fixture aesthetics play a greater role in lighting design. Based on their uncertainty, KEMA hypothesizes that efficient lighting for this category of space is not well-defined and, as a result, leads to conflation of efficient fixtures with fixtures that deliver the lighting quality that designers seek. Alternatively, because lighting technology evolves rapidly (LED fixtures are an excellent example), architects and electrical engineers have little time to thoroughly evaluate fixtures for spaces where display and accent lighting are critical design features.

Most market actors, regardless of size or target market, believe that they are installing highly efficient lighting fixtures and controls. Most respondents believe that the fixtures they specify are highly efficient. Whether their confidence is due to the fact that lighting fixtures are significantly more efficient than models sold even 5 to 7 years ago, that Massachusetts has a strict lighting code, or that designers now install more lighting controls is unclear. This finding highlights the need for systematic lighting design reviews against metrics for lighting efficiency and efficacy. Otherwise, market actors may be missing opportunities to optimize lighting loads, which can constitute a significant portion of a building's entire energy load.

All architects and engineers interviewed recommend advanced lighting controls. Architects and engineers are recommending advanced lighting controls such as daylight dimming systems and occupancy sensors (in addition to spaces where they are required by code) more frequently now than three years ago.

Designers reported that daylight dimming systems are frequently value engineered out of projects due to higher first costs. One architect from a Top 11-25 firm (public sector) noted that he isn't able to get daylight dimming systems into his K-12 school projects unless the first cost is subsidized by a utility incentive. While many design firms indicated excellent success in the installation of advanced controls, success is not uniform across all segments.

Few designers discussed master lighting panels or lighting systems controlled by building management systems (BMS). However, one architect stated that since 2009 he no longer ties master lighting controls into BMS's because the controls tend to be too confusing for the facility staff.

All three types of market actors expressed strong interest in LED fixtures. One common application for LEDs identified by several market actors is parking lot lighting. Unfortunately, designer enthusiasm for LEDs is somewhat curbed by the current high initial first cost relative to other alternatives.

4.2.2 HVAC

In the HVAC portion of the interview, those market actors interviewed were asked to describe what technologies represent the best practices for packaged equipment, built-up central plants, and HVAC controls. Only those familiar with HVAC specification and design practices tended to answer the questions. A sampling of the wide variety of quoted responses is presented in Table 4-2.

Table 4-2 Summary of Respondent Identified Best Practices: HVAC

Types of Equipment	Efficient HVAC Equipment Selection
Packaged Equipment	Engineers ,construction firms, and several architects describe efficient packaged equipment: ▪ "Displacement ventilation air with VAV systems." [Note: these are not packaged systems] ▪ "On board control logic to operate at peak efficiency. Controls are built in and they search for the most efficient operating parameters versus the contractor coming out and programming the units." ▪ "Evaporative condensing units, demand controlled ventilation, VFD's." ▪ "RTU tonnage based on the envelope and energy management compliance. Within that there are efficiency controls for CO2 levels. Only brings in enough air that is needed to meet code in order to be more energy efficient. High efficiency motors." ▪ "Condensing chillers. Induction units (chilled beams)" [KEMA note: these are not packaged systems] ▪ "Mini-ducted heat pumps" ▪ "Try to maximize user comfort and energy efficiency. Always use high SEER."
Built-Up Central Plants	Engineers, construction firms, and several architects describe efficient central plant components: ▪ "Weissman condensing boilers; Chillers by SMART who makes Turbocore with magnetic bearings. The chiller is excellent at partial loading. [We] also like to use displacement ventilation in central systems with 100% direct outdoor air." ▪ "We specify condensing boilers. For chilled water equipment, Danfoss frictionless VFD compressors, magnetic bearings. Major manufacturers include McQuay, Trane, JCI." ▪ "You need a building management system, chilled water reset schedule, and to look at all performance curves properly on the chillers themselves." ▪ "Replacing steam lines, new insulation, etc. to bring up to code." ▪ "We have moved away from central plants -- enormous and no room for projects in city; moved to individual rooftop units - are easier to maintain (any local guy can maintain); central plants are high priced and use selective firms for servicing. Servicing drives decisions here; plus size and noise factors." ▪ "Our approach is to combine 96% efficient condensing boilers with non-condensing boilers to match the full load heating season with partial load season." ▪ "My firm recently did a co-generation plant for [a large university campus] so electricity could be generated and steam used for heating. Recommended central chiller plant on campus for its efficiencies." ▪ "VFDs on all motors and fans. Water source heat pumps with water loop, heating by small boilers sequenced and oversized cooling towers."
Controls	Engineers, construction firms, and several architects describe efficient HVAC controls as: ▪ "Energy management systems and direct digital controls (DDC)." ▪ "Occupancy sensors for control of VAV boxes so that they go to low or minimum setting for ventilation. The latest trend in BMS systems is web-based systems that can be operated remotely." ▪ "Trending and tracking on BMS to tell when a control system needs to be adjusted and have components that are electrically metered (i.e. submetered) and sensors that are tracked and trended." ▪ "Demand controlled ventilation, water temperature resets, operational start/stop." ▪ "Make sure the controls contractor knows how to program energy efficient technology. Make sure the occupancy schedule is right."

There were no consistent trends in respondents' views on what constitutes best practices in regard to specification of packaged HVAC equipment. Opinions about packaged units varied greatly, and often respondents mentioned HVAC terminal delivery systems (such as VAV boxes and chilled beams) as if they represented the entire HVAC system.

- Several architects and one Owner answered that they try to avoid packaged units due to their short life cycle, difficult maintenance, and poor controllability. However, in direct contradiction, one architect stated that his firm is trying to use fewer central plants because packaged rooftop units are easier to maintain.
- When packaged units are specified, respondents look for high EER and SEER values, although no numerical values were mentioned in the interviews.
- Engineers look for systems that have smart on-board control logic so that packaged units operate at peak efficiency. Smart on-board control logic seems to be preferable to programming provided by a controls contractor.

Similar to packaged units, there were no consistent trends for best practices in design of built-up central plants. The most common central plant strategies reported by firms that work on building scale systems include:

- High efficiency condensing boilers coupled with a non-condensing boiler for peak heating season;
- Proper matching of chillers efficiency and building heat loads;
- Chiller compressors with magnetic, frictionless bearings; and
- Ventilation reduction for labs.

Several design opportunities emerged from the Top 10 design and construction firms who work on campus projects including:

- Upgrades to district distribution systems, i.e. pipes and improve pipe insulation;
- Seek economies of scale via central chiller plants; and
- Implement co-generation systems where a year-round heat source can be used effectively.

Building management systems (BMS) are not always effective tools for energy management. Several engineers indicated that complex controls can often be more problematic than helpful. An architect from a Top 11-25 firm that specializes in public building design warned against poorly trained facility managers using BMS's:

> *Building management systems can be a good mechanism for saving energy but frankly, you have to very careful about how and what you implement. If the operator taking over the system is not well-versed or educated on the system, then the BMS can easily be overridden and savings completely negated. Who knows whether the [Owner] will actually pay for a controls contractor to regularly update the BMS software and make sure that sensors are still within their calibration range?*

Variable Frequency Drives (VFD's) are a preferred efficiency measure for packaged units and built-up central plants. Engineers feel strongly that VFD's are an important efficiency measure for pumps and fan motors - anywhere they can be utilized. As one engineer said emphatically, "VFD's for *everything."*

The percent of projects with efficient HVAC equipment since 2008 has either increased or stayed the same for all respondents. Respondents provided the following reasons for the increases observed since 2008:

- "Code driven and energy modeling driven. Cost-wise with new codes they can put in smaller unit and have savings for everybody."
- "People are responding to cost of energy and concern about environment."
- "Owners are reaching for higher value and recognizing the ROI."
- "Mainly the utility incentive."
- "America has finally awakened to the green message. People are aware of it. No longer need to explain why energy efficiency is good."
- "The energy code is more and more restrictive so you have to increase efficiency."
- "Awareness of lower operating costs for efficiency; reduction of greenhouse gases."
- "Equipment technology has improved in terms of its efficiency, and prices have improved."

4.2.3 Building Shell

In the building shell portion of the interview, market actors were asked to describe what design and technologies represent the best practices for producing a high performance building envelopes. When it comes to the types of technologies or materials that are used, most agree that to produce a high performance envelope, increased insulation, low-e glass, air- and vapor barriers, and shading devices are becoming more common practice. Envelope design seems to be the area where architects and engineers are working more closely together. Two engineers stated that the architects do consult them on insulation issues and air-barrier; traditionally, the design of wall sections was only performed by the architect.

Based on the interviews, there does seem to be some concern and confusion about how to piece together the different components of the wall and roof assemblies as well as a lack of understanding of what the best strategies are for designing a high performance building envelope.

Table 4-3 presents some of the recurring comments from the respondents.

Table 4-3 Summary of Respondent Identified Best Practices: Building Envelope

Best Practices for Building Envelopes
▪ Engineering firms prefer roof insulation of R-40 and tend to instruct architect to construct at least an R-30 roof and R-20 in the walls. Architects will argue that the increased insulation reduces the net floor space in the building.
▪ Architects complained that no one has come up with a suitable envelope assembly. Insulation has been moved from the inside of the wall to the exterior of the wall and no one knows where to put the air barrier and vapor barrier - and one ends up putting fasteners for the veneer through the air and vapor barriers anyway.
▪ One architect stated he would like to see out-swinging and in-swinging operable windows to reduce the losses from incomplete seals of operable windows. He also expressed interest in automatic system controlled by a Building Energy Management System that opens and closes windows automatically.
▪ Complete wrapping of buildings, air barriers, vapor barriers, and rain screens are code.
▪ It is becoming more common to consider and specify thermal breaks, shading devices, scanning and testing, commissioning of the envelope, and double facades.
▪ Industry vendors are starting to realize they need to look at envelope design as a whole assembly and are offering more options.
▪ Architects are pushing to work in the field more to ensure that envelope components are installed properly.
▪ Increasingly, contractors are requesting mark ups of exactly how the envelope is to be constructed before proceeding with a project.

Optimal envelope design continues to be a source of debate among architects and construction professionals. Building envelopes must serve multiple functions such as, basic aesthetics, moisture management, and management of interior thermal conditions. Envelope design has become increasingly complex. In addition to the many technical functions of the envelope and the aesthetic considerations, designers also have a wide variety of building façade, sub-façade, and insulation products to consider. One architect from a Top 11-25 firm asked that the utilities provide a description of an energy efficient wall assembly.

Most architects stated that high efficiency envelopes were installed on their projects. Twenty-two of 31 architects stated that at least 90% of their projects were designed with highly efficient envelopes. Contractors tended to agree with these statements. Only one contractor stated that less than 85% of the buildings he worked on used a high efficiency envelope system. Market actors provided the following strategies to increase efficiency:

- Extensive air sealing;
- Increased wall and roof insulation;
- More efficient glazing assemblies;
- Less glazing overall;
- Double façades;
- Commissioning of the building envelope;
- The use of thermal scans and envelope testing (for air leakage);
- Complete wrapping of envelope tied to windows ;
- Code-required vapor barrier; and
- Pressure testing of assemblies.

Most of the market actors interviewed agreed that the share of buildings using high efficiency envelopes had increased over the last 3 years. Most respondents stated that the primary reason for this increase was due to the building code. However, others stated that general awareness, energy costs, and increased availability of energy efficient products have also played a role. There were six architects who commented that the efficiency of building envelopes had not changed over the last three years. When asked, they explained that it's been their standard practice for a long time to design efficient envelopes.

4.2.4 Building Simulation Modeling

The evaluation team administered questions concerning the use of building simulation modeling in the design and construction process only to architects and engineers.

All engineers reported that building simulation modeling is used to inform the design of the building while architects were generally mixed on whether or not building simulation modeling is used to inform the design. The engineers' responses seemed to conflict with those of the architects which may be an indication that engineers typically don't use whole building simulation modeling to help architects make design decisions on things like increased wall or roof R-values or window to wall ratios. Overall, answers reflect a variety of experiences with building simulation software; some firms embrace modeling as part of the early design process and use it to inform design while others only see modeling as a way to verify the energy performance of the design. In cases where building modeling is required (e.g. LEED or MA-CHPS projects) it is not clear from the engineers' responses whether modeling is used as a design tool, or whether it is used only to verify the design.

The majority of engineers (7 out of 11) stated that modeling is used for less than 60 percent of their building projects. Although all engineers stated that their firms use building modeling, they also stated that building modeling was typically only used for LEED/MA-CHPS projects, public schools and other institutional projects where it is required. More sophisticated clients that are well informed on energy issues - such as hospitals and data centers, will use building modeling.

Most respondents have experienced difficulty in synchronizing the process of design with the timing of building an energy model. As mentioned above, many respondents reported that they used modeling only for design verification rather than a tool to inform design. When questioned further about why this occurs, respondents replied that modeling firms were not engaged early enough in the design process or that modeling firms were not able to meet the project deadlines. This may be a result of design teams failing to recognize the value of modeling as a design analysis tool.

Most respondents who embrace modeling use it on all projects. A handful of respondents indicated that modeling is driven by LEED requirements and is valuable when buildings are large and house complex, interactive systems.

Relatively few respondents showed an understanding of the relationship between site planning and energy consumption. A mix of responses was received to the questions regarding whether or not energy efficiency is a consideration during the site planning phase. Only six architects and three engineers said that energy consumption is always a factor to consider when planning for a new building. Based on the statements made, many respondents confused landscape/civil design (e.g. exterior lighting, and storm water management) with strategically siting a building (see examples below) to reduce energy consumption. Of the respondents who stated that energy consumption was a factor in site planning, their level of analysis and its overall importance was unclear.

Design teams are most likely to consider energy efficiency in site planning when the owners understand that building orientation affects building performance. Many architects mentioned the need to maximize energy efficiency through proper solar orientation of the building and planning for different treatments for the south and north façades. Even so, new construction siting is often limited by space constraints in urban settings, and street grid patterns.

Mechanical engineers rarely play a role during the planning level of design. According to most respondents, by the time an engineer becomes engaged in the project, the architect has already placed the building on site. Engineering firms expressed interest in becoming involved earlier in the design stage; even if it is limited to building massing, orientation, and evaluation of shading – overhangs and fins.

4.2.5 Building Commissioning

Building commissioning was discussed only with architects and engineers. In general, respondents were "somewhat" to "very familiar" with commissioning process and spoke positively about the importance of commissioning.

Overall, architects and engineers felt commissioning was very important to the performance of a new building. For the most part, both engineers and architects felt commissioning was valuable to the performance of a building; however, a few respondents indicated that if the contractors and engineers did their job right in the first place it wouldn't be necessary. Furthermore, costs of commissioning are viewed as prohibitive for some Owners or developers.

Owners typically have trouble justifying the cost of building commissioning. The two consistent barriers that emerged during the interviews that prevent commissioning from becoming standard practice are (1) the costs to hire a commissioning agent and (2) the lack of understanding from a building owner's perspective of its impacts and avoided costs.

Projects are only likely to be commissioned if the project is pursuing a LEED or Collaborative for High Performance Schools (CHPS) certification or if it is a state funded project. The types of projects likely to be commissioned according to the respondents include:

- LEED/CHPS Projects – Construction phase commissioning is mandatory for all LEED projects. Design and construction phase commissioning is required for CHPS projects supported by the PAs.
- DCAM - For all new construction and major renovation projects under auspices of the MA Division of Capital Assets Management. LEED certification is required.
- MSBA - All new construction and major renovation projects under auspices of the Massachusetts School Building Authority. The MSBA values the commissioning process to the extent that it arranges and pays for comprehensive commissioning services for design and construction phases.

The importance of commissioning is increasing. Three engineers stressed how commissioning is becoming more important because equipment and controls are getting increasingly sophisticated and complicated. One engineer stated that “as systems get more complicated it’s harder to make sure they operate correctly.” Architects generally agreed with this assessment and stated further that systems do not always get installed the way they’re designed.

4.3 Energy Codes

During the last four years, the Massachusetts building energy code has changed significantly. The Massachusetts Board of Building Regulations and Standards (BBRS) implemented the 7th edition of the building energy code (January 1, 2009), based on IECC 2006 with 2007 amendments. The update was quickly replaced the 8th edition (July 1, 2010), based on IECC 2009. Both editions include a voluntary appendix known as the Stretch Code. At their discretion, Massachusetts municipalities may adopt the Stretch Code, which effectively requires commercial building performance to be 20% better than the current statewide energy code.

This section examines the effects of energy code upgrades on the design and specification practices of firms operating in the Massachusetts commercial and industrial market.

Most architects indicate that they are somewhat familiar with the code changes. Since the 8th edition of Massachusetts State Energy Code *(780 CMR) went into full effect recently, July 1, 2010, many designers have not had a chance to work on a project under the current code, which is IECC 2009 with Massachusetts amendments. Similarly, even fewer have had the opportunity to work on projects in municipalities that have adopted the Stretch Code.

The energy code is a moving target and something that design consultants have to be ready to respond to going forward. Prior to 2009, Massachusetts had maintained the same energy code standard (ASHRAE 90.1-1999) as established in the early 2000's. During that nine-year period firms working in the state did not need to reassess the efficiency of their design practices. In the space of 1 ½ years, the code has effectively changed 3 times – including the new Stretch Code, which, as of this writing, has been adopted by over 70 communities.

One respondent stated that the rapid code changes have made things difficult for his staff. The implication is that the extra time needed to master the code changes is eating into A&E firms' project fees.

In general, architects and engineers have to pay more attention to everything they design and specify related to lighting, envelope, and mechanical systems. Code changes force engineers and architects to examine their specification practices more closely. Standard products, brands, models, and layouts, may or may not work in a new code environment. Consequently, designers have to spend more time on product selection, detailing of assembly instructions (for walls and roofs), and interacting with local code officials.

Designers reported that to meet code, they must be much more careful in their placement of the vapor and air barriers and that they must ensure that the air barrier is continuous. Similarly, engineers noted that the new code requires heat recovery and economizers for smaller capacity air handling units and that HVAC equipment in general must meet higher efficiency standards. The new code is introducing a level of uncertainty that has been absent in recent years. Designers have to spend more time balancing the envelope efficiency with lighting and HVAC efficiencies to understand the overall building performance. Borrowing from previous time-tested designs and strategies is not guaranteed to meet code.

The code is changing envelope design. It encourages better specifications for vapor and air barriers and requires the barriers to connect with the envelope. A few architects stated they "have to pay more attention" to their designs because of new code requirements and that they now implement measures that would have before been considered alternative energy efficiency measures. Engineers stated that they have more difficulty meeting the lighting power density requirements while also trying to meet the architects' lighting requirements.

There are fewer equipment options to meet code. Recent changes in the code have essentially made mandatory a set of common energy efficiency measures that had previously been optional. These include reduction in lighting power allowances, increases in minimum efficiency ratings for heating and cooling equipment, and increases in required insulation levels.

However, the indirect effect of restricting design to fewer equipment choices means that, "In a way, the code changes have made it simpler; now there is only one way to meet the energy code." This comment was made by an electrical engineer from a Top 10 firm. He also noted that the challenge of meeting the current code and Stretch Code has pushed his firm in a "good direction" by forcing them to analyze their designs, carefully select and place lighting, and carefully select HVAC equipment and delivery approaches.

In most cases, those engineers, architects and contractors who do work outside of Massachusetts, stated that they do not alter their strategies for states whose codes are less strict. When it comes to energy systems, design practices were generally the same for projects in other states. A few exceptions that were noted include: continuous vapor and air barriers, for which one architect noted that although thermal breaks are required in Massachusetts, the codes are wrong in terms of where they should be placed. One engineer stated that they will specify evaporative condensers in this area, but not south of Philadelphia. Another engineer stated that every state will soon be adopting the latest IECC codes, and the fact that Massachusetts is ahead of the game is a good thing.

4.4 Promotion of Efficient Design Practices

This section examines the firms' current promotional efforts to encourage customers to select energy efficient designs and equipment.

Almost all firms interviewed market their ability to deliver energy efficiency. The most common marketing method is directly to clients through proposals. Firms highlight completed projects that are LEED certified, and the number of LEED accredited professionals they have on their staff. Naturally, their firms market their high performance design prowess on their websites. A few firms present at conferences, seek awards (e.g. from the Illuminating Engineers Society), and develop case studies on selected projects.

All engineering and architecture firms indicated that they promote energy efficient designs and equipment. In general engineers and architects provide energy efficient options to their clients when developing the building program. Contractors get involved on an at-risk basis. After they review construction plans and specifications, they assist in choosing equipment or provide alternative options to clients. One Top 10 contractor stated that they evaluate plans and often recommend equipment that is more efficient. In regard to promotional methods, most architects reported that they provide options and recommendations based on some technical analysis to show the benefits of certain systems. Two large engineering firms and two architecture firms in the Top 10 stated that they offer a rigorous analysis of returns on investment and a life cycle cost analysis.

Customer demand for energy efficiency and changes in building codes were the main reasons for increased effort in promoting energy efficient equipment. The customer demand for more energy efficient equipment is likely prompted by the recession and a much greater focus on operational costs. Some firms have committed to AIA's 2030 Challenge and to the LEED 2020 Net Zero Goal.

All market actors interviewed indicated that they were promoting efficiency the same as or more than they did in 2008. Many stated that the reason is related to increased client awareness of energy and green issues as well as to meet client's desires for decreased operating costs. Respondents cited:

- **Altruistic motives**. "It's the right thing to do;" and "…energy efficiency and sustainability are a core belief of our firm and a basis for how we operate."
- **Client demands.** "…if we didn't [provide energy efficient design], we wouldn't win any jobs."
- **Building codes.** "…codes, the USGBC, and a whole cultural push toward energy efficiency" drove their change.

A majority of market actors responded that overcoming first costs of efficiency upgrades is their greatest challenge. Capital costs are a concern for private and public projects. Including the higher first cost of energy efficiency options in public sector projects can be particularly difficult because construction budgets are tight and project documents, such as budgets, are open to public scrutiny.

Respondents identified a range of other challenges associated with delivery and operation of energy efficient options. Contractors and the construction trades are used to "doing things in a certain way." In other words, they may not follow the construction document, specifications, and control sequences exactly as written. They may substitute with "cheaper" products that don't perform as well.

The most cited challenges include:

- Convincing clients to use unproven technologies;
- Training personnel to install newer, more complicated systems;

- Communications between different types of equipment;
- Capital costs (owners tend to focus on up-front costs);
- Specifying and coordinating more sophisticated equipment and controls (i.e. constructability of the design); and
- Insufficient lead times to allow for additional time needed for acquiring and incorporating energy equipment and design into projects.

Most respondents stated that their ability to offer energy efficient design is very important to their firms' overall business success. Those who highly rated the importance of their ability to offer energy efficient design firmly stated that all building designs need to take into account efficiency because it's what clients demand. Firms that did not place a high regard for ability to offer energy efficient design stated that there are other factors that drive a customers' decision to hire them. One architect stated "These days every one claims to be green or energy efficient, so it's not really a differentiating factor."

Few architects consider greenhouse gases in their design and specifications practices. Generally, architects address GHG's indirectly through energy efficiency reductions and by following LEED credits on Enhanced Refrigeration. Only one architect stated that they were calculating and quantifying GHG's for one of their projects. This was viewed as a "voluntary" attempt to meet the Massachusetts Environmental Policy Act (MEPA)[16] requirements. Several architects working on projects at college and university campuses were addressing GHGs to meet the institutions' commitment to the American College & University Presidents' Climate

[16] MEPA is administered by the Executive Office of Energy and Environmental Affairs (EEA). The Policy applies to any new project for which an Environmental Notification Form is filed for MEPA review after October 31, 2007. Specifically, the Policy applies to MEPA project proponents who are required to complete an environmental impact report and where the proposed project (i) is undertaken by the Commonwealth or a state agency, (ii) will receive financial assistance from the Commonwealth or a state agency, (iii) requires any air quality permit from the Department of Environmental Protection, or (iv) requires a vehicular access permit from the Massachusetts Highway Department under its new permitting rules.

If a project is subject to the Policy, EEA requires a project proponent to calculate the baseline condition, which includes quantification of GHG emissions from three separate sources: direct emissions from stationary sources, indirect emissions from energy consumption, and indirect emissions from traffic generation and associated fuel combustion.

Commitment[17] (ACUPCC). Other reasons market actors consider GHG in design of new building include:

- "The inevitability of global warming is a factor."
- Environmental stewardship concerns of customer, firm, or both.
- LEED requirements.
- Reduction of operating costs.
- MEPA requirements.

Specific actions that respondents have taken to address greenhouse gas emissions include:

- Specification of energy efficient equipment and creating efficient envelope design
- Specifying low or no VOC building materials and finished surfaces.[18]
- Reduction of high heat trapping greenhouse gas refrigerants in air conditioning systems.
- Specification of local materials and materials that have low embodied energy.
- Use of low-sulfur diesel fuel in construction equipment.

Most chains or franchises have lighting and HVAC guidelines for energy efficient design or equipment purchases, but few have guidelines for envelope design. In general, respondents do not make recommendations that differ from the chain or franchise standards. One respondent stated that in one case they noticed that many of the standards they were directed to use were out of date and not the most efficient on the market. In some cases, chain and franchise stores who were pursuing LEED certification needed to change the client's standard designs to meet the LEED requirements.

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[17] The signatories of ACUPCC commit to developing policies and plans and undertaking specific actions to work toward climate neutrality on their respective campuses. To have a goal of climate neutrality means that operations of a campus will not adversely impact the global climate.

[18] Some practitioners confuse volatile organic compounds (VOC's) with greenhouse gases. GHG's are dominated by relatively stable compounds at ground level. They include carbon dioxide, carbon monoxide, methane, nitrous oxide, fluorinated carbons, sulfur hexafluoride, and HFC's. VOC's, on the other hand, are recognized to be irritants and potentially carcinogenic, particularly within a building interior and are generally associated with insulation, sealants and adhesive products. Examples include formaldehyde, benzene, acetone, toluene, but these are just handful of chemicals from a much longer list of VOC's found in the built environment.

4.5 Program Awareness

The electric and gas PAs have offered new construction assistance programs since 1987 and 1997, respectively. This section assesses program awareness among firms. It also assesses the effectiveness and influence of new construction incentive programs on the design, specification, and/or construction processes. It concludes with customer suggestions for improvements to the new construction programs currently offered by the PAs.

Table 4-4 provides selected responses from market actors on the importance of new construction program incentives to their decision-making process.

Table 4-4 Effect of Incentives on Adoption of Energy Efficiency Measures

Effect of Incentives on Adoption of Energy Efficiency Measures
▪ Designers and contractors who participate in PA-sponsored incentive programs are very supportive of the programs. A clear example is provided by an architect who had worked in a municipal light & power territory. The customer adopted some measures because they were the right thing to do, but certain measures, like daylight dimming systems, were ultimately rejected by the customer due to the increased capital costs.
▪ “It helps the first cost of an incremental upgrade, can make a difference in what is installed.”
▪ “Most clients are aware that it's now easier to get money back into their pockets.”
▪ “Decision isn't just driven by incentives - in a comprehensive design assistance approach there might be more influence but often the design process is too far gone to do the CDA approach.”
▪ “It depends, some clients don't want to spend money, or may not be familiar with programs.”
▪ “Varies widely on building owner type. Very important for owner who is paying bills; only semi-important for developer unless incentives payback first cost. “
▪ "It's all about money for the customers. They simply wouldn't spend the extra money for efficiency if they didn't receive incentives to do so.”

Larger clients tend to be more familiar with the programs. One architect noted that the smaller clients “usually don’t have a clue” about incentive programs. A few architects became defensive during the discussion of the programs, stating that the utilities should do a better job at advertising and educating firms about their incentives. Several suggested that the program managers currently focus more outreach and attention on engineers, and therefore the architectural community is less informed.

Other architects were very aware of the programs and indicated that, "utility representatives are extremely attentive to our clients." Sometimes the larger clients are more aware of incentive offerings than the architecture firms are. This seems to be the case for firms who work on sizeable projects that involve substantial kWh and therm savings.

Architects working on public school projects appear to have an excellent knowledge of the incentive programs and work closely with the engineers to maximize rebates.

Engineers and construction firms/developers demonstrated the most awareness of new construction energy efficiency programs. Some architects have excellent awareness, but many either rely on the design engineering firms or other consultants to engage programs, or do not participate in programs at all.

- Of those interviewed for this study, 23 out of 31 architects, 11 out of 11 engineers, and 8 out of 9 construction management firms had heard of MA new construction incentive programs.
- Based on the interviews and the experience of our team, we hypothesize that architects do not fully recognize their roles as key contacts and drivers to engage clients/projects with the energy efficiency programs. Architects typically assemble design teams, including mechanical, electrical, plumbing, civil, and structural engineers, and landscape consultants; they represent the entire design team and manage client relations. Their primary responsibility is to deliver a process and design that meets their client's needs – developing and articulating a functional building design, evaluating alternate designs, managing construction costs, coordinating design work of other trades, keeping the design process on schedule, and meeting with code officials. Architects are juggling multiple tasks and typically doing so under the pressure of project deadlines. Consequently, many architects view energy efficiency as one of many competing objectives and do not recognize, as design team leaders, their potential influence in engaging their clients and the PA's to optimize efficiency.

Although new construction incentives are considered to be "very important", they compete with other client objectives, depending on the type of client and building type. Market actors generally agree that clients who own and operate buildings are more willing to consider increased first costs in a trade off for lower operating costs. Consequently, owner/operators are more likely to pursue incentives. The exceptions are owners of complex facilities such as medical centers, lab facilities, bio-tech firms, and university buildings who typically weigh multiple factors during system selection. They consider the ability of their staff to control and maintain equipment, the cost of maintenance and replacement, and the risk of equipment failure. In these cases, it appears that incentives may not offset the risks of unfamiliar equipment and unknown maintenance reliability.

Architects and engineers are not able to consistently identify the most appropriate point during the design process to contact PA's. Some architects who are aware of the programs do not have any knowledge or direct experience of when to contact the energy efficiency program managers. For those who did, answers still range from "the first meeting with the customer" to much further along in the process. One architect notes that, "Consultants usually wait until the mechanical engineer has a good grasp of what they're doing - usually by design development - to contact the utility. It's hard to provide much to utilities in schematic design because they just have narratives and you start selecting equipment in design development - there's nothing to see in schematic development."

In order to have an impact on the project design, utilities must engage the customers early, be consistently engaged throughout the course of a project, and meet project milestones. One major developer and construction management firm noted that in the past they haven't received feedback from the utilities in a timely manner. They can't wait for the utilities to make technical suggestions because they have schedules they need to meet. This finding highlights the importance of delivering program technical support and modeling in accordance with project schedules.

Few respondents indicated that they received technical assistance from the program. Architects are not as familiar with technical assistance offerings from new construction programs as engineers. Most architects we spoke with indicated that they

- Have not received any services,
- Have received services but couldn't identify what they were, or
- Have received energy modeling assistance (indirectly) or lighting design assistance.

Five out of 10 engineers stated that they had received technical assistance, but only three of those claimed to have received assistance with energy models. Other assistance came in the form of advice on specifications or help processing paperwork.

Those market actors interviewed provided mixed responses when asked about how effective the programs were in promoting energy efficient design. The main reasons are:

- Not everyone takes advantage of the offerings.
- It's an arduous process.
- They do help make more costly energy efficient equipment more accessible.
- The programs are behind on some technologies (e.g. LEDs).

Respondents had a variety of responses when asked if their firm's participation in the programs had an influence on their design/ specification/ construction practices. There were many non-responses. Those who did respond reported a variety of experiences. On one end of the spectrum, one firm that designs schools stated that they have developed standard practices that meet the new construction program requirements - and they carry over to projects with municipal utilities where there aren't any incentives. On the other end of the spectrum, architects struggled to identify how the programs may have changed their design and specification practices. This may be due to the fact that the majority of incentives address mechanical and electrical specifications, but touch less directly on the siting of a building, construction of the building envelope, or fenestration choices, for which architects are directly responsible.

Respondents identified a number of potential improvements to the new construction programs. These included**:**

- Create a website that shows rebate info for equipment and by manufacturer.
- Put informational packages together and send them directly to architects
- Create informational sessions that help architects earn continuing education units (CEUs).
- Host "lunch and learns" at architecture firms.
- Engage architects more thoroughly so that they are aware of programs and can sell them to their colleagues and clients.
- Support and educate designers on more innovative technologies and practices.

Additionally, one architecture firm complained that the prescriptive programs were a little too prescriptive and had had an issue with a certain lighting specification. Their suggestion was that there should be something in between a straight forward prescriptive approach and full building modeling. Another architect also suggested that the utilities host sessions or workshops at the annual AIA meeting and further suggested that if this already occurs then publicity of the event needs to be increased. They also recommend distribution of mailers to the design firms - not just architects but also to electrical engineers.

5. Conclusions & Recommendations

Below we summarize the key conclusions from the market characterization research reported in Sections 3 and 4. We use these findings to support the development of recommendations for improvement of the PA's commercial new construction programs.

5.1 Conclusions

Demand for energy efficiency design and equipment has been increasing. Examples of each include:

- Increased awareness of energy costs and savings from energy efficiency measures
- Market-driven green building rating systems such as LEED and MA-Collaborative for High Performance Schools
- A quick succession of energy code changes
- The adoption of the energy "Stretch" code by 70+ Massachusetts municipalities
- The mandate for 20% more efficiency in new construction for state buildings (Executive Order 484)
- Rapid advancement and greater availability of energy efficient technologies

Building professionals in the commercial sector continue to face barriers in energy-efficient design and specifying energy efficient equipment. Building professionals recognize the importance to their businesses of promoting energy efficiency, but continue to face obstacles in delivery. The principal barriers include:

- First costs of energy efficient equipment (owners tend to only focus on up-front costs).
- Extreme diversity in construction decision-making structures and the decision making criteria among the various customer segments in the commercial sector.
- Reluctance of designers and contractors to change established procedures and specifications.
- Lack of awareness of the relationship between fundamental construction decisions such as building siting and subsequent opportunities to effectuate energy savings.

Additional challenges that architects, engineers, and construction managers face when trying to incorporate energy efficient equipment are:

- Convincing their clients to use unproven technologies
- Resistance from owners who need to train personnel to understand and operate more complicated systems
- Coordinating more sophisticated equipment and more sophisticated controls
- Lead times, product availability and constructability

Some building professionals are well-informed on PA program offerings and are comfortable in using those programs. Most, however, have only modest knowledge of the programs and report that they have experienced problems in accessing program services. Many of the architects interviewed are unaware of how new construction programs work. They tend to rely on mechanical engineers or other consultants to pursue incentives, although most are interested in learning about new construction incentive programs. Other possible causes for lower market penetration include:

- The time it takes to coordinate and apply for the incentives is a deterrent in this market where consultants need to reduce fees as much as possible and aren't able to budget for the extra time it takes to participate in the program.
- The point at which the design teams engage the utilities in the project is inconsistent; therefore, there are mixed results on the perceived helpfulness of the programs.

Recent changes to the Massachusetts Energy Codes have pushed building professionals to reconsider their approaches to energy-efficient design.

- Equipment technologies seem to be keeping adequate pace with code updates and stricter energy efficiency requirements. Although equipment selection was noted as a challenge, there were no complaints that it was impossible.
- The recent rapid pace of code changes is causing some concern in that consultants find themselves with a constant learning curve ultimately costing them time and money.
- It is believed that due to the adoption of the Stretch Code there is some spillover effect in communities that have not adopted that code. Engineers and architects tend to design to match the higher standard. There is evidence that this spillover effect crosses state lines as well.

In regard to specific energy efficient equipment, trends, and technologies, a wide range of responses was reported.

Lighting

- Architects, engineers, and construction managers expressed strong interest in LED fixtures; almost all mentioned that LED's are still too expensive to fit out more than just a portion of a building project – with the exception of parking fixtures.
- The use of occupancy sensors is becoming standard practice, but daylight dimming systems, at a cost premium, do not get into nearly as many projects.
- There is an inherent struggle for lighting designers to try to minimize lighting power densities, while adequately addressing the lighting desires of the architects.
- Market penetration of efficient fixtures has increased to the point that in some cases it is actually cheaper to install the more efficient fixtures.
- There appears to be high market penetration of high performance T-5 and T-8 pendant, direct/indirect fixtures; however, based on survey responses, designers and construction managers do not demonstrate consistent knowledge of the types of fixtures and lamps that are considered to be high efficiency.

HVAC

- Variable Air Volume HVAC systems are becoming common in practice in the design and construction market
- Evaporative condensing units, chilled beams and cogeneration systems are gaining wider acceptance and recognition
- The benefits of incorporating advanced controls, monitors and sensors are being recognized. These systems are being more widely used although some engineers are wary of these technologies because they are seen as more problematic than helpful.
- The use of variable frequency drives is widely recognized as an energy efficiency best practice

Building Shell

- While it is generally agreed that increasing wall and roof insulation is desirable, there are fundamental disagreements among architects and construction managers about what constitutes an efficient wall or roof assembly.
- Low-e glass, thermal barriers, and shading devices are common in practice.
- Code has had a significant effect on the way wall assemblies are designed and constructed
- There is lack of understanding and agreement on proper design strategies among architects and construction managers for high performance building envelopes

Building Simulation Modeling

- Opportunities to fully engage design teams in the Comprehensive Design Assistance (CDA) program are lost when building simulation models and incremental system cost information cannot be obtained quickly enough to affect efficient equipment and measure selection.
- Buildings that are not required to be modeled due to a LEED certification process, government mandate, or participation in utility incentive programs generally do not get modeled.

Building Commissioning

- Building commissioning is regarded very favorably by architects and engineering firms and is viewed as necessary for complex buildings like bio-technology laboratories, medical facilities, large institutional buildings, and schools.
- Because the value of the commissioning process is difficult to quantify, Owners who do not work in facility management, do not readily understand its value. One architect noted that Owners view commissioning as a luxury. This effect appears to be exacerbated by the fact that one cannot predict the impact of commissioning on operations, which makes the cost of commissioning difficult to justify.

In general, market actors have thoroughly embraced high performance T5 and T8 lamps and electronic ballasts, and they are specifying far more lighting controls. All three types of market actors expressed enthusiasm for LED lamps and the associated savings they offer. It will be important for PA's to monitor the LED market to ensure that when new LED products are accepted into new construction programs, the information is quickly communicated to the market.

In regard to HVAC and motors, variable frequency drives (VFDs) were mentioned very often as superior efficiency measures. Engineers and construction managers seek high efficiency boilers and opportunities for co-generation systems. Two engineers mentioned that they like to specify compressors with frictionless magnetic bearings (for chillers).

With recent updates in the Massachusetts Building Code and adoption of the Stretch Code in 70+ municipalities, architects and engineers from all types and sizes of firms are having to re-evaluate their design strategies. Rather than swapping out one piece of equipment for one that is incrementally more efficient, they' re determining whether they can downsize or even eliminate equipment. They are pairing non-condensing boilers for the peak heating season with condensing boilers for shoulder season loads. They are asking for independent reviews of lighting layouts and watts/SF calculations three times before finalizing designs. Innovation, evaluation and re-design are critical tools in reaching the next efficiency threshold.

5.2 Recommendations

Throughout the course of the interviews, participants offered a variety of suggestions that they thought would help improve the programs. Statements made that align with common themes include:

“More awareness and outreach is needed to the architectural and engineering community. The programs need to be advertised better.” This was common among all groups – architects, engineers, and construction managers.

“We’ve seen different forms for pumps and HVAC, seems like they could streamline the process a little better” -Engineer

“Make the program more understandable to architects, and maybe provide examples of good lighting practices” - Architect

“The CDA approach needs to be improved. The biggest problem is that you don’t know what you’re going to get for incentives until you’re too far along in design to make changes.” - Engineer

"Apply prescriptive programs more broadly and improve the application process." - Engineer

"Compensate engineers." - Engineer

"[They] need to get up to speed on LED lighting." – Electrical engineer

Based on the interviews and findings, the LCIEC Team has developed a list of recommendations intended to help improve the functionality and overall success of the programs. The recommendations are based on the challenges and barriers to energy efficiency deployment mentioned above.

To address the more significant design and construction challenges relating to furthering energy efficiency and continuing to improve program results, we recommend:

- Address the First-Cost Barrier – Consider alternative incentive approaches such as tiered incentives for higher levels of efficiency. Consider expanding financial or technical assistance offerings for life cycle cost analysis to demonstrate the longer term value of accepting higher first costs.
- Improve the value of technical assistance offerings by being consistently engaged with project design teams. The impact of the utility intervention is not fully realized because information about incentives and alternative technologies choice is not delivered on time to design teams. Modeling firms need to quickly upgrade models and turnaround results to customers. For program implementers or technical TA's to become an integral a part of the design team, architects and engineers will need to be reminded of the value of keeping implementers/TA's up to speed on design changes so that they may provide value to design decisions.
- Assist architects and engineers in understanding appropriate high performance building envelope design strategies for the Massachusetts climate. Effective envelope design is critical to achieving long term electrical and thermal savings in buildings. KEMA recommends enhancing current program offerings to fully address the knowledge gap on high efficiency envelope design in the market. We suggest a two pronged approach to advance high performance envelope design: 1) Convene a working group consisting of stakeholders such as Massachusetts DOER, the Massachusetts Board of Building Regulations and Standards and the Massachusetts Net Zero Energy Building Task Force and representatives from the architect, contractor, and building science community to study the challenges associated with high performance building envelope design, and 2) based on input from the working group, commission a study of advanced

building envelope designs beyond what is required by code and provide examples of appropriate, high performance designs for Massachusetts. Note that the Boston Society of Architects has previously been commissioned by the Massachusetts Board of Building Regulations and Standards to provide sample details of envelope design that *meet* code.

- Continue to build upon educational seminars, similar to Advanced Building seminars, to provide education and programmatic support on integrated design and whole building performance. Address siting and envelope issues such as climate-responsive design, building orientation, massing, building-integrated lighting controls (e.g. sunshades), programming of space needs vis-a-vis thermal comfort, insulation, and facade treatments. The goal is to achieve deep savings; therefore we recommend that the new construction programs take a leading position on building performance by embracing a program that researches and promotes whole building design practices for the Massachusetts region. This cutting edge program would help define the conversation on building design. We suggest partnerships with the Massachusetts Department of Energy Resources, Boston Society of Architects, graduate schools of architecture, building science and engineering programs, and for-profit and not-for-profit architectural/engineering entities (e.g. Association of Energy Engineers and Massachusetts-Chapter of the USGBC) for both short term and longer term needs.
- Streamline the application process by reducing the amount of paperwork that is required for participation. Aim to minimize the time architects and engineers have to spend on completing the applications. Otherwise, provide compensation directly to the design team which will help offset their costs for participating.
- Establish contacts within the top 25 architects, design engineers and construction management firms who can provide regular updates regarding project plans and timing, and industry trends. Instill the mantra that participation in the incentive programs during the early stages of design will help them maximize the potential building performance levels.

Secondarily, we offer the following as considerations to help further improve program effectiveness and participation:

- Add lighting designers to PA staff. Aggressively market lighting review capabilities to electrical engineers and architects. Track projects as they move through design stages so that there is a final review prior to the end of the construction documents phase. Lighting design is especially important because it can drive savings and affect sizing of cooling equipment.

- Increase the number of architects on the staff of the energy efficiency programs. They can help optimize building siting and envelope measures. They can also help reach out to and educate architects on the programs and efficiency measures.
- Create standard RFP language that requests design teams to optimize incentives on behalf of the Owner. Tailor specification language to different building segments.
- Develop standard construction specification language for the General Conditions section of the specifications that indicates that all new construction incentives will be sought on behalf of the Owner unless the Owner opts out. The specification language should designate a specific member of the design team to follow up with the Program Administrator on behalf of the Owner. Specifications should also alert the general contractor and subcontractors that their equipment selections must meet efficiency criteria or they will be rejected.
- Engage state and local government, the design and construction community, and academic institutions to create program content. Support local academic institutions in creating whole building design education and outreach programs that can serve as a seat of research, testing, education, and design review. In order for buildings to reach higher levels of energy efficiency, skills must be developed to help designers analyze building components, design scenarios, and energy resources.
- Continue to engage local professional real estate associations (e.g. NAIOP), real estate advisors and lawyers. Increase utility program participation in association events that help members understand the benefits of energy efficient design and how the programs can assist. Developers regularly rely on these individuals for advice.
- Expand the current efforts to engage the architectural community in more face-to-face interaction with program administrators through workshops and information sessions, brown bag lunches, etc. In addition, more program mailings, flyers, and other marketing materials were requested by a number of architects.
- Increase marketing and outreach for the energy efficiency programs to commercial and industrial customers. Target trade groups and chambers of commerce to reach a broad audience. Additionally, it may be helpful to reach out to code officials and the Massachusetts Municipal Association to promote awareness with local oversight organizations and to extend the Program Administrators abilities to reach customers who rarely build.

A. Supply Chain Interview Guide

Contact Name: ____
Company: ____
Address: ____
City, State, ____
Telephone: ____
Fax Number: ____

Interview Date: _______ **Interview Time:** _______

[NOTES TO INTERVIEWER:

The primary objectives of this interview are:

- Understand current design and specification practices
- Understand any recent changes in design and installation practices
- Understand perceptions of changes in customer demand for energy efficient design and equipment
- Collect perceived drivers of those changes
- Understand the chain and franchise market and the value of energy efficiency to them
- Characterize the influence of the program on designers and construction managers

Do not read lists unless instructed

Write down all responses for eventual post-coding and analysis. Only use provided response categories for exact matches, do not attempt to classify responses to the most similar category.]

LEAD-IN:

Hi, my name is _______ calling from KEMA on behalf of the Massachusetts electric and gas utilities' Energy Efficiency Program Administrators. We are conducting research on the design and construction of large commercial and industrial buildings in Massachusetts. May I please speak to [Contact name] or someone else at your firm who is familiar with your design and specification practices?

[WHEN CORRECT PERSON]
We have been hired by the electric and gas utilities' Energy Efficiency Program Administrators to research the design and specification practices of key firms working in Massachusetts. Your input will be used to improve the implementation of the statewide energy efficiency programs. I want to assure you this is not a sales call and that the information you provide will be kept strictly confidential. This interview should only take about 30 minutes of your time.

[ENTER NAME OF CONTACT:] ______________________________
[IF CONTACT IS NOT AVAILABLE, ASCERTAIN BEST TIME TO CALL.]

[REPEAT INTRO AS NEEDED, CONTINUE OR ARRANGE FOR CALLBACK]

[IF NEEDED]
For further questions about this study, you can contact Andrew Wood at National Grid. His phone number is (781) 907-2234. Please make sure that you reference the Commercial New Construction Supply Chain Study.

General Company Information & Firmographics

[Note to interviewer: The interview focuses on interviewees' experience and business practices in Massachusetts.]

I'd like to ask for some general information about your company's operations at this location.

F1. What is your job title?

1. Architect
2. Engineer (e.g., Mechanical)
3. Construction Manager
4. Other [SPECIFY]: ____

97. [DON'T KNOW]
98. [REFUSED]

F2. What is the full range of services provided at your location?

[ACCEPT MULTIPLE RESPONSES]

1. Architecture/Design
2. Mechanical Engineering
3. Electrical Engineering
4. Structural Engineering
5. Civil Engineering/Site Planning
6. Construction Management
7. Energy Efficiency Consulting
8. Building or energy systems commissioning
9. LEED consulting
10. Other [SPECIFY]: ____
97. [DON'T KNOW]
98. [REFUSED]

F3. How many full-time employees does your company employ at this location?

[ENTER NUMBER]: ______________
99997. [DON'T KNOW]
99998. [REFUSED]

F4. What is the geographic scope of your (entire) firm's operations?

1. Local/Metropolitan Area
2. Massachusetts only
3. Northeast Region
4. National
5. International
9. Other [SPECIFY]: ____
97. [DON'T KNOW]
98. [REFUSED]

F5. Approximately what percentage of your (entire) firm's annual revenue is represented by projects in Massachusetts?

[ENTER PERCENT]: ______%
997. [DON'T KNOW]
998. [REFUSED]

F6. In the past year, has your (entire) firm provided services to 3 or more projects in Massachusetts in the following categories? [READ LIST IN TABLE]

[If needed: Major renovations include the physical expansion of existing facilities (i.e. additional square footage) and major conversions of existing facilities to accommodate new occupants or uses/functions of the facility. Customers that replace failed equipment (eligible for 2010 Mass Save New Construction Program) are not considered new construction program participants for purposes of this research.]

	Yes	No	Don't Know	Refused
F6a. Commercial new construction	1	2	97	98
F6b. Commercial renovation	1	2	97	98
F6c. Industrial new construction	1	2	97	98
F6d. Industrial renovation	1	2	97	98

[If NO projects of any kind completed in MA in the past 2 to 3 years then THANK and END THE INTERVIEW]

F7. In the last 3 years, has your firm specialized in particular types of buildings?

1. Yes
2. No [SKIP TO D1]
97. [DON'T KNOW] [SKIP TO D1]
98. [REFUSED] [SKIP TO D1]

F8. [IF F7 = YES, ELSE SKIP TO D1]: What types of buildings?

[Accept Multiple Responses. Probe if necessary]

1. Office buildings
2. Healthcare
3. Primary/Secondary Education
4. Colleges/Universities
5. Multi-family residential/Senior living facilities
6. Retail
7. Hotel/Motel
8. Restaurants
9. Process Industrial
10. Assembly Industrial
11. Other (Specify:_________________________________)
12. No specialization
97. [DON'T KNOW]
98. [REFUSED]

Changes in Customer Demand for Energy Efficiency

Next I'd like to talk about your customers' interest in energy efficient design and construction.

D1. On a scale of 1 to 5 where 1 means 'Not at all Important' and 5 means 'Very Important' how important is energy efficient design and construction to your clients?

1. Not at all important
2. Somewhat Unimportant
3. Neither Important nor Unimportant
4. Somewhat Important
5. Very Important

97. [DON'T KNOW]
98. [REFUSED]

D2. Has your customers' demand for energy efficient design in new construction increased, decreased or stayed the same since 2008?

1. Increased
2. Decreased
3. Stayed the same

97. [DON'T KNOW]
98. [REFUSED]

D3. What is the primary reason your customers are interested in energy efficiency as a design objective?
[ACCEPT ONLY ONE RESPONSE. DO NOT READ LISTS]

D4. Any other reasons?
[ACCEPT MULTIPLE RESPONSES. DO NOT READ LISTS]

Reasons	D3 *Most important reason [Accept one response]*	D4 *Other reasons [Accept multiple responses]*
1. Energy efficiency	1. o	1. o
2. Lower utility bills	2. o	2. o
3. Reduced environmental impacts	3. o	3. o
4. Incentives from Program Administrators	4. o	4. o
5. Building codes/regulations	5. o	5. o
6. Occupancy/tenant retention	6. o	6. o
7. Education and awareness by Program Administrators	7. o	7. o
8. Other (Please indicate: ____________________)	8. o	8. o
9. No other reasons	9. o	9. o
97. Don't know	97. o	
98. Refused to answer	98. o	

D5. What objections, if any, do your clients typically raise when you recommend energy efficient equipment or design?

[RECORD RESPONSE:]____

____

____

D6. Generally, who within your clients' organizations has the most influence on decisions relating to energy efficient design and construction on a project?

[RECORD RESPONSE:]____

____

____

D7. Who else is involved?

[RECORD RESPONSE:]____

____

____

[A&E Only] Changes in Respondent's Design Practices

[ASK THIS SEQUENCE FOR A&E ONLY, CONSTRUCTION MGRS SKIP TO CM1a]

Now I would like to talk about your firm's design practices with regard to lighting, HVAC, and building envelope.

Lighting Systems	
AE1a. What technologies do you think represent energy efficiency best practices for lighting? **1) For office space** **2) For retail space, not including high bay spaces** **3) For high bay spaces** [T12] [T-8 (standard)] [T-8 (high performance)] [T-5 (all varieties)] [Probe start metal halide (HID)] [Pulse start metal halide (HID)] [Low-pressure sodium (HID)] [High-pressure sodium (HID)] [Mercury vapor (HID)] [LED] [Induction] [Other (Specify) ________________________]	[Record Response separately for each space type]: 1) For office space: 2) For retail space, not including high bay spaces 3) For high bay spaces
AE1b. In about what percentage of your projects do you specify high efficiency lighting design?	[ENTER PERCENT]: ________% (997=DK; 998=R)

AE1c. In what percentage of your projects are these recommendations installed?	[ENTER PERCENT]: ________% (997=DK; 998=R)
AE1d. Has the percentage of projects installing high efficiency fixtures increased, decreased, or stayed the same since 2008?	1. Increased 2. Decreased 3. Stayed the same 97. [DON'T KNOW] 98. [REFUSED]

AE1e. Why? **[Record answer]**	
AE1f. In what percentage of your projects do you recommend advanced controls? [Probe if Necessary: Occupancy Sensors, Daylight Sensors, Central Lighting Controls, Wireless Control Systems]	[ENTER PERCENT]: ______% (997=DK; 998=R)
AE1g. In what percent of your projects are these recommendations installed?	[ENTER PERCENT]: ______% (997=DK; 998=R)

HVAC Systems	
AE2a. What technologies do you think represent energy efficiency best practices for HVAC? [Interviewer Note: We recognize this is a broad topic; use the technologies below in [ ] to probe for top of mind responses regarding best practices in EE HVAC design.] **For packaged equipment:** [Pkgd Eqmnt: DX Heating/Cooling Rooftop Units, Split Cooling Units] **For built-up central plant:** [Boilers/Chillers feed coils in air handling units –heating/cooling occurs outside of the air handling unit and is pumped in.] **For controls:** [Building Management Systems with ability to track/trend data; boiler temperature reset; CO2 sensors for demand controlled ventilation.]	1) Packaged Equipment 2) Built-Up Central Plants 3) Controls
AE2b. In about what percentage of your projects do you specify high efficiency HVAC systems?	[ENTER PERCENT]: ______% (997=DK; 998=R)
AE2c. In what percentage of your projects are these recommendations installed?	[ENTER PERCENT]: ______% (997=DK; 998=R)
AE2d. Would you say the portion of projects in which energy efficient HVAC equipment is installed has increased, decreased or stayed the same since 2008?	1. Increased 2. Decreased 3. Stayed the same 97. [DON'T KNOW] 98. [REFUSED]
AE2d. Why? **[Record response]**	

Building Envelope (e.g., Windows, doors and insulation)	
AE3a. What technologies, designs, or practices do you think represent energy efficiency best practices for building envelopes (e.g., insulation, windows, air sealing etc.	Record Response:
AE3b. In about what percentage of your projects do you specify high efficiency building envelopes?	[ENTER PERCENT]: ______% (997=DK; 998=R)
AE3c. In what percent of your projects are these installed?	[ENTER PERCENT]: ______% (997=DK; 998=R)
AE3d. Would you say the portion of projects in which energy efficient envelope features are installed has increased, decreased or stayed the same since 2008?	1. Increased 2. Decreased 3. Stayed the same 97. [DON'T KNOW] 98. [REFUSED]
AE3e. Why? [Record response]	

I'd like to ask some questions about building simulation modeling.

AE4. Does your firm use building simulation modeling to inform the design of buildings and mechanical systems?

1. Yes
2. No [SKIP TO AE6a]
97. [DON'T KNOW] [SKIP TO AE6a]
98. [REFUSED] [SKIP TO AE6a]

AE5a. [IF AE4 = YES, ELSE SKIP TO AE6a]: In what percent of your projects do you use building simulation modeling?

1. Between 90 - 100%
2. 50-90%
3. 10 -50%
4. Less than 10%
5. 0%
97. [DON'T KNOW]
98. [REFUSED]

[IF AE5a = 1, 2, 3 or 4, ELSE SKIP TO AE6a]

AE5b. What types of projects are most likely to include building simulation modeling?

[RECORD RESPONSE:]____

____

____

AE6a. In what portion of projects do you consider energy efficiency in developing site plans?

[DO NOT READ: Examples of site energy efficiency include: building orientation – for solar and wind patterns, shielding provided by vegetation (trees) or the landscape.]

1. All
2. Most
3. Some
4. Rare instances
5. Never [SKIP TO AE7a]
97. [DON'T KNOW] [SKIP TO AE7a]
98. [REFUSED] [SKIP TO AE7a]

[IF AE6a = 1, 2, 3 or 4, ELSE SKIP TO AE7a]

AE6b. In what types of projects, if any, are you most likely to consider energy efficiency when developing site plans?

[RECORD RESPONSE:]____

____

____

AE6c. Why?

[RECORD RESPONSE:]____

____

____

AE7a. How familiar are you with the practice of building commissioning?

1. Not familiar
2. A little familiar
3. Somewhat familiar
4. Very familiar

97. [DON'T KNOW] [SKIP TO AE8a]
98. [REFUSED] [SKIP TO AE8a]

AE7b. [IF AE7a = YES, ELSE SKIP TO AE8a]: About what percentage of your firm's building projects are commissioned by an independent third party?

[ENTER PERCENT]: ______%

997. [DON'T KNOW]
998. [REFUSED]

AE8a. Using a scale of 0 to 10, where 0 is 'not at all important' and 10 is 'very important': How important is commissioning to the performance a new or newly renovated building?

[ENTER NUMBER (0-10)]: _____________

97. [DON'T KNOW] [SKIP TO EC1]
98. [REFUSED] [SKIP TO EC1]

AE8b. [IF AE8a = 0 - 10, ELSE SKIP TO EC1]: Why do you say that?

[RECORD RESPONSE:]____

____

[CM] Construction Trends – Changes in Construction Practices

[ASK THIS SEQUENCE FOR CONSTRUCTION MGRS ONLY, A&E SKIP TO EC1]

Now, I would like to talk about your firm's construction practices with regards to lighting, HVAC, and building envelope.

Lighting Systems	
CM1a. What technologies do you think represent energy efficiency best practices for lighting? **1) For office space** **2) For retail space, not including high bay spaces** **3) For high bay spaces** [T12] [T-8 (standard)] [T-8 (high performance)] [T-5 (all varieties)] [Probe start metal halide (HID)] [Pulse start metal halide (HID)] [Low-pressure sodium (HID)] [High-pressure sodium (HID)] [Mercury vapor (HID)] [LED] [Induction] [Other (Specify) ___________]	[Record Response separately for each space type]: For office space: For retail space, not including high bay spaces For high bay spaces
CM1b. In about what percentage of your projects do you install high efficiency lighting?	[ENTER PERCENT]: ______% (997=DK; 998=R)
CM1c. Would you say the portion of projects in which energy efficient fixtures are installed has increased, decreased or stayed the same since 2008?	1. Increased 2. Decreased 3. Stayed the same 97. [DON'T KNOW] 98. [REFUSED]
CM1d. Why?	[Record Answer]

HVAC Systems	
CM2a. What technologies do you think represent energy efficiency best practices for HVAC? [Interviewer Note: We recognize this is a broad topic; use the technologies below in [ ] to probe for top of mind responses regarding best practices in ee HVAC design.] **For packaged equipment:** [Pkgd Eqmnt: DX Rooftop units, DX Heating/Cooling Rooftop Units, Split Cooling Units] **For built-up central plant:** [Boilers/Chillers feed coils in air handling units –heating/cooling occurs outside of the air handling unit and is pumped in.] **For controls:** [Building Management Systems with ability to track/trend data; boiler temperature reset; CO2 sensors for demand controlled ventilation.]	[Record Response separately for each eqmt type]: 1) For packaged equipment 2) For built-up central plant 3) For controls
CM2b. Approximately, in what percentage of your projects do you install high efficiency HVAC systems?	[ENTER PERCENT]: ______% (997=DK; 998=R)
CM2c. Would you say the portion of projects in which energy efficient HVAC equipment is installed has increased, decreased or stayed the same since 2008?	1. Increased 2. Decreased 3. Stayed the same 97. [DON'T KNOW] 98. [REFUSED]
CM2d. Why?	[Record Answer]

Building envelope (e.g., Windows, doors and insulation)	
CM3a. What technologies, designs, or practices do you think represent energy efficiency best practices for building envelopes (e.g., insulation, windows, and air sealing?)	Record Response:
CM3b. In about what percentage of your projects do you construct high efficiency building envelope systems?	[ENTER PERCENT]: ______% (997=DK; 998=R)
CM3c. Would you say the portion of projects in which energy efficient envelope features are installed has increased, decreased or stayed the same since 2008?	1. Increased 2. Decreased 3. Stayed the same 97. [DON'T KNOW] 98. [REFUSED]
CM3d. Why?	[Record Answer]

Energy Codes

EC1. How familiar are you with the recent updates to the Massachusetts Energy Code?

1. Not familiar
2. A little familiar
3. Somewhat familiar
4. Very familiar
97. [DON'T KNOW] [SKIP TO EC4]
98. [REFUSED] [SKIP TO EC4]

EC2. Have the recent code changes affected your [design/ specification/ construction] practices?

1. Yes
2. No [SKIP TO EC4]
97. [DON'T KNOW] [SKIP TO EC4]
98. [REFUSED] [SKIP TO EC4]

EC3. [IF EC2 = YES, ELSE SKIP TO EC4]: How have these changes affected your [design/specification/construction] practices?

[RECORD RESPONSE:]____

____

____

[Skip if firm does not do business outside Massachusetts]

EC4. Are there certain [design/specification/construction] practices that you employ in Massachusetts that you do not use in other states?

1. Yes
2. No [SKIP TO P1]
97. [DON'T KNOW] [SKIP TO P1]
98. [REFUSED] [SKIP TO P1]

EC5. [IF EC4 = YES, ELSE SKIP TO P1]: Please describe.

[RECORD RESPONSE:]____

____

____

Promotion of Efficient Design Practices

[Reminder to interviewer: all interview responses are with regards to the firms' experience and business practices in Massachusetts.]

P1. Does your firm market its capabilities to design and deliver energy-efficient buildings?

1. Yes
2. No [SKIP TO P3]
97. [DON'T KNOW] [SKIP TO P3]
98. [REFUSED] [SKIP TO P3]

P2. [IF P1 = YES, ELSE SKIP TO P3]: How?

[RECORD RESPONSE:]____

____

____

P3. In the course of working with customers, does your firm promote the selection of energy-efficient designs and equipment?

1. Yes
2. No [SKIP TO P5]
97. [DON'T KNOW] [SKIP TO P5]
98. [REFUSED] [SKIP TO P5]

P4. [IF P4 = YES, ELSE SKIP TO P5]: How?

[RECORD RESPONSE:]____

____

____

P5. Have your firm's efforts to promote energy efficient design increased, decreased or stayed the same since 2008?

1. Increased
2. Decreased
3. Stayed the same
97. [DON'T KNOW]
98. [REFUSED]

P6. [IF P5 = INCREASED or DECREASED, ELSE SKIP TO P7a]: What were the main reasons for this change in approach?

[RECORD RESPONSE:]____

____

____

P7a. Using a scale of 0 to 10, where 0 is 'not at all important' and 10 is 'very important': How important to your firm is the ability to offer energy efficient design to your clients?

[ENTER NUMBER (0-10)]: ____________
97. [DON'T KNOW]
98. [REFUSED]

P7b. [IF P7a = 0 - 10, ELSE SKIP TO P8]: Why do you say that?

[RECORD RESPONSE:]____

____

____

P8. What are the main challenges does your firm faces in delivering energy efficient [design/ specification/ construction]?

[DON'T READ CHOICES OR GENERAL AREAS]

[RECORD RESPONSE:]____

____

____

____

____

____

P9. Are greenhouse gas emissions a consideration in your [design/specification/ construction] of a new building?

1. Yes
2. No [SKIP TO CF1]
97. [DON'T KNOW] [SKIP TO CF1]
98. [REFUSED] [SKIP TO CF1]

P10. [IF P9 = YES, ELSE SKIP TO CF1]: What specific actions, if any, have you taken to address greenhouse gas emissions?

[RECORD RESPONSE:]____

____

____

P11. [IF P9 = YES, ELSE SKIP TO CF1]: Why?

[RECORD RESPONSE:]____

____

____

Chain and Franchise Trends

CF1. Since 2008, has your firm been involved with any projects involving chains or franchises?

[If definition needed: Chains and franchises include lodging, restaurants, grocery, retail, regional banks, and hospitals and healthcare facilities]

1. Yes
2. No [SKIP TO PA1]
97. [DON'T KNOW] [SKIP TO PA1]
98. [REFUSED] [SKIP TO PA1]

CF2.What percentage of chain and franchises that your firm has worked with had guidelines or specification for energy efficient design and equipment purchases?

[ENTER PERCENT]: ______%
997. [DON'T KNOW]
998. [REFUSED]

CF3. Please describe the guidelines or specifications for energy efficient lighting, HVAC, or building envelope measures:

a. Lighting
[RECORD RESPONSE]:____

b. HVAC
[RECORD RESPONSE]:____

c. Building envelope
[RECORD RESPONSE]:____

CF4. Did you make recommendations regarding design or equipment that differed from these guidelines?

1. Yes
2. No [SKIP TO PA1]
97. [DON'T KNOW] [SKIP TO PA1]
98. [REFUSED] [SKIP TO PA1]

CF5a. [IF CF4 = YES, ELSE SKIP TO PA1]: What were the differences?

[RECORD RESPONSE:]____

CF5b. Why did you recommend a change?

[RECORD RESPONSE:]____

CF6a. Did your chain and franchise clients accept these recommendations?

1. Yes
2. No
97. [DON'T KNOW]
98. [REFUSED]

CF6b. Why-?

[RECORD RESPONSE:]____

Program Awareness & Experience

PA1. Are you familiar with the incentives the Massachusetts electric and gas utilities offer for new construction and major renovation projects?

1. Yes
2. No [SKIP TO PA3]
97. [DON'T KNOW] [SKIP TO PA3]
98. [REFUSED] [SKIP TO PA3]

PA2. Has your company worked on projects that received support from any of those programs?

1. Yes
2. No
97. [DON'T KNOW]
98. [REFUSED]

PA2a. Using a scale of 0 to 10, where 0 is 'not at all important' and 10 is 'very important': How important are the incentives in a customer's decision to use an energy efficient building design?

[ENTER NUMBER (0-10)]: ____________
97. [DON'T KNOW]
98. [REFUSED]

PA2b. Why do you say that?

[RECORD RESPONSE:]____

____

____

PA3a. Did your firm receive technical assistance from any of these programs?

1. Yes
2. No
97. [DON'T KNOW]
98. [REFUSED]

PA4. On a scale of 0 to 10 where 0 is "Not at all Effective" and 10 is "Very Effective" how effective do you think these programs have been in promoting energy-efficient design and equipment specification in new construction and major renovation?

[ENTER NUMBER (0-10)]: _____________
97. [DON'T KNOW]
98. [REFUSED]

PA5. Why do you say that?

[RECORD RESPONSE:]____

____

____

PA6. Do you recommend any changes to the programs to make them more effective?
[RECORD RESPONSE:]____

____

____

PA7. Has your firm's participation in the programs influenced its [design/ specification/ construction] practices in any way?

1. Yes
2. No [SKIP TO End of Interview]
97. [DON'T KNOW] [SKIP TO End of Interview]
98. [REFUSED] [SKIP TO End of Interview]

PA8. [IF PA7 = YES, ELSE SKIP TO End of Interview]: In what way [IF NECSSARY: In what way have the programs influenced your design and construction practices?]
[RECORD RESPONSE:]____

____

____

End of Interview.
THANK YOU VERY MUCH FOR YOUR TIME.