Final Report
Project 1C Combined Heat & Power 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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Burlington, Massachusetts, June 1, 2011

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1. Executive Summary

This Executive Summary provides a high level review of the results for *Project 1C Market Characterization of Combined Heat and Power* for the evaluation of the large commercial and industrial (C&I) programs operated by the Massachusetts program administrators (PA). In this section, we state the study objectives, summarize the evaluation approach, and present key findings and recommendations.

1.1 Evaluation Objectives

The overarching objective of all LCIEC Market Characterization studies is:

> **"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."**

Table 1-1 provides the principal research objectives of the CHP Market Characterization.

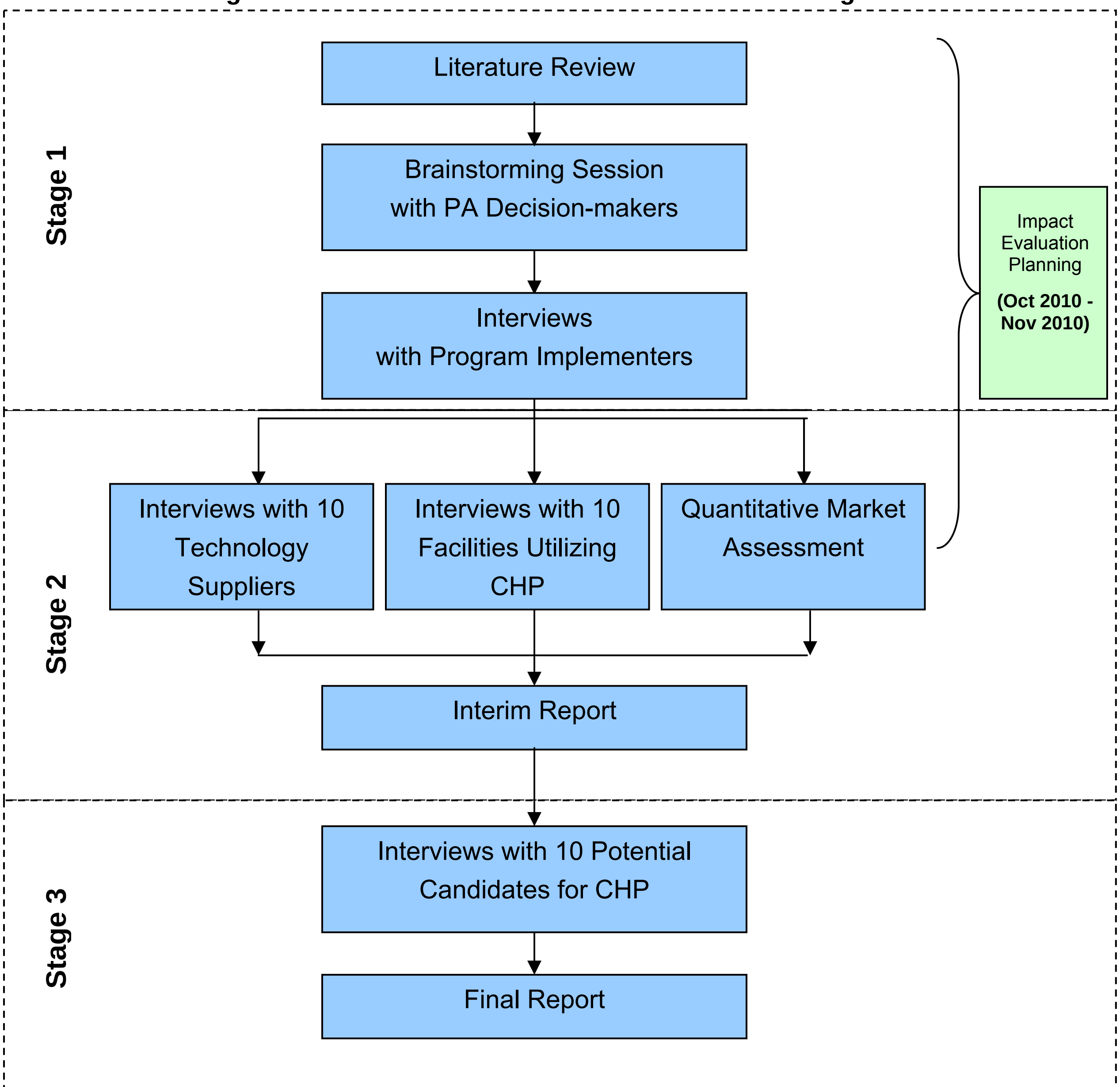
Table 1-1 Research Objectives

#	Primary Objective
1	Characterize the CHP market including key players and market segments.
2	Understand the decision making processes used by potential CHP customers including reasons customers elect to install CHP, selection of specific types or configurations of CHP, and the factors most influencing decisions to purchase CHP systems.
3	Identify the current mix of CHP technologies including the CHP systems types deployed, installed and operating costs of the technologies, and identify anticipated changes in the CHP market or improvements in the technologies.
4	Identify barriers impacting entry for customers including the key factors that dissuade potential customers from evaluating CHP technologies or have led customers who evaluated CHP technologies to decide not to install it.
5	Estimate CHP opportunities by key market segments and provide PAs with a list of customers likely suitable for CHP.

Overview of Approach

This section provides a high level synopsis of the Project 1C Team's approach to characterizing the market for CHP in Massachusetts. provides the research agenda developed in accordance with the RFP and the additional information and insights gained via the evaluation team's participation in the CHP Working Group, CHP Evaluation Team, and PA implementers' meeting. Following the table is a summary of each task.

Figure 1-1 CHP Market Characterization Research Agenda



Overview of Research Activities:

- **Literature Review.** Extensive literature review of existing major CHP support programs in the U.S. The results of the Literature Review were presented to the PA C&I implementation team on September 29, 2010.

- **Brainstorming Session with PA Decision Makers.** In-person meeting with PA decision makers and implementation staff provided the evaluation team with PA decision maker perspectives on the CHP market and further elucidated the research needs of the PA program implementers.

- **Interviews with Program Implementers.** Meetings with PA implementation staff provided the evaluation team with additional background on the MA CHP programs, implementer perspectives on the CHP market in MA, and concrete ideas regarding the types of information that would be most valuable to the implementation staff in their efforts to identify CHP opportunities in their service territories.

- **Interviews with Suppliers and Users of CHP.** Interviews with 10 suppliers and 10 current users of CHP in Massachusetts were used to characterize the current market for CHP and identify specific factors that lead to successful or unsuccessful installations. The exploration of motivations for and barriers to installation of CHP; and identification of key market segments, customer types and system sizes suitable for CHP in MA provide useful insight to the PA implementers and supplemented, as well as guided, the quantitative market assessment results.

- **Interviews with Potential Users of CHP.** Interviews with 10 potential users of CHP in Massachusetts were used to identify reasons why sites are motivated to install CHP and the leading factors that convince sites to forego CHP. This identification may improve targeting of the CHP outreach efforts and increase the ratio of successful CHP installations to utility transaction cost.

- **Quantitative Market Assessment.** The team estimated CHP opportunities, in terms of number of customers, business types, and equipment size category in the service territories served by the PAs. This is not a technical potential, economic potential or market potential study. The focus of the study is in the near term, considering pricing, technologies, and market barriers that exist today. Also, financial viability of systems is determined from a customer perspective using payback as a screening criterion and not all cost-effective units using state prescribed screening criteria. This market view is a subset of all cost-effective statewide CHP opportunity.

- **Lead List.** This analysis provides the PA implementers with working 'lead lists' of high-value candidate sites for the PAs to pursue. Throughout this report, the term "opportunity" should not be taken to represent all systems that could pass the cost-effectiveness screening, but rather those 'high value' customers with estimated systems that meet certain criteria including:
    - Sized to meet a five year payback threshold with the current rates and incentives,
    - Meet a minimum size threshold of 60 kW,
    - Currently use gas,
    - Located in PA served territories,
    - Do not have confirmed existing generation,
    - Not located on a network that makes interconnections difficult.

1.2 Conclusions

This section integrates the findings of the interviews with stakeholders and the quantitative market assessment to provide a high level overview of the CHP market in Massachusetts and identify high-value CHP opportunities based on the research conducted. This section ends with short-term and long-term recommendations for PA implementer consideration.

Based on the qualitative and quantitative analyses, the market in Massachusetts was divided into four different categories based on the size of the generating capacity of the CHP system. The categories are:

- 60 to 150 kW
- 150 to 300 kW
- 300 kW to 1 MW
- > 1 MW

Table 1- provides a summary of key findings and conclusions from the interviews with various stakeholders and the quantitative market assessment. As illustrated in the table, each one of these segments has different customer types and attributes, specific CHP technologies, and market barriers. Although there are overlaps, **each of these market segments require a different approach both in terms of educating the site on what CHP is and the time required to develop the CHP site and to install the system.**

Based on the interviews that were part of the Market Characterization, it became evident which industries fell into each of the sized segments. Nursing homes of 150 beds or less and segments with smaller thermal and electrical loads were at one end and at the other end are colleges and universities and manufacturing with high thermal and electrical loads. **Based on the quantitative market assessment we are able to estimate the number of "high-value" opportunities within each sector.** For example, the market assessment concluded that there are 102 customers (gas accounts) that may be suitable sites for CHP in the greater than 1 MW system size category.

The four segments defined by equipment size also require different time for a complete installation based on the size of the capital outlay and the decision making process. A 75 kW internal combustion engine (ICE) to be installed at a 100 bed facility most likely will require less time for a developer to make the sell and to complete the install versus a 2 MW gas turbine at a university. **However, the sophistication and general knowledge of their thermal and electrical loads will be much higher for those larger installations than the smaller.** This has a significant effect on the level of effort required on the part of the PA implementers in supporting the installation process.

Table 1-2 Summary of Key Findings by Technology Size

Characteristics	60 to 150 kW	150 to 300 kW	300 kW to 1 MW	> 1 MW
Typical sites based on interviews	Nursing homes; 100-150 bed facilities; smaller apartment buildings	Hotels, heath clubs with pools; hockey rinks	Housing projects (including apartment buildings); small manufacturing, prisons, hospitals	Manufacturing; universities and colleges
Time to sell a system[1]	2 to 7 months	3 to 8 months	6 to 12 months	12 – 18 months
Time from signed contract to commissioning[2]	6 to 12 months depending on factors such as interconnection	6 to 12 months depending on factors such as interconnection	6 to 18 months depending on other factors	12 to 24 months depending on other factors
Influence of PA	Incentives and credibility, technical advice	Incentives and credibility, technical advice	Incentives and some support but site will have resident experts	Minimal, incentives and interconnection
Knowledge of CHP, thermal and electrical load by sites	Minimal knowledge of CHP and likely little of their facility loads	Some on CHP, better on their loads and operations	Good background overall on CHP and energy use	Experts in all facets of CHP, the physical plant and energy use
Technology[3]	ICE and MT	ICE and MT	ICE, smaller units often packaged instead of one larger unit.	GT, some ICE, potential for fuel cells
PA Marketing Strategy	Utilize developer channel	Utilize developer channel	Some developer channel and account executives	Direct outreach by Account Exec
"High-Value" Accounts	778	316	268	102

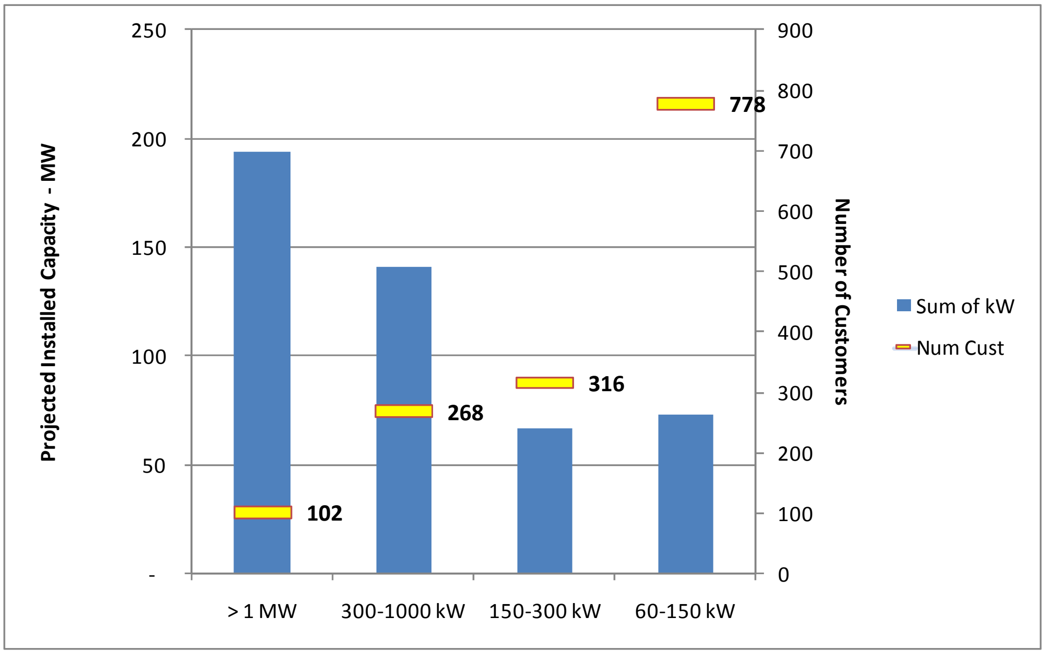
[1] Care should be taken in using the estimated time needed to sell CHP systems for planning purposes. During our interviews with the 9 developers (one interview was with a CHP center focused on providing the feasibility of CHP systems) ranges on time to sell ranged a fair amount particularly for those smaller systems. Time to sell was framed as time from beginning of negotiations to a signed contract.

[2] These are approximate timeframes developed from a small sample size and should be used carefully. Although interviews with Developers indicated time from contract to commissioning could be as little as 3-6 months, interviews with Sites indicated longer time periods were required. In addition, PAs indicate that interconnection times may extend this time period.

[3] GT = gas turbine; ICE = internal combustion engine; MT = micro turbine.

As shown in Table 1- the market assessment estimates there are 1,464 customers (gas accounts) that are considered 'high value' sites for CHP. Figure 1-2 presents the CHP opportunities by installed capacity and technology size segments. The two smaller technology size segments have many sites but limited total opportunity in terms of installed kW and the larger sites have fewer sites and larger opportunities.

Figure 1-2 CHP Opportunity – by Equipment Size Intervals



Error! Reference source not found. provides these same 1,464 high-value opportunities further segmented by PA service territory. Although NSTAR has the largest opportunity overall, the average system size is smaller than WMECO or National Grid. This may be due in part to the network in downtown Boston which restricts participation of some of NSTAR's largest customers, possibly driving the NSTAR average down.

Figure 1-3 PA CHP Opportunity by Equipment Size Interval

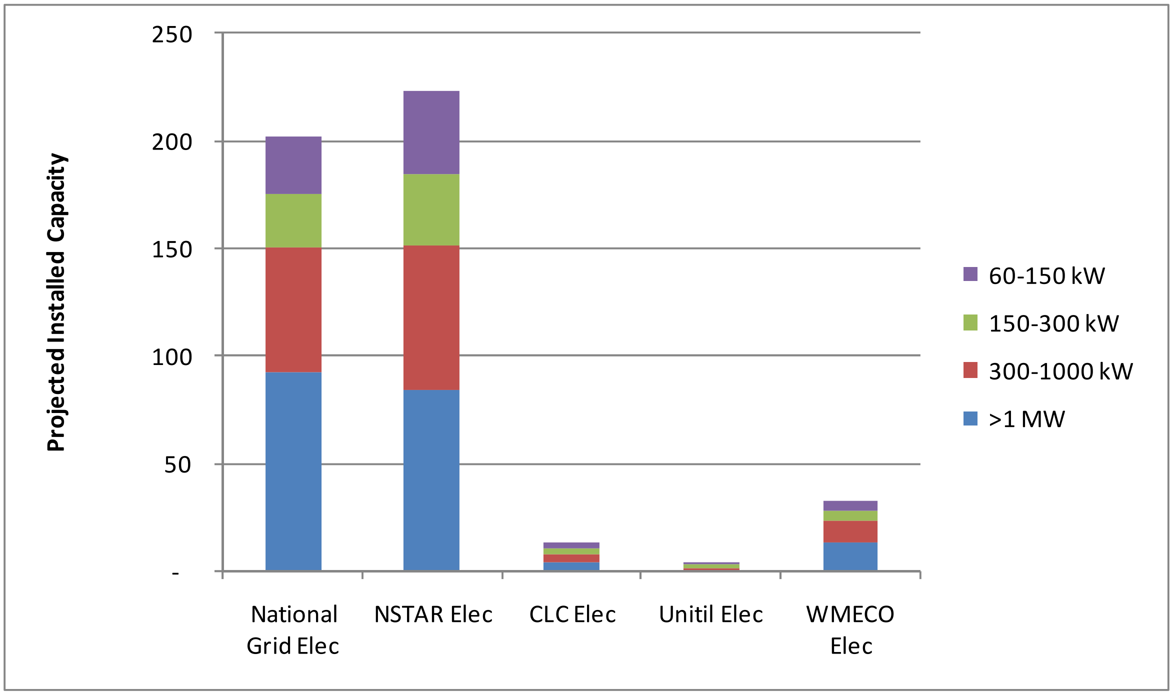


Table 1- provides a summary of CHP opportunities by PA. The opportunity is summarized by PA with estimates of the total capacity, generation, net fuel, installed cost, and budget. The quantitative market assessment methodology is built from the bottom up using individual gas account estimates, therefore factors that could not be attributed to an individual account were not incorporated into the final results. Two such factors, which are not included in Table 1-, are about a 30% reduction in opportunity due to HVAC systems that are incompatible with CHP implementation (direct fired gas rooftops cannot easily use heat from CHP) and about a 7% additional opportunity represented by customers using oil. The table does not account for any impact on participation due to standby rates or limitations on system size due to mismatches between electric and gas loads, although these topics are explored in Appendix D.

Table 1-3 Summary of PA Opportunity

Electric PA	Accounts	Projected Installed Capacity (kW)	Generation (kWh)	Net Fuel (therms)	Customer Installed Cost	Incentive	Net Customer Annual Savings
Cape Light Compact	57	13,588	93,113,183	(4,427,841)	$24,485,494	$10,190,966	$5,355,860
National Grid	543	201,650	1,513,003,618	(69,276,951)	$350,826,451	$151,237,474	$73,908,145
NSTAR Electric	743	222,922	1,432,580,376	(66,143,217)	$389,478,438	$167,191,721	$83,679,013
Unitil Electric	23	4,345	21,997,572	(1,090,561)	$7,908,763	$3,258,963	$1,713,533
Western Mass Electric	98	32,662	257,940,342	(11,952,305)	$57,700,524	$24,496,242	$12,008,945
	1,464	475,167	3,318,635,091	(152,890,875)	$830,399,669	$356,375,367	$176,665,497

Average Installed Cost:	$ 2,498	per installed kW
Average incentive per kWh generated:	$ 0.11	$ / kWh
Net gas usage per kWh generated:	(4,607)	BTUs
Customer Annual Net Savings	$176,665,497	
Estimated PA net benefits:	$2,897,099,864	
BCR estimate:	2.4	
Estimated PA net benefits without heat recovery:	$192,378,820	
BCR estimate:	0.2	

As part of the quantitative market assessment, the LCIEC Team divided customers into four groups based on annual gas usage. **Error! Reference source not found.** provides a summary of CHP opportunities by customer size categories based on annual fuel usage. We conclude:

- **Largest opportunity for CHP is in the 90,000 to 950,000 therms customer class.**
- **Large customers from the greater than 950,000 therms customer class are favorable candidates for CHP; however there are only 51 high-value accounts. The prevalence of existing generation reduces the opportunity for CHP at the largest customer sites.**
- **Minimal to no high-value opportunities in the smaller two size categories.**

- **CHP systems, if properly sized and operated with little or no thermal dumping, provide broad benefits to the customer and stakeholders as indicated by the BCR ratio. At the other extreme, however, systems which primarily generate electricity with little or no heat recovery can result in projects with a BCR ratio less than 1.**

Table 1-4 Summary of CHP Opportunities by Customer Size

Characteristics	Customer Gas Usage			
	>950k Therms	90k-950k Therms	16.5k-90k Therms	<16.5k Therms
Customer Types[4]	university campuses, large industrial and commercial sites, and large hospital complexes	housing authorities, larger hotels, senior housing, smaller community hospitals, colleges and university sub-accounts, bio-tech, and food processing operations	nursing homes, grocery stores, residential public and private housing, big box retail, YMCAs, and high volume restaurants (not fast food)	NA
Population (number of accounts)	96[5]	1,229	7,725	105,990
Average Annual Usage (population)	2,883,395	218,517	35,112	2,491
Passed CHP Screens	50%	70%	10%	Only 1 account
"High-Value Accounts"	51	828	584	1
Conclusions	Good but few candidates.	Largest opportunity.	Very small number of high-value sites. High cost of engagement.	No opportunities.

[4] This is not an exhaustive list.

[5] 24 customers confirmed to have on-site generation.

There is a common understanding among the market actors interviewed (Developers of CHP, Sites where CHP has been installed, and candidate sites) of the motivations for and the barriers to the installation of CHP. **Error! Reference source not found.** presents the primary motivators and barriers to installing CHP in Massachusetts listed in order of importance. Reducing energy costs was the most common motivator followed by environmental benefits for the Developers, Sites and Candidates. The most cited barrier to the adoption of CHP is knowledge of the technology, followed by payback; interconnection or permitting issues.

Table 1-5 Motivations and Barriers to Installation of CHP

Motivations for Installation of CHP	Barriers to Installation of CHP
▪ Economics: Utility rates &Cost savings. ▪ Utility Incentives. ▪ Environmental. ▪ Supportive utilities.* ▪ APS program. ▪ Relaxed qualifying restrictions.* ▪ Power reliability. ▪ Emergency power capability.**	▪ Knowledge of CHP. ▪ Payback. ▪ Interconnection/permitting. ▪ Spot or street networks.*** ▪ Economy. ▪ Air emissions. ▪ Electric utility changing habits.*** ▪ Upfront cost. ▪ Metering.* ▪ Qualifying for program.
* Only mentioned by Developers. ** Not mentioned by Developers. *** Not mentioned by Current Users of CHP. Spot networks refer to electrical networks that serve a single site, whereas street networks refer to electrical service covering several city blocks.	

1.3 Recommendations

The Project 1C Team presents the following short-term and long-term recommendations to the PA implementers for consideration.

1.3.1 Short-term recommendations

1. **Determine realistically achievable targets.** Energy-saving goals of the Program are tied to the time it takes to sell, install and commission CHP systems. The PAs can help insure the Program achieves these goals by taking into account the project development timeframes and establishing a "pipeline" approach that associates the different market segments to the anticipated timeframes. For example, a high-value 2 MW gas turbine site being developed in spring of 2011 will realistically not be commissioned until the end of 2012 at the earliest. Consequently, energy savings from this site will not be available

until the latter part of 2012 or early 2013. Developing a pipeline approach will assist in identifying expected annual energy savings, prioritizing market segments that can deliver those energy savings and help focus marketing and implementation activities. Variables to consider in developing the pipeline are:

a. Size of each segment
b. Time for installation by segment
c. Conversion percentages
d. Yearly targets for leads, assessments, and installation segment

2. **Outreach to large sites**. The PAs should identify and reach out to high-value large sites using the account executive teams from the different utilities. These sites take the longest estimated time from signed contract to commissioning; they are also the most sophisticated. They do not need time learn about CHP, they need to be educated about the incentive, which may be the final variable that helps a project exceed its internal hurdle rates. In addition, educating large sites and developers on the program now may assist in managing any ambiguity on attribution of the program.

3. **Focused outreach for under 300 kW.** For sites 60 – 300 kW, the PAs should work with partners to promote the incentive program. The PAs role with these customers is to build the credibility of CHP technology and act as the role of energy advisor by providing customers with an integrated solution of energy efficiency measures including CHP systems.

4. **Training Using Webinars.** The evaluation team understands that planning for webinar training sessions is currently underway via the PA Implementers' CHP Working Group. The evaluation team supports this endeavor and recommends training session in the following areas:

a. Understanding of the CHP technology.
b. Understanding of the services offered by the program.
c. Interconnection process, issues and solutions.
d. Identification of barriers to installation and steps to address barriers.
e. Methods to reduce installation costs.
f. Case studies of successful installations.

5. **Program Stability-Coordination.** The program should consider increased coordination with other CHP initiatives (i.e. Alternative Energy Portfolio Standards requirements) to leverage overlapping requirements for cost-effective execution of both programs.

Inconsistency and duplication across programs can lead to customer frustration and act as a barrier. Specific areas of consideration include the development of consistent metering approaches. The metering approach can and likely should vary by the size of the customer.

6. **Partners to collaborate.** The program should consider collaborations with existing groups such as trade groups, vendor associations, and customer groups with the goal of leveraging existing mass marketing efforts. Examples of collaboration activities include:

    a. Training and education to validate to effectiveness of the technology in specific applications (e.g. hospitals, nursing homes, college and universities).

    b. Coordination with but not endorsement of vendors.

        i. The approved vendor list being developed by one utility is a step in the right direction.

        ii. Partner with CHP vendors to conduct training on their technology. The focus should be on training and not selling the specific technology.

    c. Cooperation and collaboration with DOER on coordination of EE CHP and APS incentive programs.

1.3.2 Long term recommendations

The short-term recommendations outlined above will help to act as catalyst for more CHP adoption. The following long-term recommendations based on our analysis require a longer time horizon.

1. **Network Interconnects.** The challenges of spot networks have been addressed by a number of metropolitan areas (e.g. Manhattan). Changing the policies by the utilities in Massachusetts to allow for CHP interconnection on a distribution spot network like Boston will take time. However, not addressing this issue is resulting in not capturing 23 MW of identified capacity.

2. **Interconnection process**. In addition to spot networks, the utilities could focus on more long term interconnection issues such as simplifying the forms or harmonizing them within the state to make it easier for developers working with different utilities.

3. **Refinement of targeting under 300 kW.** After the initial push to educate and inform those sites under 300 kW in 2011, the PAs should consider using metrics to determine

their success ratios and look to refine any processes to help hit the targets in 2012 and beyond. This process of measurement, review and continuous improvement has proven to be successful in many industries.

4. **Incentive Types.** CHP programs across the country are considering capacity-based incentives paid up front, performance-based incentives paid over time and hybrid structures where a portion of the incentive is paid up front and the remainder is paid out as a performance incentive. There is no single approach that is being adopted across the board. CHP project developers prefer upfront incentives which help defer capital costs and reduce financial risk. Prospective CHP sites also prefer the financial benefits associated with upfront, lump sum incentives, but like the reassurance of project developer and manufacturer involvement that is tied to performance payments. From an implementation perspective, performance incentives represent additional complexity and transaction costs. By requiring system warranties on incented projects, the Massachusetts Program has taken steps to help insure sustained CHP system performance. Consequently, using upfront incentives tied with system warranties may be the best way to help motivate CHP project development under the Program and insure high sustained performance. We recommend the continued use of upfront incentives.

2. Introduction

This report provides the results for Project 1C Market Characterization of Combined Heat and Power for the evaluation of the large commercial and industrial (C&I) programs operated by the Massachusetts program administrators (PA). In this section we provide a review of the study objectives, summarize the evaluation approach, and describe the organization of the remainder of the report.

2.1 Evaluation Objectives

The overarching objective of the LCIEC Market Characterization study 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 CHP Market Characterization are provided in Table 2-1.

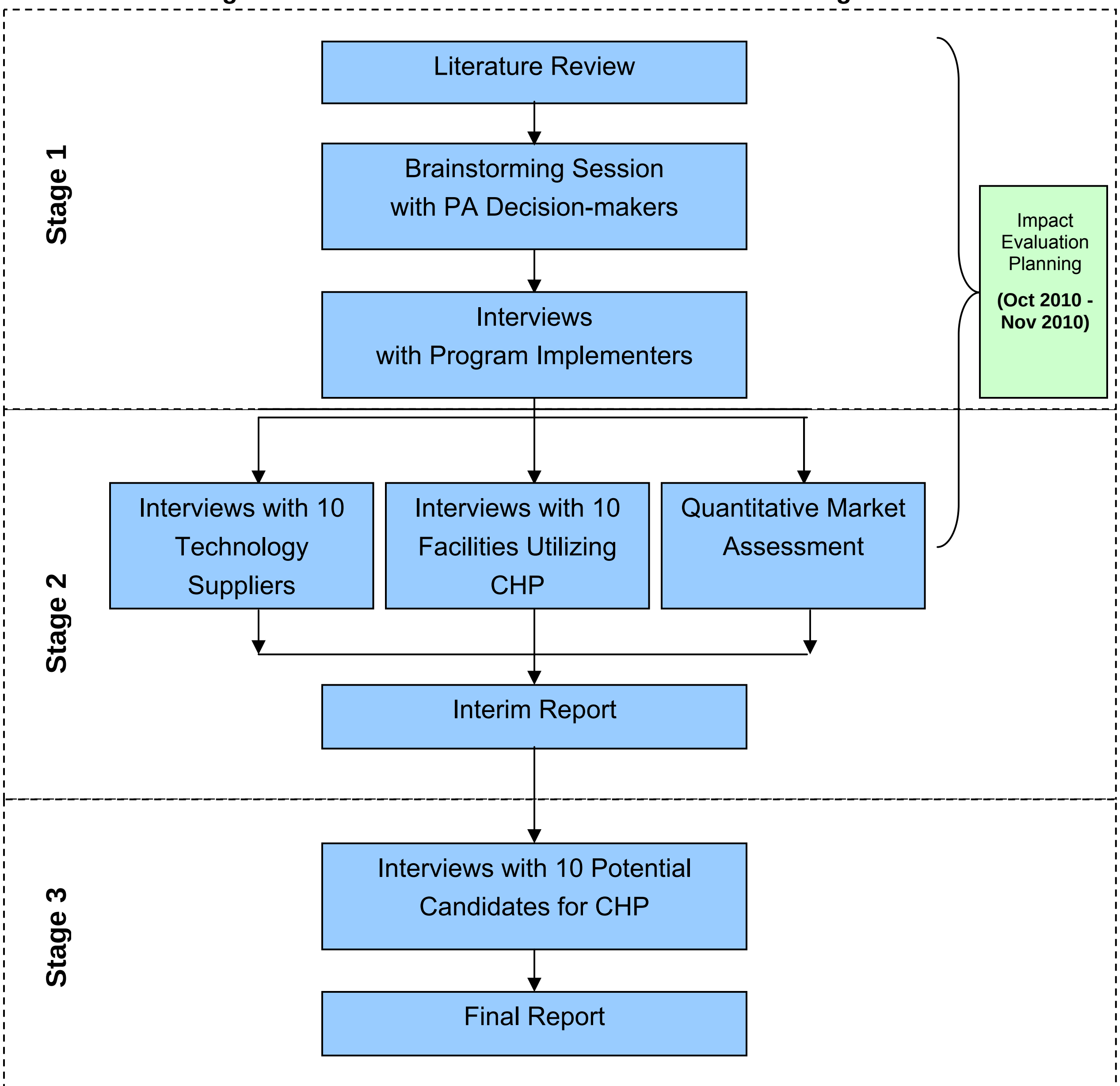
Table 2-1 Research Objectives

#	Primary Objective
1	Characterize the CHP market including key players and market segments.
2	Understand the decision making processes used by potential CHP customers including reasons customers elect to install CHP, selection of specific types or configurations of CHP, and the factors most influencing decisions to purchase CHP systems.
3	Identify the current mix of CHP technologies including the types of CHP systems being deployed, installed and operating costs of the technologies, and anticipated changes in the CHP market or improvements in the technologies.
4	Identify barriers impacting entry for customers including the key factors that dissuade potential customers from evaluating CHP technologies or have led customers who evaluated CHP technologies to decide not to install it.
5	Estimate CHP opportunities by key market segments and provide PAs with a list of customers likely suitable for CHP.

2.2 Overview of Approach

This section provides a high level synopsis of the Project 1C Team's approach to characterizing the market for CHP in Massachusetts. provides the research agenda that was developed in accordance with the RFP and additional information and insights gained via the evaluation team's participation in the CHP Working Group, CHP Evaluation Team, and PA implementers' meeting.

Figure 2-1 CHP Market Characterization Research Agenda



2.3 Organization of Report

The remainder of the Interim Report is organized as follows:

- **Section 3. Literature Review** presents the results of the literature review of existing major CHP support programs in the U.S. These results were also presented to the PA C&I implementation team on September 29, 2010.

- **Section 4. PA Program Staff Input** provides a summary of the evaluation team's interviews with the PA decision makers and implementation staff. These in-person meetings were used to provide the evaluation team with additional background on the MA CHP Programs, PA decision maker perspectives on the CHP market, and further elucidate the research needs of the PA program implementers.

- **Section 5. Interviews with Supplier and Users of CHP** presents the methodology and results of the evaluation team's in-depth interviews with 10 suppliers, 10 current users of CHP, and 10 potential candidates for CHP.

- **Section 6. Quantitative Market Assessment** presents estimates of CHP opportunities in the service territories served by the PAs.

- **Section 7. Conclusions and Recommendations** integrates the findings of the interviews with stakeholders and the quantitative market assessment. The evaluation team presents a high-level overview of the CHP market in Massachusetts and identifies key CHP opportunities based on the research conducted. Short-term and long-term recommendations are provided to the PA implementers for consideration.

- **Appendices**
    - A. Literature Review Sources
    - B. Vendor Interview Guide
    - C. Site Interview Guide
    - D. Detailed Methodology: Quantitative Market Assessment
    - E. Potential Site Interview Guide

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3. Literature Review

3.1 Introduction

The CHP Market Assessment project began with a review of existing major Combined Heat and Power (CHP) support programs in the US.[6] Given the relative size of the CHP programs in California (CA) and New York (NY), research and evaluation effort was spent more on these programs. The evaluation team also included a review of the CHP programs in some of the other key states including Connecticut, Pennsylvania, Wisconsin, New Jersey, North Carolina, Oregon, Vermont, Ohio, and Washington.

As part of our review, we identified the primary types of support mechanisms for CHP and focused the research on the mechanisms that rely on financial incentives and their primary parameters. Given the high up-front costs of CHP systems, incentives are a heavily used policy measure to increase adoption. However, incentives alone are not the only mechanism to increase adoption or reduce barriers. We also reviewed and presented observations about the program designs that cut across various states paying particular attention to the CA and NY CHP programs.

This section is organized as follows:

- Methodology for conducting the literature review including the rationale behind the selection of case study states
- Summary of various types of CHP support mechanisms and program design parameters as observed in the case study states.
- Observations and key takeaways about the CHP program experience of two case study states – California and New York.

3.2 Methodology

The evaluation team conducted an extensive literature review that drew on program design documents and program evaluation reports. These sources include:

[6] This information was presented to the PA C&I Implementation team on September 27, 2010.

- U.S. Department of Energy
- U.S. Environmental Protection Agency
- California Public Utilities Commission
- New York State Energy and Resources Development Authority

A detailed list of the references including URLs is provided in the Appendix.

3.2.1 Selection of States

The criterion for selection of states was based, primarily, on the recent analysis by Kaufman and Elliott (2010) that used CHP project-level database maintained by ICF, see **Error! Reference source not found.**.[7] Kaufman and Elliott discuss the role of incentives in addressing the major barriers faced by CHP in various states. They score the various states on a scale of 1 through 5 with respect to how successful they were in encouraging CHP. They conclude that both financial incentives and a favorable regulatory environment contribute to encouraging CHP installation.

Table 3-1 Top twelve states in terms of the number of CHP projects installed during 2005-2009 period (Source: Kaufman and Elliott, 2010)

State	Number of New Sites (2005-2009)	Capacity (MW)	Average Capacity of New Sites (MW)
California	137	113.0	0.8
New York	94	98.8	1.1
Connecticut	61	181.9	3.0
Massachusetts	32	36.7	1.1
Pennsylvania	24	50.9	2.1
Wisconsin	20	83.0	4.2
New Jersey	18	14.1	0.8
North Carolina	13	17.6	1.4
Oregon	10	38.8	3.9
Vermont	10	3.2	0.3
Washington	8	97.6	12.2
Ohio	7	48.6	6.9

[7] http://www.aceee.org/proceedings-paper/ss10/panel05/paper01

The twelve states with the largest number of CHP projects installed during the period 2005 through 2009 were selected for review.[8] Although the exact number of CHP projects and the total installed capacity differed from other sources (e.g. evaluation of CA's CHP programs), the differences are probably due to the potentially different definitions of systems used by the study teams.

CA and NY have the largest CHP programs in the US. CA's Self-Generation Incentive Program (SGIP), which started in 2001, accounts for 400 CHP projects (192 metered) with approximately 212.9 MW of total capacity installed from 2001 through 2009 and approximately 665,000 MWh of annual generation in 2009. From the beginning of the program in 2001, the SGIP has paid out approximately $159.5M as incentives to CHP projects as of end of 2009.[9]

The New York State Energy Research and Development Agency (NYSERDA) administer three programs: DG/CHP, Existing Facilities, and New Construction. These programs account for 127 projects (out of which 70 are operational) with 193 MW total capacity. NYSERDA has paid out $94M in incentives while additional funds of $411M have been raised from other sources.[10]

3.3 CHP Support Mechanisms

There are two basic types of support mechanisms used to increase the adoption of CHP systems.

- **Financial Incentives:** The various types of financial incentives offered by federal, state, and local governments in addition to rate-payer funding include: grants, low-cost loans, rebates (capacity-, performance-, and cost-based), favorable tariffs, and tax-based.

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[8] Massachusetts is the fourth largest states in terms of number of CHP sites. In subsequent discussion, the focus is on the remaining 11 states that have the most number of CHP sites.

[9] Until 2008, SGIP also included solar PV which accounted for a large portion of the incentives paid out through the program. Since 2009, only wind and fuel cells are eligible for incentives under SGIP. Solar PV was covered under the California Solar Initiative while the fuel combustion technologies were deemed to not need further incentives.
http://www.cpuc.ca.gov/NR/rdonlyres/B9E262AA-4869-461A-8D5C-EE3827E9AA9D/0/SGIP_Impact_Report_2009_FINAL.pdf

[10] http://www.nyserda.org/Programs/pdfs/CHP%20brochure.pdf

- **Favorable Regulatory Treatment Mechanism:** the main examples include provisions for standard interconnection requirements, net metering, and favorable output-based regulations (e.g. those that apply to air emissions).

CHP support mechanism available in the top 11 CHP states are summarized in **Error! Reference source not found.**.

Table 3-2 Summary of various CHP support mechanisms[11]

State	State-wide					Utility-specific			
	Tax	Grant	Loan	Incentive: Fixed (Capacity and Cost)	Rebate - PBI[12]	Grant	Loan	Incentive: Fixed (Capacity and Cost)	Rebate - PBI
CA		X	X	X		X	X	X	
NY	X	X	X	X				X	
CT	X	X	X	X			X	X	
PA		X	X						
WI	X	X	X	X		X	X		
NJ	X	X	X	X					
NC	X	X		X					
OR	X	X	X						
VT	X	X	X		X	X			X
OH	X	X		X		X		X	
WA	X	X			X				X

3.4 CHP Program Parameters

As part of the review of CHP program designs, we identified three key parameters that were used to describe the systems eligible for participation in the different incentive programs and the structure of the financial incentive mechanism

[11] MA is not included here as this literature review focuses on the experience of other states and what that had to offer to stakeholders in MA.

[12] PBI = performance based incentive

. The parameters are:

1. **Technology**
   - Six types of CHP technologies are most commonly eligible for participation in CHP programs. They are: reciprocating engines (both spark- and compression-ignition), combustion (or gas) turbines, Organic Rankin cycle, steam turbines, micro turbines, and fuel cells.
   - In CA's SGIP program, approximately 60% of the installed capacity is accounted for by CHP technologies, with the balance coming from PV and wind. Of this 60%, 69% are combustion engines, 12% turbines, 12% micro-turbines, and 7% fuel cells.
   - In NY's DG-CHP program, all CHP technologies are eligible for participation except commercially available fuel cells while in the Existing Facilities program only internal combustion engines and gas turbines can participate.[13]
2. **Fuel Type**
   - Both fossil (i.e. natural gas, propane, fuel oil, and coal) and renewable (i.e. biomass such as wood and ethanol, biogas, and landfill gas) fuels are typically eligible for use in the CHP technologies listed above. Hydrogen derived from natural gas can also be used in some of the CHP technologies.
   - While CA's SGIP allows all fossil and renewable fuels, NY's DG-CHP excludes anaerobic digester gas and its Existing Facilities program allows only natural gas as the CHP fuel. [14]
3. **Timing and Type of Financial Incentive**
   - Governments of all the eleven major CHP states listed in **Error! Reference source not found.** (excluding Massachusetts) offer some type of financial incentives. However, utilities in only seven states offer financial incentives for CHP as shown in **Error! Reference source not found.**. The most common type of financial

[13] Technologies eligible under the New Construction program are not specified. The eligibility is assessed on a case-by-case basis as long as the project meets the objective of improving energy efficiency.
[14] Fuels eligible under the New Construction program are not specified. The eligibility is assessed on a case-by-case basis as long as the project meets the objective of improving energy efficiency.

incentive offered by state governments are grants followed by taxes, low-cost loans, and rebates.

- Only two states, Vermont and Washington, offer performance-based incentives.

Error! Reference source not found. below provides a summary of selected state CHP program goals, the financial incentives and size limits.[15]

[15] Only those states that have sufficient and verifiable information about program objectives and design was available are included here.

Table 3-3 Selected State Goals, Incentives and Size

State	Goals	Incentives/ Rebate	Size
CA	• Peak-load mgmt • Clean Technology • No explicit targets	• $2.5-4.5/W • 20% added for those with manufacturing in-state	• <3 MW but with reducing incentives (see text below)
NY	• Peak-load mgmt • Environmental goals • DG/CHP program target - ~800 MW in NYC	• Existing - $0.10/kWh + $600-750/kW capped at $2M per project • New Constr. - 50-75% of incremental costs capped at $850K-1.65M	• Existing - >250 kW • No limits for new construction
CT	• Conservation	• 30 -50% installed cost	• Custom
MA[16]	• Reduce energy use and carbon foot-print	• Up to $750/kW • Up to 50% of installed cost • Subject to program administrator budget limits • APS Performance Based Incentive from State	• No limits
WI	• Support renewable	• Grant - $10K-100K • Performance based incentive: • Alliant - $0.12/kWh on-peak, $0.0735/kWh off-peak • WE - $0.155/kWh on-peak, $0.0614/kWh off-peak • Xcel - $0.073/kWh	• Biomass fueled only • Alliant – 20kW-2MW • WE Energies - <2 MW • Xcel – 20kW-800kW
VT	• Support renewable	• Custom grant + $0.04/kWh	• Project Specific
OH	• Energy Efficiency Resource Standard (EERS) • Peak-load management	• $0.08/kWh +$100/kW	• Max $300K or 50% of total cost
WA	• Support renewable	• Varies by Public Utility District ($0.21-1/kWh)	• Incentive for <25 kW-AC

3.4.1 Incentives and Performance in CA and NY

The CHP incentive support program design can be complex and vary substantially across states. In this review, we focused on CA and NY to illustrate the complexity of program designs.

[16] http://www.masssave.com/professionals/training-and-certifications/~/media/76A9883D758743239B8FAC5536A55121.ashx; http://www.mass.gov/?pageID=eoeeasubtopic&L=3&L0=Home&L1=Energy,+Utilities+%26+Clean+Technologies&L2=Green+Communities&sid=Eoeea

3.4.1.1 California SGIP and New York NYSERDA Program

SGIP has been operating since 2001 and currently has an end date of 2016. The total program funding currently available per year is $83 million and any excess dollars are carried forward. The current program covers only wind and fuel cell technologies. Until 2008, the program also included solar PV and combustion technologies (e.g. internal combustion engines) with total incentives paid out over 2001-2009 period (i.e. 8 years) being $622.6M averaging approximately, $80M per year. Funding for the program is legislatively set through the end of 2011. The SGIP is a separate program that is not part of the investor owned utility energy efficiency programs. From the beginning of the program in 2001, the SGIP program did not have any specific capacity targets, cost targets, mandatory maintenance requirements, or mandatory requirements for metering of electrical output, waste heat, and fuel use.[17]

Under CA's SGIP, incentives of $2.50/W to $4.50/W, varying by fuel type, are provided for CHP systems. An additional 20% incentive is awarded to projects that use systems manufactured in California, which attempts to ensure that the economic development benefits accrue to CA. The CHP projects eligible for participation are limited to a maximum size of 3 MW with the available incentives decreasing as the project size increases. More specifically, 100% rebate is available for systems up to 1 MW, 50% for additional capacity between 1 to 2 MW and 25% for additional capacity between 2 to 3 MW.

CHP combustion systems participating in the SGIP program needed to meet efficiency (>40% for electric component and >42.5% combined electric and heat on an LHV basis) and waste heat utilization levels (>5% waste heat recovery annually). The systems must also meet air emission standards of less than 0.7 lbs of NOx per MWh. The use of the waste heat in the SGIP program is provided below in **Error! Reference source not found.**.

[17] Program administrators may install metering systems for program evaluation purposes in some cases.

Table 3-4 End-Uses Served by Recovered Useful Thermal Energy as of End of 2009[18]

End Use Application	On-Line Systems (n)	On-Line Capacity (kW)
Heating Only	243	97,469
Heating & Cooling	79	62,257
Cooling Only	39	34,051
To be indentified	2	360
Total	**363**	**194,137**

Beginning in January 1, 2008, combustion technologies were eliminated from the program in response to special legislation (AB 2778).[19] In general, combustion technologies were eliminated from the SGIP due to concerns over NOx air pollution emission rates. Currently the California Public Utilities Commission is re-evaluating eligibility of combustion-based technologies to the SGIP.

Capacity factor is the ratio of the actual power generated by a system to the rated power of the system over the same amount of time. As such, changes in capacity factor can be used to identify performance trends for generation systems. **Error! Reference source not found.** highlights the change in capacity factors over time for different SGIP technologies. Many factors contribute to the change in the utilization of installed systems such as the cost of electricity produced by the distributed generation system compared to the cost of electricity purchased from the utilities.[20] At a particular decision point, a host owning a CHP system that utilizes

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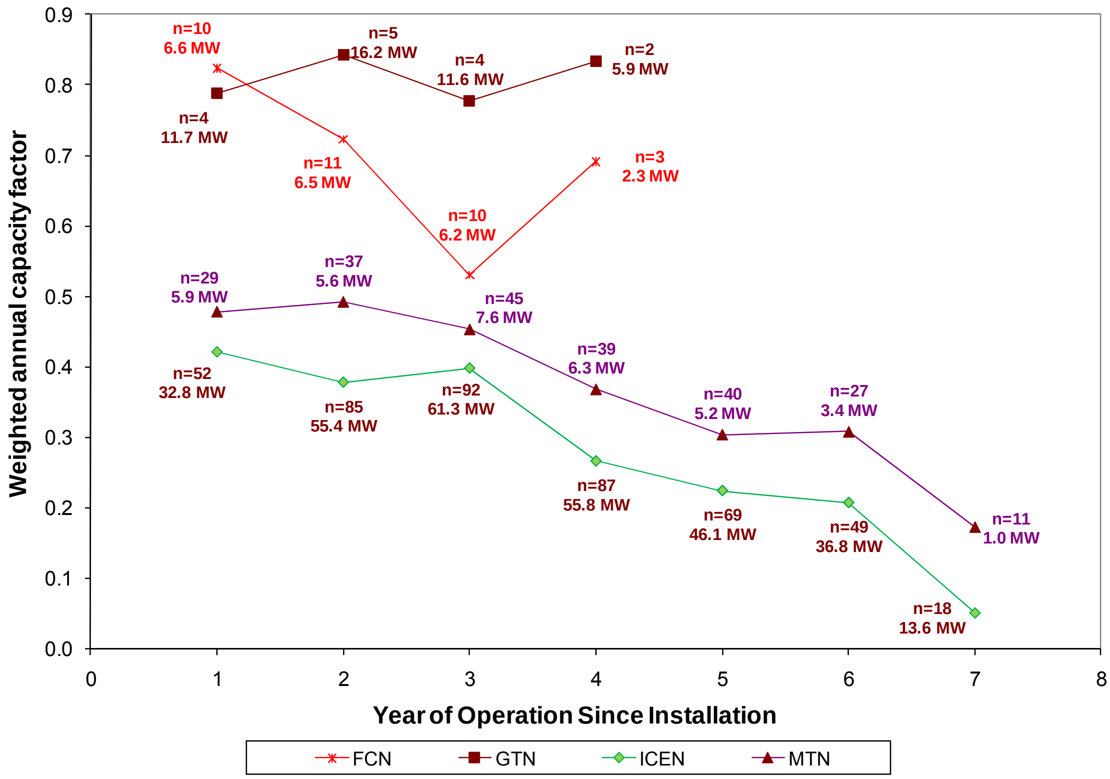
[18] SGIP 9th Year Impact Evaluation. www.cpuc.ca.gov/NR/rdonlyres/B9E262AA-4869-461A-8D5C-EE3827E9AA9D/0/SGIP_Impact_Report_2009_FINAL.pdf

[19] Assembly Bill 2778 (Lieber, February 24, 2006) limited eligibility in the SGIP to fuel cells and wind technologies. It further required that fuel cells eligible under the program must meet or exceed NOx emission standards outlined by the California Air Resources Board for distributed generation systems.

[20] Utilization or the time a piece of equipment was running should not be confused with availability, which is the time a machine would be available to run.

natural gas may decide to cease operations. Other factors that may impact the systems utilization are the maintenance of the equipment or the availability of staff to run the CHP.

Figure 3-1 Annual Capacity Factors for SGIP Technologies using natural gas*



*Note: FCN = fuel cell (natural gas); GTN = gas turbine (natural gas); ICEN = internal combustion engine (natural gas) and MTN = microturbine (natural gas). Note that "n" in the graph refers to number of metered systems (within a larger population)

Under NY's Existing Facilities program, incentives of $600 per kW and $0.10 per kWh are offered for CHP systems located in upstate NY. For systems located in Con Ed service territory (primarily, New York City and Westchester County), incentives of $750 per kW and $0.10 per kWh are provided. The systems kWh potential is calculated and included as part of the payments. The total project incentive paid to an Applicant may not exceed $2 million or 50% of project costs, whichever is less.

Unlike the CA SGIP, in NY's Existing Facilities program the financial incentives are paid out in lump sums based on the estimated system performance with 40% being paid out at the time of commissioning, 30% after one year, and the balance after two years of performance. The payouts after the commissioning are based on the measurement and evaluation studies of the installation.

For NY's Existing Facilities program, the minimum annual fuel conversion efficiency of participating CHP systems must be 60% (on an HHV basis) and the systems must achieve a minimum of 60% reduction in the contracted summer peak demand of the customers. They must also meet air emission standards of less than 1.6 lbs of NOx per MWh.

3.5 Key Observations

Both governments (i.e. federal, state, and local) and regulators/utilities are using a wide-range of programs/policies to support CHP in their respective jurisdictions. The objectives of these programs and policies include:

- peak load management,
- energy efficiency, conservation,
- climate change mitigation,
- increasing adoption of clean energy, and
- economic development (e.g. employment).

The program designs attempt to explicitly address specific barriers that CHP is facing such as high upfront cost, high operations and maintenance (O&M) costs, while meeting the needs of the State in terms of measurement and evaluation.

In some jurisdictions, CHP project developers can obtain financial support, simultaneously, from multiple programs and policies. As seen in Table 3-5, and mentioned earlier, there are multiple types of financial payments and incentives among the selected States. Coordination among providers of these incentives and their requirements is essential for smooth operation of a CHP program and ensuring that total benefit provided to the CHP project developer does not exceed the total costs. This coordination is especially important from the perspective of the eligibility requirements defined in terms of the three key parameters – technology, fuel, and size/timing of financial incentives.

Table 3-5 Financial Incentives for Selected States

State	Financial Incentives
CT	• 100% sales tax exemption on the CHP equipment. • Grant: $3.20-4.70/W (max. $4M per project)+2 cents/kWh production incentive • Loans: <$60K, Rebate: varies per project, program budget <$150M
PA	• Grants/Loans varies by project and tied to employment creation (program budget $165M) • Loan guarantees: res. <$100K and comm. <$2M (program budget: $25 M) • State Grant Heat Recovery program: <$1M per project (program budget: $16M), • Local grants: <$25K per project and some vary by project, • Local loans: <$500K per project and some vary by project,
WI	• Biomass tax credit: 10% of cost (max. $100K per claimant) • 100% sales tax exemption • Rebate: varies for biomass facilities (max. program budget $8.2M) • Grants: varies by project (max. $500K)
NJ	• Property tax: 100% exempt. The exemption applies until the equipment operates. The assessor also has right to inspect the system • Rebate: $0.15 - $5/W DC (varies by tech. and size) Max. 40% or $1.5M (program budget: $66.5M) • Loans/grants: combined, Grant: $450/kW (max. per project: $5M, program budget: $18M)
NC	• Personal tax credit: 35% of cost (max. varies by tech.) • Grant: max. $500K, Loan: <8% interest and term <20 yrs, • Green building incentive: reduced building permit fees
OR	• Personal tax credit: Fuel Cells ($3.00/W-DC, max. $1500/yr or 50% of cost) • Biomass $0.40/kWh (1st yr)+$300 or 25% of the cost whichever is less), • Corporate tax credit, Property Tax, Grant (Max. $50K), Loan ($20K - $20M)
VT	• 100% sales tax exemption that applies only to the equipment, Varies with grants, Loans – 2% rate
OH	• Grant 25% project cost (max. total $100K), 100% tax exemption
WA	• 100% sales tax exemption, <$35K (local grant)

3.5.1 Lessons Learned from CA and NY

Based on the relatively long experience of the CHP programs in California and New York, the following observations may potentially improve future CHP program designs:

- ***Targets and Goals:*** Establishing an explicit target for capacity installed, kWh generated or therms reduced can help in achieving substantial market penetration and focus the supporting utilities toward meeting goals. Programs such as California's SGIP had no targets, and that in turn yielded low market penetration. Later programs such as the California Solar Initiative or Statewide Solar Thermal Program have both capacity and cost targets that have yielded steadily increasing market penetration. Although the SGIP program initially included combustion technologies, they were eliminated after 2007 with the understanding that this decision would be revisited later. In 2009, distributed technologies that contribute to greenhouse gas reductions were included in SGIP. A draft decision from the CPUC released on April 21, 2011 identifies a number of CHP technologies including fuel cells powered by natural gas or on-site biogas; gas turbines fueled by natural gas or on-site biogas; and IC engines or microturbines fueled by on-site biogas are potentially eligible under a revised SGIP.

- ***Tariff design and interconnection:*** Tariff design becomes a form of a financial incentive if certain charges are avoided using distributed generation CHP systems. Examples of these charges include standby fees and other charges associated with utility loss of load. Interconnection rules such as limiting interconnection in particular areas and having a lengthy interconnection process can act as barriers as parties wait to be interconnected and begin generating electricity and utilizing waste heat locally.

- ***Rules to limit impact of performance degradation:*** Performance of CHP systems deteriorates over time due to market factors. For new programs, there may be a need for requirements to ensure performance persistence. These requirements can include but are not limited to:

    - Implementing mandatory maintenance or warranties
    - Including performance based incentives
    - Re-commissioning studies

4. PA Program Staff Input

As part of the project kickoff, the evaluation team spent time with the PA decision makers reviewing the literature search material and interviewing a number of program implementers (sales/account managers and the program team) on the CHP program and market. Below is a summary of the findings from the interviews with the program implementers.

4.1 Interviews with Program Implementers

As part of the evaluation team's analysis we spent time interviewing seven staff members through six interviews with the Program Administrators (PAs) reviewing the CHP program and identifying potential barriers they thought may exist in the CHP market. The individuals we spoke with were either from the sales team, focused on segments of the market that may be viable segments for CHP or individuals specifically tasked with managing the CHP programs for the different PAs.

4.1.1 Customer Motivation and Contact with PA

During our interviews with the PA implementation team we asked what they thought were the primary reasons for sites to install a CHP system at a particular location. The majority cited reducing existing gas cost through avoided gas purchases for heat or domestic hot water. The next was the reduction in their electricity bill and general financial savings when energy produced on site is less per kWh than electricity purchased from the grid. One mentioned environmental benefits based on a site that had come through the program recently in 2010.

Those locations that are installing CHP systems had come to the utility through different means depending on what was needed and on what part of the utility organization they spoke with first. The utility account executive often heard about the proposed CHP system through their interaction with the utility customer. The program team discovered new sites either through the utility account executive or through developers who were requesting information. At the time of our interviews in late September of 2010, the PA's mentioned that they had performed some outreach to the community but not a material amount. A majority of their efforts had been educating the developers on the program and the benefit cost tool and less time and effort with the end customers.

In terms of customer acquisition and finding customers, the former gas representatives were familiar with the process of identifying potential customers that were suitable for CHP systems (typically a fuel switching arrangements prior to the gas and electrical companies merging in some areas) and linking customers to developers. Interviews with the sites that mentioned they received good information from gas utilities about CHP corroborated this.

4.1.2 The Marketplace and Barriers

During our interviews with the PA implementers, they provided us their perspective on the current market. It was mentioned the importance of the federal investment tax credit and the Alternative Portfolio Standard (APS) credits in addition to the utility incentives assisting in improving project economics and the financial payback. Some of the implementers during the interviews also indicated that CHP was a sophisticated product unlike other energy efficiency measures and as a result it needed to be "marketed appropriately".

The element of sophistication was also mentioned during the interviews in terms of the developers who were installing systems and their ability to execute. It was concluded during one interview that some developers who were focusing on the smaller systems were not providing enough detail in their proposals and it was requiring time for the utilities to educate them on the processes. As identified in later sections however, it is these small systems that may be providing a fair amount of delivered kWh reductions. Approaches should be developed to 1) reach these harder to reach and less sophisticated group and 2) identify ways to streamline the review process within the utilities to manage these types of applications. If these are not addressed it may become a barrier for the success of the program.

Other barriers that were identified by the PA implementers are identified in the table below:

Table 4-1 Frequency of Barrier Mentioned

Barrier	Frequency
Financial/Economics	3
Utility benefit cost test	3
Interconnection	2
Awareness of the program	2
APS	2
Utility rates	1

4.1.3 Conclusions

The evaluation team's goal of interviewing the PA implementers was to establish a baseline of the utilities understanding of the CHP market place and review with them potential barriers they believed existed. We found after our interviews a high degree of understanding of the market. This was due to former gas company employees who had previously been targeting sites and outreach that had occurred during the development of the current program.

CHP systems can provide significant GHG emission reductions. For utilities such as those located in the New England ISO, GHG emission reductions result from displacement of electricity that would otherwise be purchased by the electric utility. If the CHP system is fueled only by natural gas, it will have lower emissions per unit of generated electricity than the utility systems, which are fueled by a resource mix that includes natural gas, oil and coal. In those situations where the utility central station is powered by natural gas, CHP systems fueled solely by natural gas still result in lower GHG emissions due to recovery of waste heat which displaces natural gas used to fire on site boilers. However, GHG emission reduction benefits were not cited in the interviews with the PAs or program implementers. Although GHG emission reductions from CHP facilities were not called out specifically within the Massachusetts Clean Energy Plan for 2020, these reductions could be significant as the CHP Program continues to grow.

In reviewing these and our interviews with the developers and customers of the utilities, we found some overlap in knowledge of the drivers and barriers. In the next section, we will review those interviews with the developers and customers and draw some conclusions where gaps in perception may exist.

5. Interviews with Suppliers, Users and Potential Users of CHP

Combined Heat and Power (CHP) technologies tend to be more complex than most energy efficiency measures or non-rotating distributed generation (DG) applications such as photovoltaic (PV) systems. They are also active machines, unique to each site where they are installed, responding to external factors that influence the demand and the thermal and electrical output from them. Due to the interaction between thermal and electrical loads, CHP systems also behave differently than backup generators, which typically come on only for short periods of time and usually provide only electricity.

Many decisions to install CHP technologies are driven by internal stakeholders motivated by a number of factors, including upgrading the entire physical plant, core business values that may not relate directly to the economics of the system and other factors that are not traditionally considered in energy efficiency measures and distributed generation systems like solar PV. An understanding of these motivations by stakeholders engaged with managing installed systems and those selling them would be valuable for the PAs of the Massachusetts CHP Incentive Program. It provides an opportunity to “listen to the market” and identify any perception gaps. To accomplish this, the following section provides the findings from in-depth interviews with 10 sites that installed CHP systems at their facility, 10 developers/manufacturers that provide and/or install CHP equipment and 10 candidate sites for installation of a CHP system.

5.1 Methodology

In-depth interviews with CHP stakeholders were undertaken to provide insights to the Massachusetts PAs on the structure and function of the CHP market in MA. Key research questions include:

- What are the specific processes and motivating and technical factors that lead to identifying good sites for CHP for developers and successful projects for the owners and do they vary by size?
- What are the key motivators that prompt sites to move forward with installing CHP and conversely, what factors lead sites to forego CHP?
- What are the barriers to successful installation or interconnection and how can the PA’s reduce these?

- Which data and tools are used to measure electrical and thermal loads?
- What monitoring and other services are provided in the market place?
- What are the most effective ways the utilities can inform and share knowledge with their customers about CHP technology and the PA's current program for CHP?
- What specific lessons learned were identified that should be explored as the CHP program develops?

Over the course of eight weeks, the Evaluation Team performed 30 in-depth interviews of stakeholders involved in the installation of CHP to help address these and other research questions. Ten interviews were conducted with each of the following three groups:

- **"*Developers.*"** Manufacturers of CHP systems, developers, installers and non-profits engaged in the feasibility analysis, sale or installation of CHP systems in the Commonwealth of Massachusetts.

- **"*Sites.*"** PA customers that either installed CHP systems through the current energy efficiency CHP program being offered by the electrical utilities or sites that had installed CHP before this program.

- **"*Candidates.*"** PA customers that were identified by the CHP Evaluation Team for Massachusetts[21] as potential sites for installation of CHP. The identification of the "***Candidates***" was based on the results of the interviews with ***Developers*** and ***Sites***, and the Quantitative Market Assessment discussed in Section 6 of this report.

These 30 interviews do not represent a statistical sample but were selected to be generally representative of companies engaged in selling and advising on the feasibility of CHP systems (i.e. ***Developers***), those sites that had installed a CHP system (i.e. ***Sites***), and those sites who had been identified as potential sites for installation of CHP (i.e., ***Candidates***).

Table 5-1lists the key research topics covered in the interviews with Developers, Sites and Candidates. The evaluation team used these instruments to collect the data for an exploration of specific aspects of the CHP market from the perspective of Developers, Sites and Candidates.

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[21] The CHP Evaluation Team for MA is comprised of representatives from the PAs, the EEAC and LCIEC.

The Developer, Site and Candidate interview guides are provided as Appendices B, C and E, respectively.

Table 5-1 Interview Guide Topics

Key Research Questions	Developers	Sites	Candidates
Background			
Job Responsibilities	√	√	√
Customers Served/Facility	√	√	
Technologies focus/installed	√	√	
Process of CHP Customer Selection	√		
Coordination successes	√		
Knowledge of Program			
Awareness of Program	√	√	√
Participation in Program	√	√	
Program strengths, weaknesses and suggestions for improvement	√		√
Knowledge and feedback on PA outreach materials	√	√	√
Technology Fit and Decision Making			
Requirements and Motivation to install CHP	√	√	√
Knowledge of thermal/electrical loads	√	√	√
Monitoring information	√	√	√
Energy efficiency considered	√	√	√
Installation and CHP adoption			
Satisfaction with installation/interconnection		√	
Time and satisfaction for completion		√	
Primary barriers	√	√	√
Primary drivers	√	√	√

5.1.1 Developer and Site Sample Selection

The list of potential ***Developers*** and ***Sites*** to interview was provided to the evaluation team by the Program Administrators (PAs). This list was not a statistical sample, but a cross stakeholder survey to assist the PAs in the continued development of their CHP program and to supplement the quantitative market assessment with qualitative information. We prioritized the list we were provided to derive a list of interviews representing developers and manufacturers that focused on CHP systems of different sizes. We also applied the same process in prioritizing the ***Sites***.

Once the list was prioritized, the Evaluation Team proceeded to contact the potential interviewees by phone and email when that information was available, and using other resources (e.g. the internet) to find other contact information. Once scheduled, the interviews typically lasted an hour with two or three interviewers including one senior staff member. The interviews took place over a 7 week period of time from December 21, 2010 until February 10, 2011. Interviews of the ***Developers*** and ***Sites*** were performed in parallel.

Interviews with the different companies included CEO's, Presidents, and director of sales for the northeast for the ***Developers.*** The ***Site*** interviews were conducted with company personnel who were most knowledgeable on the CHP system located at their facility. They included facility managers, director of operations, project engineers, project managers and maintenance supervisors.

For the ***Developers***, roughly half were small developers who had completed 5 or fewer systems over the past 2 years; almost half had installed 5 to 15 CHP systems over the past two years and one had installed more than 15 over the past two years. For most of the Developers, the CHP installations in the Commonwealth presented 20% or less of their business. Other business revenue may have been CHP systems sold and installed outside of Massachusetts, audit services or the installation of other distributed generation such as solar systems.

As part of our prioritization, for diversity in equipment provided, we sought to identify developers and sites that had different types of equipment. The majority of the ***Developers*** (five) we spoke with provided equipment for business segments that required CHP systems that were 300kW or smaller. A smaller number of ***Developers*** (three) we interviewed provided systems from 150kW to 1MW (usually providing multiple 200kW sized engines and only one provided systems greater than 1MW).[22] There is overlap between the developers in the 150 to 500kW segment. Also, as the data in the quantitative market assessment indicates, this break down makes sense given the large number of potential sizes in the lower kW range.

Developers that we interviewed targeted a number of different business segments. We categorized the business segments based on frequency the interviewees identified a targeted market. Table 5-2 presents the segments and the categories:

Table 5-2 Developer Mentions of Target Markets

Most Often	Often	Least Often
Nursing homes or assisted living locations	Apartment Buildings and housing co-ops	Industrial and manufacturing
Hotels and hospitality	Health clubs with pools	Office buildings
Universities/Colleges		Waste water treatment facilities
		Hospitals

For ***Sites*** we attempted to follow the same prioritization to maximize a good cross section of sized systems and sites based on the list of potential sites provided by the PAs. This list and the interviews were completed in parallel with the ***Developer*** list and interviews.

A majority of the sites we interviewed were sites that had systems under 500 kW, with only one site with a system between 500 kW and 1 MW and three sites that were systems greater than 1 MW. The segmentation of ***Sites*** we were able to recruit for interviews is listed below:

- (3) Industrial or light manufacturing sites
- (2) Apartment building complexes
- (2) Nursing homes/assisted living facilities
- (1) University/college
- (1) Office/laboratory
- (1) Ice rink/hockey complex

[22] The total is 9. We completed one additional interview with an educational institution that provided CHP assessments. While they are not a CHP developer, their insights into the marketplace are valuable.

While a bit more weighted toward the larger systems and industrial/light manufacturing given the probable population of sites, the insights gleaned from the large sites including potential hurdles and knowledge of the CHP utility program were valuable.

5.1.2 Candidate Sample Selection

Following the submission of the draft Interim Report, the CHP Evaluation Team for Massachusetts met to discuss the target population for the 10 interviews with potential users of CHP. Based on the results of the Quantitative Market Assessment and the interviews with ***Developers*** and ***Sites***, the LCIEC Team targeted the 828 "High-Value" sites with an annual gas usage between 95,000 and 950,000 therms (refer to **Error! Reference source not found.** and Table 7-3). Within this category, sites were selected across different customer segments and across PA service territories, where possible.

Candidate interviews either were conducted with site personnel most likely to make the decision to move forward with installation of a CHP system or who were responsible for energy management practices at the site. These included energy managers, VP of operations, chief engineers, and directors of operations, engineering, and modernization/procurement.

The segments we captured in the ***Candidate*** interviews were as follows:

- (3) Apartment building complexes
- (3) Industrial or light manufacturing sites
- (2) Health care (hospital)
- (2) University/college

The potential size of CHP systems among the interviewed ***Candidates*** is estimated to range from 70 kW to 2 MW.

5.2 Results

The below section provides the results of the ***Developer***, ***Site,*** and ***Candidate interviews***. It includes the following sections:

- Motivation for Pursuing CHP
- Financing a CHP System and Importance of Economic Factors
- Site characteristics
- Selling and installing CHP system

- Current CHP Program and Relationships with the PAs

5.2.1 Motivation for Pursuing CHP

One of the first areas we wanted to pursue with the interviews was learning about the motivation for installing a CHP system at a facility, understanding who made the final decision and once installed, how the systems were operated in terms of electrical or thermal loads. With this information, the PAs may be able to improve their targeting of prospective CHP sites customers.

The installation of a CHP at a site is primarily pursued for financial/economic reasons. Reducing energy costs was the primary and most common motivator indicated by the ***Developers***, ***Sites*** and ***Candidates.*** For both ***Sites*** and ***Candidates***, lowering energy costs ranked as the top motivator with nine of the ten interviews in each category listing cost savings as the number one factor and sometimes the only factor. The remainder listed cost savings equal to or right behind environmental and reliability motivators. Four of the 10 ***Sites*** interviewed mentioned environmental reasons in addition to other reasons as a motivator to install CHP and six did not. Among the ***Candidates***, 7 of the sites indicated environmental benefits ranked above average as a motivating factor in considering CHP. Only 3 of the ***Candidates*** indicated the use of CHP for backup power as a high motivator.

These results and others are provided below in Table 5-3

Table 5-3 Motivations for Installing CHP[23]

Motivations	Developers	Sites	Candidates
Economics: Utility rates & Cost savings	10	10	10
Utility Incentives	10	10	4
Environmental	6	4	7
Partnering with utilities	4	N/A	N/A
APS program	2	1	N/A
Relaxed qualifying restrictions	1	N/A	N/A
Power reliability	1	1	N/A
Emergency Generation Capability	0	1	3

With a CHP system, facilities are now able to meet their electrical and thermal demands at a lower cost, with less impact on the environment, and increased reliability in some cases. The "spark spread" or the difference between the costs of generating their own electricity versus acquiring it from the grid was a major impact on the financial attractiveness and economics of CHP. An ability to run independent of the Grid was not a primary factory and many Sites were not interconnected to provide backup power. Nonetheless, it was cited as a motivation by one ***Site***.

While financial/economic reasons were the predominant drivers for installing a CHP system, the energy savings and associated environmental benefits were also a motivation. This was particularly the case for the following types of sites:

- companies with larger sites and a significant public exposure,
- apartment buildings that were engaged in other environmental and energy efficiency programs through the utilities in the Commonwealth, or those that were participating in federal programs (e.g. subsidized HUD sites), and
- sites using the CHP system to help in accumulating LEED points for their facilities.

[23] The topics listed were not in some cases directly asked but brought up by the participants during the course of the interview. Therefore, the table may not reflect the overall community census but gives insight into the main drivers identified by interviewees.

5.2.2 Financing a CHP System

CHP systems being installed are viewed as capital projects using the same financial metrics decision makers use when pursuing other large investments, including the internal rate of return for the project or what the payback period will be. Across the ***Developers*** and ***Sites*** interviews a 2-3 year payback was mentioned as ideal with a maximum payback ranging 4-5 years. Paybacks above 5 years were not mentioned except in the case of a system that was being built to also act as a backup system for a manufacturing process. In one interview, the typical payback mentioned for their firm was 3 years for capital projects but because this was an environmental project the accepted payback was raised to 5 years.

The needed payback mentioned in the ***Candidate*** interviews ranged from 1 to 20 years. However, a clear relation became apparent between the required payback and those sites which installed or continued to pursue CHP. We found that even for sites that are a good fit for CHP based on matching electrical and thermal demands, only those sites that can afford a payback period of five years or less move forward with the installation of CHP. This is consistent with the responses of the ***Developer*** and ***Site*** interviews.

Through the ***Candidate*** interviews we did not find a clear relationship between the segments most likely to afford a 5 year payback and the capacity of the potential CHP system. Instead, we found the customer segments most likely to afford a 5 year payback period are those with good financial stability and a long-term business history. The segments that best fit these criteria were established Hospitals, Universities, Large Industrials, and multifamily housing facilities.

Based on the interview results, we segmented the level of importance of the utility incentive to a facility into three desired payback categories.

1. **Sites needing a 1-3 year payback:** the utility incentives are generally insufficient to move the CHP system forward and are of low importance.
2. **Site needing a 5 year payback:** the incentives are crucial in pushing the project into this payback range. A comment from a developer supports this relation saying they try to sell their CHP without the incentive, but if the payback needed is 5 to 6 years, the utility incentive helps move the project forward.
3. **Site affording a larger payback of 10-20 years:** the incentives are important but not crucial. Generally, the project will likely move forward without the incentive, especially if coupled with an existing facility project or the facility's desire to "go green."

Among the ***Candidate*** interviews, only the smaller Industrial sites needed a payback period of less than 5 years; specifically 1-3 years. All three of the sites have a need for the thermal output from the CHP system, but the payback period for the CHP project exceeded their allowable threshold.

One of the main factors driving the payback time variable is the current state of the economy. One developer providing CHP from 100kW to 30 MW said, “The economy is the main barrier; people don’t know where they are going to be in two years.”

The decision to install the CHP device according to the interviews was ultimately made by the CEO, the Broad of Trustees or a firm’s financial department, depending on the size of the capital outflow. As a result, developers and equipment manufacturers would provide financial information on the investment to assist those decision makers. Information used in this process included the cost of the capital, operating expenses, fuel expenses and assumptions on the prices of energy (electricity and gas) in the future. For those ***Sites*** that had already installed a CHP system, most were pleased with the performance of their CHP system and believed they were reaching or beating their payback targets. Most attributed this to the operation of the machine and the lower cost of natural gas than originally modeled.

During the ***Developer*** interviews, another critical person identified is the person responsible for the operation of the device or someone technical who could be an internal champion. The ***Developers*** viewed this person as necessary to move the project forward.

5.2.2.1 Power Purchasing Agreements

To help address the payback and financial risks, developers have been exploring using power purchasing agreements (PPAs) in addition to the utility incentives and the Commonwealths Alternative Portfolio Standard (APS) credits. The PPAs provide a minimal capital investment to the customer because the system is owned by a third party, therefore requiring no capital outlay by the host customer. In turn, the third party owner of the system sells electricity to the host site at a kWh rate below the grid price, along with recovered waste heat. Some PPAs provide an option to buy the system once they have experience with its performance and have a better sense of their own business security. PPAs also limit any risk for the location to seek financing for the capital and since the Developer or a third party owns and operates the system, PPAs do not need additional Site staffing to manage and run the CHP system.

Roughly half the ***Developers*** who targeted the smaller sized systems offer PPAs. Typically many locations requiring an under 300 kW sized system do not have the access to capital, and did not want to become experts in running a CHP system, therefore a PPA may make more sense for them. However, this financial offering had not been pursued by the ***Sites*** we interviewed as they all owned their CHP systems. However, one site, under 150kW, thought about pursuing a PPA lease, but with their own external financing (a business loan typically) and the utility incentive it then made more economic sense to own the system. PPAs are less common for larger sites (greater than 1 MW) as these customers typically have easier access to capital and already have a full staff dedicated to managing their heating and cooling systems.

5.2.2.2 Use of and Awareness of the Incentives

All ***Developers*** and ***Sites*** agreed that the incentives are important for more adoption of CHP in Massachusetts. Half of the ***Developers*** mentioned that the incentives were important and critical in moving forward with a project. The other half said incentives are important, but projects have moved forward without them and the inclusion of the incentive was "icing on the cake". Interviews with the ***Candidates*** also indicated that utility incentives are important for facilities looking at payback periods of longer than five years.

One of the barriers identified by ***Developers*** and ***Candidates*** during the interviews was a lack of understanding of CHP technology amongst potential customers as well as lack of credibility for the technology based on the minimal understanding of the technology. This is particularly the case for sites that were 300 kW or smaller where typically the person assigned to the locations energy operation had limited experience with electrical generating equipment. Utilities are looked upon as experts in energy and the availability of an incentive from the utilities provided a level credibility for the applied technology to this less informed segment of the market.

In terms of the awareness of the current CHP program provided by the electrical utilities, the majority of the ***Developers***, except those that are targeting the over 1MW sites, were knowledgeable of the program. The awareness of the ***Developers*** was predominately due to their involvement with the development of the current utility program. A few ***Developers*** were familiar with the program as a result of the utility seminars and a few by word of mouth.

Conversely three of the ***Sites*** were aware of previous gas company incentives but were not aware of the current electrical program. Five ***Sites*** were aware of the program through their utility and others through word of mouth. Two ***Sites*** were not aware of the program at all until they started to investigate the feasibility of installing a CHP system. The lack of awareness of the incentives for large developers and lack of awareness of *Sites* about the CHP program offering by the electrical side of the utility indicates there is confusion about the program. This confusion can lead to misunderstandings in the market place about which side of the utility is leading development of CHP.

Within the ***Candidates,*** 8 of the 10 were aware of the current program through the electric utilities. Two were unaware of the program though one was knowledgeable about previous gas company incentives for CHP.

5.2.2.3 Conclusions

Overall, the primary motivator to install a CHP system is the financial benefit with the environmental benefits and back-up power as secondary attributes in the majority of cases. The utility incentive and the credits earned from the Alternative Portfolio Standard (APS) improve the financial payback, and according to many developers, the financial incentives can be enough to help motivate a customer and increase the likelihood that the system will meet its payback requirements. In addition, we heard across the set of interviews the viewpoint that utilities are “the experts on power.” Consequently, utility incentives not only help the project economics, but also help bring credibility to the technology and mitigate the risk of the unknowns of new technology, particularly for those sites that are not knowledgeable about CHP. Promoting successful CHP installs, especially those installed by the utilities (e.g. the National Grid LNG facility) or which passed utility screening criteria may be very effective in creating a template of projects that are a “good fit” for the Massachusetts CHP Program and good financial and environmental opportunities for the community. In addition, educating large sites and developers on the program now will assist in promoting the program and may assist in managing any ambiguity on attribution of the program.

5.2.3 Site Characteristics

During the interviews with the ***Developers*** and ***Sites*** we wanted to identify if there were different segments to assist in the quantitative market assessment and to assist the PAs in approaching the different potential customers. From the interview, we concluded that the segments could be broken into 4 customer classes based on the electrical generating size of the CHP device. [24] Those segments are:

- 60kW to 150kW,

[24] These market segments are also used in the Market Assessment report in Section 5.

- 150kW to 300kW,
- 300kW to 1MW, and
- Greater than 1MW

Table 5-4below summarizes the characteristics of these segments based on our interviews with the developers.

Table 5-4 Size Segmentation of CHP Site and their Characteristics

Characteristics	60 to 150 KW	150 to 300 kW	300 kW to 1 MW	>1 MW
Typical sites based on the interviews	Nursing homes; 100 bed facilities	Hotels, heath clubs with pools; hockey rinks, single wing housing facilities	Housing facilities like apartments; small manufacturing, prisons, hospitals	Manufacturing; universities and colleges
Knowledge of CHP, thermal and electrical load by sites	Minimal knowledge of CHP and likely little of their facility loads	Some on CHP, better on their loads and operations	Good background overall on CHP and energy use	Experts in all facets of CHP, the physical plant and energy use
Technology	ICE and MT	1 ICE to multiple ICE, maybe MT	Multiple ICE	GT, some ICE, potential for fuel cells
Reliance on technology provider	High	Medium to High	Low	Minimal
Part of a larger energy project	No	No	Probably	Highly likely
Absorption chillers	No	No	Yes	Yes
Energy management system (EMS)	No	Not likely	Yes	Yes

5.2.3.1 Sizing of Systems and Operations

Based on this segmentation we wanted to explore deeper the effect of operational differences or how the developers sized systems and sold into these segments. Below in Table 5-5 are methods listed by the Developers to determine the thermal load of the facility. The utility bill, with one exception, is a critical piece of information used by all developers.

Table 5-5 Means of Estimating Thermal Load[25]

How Developers estimate facility thermal loads	# of Developers
Utility bills for modeling purposes	9
Knowledge of load types (Experts in boilers, processes, HVAC)	4
Facility type benchmarking (e.g. 100 beds = 75 kW)	2
Site walk through	2
Temporary metering of loads	2

The majority of the locations' heat load came from space heat and domestic hot water. Larger CHP systems often also use waste heat for processes and the use of absorption chillers. Some sites explored the use of absorption chillers to make use of the waste heat during the summer when there was much lower thermal demand. However, in many cases the use of absorption chillers were not pursued due to the cost associated with them or because new and efficient electric chillers had been installed recently.

We found during the interviews that the smaller systems or those sized to cover the electrical base loads had a higher likelihood for heat dumping. These locations may have the electrical demand without the year round thermal demand.

Based on these sources of thermal data and electrical demand, generally we found that there were two approaches used in sizing a CHP system, both based off two outputs from a CHP system: electrical generation and waste heat to be utilized for the sites thermal needs.

1. **Size the CHP system to a percentage of the minimum electrical load (e.g. 90% of the electrical load at 1 am).** If there were enough thermal demand based on this electrical output the system would be sized from this metric. If there was less thermal load (not needing full thermal load between 5,000-6,000 hours over the year), the system was downsized to meet the thermal load requirements. If there were more thermal load than base electrical load, the CHP system would be expanded to the point where the economics and local operating conditions best matched the two.

[25] Developers will use multiple means to determine the thermal load at a site,

2. **Size the CHP system to the minimal thermal load then vary the size of the system depending on the electrical needs of the facility.** The base thermal need was identified. If the electrical needs were less than the size needed for thermal, the system is reduced in size to meet the electrical generation requirements.

Both approaches attempt to balance the electrical and thermal requirements with the right sized CHP system. In the majority of the interviews with the ***Developers,*** insuring that that the system was using 5,000 to 6,000 hours of the waste heat was critical for the project economics and the benefit cost test used by the PAs to qualify for the incentive.

Based on the interviews of the ***Sites,*** many of the locations indicated they wished they had a better understanding of the electrical and thermal loads at the site. In particular, they believed this would have helped them achieve better operational control of the CHP system. In addition, they believed it would have helped with the initial purchase (Table 5-6). While appropriate sizing of electrical and thermal load is critical, understanding and adjusting project timelines including construction and interconnection was also considered important. Five of the interviewees indicated project timing as something they wish they could revisit. Similarly, choosing the right auxiliary systems such as heating exchangers and the pathways for the piping were also cited often (four times) as items that the sites would have done differently if they had the opportunity to pursue the project again. None of the ***Sites*** believed their system was oversized, and only one stated that his system should have been larger.

Table 5-6 What sites would have done differently

What Sites would have done differently	# of Sites
Better understood their annual thermal and electric loads to improve CHP operation.	3
Better understood annual thermal and electric loads to improve sizing of their CHP system.	1
Looked into the use of absorption chilling and any applicable utility rebates.	1
Adjusted construction timelines to reflect reality. - Equipment lead times. - Boiler replacement and asbestos removal timelines. - Interconnection timelines. - Contractor scheduling.	5
Altered/changed CHP auxiliary equipment. - Considered duct burners. - Better heat exchanger design. - Different location for exhaust. - Better piping arrangements.	4
Pursued EE before installing CHP.	1
Better understood the interconnection and permitting process.	1
Ensured ample controls and automation on thermal side to prevent overheat or heat dump.	1

Based on our interviews we concluded the following sizing approaches for CHP systems. As you see in the table below, there was a fair amount of overlap and no clear rule as to the size of the system and method used for sizing. The reasoning behind this, based on many responses from the ***Developer*** interviews, is that every site is different and sizing CHP systems is both an art and a science, involving quantitative exercises, proprietary models, along with experience and judgment.

Table 5-7 Sizing Approaches for CHP Systems by Sector and Configuration

Characteristics	Electric Base	Elec. Following	Thermal Base	Thermal Following	Match Elec. & Thermal
Sizes	> 1MW	300kW–1MW	65kW–1MW	65kW–1MW	300kW–1MW
Sector	Universities, Manufacturing	Ice Rinks and Apartments	All	Nursing homes, hotels, pools	Apartments, offices, small mfg.
Configuration	GT	Multiple ICE	1 ICE to GT	Multiple ICE	Multiple ICE
Other	May be installed to provide back-up power	Multiple systems allow for modulation	Best configuration to meet overall efficiency	Facilities with more constant elec. may shut off in summer	May be undersized for thermal and electrical demand

5.2.4 Selling and installing CHP system

The selling and installation of a CHP system varied based on the size of the system being installed. Table 5-8 provides a summary of the selling and installation of CHP by the customer size segments defined above.

Table 5-8 Selling CHP systems and time to commissioning

	60-150 kW	150-300 kW	300kW - 1MW	>1MW
Sales Approach/ Strategy	Cold calling, selling first to internal champion	Cold calling or internal champion reaching out vendors	Likely RFP from third party or internal champion reaching out to vendors	Part of RFP and included in a larger facility project
Time to sell a system[26]	2 to 7 months	3 to 8 months	6 to 12 months	12 – 18 months
Time from signed contract to commissioning[27]	6 to 12 months depending on factors such as interconnection	6 to 12 months depending on factors such as interconnection	6 to 18 months depending on other factors	12 to 24 months depending on other factors
Factors impacting time to commissioning	• Availability of equipment • Permits • Required utility feasibility study	• Availability of equipment • Permits • Required utility feasibility study	• Availability of equipment • Construction and coordination with other parts of project • Permits	• Availability of equipment • Construction and coordination with other parts of project • Permits

Based on the different segments, ***Developers*** would use different tools to prospect potential customers. For example, the four ***Developers*** who were targeting sites that required systems greater than 300kW likely did not pursue potential sites but focused on inbound calls from likely customers. This was particularly the case for the ***Developers*** pursuing the greater than 1 MW segment who would usually only respond to request for proposals (RFPs). (There were 5 small, 3 in the mid category 250-1 MW, and 1 large).

[26] During our interviews with the 9 developers (one interview was with a CHP center focused on providing the feasibility of CHP systems) ranges on time to sell ranged a fair amount particularly for those smaller systems. Time to sell was framed as time from beginning of negotiations to a signed contract.

[27] These are approximate timeframes developed from a small sample size and should be used carefully. Although interviews with Developers indicated time from contract to commissioning could be as little as 3-6 months, interviews with Sites indicated longer time periods were required. In addition, PAs indicate that interconnection times may extend this time period.

Those five ***Developers*** interviewed pursing the under 300kW sized sites would use a number of different tools including utilizing SIC/NAICS codes for different industries, zip codes and names of operations, or cold calls in identifying the size of the facility. During one interview, a developer stated “I will look for nursing facility that has 125 beds, 125 beds is a 65kW sized system”. . This same developer also mentioned that, at a minimum, a light manufacturing location had to have “at least 2 shifts” to have a CHP system work.

Trade shows were another means mentioned to acquiring customers but most ***Developers*** did not enthusiastically mention them as a primary way to contact customers. A majority of the ***Developers*** did mention that it would be helpful for the utilities to identify potential sites or assist in bringing sites together to help establish credibility for the technology, developers and manufacturers.

During the interviews, it was mentioned that local permitting for the construction always took longer than anticipated. This is an issue for all customer class segments. Most of the interviewees mentioned that the best means to avoid this was better planning but in some cases that did not help reduce the time or added costs. Local permitting was also cited as a challenge with solar PV systems and resolution of this barrier for this technology is reportedly receiving attention from the Department of the Energy.[28] This may be an opportunity for the CHP community and the utilities to leverage this federal solar PV effort.

In terms of interconnection with the utilities for electrical and gas services, the majority of the ***Developers*** and ***Sites*** mentioned some dissatisfaction with the electrical interconnection process. In addition, two ***Candidates*** stated that they heard that the most complications are with interconnection and standby rates. Reasons for dissatisfaction provided by interviewees included time for return calls and a sense of urgency for completion from the utility.

For larger sites, this challenge with interconnection was mitigated through early and frequent communication with the utility interconnection organization or through escalating the issue through the utility hierarchy. One developer mentioned that the first time he went through the process it took a long time, but once he went through the interconnection process multiple times it became easier.

[28] http://www1.eere.energy.gov/solar/sunshot/about.html

In terms of the gas interconnect, all of the sites except one had a positive experience. The one negative experience revolved around obtaining an interval recording gas meter once the system was installed (to help meet M&V requirements of the conservation program).

5.2.4.1 Barriers to selling

As mentioned above, one of the key barriers to the adoption of CHP is knowledge of the technology. In Table 5-9 we listed the responses to this question by Developers and Sites. The one response not included in this table but was mentioned throughout the interviews was the cost of natural gas and electricity provided and their volatility. Changes in these variables have an ongoing impact on the adoption of CHP.

Table 5-9 Barriers of CHP Adoption by Frequency of Response[29]

Barriers	Developers	Sites	Candidates
Knowledge of CHP	5	5	4
Spot or area networks	2		1
Interconnection/ local permitting	4	4	2
Economy	1	1	1
Air emissions	5		1
Electric utility changing habits	1		1
Upfront cost	1	2	3
Metering	1		
Payback	1	1	3
Qualifying for program	4	2	1

The need to develop an educated CHP market is the top issue, followed by emissions for ***Developers*** and interconnection and permitting for both ***Developers*** and ***Sites***. The interviewees believed that the PAs could help address many of these barriers.

5.2.5 Current CHP Program Process

During the course of the interviews we asked the ***Developers*** for feedback on the overlap of the CHP program and their own processes. We also solicited feedback on the CHP program

[29] Utility tariffs such as stand by charges were not mentioned by the interview subjects.

processes. Overall the ***Developers*** mentioned that the PA CHP program processes did add additional time to the development of their sites ranging from 10 to 20%, or about a week, based on the average length of a project.[30] This added time came in the form of additional paperwork and formatting of material to meet the CHP program guidelines.

While there was an additional burden of time, during the interviews, the interviewees concluded that the process was straightforward. The only exceptions to this belief were the handling of the benefit cost (B/C) tests and the changing metering requirements. Most ***Developers*** believed a more transparent B/C test would help them understand why particular projects were failing.

5.2.5.1 Monitoring

The majority of CHP sites installed in the program are being monitored either by the project developer or host site or will have monitoring conducted on behalf of the utility. Monitoring varies by site but includes: gas consumed by the CHP system, kWh out, waste heat out, and in some cases the amount of dumped waste heat. The amount of and level of sophistication of monitoring increased as the size of the systems increased. ***Sites*** typically greater than 150kW were also pursuing the Commonwealth's credits as part of the Alternative Energy Portfolio Standard (APS).

The majority of the ***Developers*** were aware of the metering requirements of the CHP program and metering requirements of the APS. However, in some instances, CHP systems were able to install metering that was more lenient than the APS requirements on paper. As a result, there was high degree of frustration that there seemed to be a lack of coordination between the CHP program and the APS program with respect to metering requirements.

In one case there was a degree of frustration from a location that had their gas meter changed from a pulse meter to a non-pulse meter, forcing the site to sub-meter the gas flow to meet the requirements of the program,. In the interview, the site contact commented, "it seemed strange that they have a requirement for metering but then they change the type of meter we have." The site contact's confusion and frustration was further exacerbated by the need for instantaneous metering whereas the reporting requirement only called for next day reporting.

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[30] The question we asked was "For a typical project, how much additional time does the CHP program process in Massachusetts require from your firm?" We then asked them to capture that as an incremental percent increase to their typical project.

Adding to this contact's frustration was that he had a different gas and electricity provider and he wished they "communicated better." Additional metering beyond what was provided to help the customers was mentioned as a burden for those developers of the smaller sites (e.g. under 150 kW) In general, developers want concrete requirements that will not leave them installing more costly metering than what is really required; and they would like uniformity between the utility and APS metering requirements.

From the ***Sites***, most of them were aware of the metering but a majority of them were unaware of the technical differences between the CHP program and the APS program or what other metering was required. The ***Site*** participants seemed happy that the systems were up running and the additional pieces were "being addressed by the developer."

5.2.5.2 Interconnection

During some of the interviews the interview participants (***Developers*****,** ***Sites*** and ***Candidates***) mentioned that the electrical utilities appeared not to be in favor of CHP. These participants expressed the fear that utilities were unsupportive of CHP project due to the potential loss of electricity revenue. A few of the ***Developers*** in particular cited the difficulty and time required for interconnection as a symptom of this reluctance to support CHP. The ***Developers*** during this section of the interviews again reiterated that it would be very beneficial to the adoption of CHP if the electric utilities took a more "positive" tone concerning the technologies as exhibited through faster interconnection. The ***Developer*** attitude on the utilities support of CHP was also impacted on whether they were engaged in the original workshops to set up the program and the transparency of the B/C model. One ***Candidate*** also voiced the opinion that utilities "need to embrace decoupling and change their attitude."

5.3 Opportunities for PA – Go to market Strategy

In the below section we provide some recommendations based on the interview results. Some of these recommendations should be pursued immediately, while others will take time to evolve and require engagement and consensus from different stakeholders.

5.3.1 Education

Educating customers about CHP, particularly those customers with opportunity for systems below 300kW, is the highest perceived need among Developers. Based on our interview results, half of the ***Developers*** mentioned "increased education" as a contributor to increased adoption.[31] During the interviews, the ***Developers*** also cited that it would be helpful if this message and education came from the utilities, who are respected energy advisors to the commercial and industrial community.

A number of ***Developers***, ***Sites*** and ***Candidates*** expressed a desire for additional contact and interaction with the utilities. Many of the interviewees specifically mentioned that having the utility come on-site was valuable as part of their decision making. To help reduce utility commitment of resources, these on-site visits could be focused by size of systems or focused on the business sector of highest interest to the utilities. In addition, utility investment at the early stage of the program could help create "template" sites that can serve as examples of CHP projects that represent a "good fit" to the program objectives and the host site needs. Depending on how the utility account teams are organized, the on-site visits will also help provide additional opportunities for the utilities to "hear the market," and make any necessary modifications to the program.

During our interviews with the ***Sites***, many of the locations educated themselves on CHP by calling up and visiting other sites. This method was primarily mentioned at those ***Sites*** greater than 1MW, but it was cited by others as well. We also heard in the ***Candidate*** interviews, the value of the PAs taking a role in developing particular case studies for small, medium and large systems across facility types and thermal applications. These case studies could identify the steps to pursue in advance of installing a CHP system (pursuing other energy efficiency measures, reviewing the physical requirements) and the keys to success. The use of case studies was also cited as a good method to increase adoption of distributed generation programs during the review of the California SGIP. [32]

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[31] The next most frequent variable that would impact adoption was low gas prices and higher electricity prices.

[32] https://energycenter.org/index.php/incentive-programs/self-generation-incentive-program/sgip-documents/sgip-documents/cat_view/55-rebate-programs/171-sgip/203-sgip-data-and-reports/210-program-reports/374-program-process-reports

As part of the case studies or industry segment on-site visits, the environmental benefits CHP and understanding a sites thermal load could be included in the material. All of the ***Sites*** interviewed mentioned an increase in the awareness of their electrical and thermal loads after the installation of the CHP system. Also, a vast majority found the use of the audits provided by the utilities to be very helpful in 1) identifying energy efficiency opportunities and 2) helping in sizing the CHP facility. This improved integrated approach with energy efficiency measures (upgrading the boiler) and the CHP generation equipment was indicated by the sites as a preferred approach to installing more systems. Some of the PAs have already started this with the development of approved vendor lists and educational webinars. Based on the information from the interviews promoting this vendor list and holding more webinars will be well received.

5.3.2 Collaboration and Communication with APS program

Metering and obtaining performance data from installed CHP projects can provide valuable information to the program. However, it is not clear at this time the extent to which metering should be conducted on the CHP facilities. The PAs are currently developing a CHP metering framework to help identify different tiers of metering. Metering equipment required in each tier will depend on the capacity of the system, the type of performance data needed and the accuracy of the data. In developing the CHP framework, the PAs should ensure that the metering requirements do not unfairly penalize smaller systems by requiring expensive metering that may not be actually required. In addition, the CHP metering framework should be coordinated with the APS requirements to ensure uniformity in the requirements. Similarly, reporting requirements should be coordinated, thereby enabling sites to leverage both program and APS reports in the same format. Having these programs utilize the same requirements would solve many of the concerns expressed by the ***Developers*** during the interview process.

5.3.3 Improved Interconnection process

Interconnection is a concern nationally for all types of distributed generation facilities. Based on the interviews with the ***Developers*** and ***Sites***, educating the ***Developers*** on the interconnection process would likely be beneficial. In addition, there is benefit in streamlining the current interconnection processes within the utilities. In particular, streamlining the interconnection process helps to address the concerns expressed by ***Developers*** that the utilities are "dragging their feet" as a way to discourage growth of CHP facilities in their service territories.

6. Quantitative Market Assessment

6.1 Introduction

This section presents the results of the CHP Quantitative Market Assessment. The market assessment estimates the combined heat and power opportunities in the service territories served by the Massachusetts program administrators (PA). These results do not represent all cost-effective CHP opportunity in Massachusetts, but a lead list of high-value candidate sites for the PAs to pursue.

This analysis should not be misconstrued as a technical potential, economic potential, or market potential study. A technical potential study completed in 2006, for example, identifies a 4,700 MW technical potential for CHP in Massachusetts or over ten times the sum of the high-value customer capacity identified in this report[33]. Technical potential is "a measure of remaining market size that is only constrained by the technological limits - that is, the ability of the technology to match customer needs" and does not consider cost or site constraints. The economic potential would include all systems that pass the statewide cost-benefit test (benefit-cost ratio (BCR) greater than one) and would consider a longer time horizon incorporating developing technologies (such as systems that are under 60 kW) that are not *currently* economically feasible. Under the current benefit-cost model, a BCR of one corresponds to about a ten year payback without incentives.

The purpose of this study is to identify particular customers that might actually invest in a CHP system under current market conditions. The key product of this investigation is a lead list of named customers that can be pursued by the PAs. The total lead list capacity is a subset of the economic potential, primarily because a five year payback with incentives is used to screen sites. While the five year payback screening reduces the economic potential as defined by a BCR>1, it is at the same time an optimistic lead screen, because most customers find a five year payback too high. The lead list is purposively optimistic from a short-term point of view, in order to include all potential candidates. Some of the factors which optimistically identify leads include:

[33] Lauren Mattison "Technical Analysis of the Opportunity for Combined Heat and Power in Massachusetts." 2006

- Reasonably minimum pricing, rather than average pricing of installed systems.
- Five year payback with full incentive level ($750/kW) for all system sizes.
- Probably about a third of the sites will have HVAC systems that are not conducive to CHP (such as direct fired rooftop units). These cannot be identified from the current data set but can be quickly screened out once an account is contacted.
- Impact of standby rates and mismatches between electric load and gas usage.
- Sites with existing suspected generation are included.

This work has been conducted as part of Project 1C Market Characterization of Combined Heat and Power for the evaluation of the commercial and industrial (C&I) programs operated by the Massachusetts PAs. From the Request for Proposals (RFP), the overall objective of this market characterization study is to **"…define the attributes [of the Combined Heat & Power (CHP) market] in enough detail that the program planners and administrators can use the information for improving program implementation."**

These results represent an update to the preliminary findings submitted to the PAs and EEAC on December 17, 2010. The two stage production of the results permitted the PAs to preview results for 2011 planning. It also afforded the PAs and the evaluation team an opportunity to digest the findings and consider refinements or other areas of related investigation prior to the final analysis and reporting.

6.1.1 Overview of Objectives

The PAs seek a detailed understanding of the CHP market because it may constitute as much as 20% of the savings achievement in 2012[34]. CHP is a new product for the electric PAs and their marketing strategies are not mature. The market assessment provides a quantitative approach to supplement the qualitative findings reported in the previous section of the report. Identification of promising markets with detailed characteristics: number of customers, business

[34] 2010-2012 Massachusetts Joint Statewide Three-Year Electric Energy Efficiency Plan", October 29, 2009. Appendix E Assessment of All Available Cost-Effective Electric and Gas Savings: Energy Efficiency and CHP

type, CHP equipment type - can lead to marketing that is more effective. Since this methodology produces estimates based on billed gas usage of a particular and identifiable customer, one of the products of the analysis is a 'lead list,' a listing of the gas accounts that appear to have the high-value opportunities for CHP. [35]

Past potential studies[36] have relied primarily on aggregate market data provided by government entities. This study uses some aggregate market data, but the core data of the method are individual gas customers billing data. This specific customer information allows for granular results based on specific customers identified by location and business type.

The specific goals of the project are to:

- Estimate the CHP opportunity for each gas account, providing customer level results: installed capacity, net thermal consumption, cost, payback, and annual kWh production.
- Identify specific customers with CHP opportunities, considering the current state of CHP technology and barriers to implementation, such as location in areas not served by a PA.
- Characterize promising market segments by the number of customers, system size, and technology type.
- Provide estimates at the PA level to facilitate customer specific marketing of the PA's CHP initiative.

6.1.2 Overview of the Approach

The estimation methodology used in this analysis utilizes individual C&I gas customer billing usage data as a proxy for thermal loading. Customer-by-customer monthly gas usage was analyzed to estimate base and weather sensitive loading for all the C&I customers served by gas distribution companies in Massachusetts. Hourly weather data was analyzed to determine the full load hours of operation of the weather sensitive load; typical base load profiles, mapped by SIC code, was used to determine the base load full load hours. An optimization algorithm selects a CHP size which meets a payback threshold. Units deemed feasible must meet a minimum size threshold equal to the smallest commercially available units.

[35] Lead lists were provided to each of the electric PAs.

[36] Lauren Mattison "Technical Analysis of the Opportunity for Combined Heat and Power in Massachusetts." 2006.

The resulting set of viable accounts might be considered a 'lead list', and should, theoretically, include all of the best candidates for CHP, but also a number of false positives. For example, nearly one-third of the lead list may have direct or in-direct gas-fired heating systems (like a rooftop packaged unit) that cannot be displaced by CHP without the added expense of installing a hydronic system serving the rooftops and retrofitting all the rooftop units with hydronic coils and appropriate controls.

These individual account results are filtered, adjusted and then aggregated by building type, technology type, and PA, providing a quantitative view of particular market opportunities. The filters and adjustments include factors such as network interconnects and existing generation.

It should be noted that the focus of the study is in the near term, considering pricing, technologies, and market barriers that exist today and were identified and explored in the previous section. Also, financial viability of systems is determined from a customer perspective using payback as a screening criterion and not all cost-effective units using state prescribed screening criteria. This market view is a subset of all cost-effective statewide CHP opportunity.

6.1.3 Organization of Reporting

Section 6.2 presents the results of the CHP market assessment.

A detailed description of the quantitative market assessment methodology, algorithms and assumptions is provided in **Appendix D. Detailed Methodology: Quantitative Market Assessment**. Appendix D is organized as follows:

- Section D.1 Estimating Account Opportunity
- Section D.2 Filtering and Aggregating Market Segments
- Section D.3 Step by step Calculations
- Section D.4 Base load profiles
- Section D.5 Partial list of confirmed Generation

6.2 Results

As noted in the introduction, the model produces account by account estimates of CHP opportunity. This section focuses on the aggregation of individual account results into market views. The last section describes the lead lists, which is a spreadsheet listing of all accounts by program administrator with quantified output per account.

The results are organized as follows:

- Population of C&I Gas Customers – this section describes the total population of gas C&I customers served by the electric energy efficiency PA program providers, the party that sponsors CHP. These are the accounts that were screened for CHP opportunity. The subsections include:
  - Definition of C&I Gas Account Population
  - Population Customer Type Characteristics
  - Population Gas Usage Characteristics
  - Breakdown of Population Served by PAs
- Estimates of CHP Opportunity – this section describes various results of the CHP screening and then aggregates high-value accounts into useful groups or 'market views'.
  - Screening of Accounts for High-Value CHP– this section describes the impact of screening of accounts resulting in the subset of high-value accounts
  - Technology Market View – this section looks at the market by equipment size intervals capturing the opportunity by the equipment types likely to serve it. CHP developers typically work within a particular size range of equipment. The size of the system will also help drive the selection of particular technologies.
  - Customer Type Market View – this section looks at the CHP market by customer type. Customers of a similar type will have similar CHP opportunity, barriers, and issues.
  - Customer Usage Market View – this section looks at the CHP market by customer annual gas usage. Customers can be classified into tiers according to their annual usage. Larger customers usually have greater CHP opportunity and more resources to implement and operate CHP.
  - PA Market View- this section considers the opportunity for each of the PAs and will reflect electric distribution rates and customer mix.
- Individual Lead List – this section classifies customers by their annual gas usage and looks at CHP opportunity by that class.

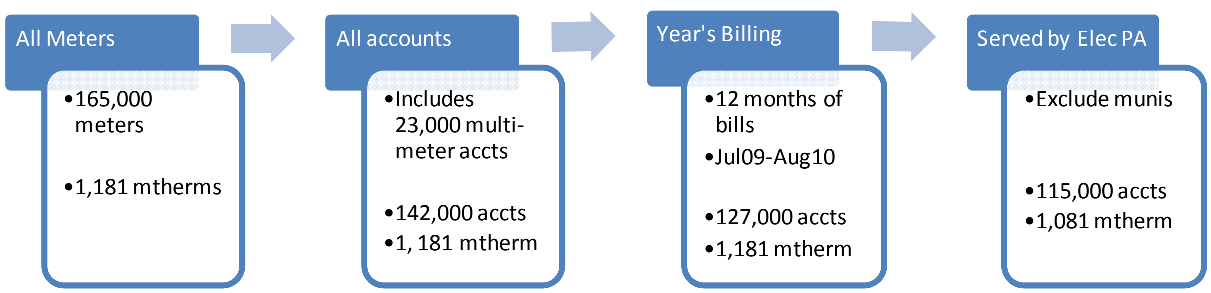
6.2.1 Population of C&I Gas Customers

This section describes the population of gas accounts used in the analysis and details the progression from population to identification of viable accounts. The population is characterized by customer type, usage patterns, and distribution between the electric program PAs.

6.2.1.1 Definition of the Gas Account Population

As shown in **Error! Reference source not found.** the analysis began with 165,000 meter records which represent 142,000 unique C&I gas accounts. Of these, 127,000 had 12 months of billing data. Accounts served by municipal power companies were excluded because they are not part of the PA's jurisdiction for CHP installation. The 115,000 accounts remaining was the population screened for market opportunity in this study. The screened results are discussed in Section 6.2.2.

Figure 6-1 C&I Gas Customer Account Population



6.2.1.2 Population Customer Type Characteristics

Each account was assigned a customer type for the purpose of identifying customer marketing segments and also to assign operating characteristics in the opportunity estimation algorithms.

Like customers will utilize gas in a characteristic manner. For example, restaurants will use gas for cooking, domestic hot water, and for space heating in similar proportions. Financial hurdles, staff resources and other factors likely to affect CHP outcomes will be similar within customer groups as well. In this section, we investigate CHP opportunities by customer types.

The first step was to assign accounts to a customer type using the SIC code. An SIC code field was provided by all the gas distribution companies (except Columbia Gas), although it was not always populated. The evaluator supplemented the SIC match with manual coding based on the account name. In addition, customer names (except for Columbia Gas which did not provide names) were searched using key for some additional examination of particular customer types, such as YMCAs.

Table 6-1 provides a tabulation of the number of accounts, total usage, average usage, and estimate of the annual bill by customer type. The annual bill is estimated using the delivered price of gas and is described in Appendix D.

Table 6-1 Population Statistics by Customer Type[37]

Customer Type	Number of Accts	Sum of Annual Use	Average Usage (therms)	Average Bill
Muni/Utility	165	30,605,240	185,486	$233,058
Retail	3,381	13,557,065	4,010	$5,038
Education	1,903	57,621,688	30,279	$38,045
Lodging	595	10,021,693	16,843	$21,163
Residential	12,124	85,902,724	7,085	$8,903
Assisted Living	258	6,758,686	26,196	$32,915
Industrial	153	110,669,016	723,327	$908,840
Office	39,317	376,285,463	9,571	$12,025
Grocery	886	6,740,341	7,608	$9,559
Health Care	1,307	37,650,607	28,807	$36,195
Restaurant	3,691	24,465,382	6,628	$8,328
Unknown	51,260	320,346,671	6,249	$7,852
	115,040	1,080,624,576	9,393	$11,803

[37] Approximately 35,000 of the Unknown accounts are Columbia Gas accounts. The provided Columbia Gas usage data did not include the fields necessary to classify by Customer Type.

The next figure presents the population by customer type. Viewing both Table 6-1 and Figure 6-2 industrials, for example, have a very high usage per customer, as does health care. The unknown accounts have the lowest usage per account, which may reflect that smaller accounts are less likely to be coded.

Figure 6-2 Population Distribution by Customer Type

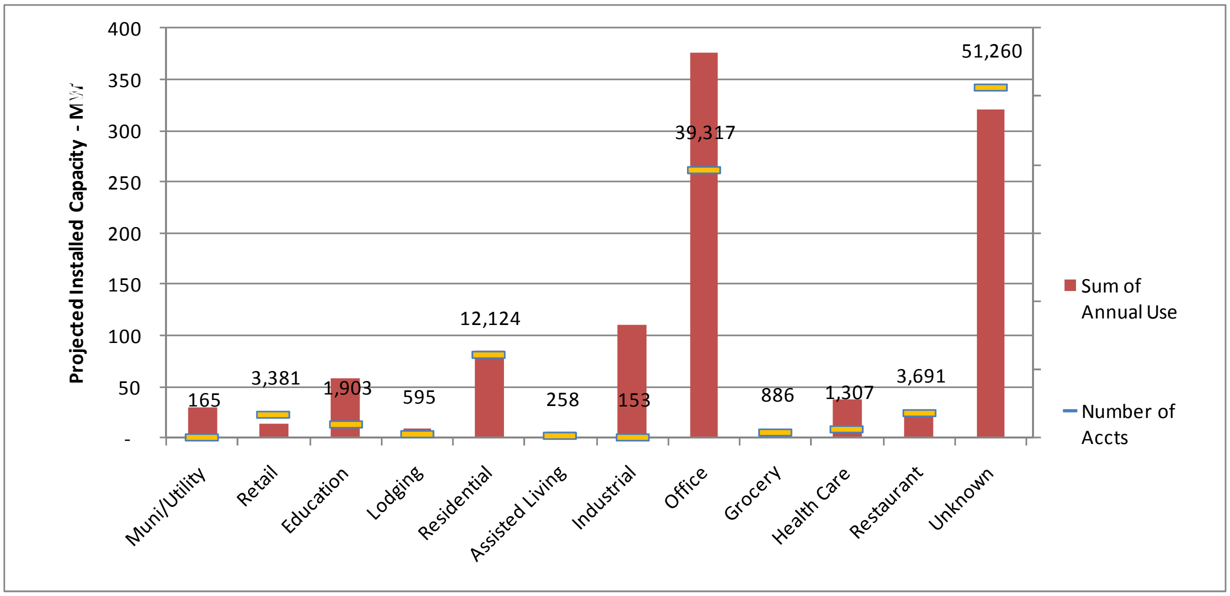


Table 6-2presents a sample of a listing of number of accounts and usage by SIC code. Nearly half (51,260) of the 115,000 accounts are not coded. The full listing will be provided upon request.

Table 6-2 Partial Listing of Accounts by SIC Code

2 Digit SIC	SIC Description	Num of Accts	Annual Use
15	GENERAL BUILDING CONTRACTORS	153	3,646,224
16	HEAVY CONSTRUCTION CONTRACTORS	168	2,206,184
20	FOOD AND KINDRED PRODUCTS	138	10,138,643
22	TEXTILE MILL PRODUCTS	28	3,371,565
26	PAPER AND ALLIED PRODUCTS	37	4,897,948
27	PRINTING AND PUBLISHING	145	1,932,107
28	CHEMICALS AND ALLIED PRODUCTS	107	20,209,031
39	MISCELLANEOUS MANUFACTURING INDUSTRIE	417	58,277,581
49	ELECTRIC, GAS, AND SANITARY SERVICES	220	10,041,496
58	EATING AND DRINKING PLACES	3,691	24,465,382
59	MISCELLANEOUS RETAIL	1,468	3,321,578
60	DEPOSITORY INSTITUTIONS	511	1,633,076
65	REAL ESTATE - Housing	11,788	70,577,608
70	HOTELS, ROOMING HOUSES, CAMPS, AND OTH	595	10,021,693
72	PERSONAL SERVICES	28,180	287,679,813
805	ASSISTED LIVING/NURSING FACILITIES	258	6,758,686
806	HOSPITALS	253	33,756,714
82	EDUCATIONAL SERVICES	1,903	57,621,688
86	MEMBERSHIP ORGANIZATIONS	1,827	9,050,846
88	PRIVATE HOUSEHOLDS	336	15,325,116
99	Coded unknown	51,260	320,346,671
		115,040	1,080,624,576

6.2.1.3 Population Gas Usage Characteristics

This section presents a breakdown of the population based on annual gas usage. Implementers can find it useful to classify customers by their gas usage. Generally, larger users will have a greater opportunity for CHP. Large accounts may also have key account managers that can be enlisted in a marketing effort.

Each account was assigned to one of four groups based on annual gas usage. The boundaries between the classes were designed such that the sum of the usage of each group, or quartile, represents close to a quarter of the total gas sales for the population of 115,000 accounts.

Q1 – Greater Than 950,000 Therms of Annual Use – has only 96 customers but they consume a quarter of all the gas sold in the electric PA served territories. These customers are commonly recognized businesses and institutions and include power generators, university campuses, large industrial sites, and large hospital complexes. Twenty four (24) of the sites have confirmed generation and another eight (8) have suspected generation. These accounts have a large influence on the outcome of the opportunity because the sites a) use a lot of gas – and the opportunity is proportional to gas use and b) frequently have on-site generation. The confirmed generation sites are not included in the lead lists, although the suspected generation sites are included.

Q2 – 90,000 to 950,000 Therms of Annual Use – The 1,229 accounts in this quartile are housing authorities, larger hotels, senior housing, smaller community hospitals, colleges and university sub-accounts, bio-tech, and food processing operations. Three accounts have confirmed generation and there may be some unidentified generation served by these accounts.

Q3 – 16,500 to 90,000 Therms of Annual Use – In the 7,725 accounts in this quartile, are included nursing homes, grocery stores, residential public and private housing, big box retail, YMCAs, and high volume restaurants (not fast food).

Q4 – Less than 16,500 Therms of Annual Use – These are the smallest accounts and include a variety of building types. .

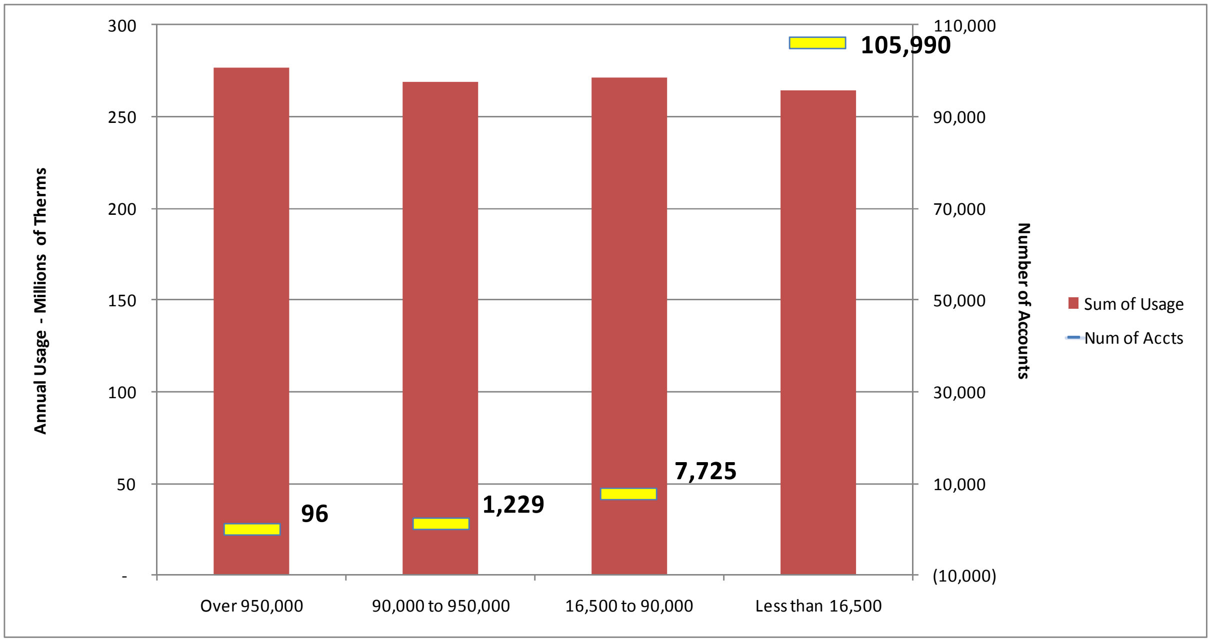
Table 6-3 provides a tabulation of the number of accounts, total usage, average usage, and estimate of the annual bill for each quartile. The annual bill is estimated using $1.26 per therm as an average price of delivered gas described further in the Appendix D.

Table 6-3 Population Statistics by Usage Quartile

Usage Quartile	Num of Accts	Sum Annual Usage	Average Annual Usage	Average Bill
Over 950,000	96	276,805,944	2,883,395	$3,622,906
90,000 to 950,000	1,229	268,557,292	218,517	$274,560
16,500 to 90,000	7,725	271,240,474	35,112	$44,117
Less than 16,500	105,990	264,020,866	2,491	$3,130
	115,040	1,080,624,576	9,393	$11,803

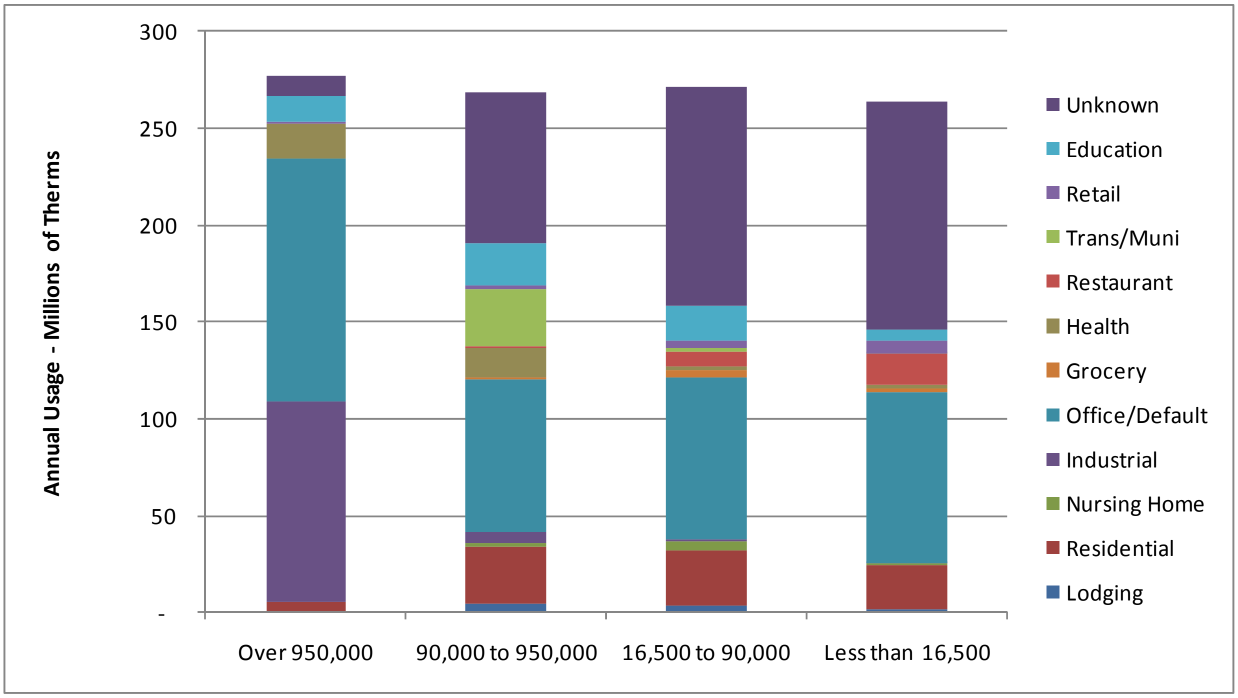
Figure 6-3 presents the population total usage and number of accounts per usage quartile. The distribution of a few customers constituting most of the usage is not an unusual pattern. In this population, 8% of the accounts use 75% of all the consumed for this population.

Figure 6-3 Number of Gas Accounts by Annual Usage Quartile



The graph in Figure 6-4 indicates the gas usage by customer type by quartile for the population. Unknown accounts constitute an increasing portion of the quartile as the accounts become smaller, which is typical for customer information systems because large accounts are important and easier to identify and therefore to code. Despite the shortcomings of the coding, the graph does show interesting trends. The make-up of each quartile is somewhat distinct. Industrials and municipal/utilities comprise a significant portion of the largest quartiles and are not significant in the two lower usage quartiles. Residential accounts constitute about an equal fraction of the three lower usage quartiles. Businesses working in office settings comprise most of the known usage in all of the quartiles.

Figure 6-4 Population Customer Type by Usage Quartile



6.2.1.4 Breakdown of Population Served by PAs

Each PA serves a distinct customer mix and is subject to particular electric rate structures that impact CHP opportunity. Table 6-4 shows the number of C&I gas accounts served by each PA and other related statistics. The number of accounts is not equivalent to the number of customers in PA's service territory, since not all of the electric PA customers are served by gas. The annual bill is estimated using $1.26 per therm as an average price of delivered gas described further in the appendices.

Table 6-4Population Statistics by PA

PA	Number of Accounts	Annual Usage - Therms	Average Usage	Average Bill
NGRID Elec	53,784	455,299,324	8,465	$10,636
NSTAR Elec	39,927	391,589,535	9,808	$12,323
NSTAR Network	2,909	44,486,823	15,293	$19,215
CLC Elec	7,464	28,451,109	3,812	$4,789
Unitil Elec	714	3,539,233	4,957	$6,228
WMECO Elec	10,242	157,258,552	15,354	$19,292
	115,040	1,080,624,576	9,393	$11,803

Figure 6-5 indicates the gas usage patterns of the accounts served by each PA. National Grid and NSTAR serve accounts with similar overall gas usage and show a similar distribution between usage quartiles. Cape Light Compact and Unitil serve smaller customers and have almost no larger Q1 customers, hence the overall lower usage per account. WMECO shows a higher proportion of Q1 customers because of the presence of four of the five highest consuming customers that account for almost 8% of the statewide gas usage. These accounts appear to be power generation stations and a manufacturer.

Figure 6-5 Population Annual Gas Usage by PA

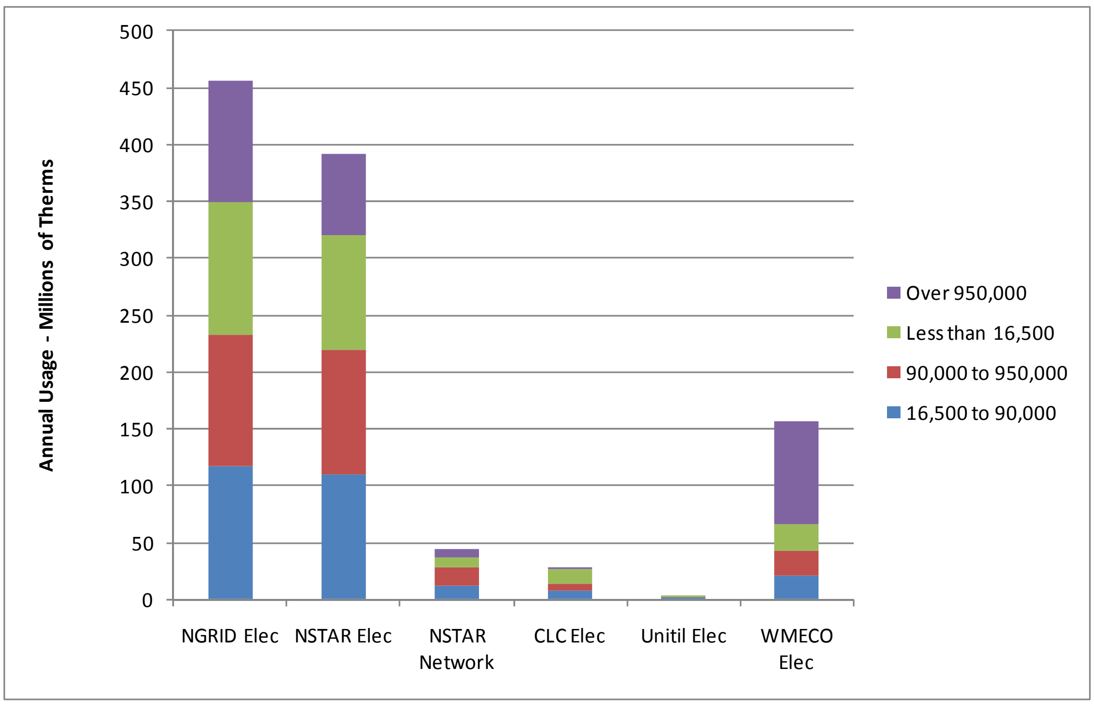
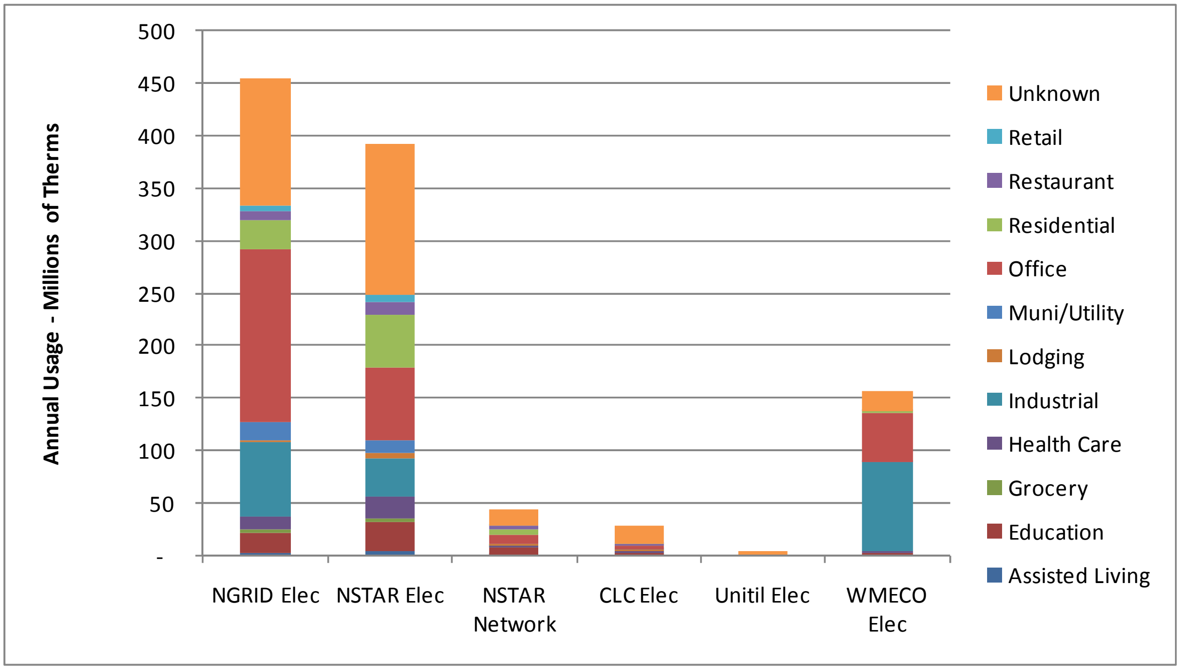


Figure 6-6 below indicates the customer type mix for each PA.

Figure 6-6PA Population Customer Type Mix



6.2.2 CHP Opportunity Results

This section presents the estimates of CHP opportunity for the population of C&I gas accounts using a model which is based on the customer's monthly billed gas usage. The power of the model is in the quality of the thermal characterization provided by the customer's billed gas usage. The billing data provides a high level of certainty about the customer's thermal load and also sets an upper bound on the CHP opportunity for that location, at that point in time.

The model produces an estimate of an optimally sized CHP unit (in kW) and the annual electrical generation, net fuel, operation and maintenance costs, installed cost and payback for that account. The accounts are screened using the criteria described in the next section. . The final compilation of screened accounts might be considered high-value or a 'lead list', and should, theoretically, include all of the best candidates for CHP, but also a number of false positives. For example, about 30% of the high-value accounts will probably have heating systems that cannot be displaced by CHP (such as gas-fired packaged rooftop unit). The high value accounts will also not include opportunities represented by oil-fired systems.

As noted in the previous section, accounts have a variety of attributes, including customer type, gas usage patterns, and an electric energy efficiency provider. The high-value accounts can be grouped using these attributes to examine the size and characteristics of the CHP opportunity by these different market views.

The first subsection briefly describes the screening. The appendices include a detailed description and discussion of the methodology with additional analysis. The subsequent subsections present the opportunity results by market views.

6.2.2.1 Screening for High-Value Accounts

The high-value accounts were identified through a series of screening steps which started with the population of 115,000 accounts. The account screening steps are illustrated in Figure 6-7 and are described as follows:

- Low usage accounts. Those accounts with less than 5,000 therms base usage or 20,000 therms annual usage were screened out without further calculations. Analysis shows that usage below this level cannot support a 10 kW CHP system cost-effectively under the most favorable rates and building profiles.

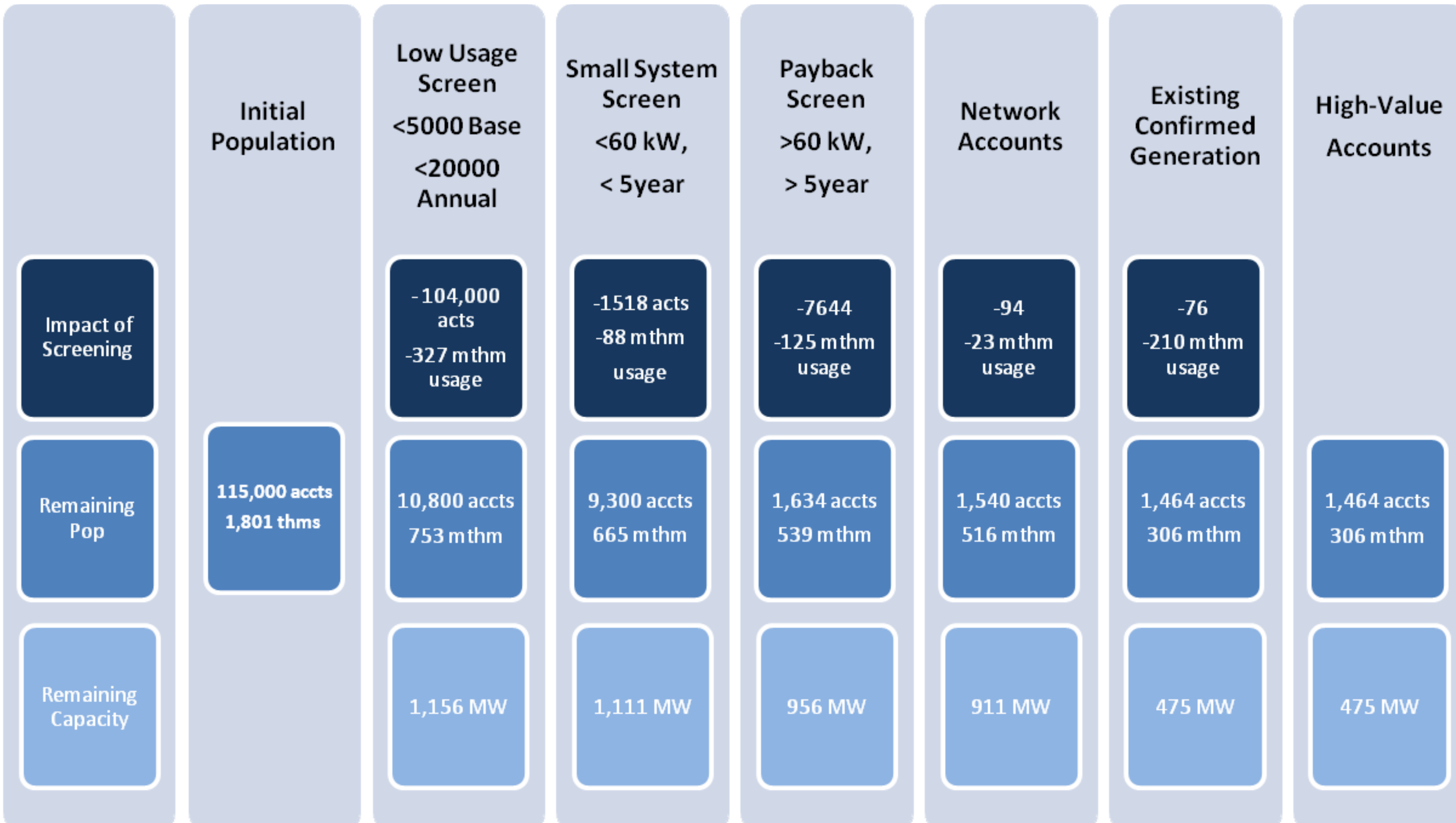
- Optimum sized CHP systems were estimated for the remaining accounts. Those accounts with an optimum system size of less than 60 kW but with a payback of less than 5 years (with PA incentives of $750 per kW) were screened out because there are no commercially available systems under 60 kW.

- Exceed payback threshold. Those accounts that had usage that could support a 60 kW system size or larger but had paybacks greater than 5 years with an incentive were screened out because they exceeded the financial screening criteria.

- Network accounts. Those accounts located on a networked (vs. radial) distribution interconnection are excluded because it is typically cost prohibitive to interconnect.

- Existing generation. Those accounts with confirmed existing generation are excluded because to a large degree the opportunities have been harvested. Figure 6-7 tabulates the impact of each of the screening steps in terms of number of accounts and related usage affected, the number of accounts remaining after the screening, and the remaining CHP potential. This process is explained and discussed at some depth in the Appendices.

Figure 6-7 Screening of Accounts for CHP Opportunity



After the final screening, 1464 accounts remain and are considered high-value. These are the accounts used to construct the market views presented in this report.

6.2.2.2 Technology and CHP Size View of the Market

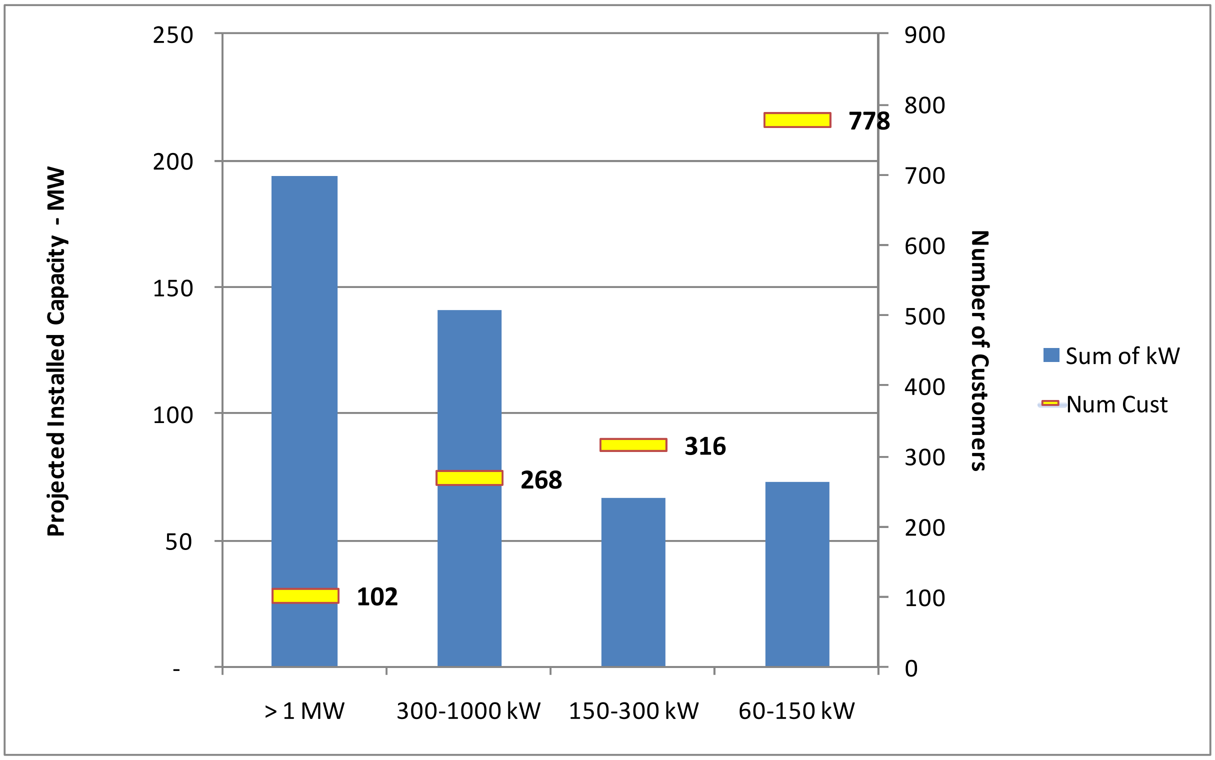
The CHP market consists of different technologies that are supplied by different vendors and distributors. These vendors and distributors target customers with characteristic thermal loads that support a CHP unit of the size they sell. This analysis characterizes CHP systems within four size intervals representing technology classes and a related vendor community.

The four CHP size intervals were selected based on the feedback from the market actor interviews as described in Section 5.

- **The largest tier, > 1 MW** These larger systems can generate steam as well as hot water and utilize a gas-fired turbine as the prime mover or operate off of a backpressure turbine installed on boiler.
- **The 300-1000 kW tier** This interval is served primarily by reciprocating engines as the prime mover. Often multiple smaller units are installed rather than a single larger unit.
- **The 150-300 kW tier** This interval is served primarily by reciprocating engines as the prime mover and possibly micro-turbines.
- **The less than 60 - 150 kW tier** This interval is served primarily by reciprocating engines as the prime mover and possibly micro-turbines.

Error! Reference source not found. presents the sum of the individual high-value account projected installed capacity by equipment type. This view of the market emphasizes the importance of larger systems (over 300 kW) which account for 70% of the opportunity.

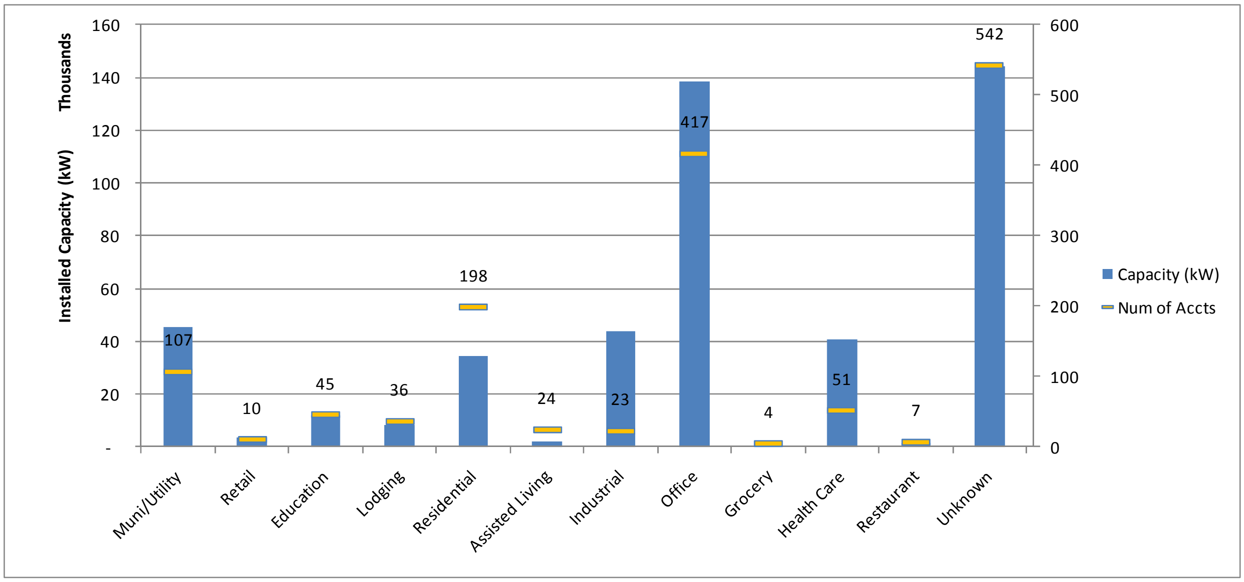
Figure 6-8 CHP Opportunity - By Equipment Size Intervals



6.2.2.3 Opportunity by Customer Type Quartile

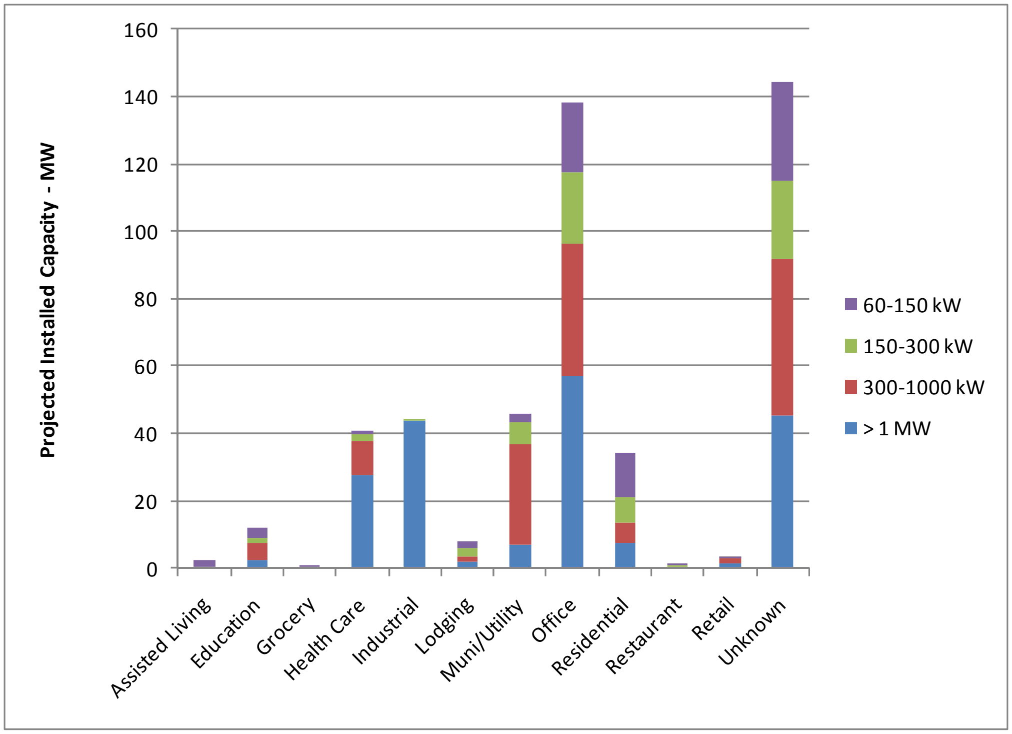
The high-value accounts can be grouped by customer type for another view of the market. Small systems are concentrated in the residential, education, lodging and 'Unknown' customer types. This can be inferred by the position of the customer count indicator in relation to the total installed capacity. For example, for Residential, the customer count indicator (198) is above the installed capacity (about 30 MW), indicating relatively small systems. In Industrials, the indicator (23) is at the bottom of the installed capacity indicator (about 45 MW).

Figure 6-9 Projected CHP Opportunity by Customer Type



The next figure, Figure 6-10 considers the equipment size interval opportunity for each customer type. This view confirms some of the inferences shown later in Figure 6-15, showing that Industrial system opportunities all exceed 1MW, for example. For the known accounts, the larger systems are concentrated in the industrials, health care and the large office customers. The municipal/utility customers appear to be candidates for the third equipment tier. The smaller systems are focused in the residential (public housing and condominiums) and office spaces.

Figure 6-10 CHP Opportunity by Equipment Type, by Customer Type



6.2.2.4 Opportunity by Usage Quartile

Figure 6-11 identifies the CHP opportunity by the gas usage Quartile. The largest opportunity exists in Q2 where gas usage, particularly a base usage, is substantial enough to support a CHP system, however, with a lower penetration of existing generation. Q1 has significant confirmed generations, which reduces the opportunity for new CHP. The projected systems size decline from the Q1 through Q3, which is indicated graphically by the slide of the customer counts indicator down the total projected capacity bar.

Figure 6-11 CHP Opportunity by Usage Quartile

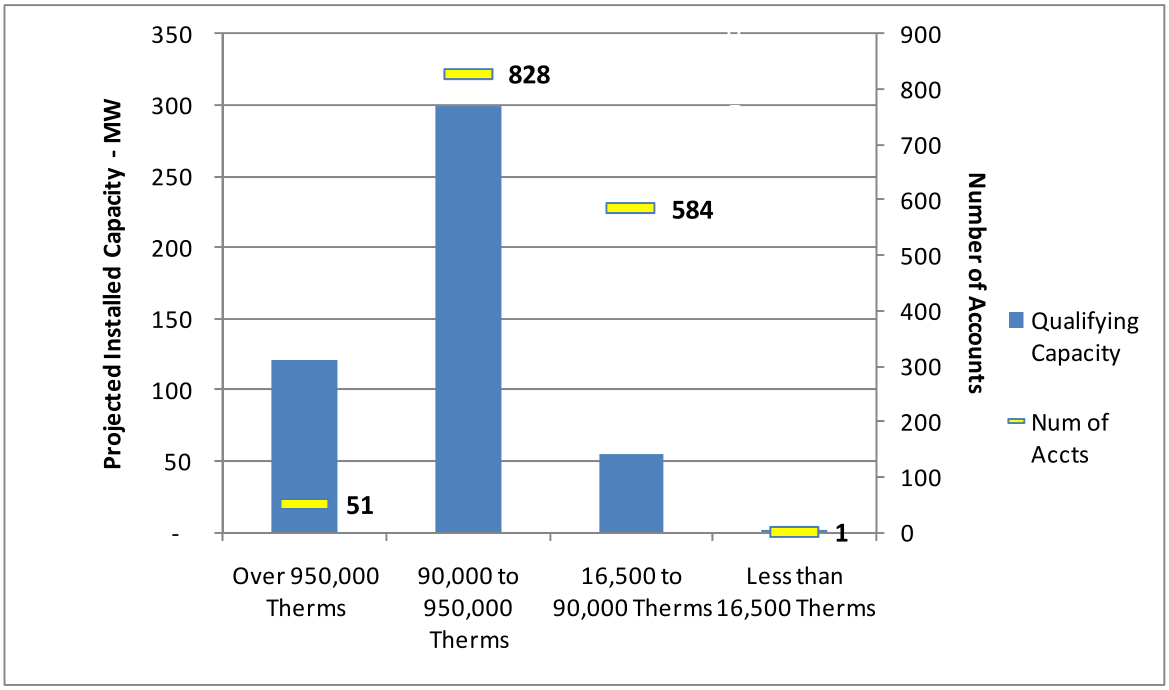
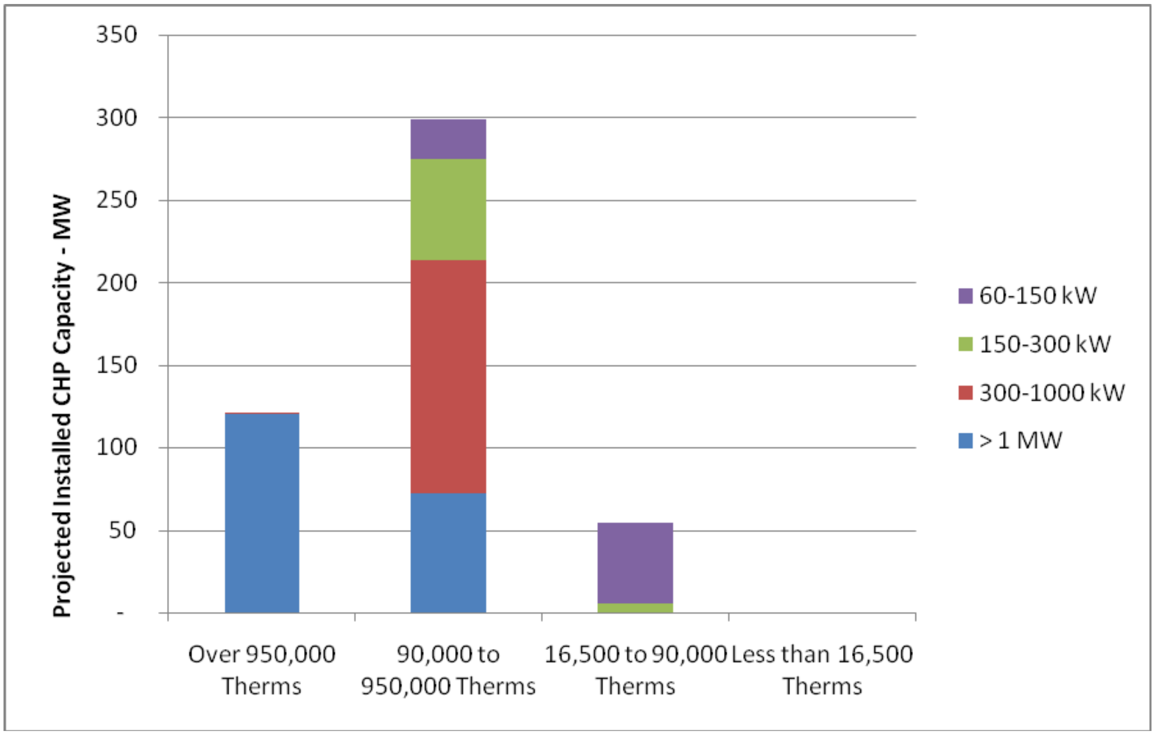


Figure 6-12 shows the equipment type composition for each of the quartiles. The largest customers have gas usage and inferred thermal loads supporting the largest CHP systems.

Figure 6-12 CHP Opportunity by Equipment Type by Quartile



6.2.2.5 PA Market Opportunity View

The high-value accounts can be grouped by the electric PA that serves them to provide a view of the opportunity by PA. This view, as the preceding views, does not include any adjustments that cannot be specifically attributed to an individual account and include heating systems that are not compatible with CHP, customers served by oil, limitations due to electric demand or standby rates.

Table 6-5 Comparison of PA Customer Gas Usage and Projected Capacity

Electric PA	Accounts	Projected Installed Capacity (kW)	Generation (kWh)	Net Customer Cost
Cape Light Compact	57	13,588	93,113,183	$24,485,494
National Grid	543	201,650	1,513,003,618	$350,826,451
NSTAR Electric	743	222,922	1,432,580,376	$389,478,438
Unitil Electric	23	4,345	21,997,572	$7,908,763
Western Mass Electric	98	32,662	257,940,342	$57,700,524
	1,464	475,167	3,318,635,091	830,399,669

The total installed cost reflects an incentive of $750 per kW for all sites for an incentive budget of $356 million or $.10 per annual kWh saved.

Graphically, the information in the table is presented in Figure 6-13. NSTAR shows the most opportunity, even though National Grid's population uses more gas overall. This slight disproportion may be due to the NSTAR vs. NGRID mix of customers and also NSTAR's higher distribution rates.

Figure 6-13 CHP Opportunity by PA

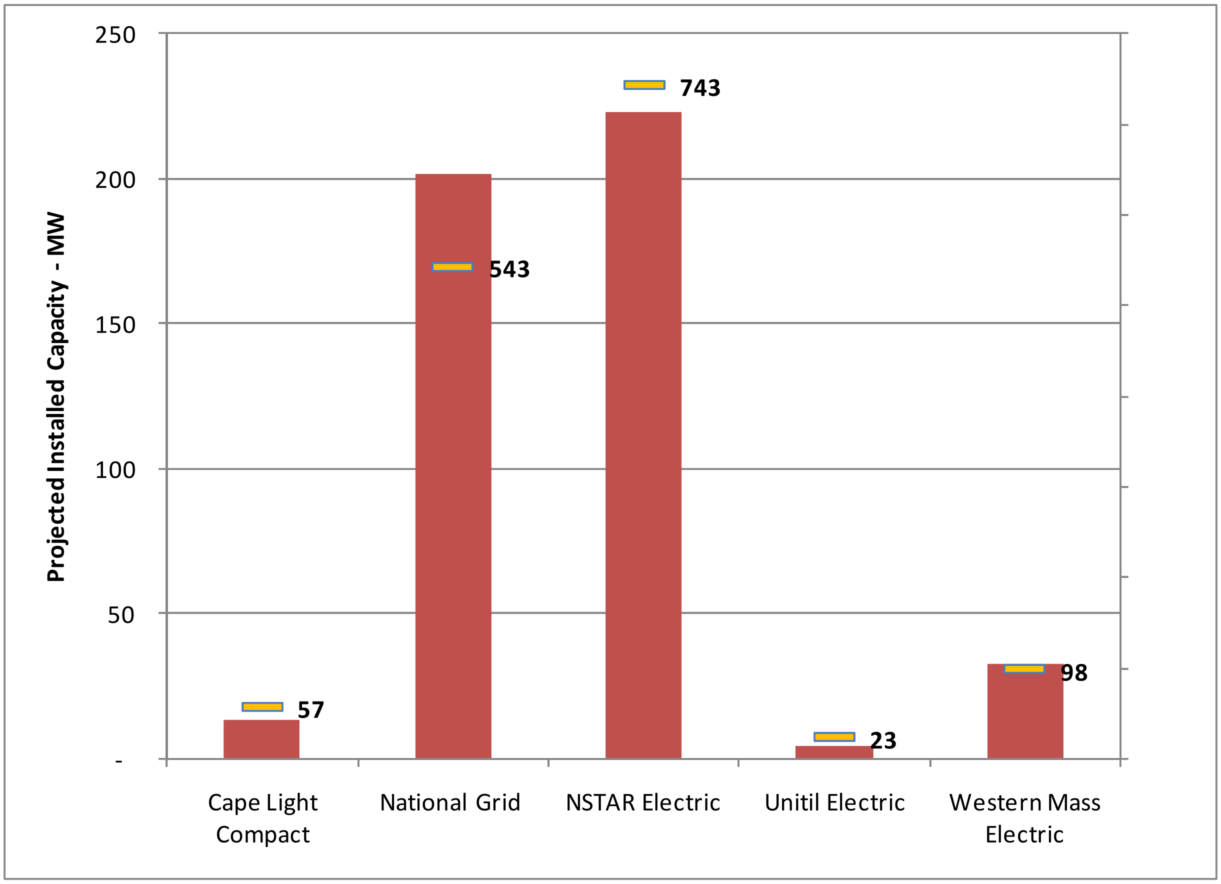
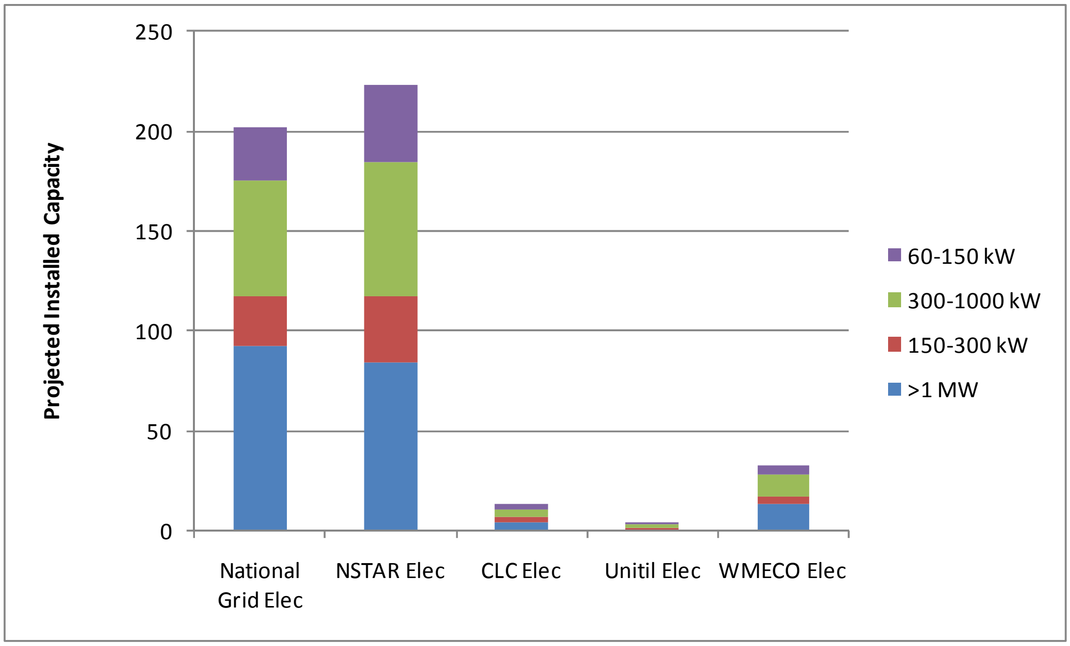


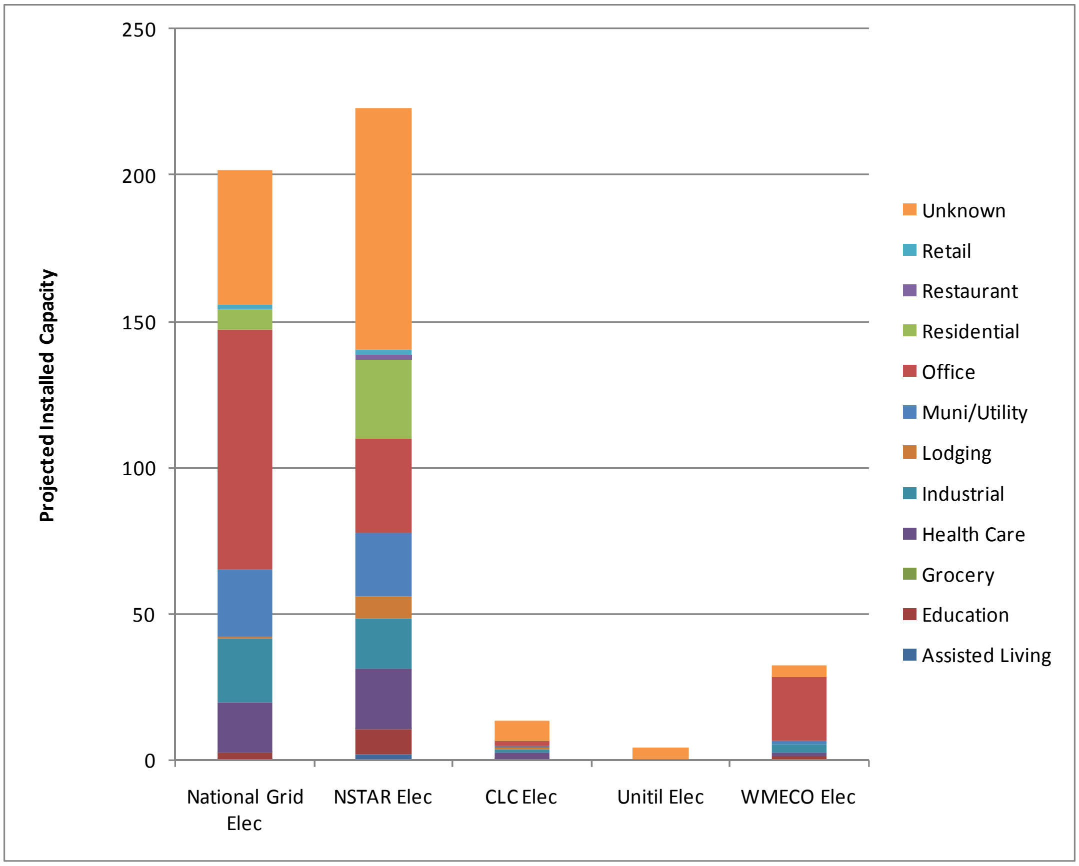
Figure 6-14 presents the distribution of equipment type by PA. The proportion of large systems is not exactly proportional by PA. Although NSTAR has the largest opportunity overall, the average system size is smaller than WMECO or National Grid. This may be due in part to the network in downtown Boston which serves some of NSTAR's largest customers.

Figure 6-14 PA CHP Opportunity by Equipment Size Interval



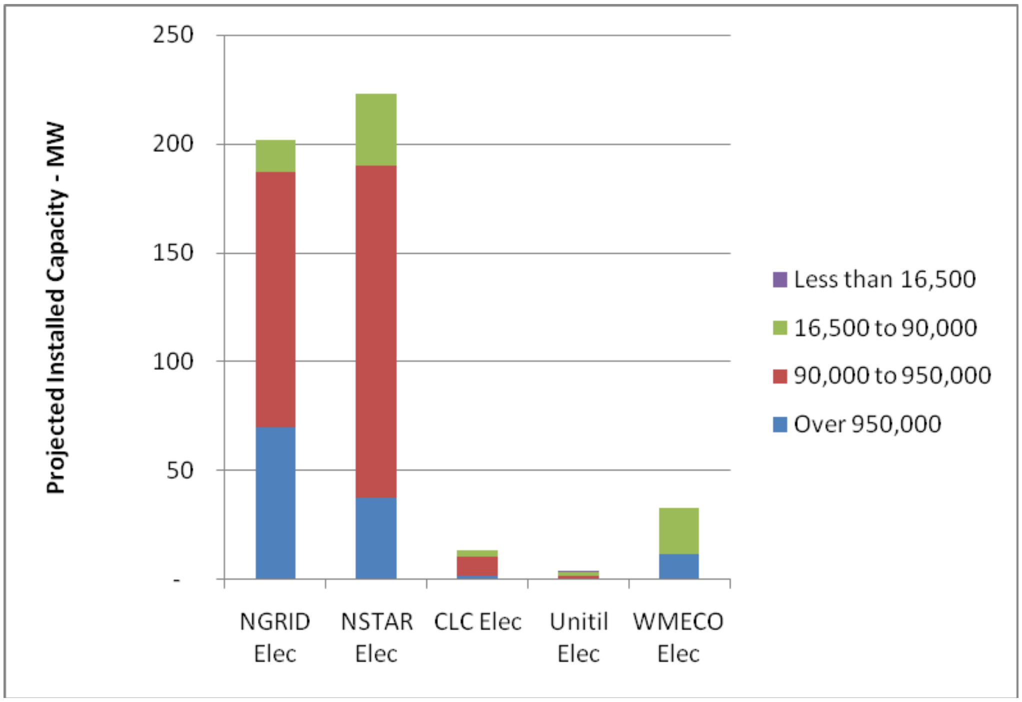
The first graph, Figure 6-15, shows CHP opportunity by customer type by PA. The distribution by PA is not uniform and may reflect differences in customer mix.

Figure 6-15 PA CHP Opportunity by Customer Type



The final figure, Figure 6-16, presents the PA opportunity by the gas usage quartile. The distribution reflects trends seen in the earlier graphs, where National Grid and WMECO reflect larger systems and more industrial customers. NSTAR's market appears to be focused in the next customer and equipment tier. Cape Light Compact and Unitil have opportunities in smaller commercial markets.

Figure 6-16 PA CHP Opportunity by Annual Gas Usage Quartile



6.2.3 Individual PA Lead Lists

PA specific lists of site by site results will be provided to each of the electric PAs, specific to the customers that PA serves. The results have customer characterization information including the customer name, service address, and town and also the SIC codes, existing generation status, and estimated load. This information will be useful for furthering detailed marketing strategies.

7. Conclusions and Recommendations

This section integrates the findings of the interviews with stakeholders and the quantitative market assessment to provide a high level overview of the CHP market in Massachusetts and identify key CHP opportunities based on the research conducted. This section ends with short-term and long-term recommendations for PA implementer consideration.

7.1 Conclusions

This section integrates the findings of the interviews with stakeholders and the quantitative market assessment to provide a high level overview of the CHP market in Massachusetts and identify high-value CHP opportunities based on the research conducted. This section ends with short-term and long-term recommendations for PA implementer consideration.

Based on the qualitative and quantitative analyses, the market in Massachusetts was divided into four different categories based on the size of the generating capacity of the CHP system. The categories are:

- 60 to 150 kW
- 150 to 300 kW
- 300 kW to 1 MW
- > 1 MW

Table 7-1 provides a summary of key findings and conclusions from the interviews with various stakeholders and the quantitative market assessment. As illustrated in the table, each one of these segments has different customer types and attributes, specific CHP technologies, and market barriers. Although there are overlaps, **each of these market segments require a different approach both in terms of educating the site on what CHP is and the time required to develop the CHP site and to install the system.**

Based on the interviews that were part of the Market Characterization, it became evident which industries fell into each of the sized segments. Nursing homes of 150 beds or less and segments with smaller thermal and electrical loads were at one end and at the other end are colleges and universities and manufacturing with high thermal and electrical loads. **Based on the quantitative market assessment we are able to estimate the number of "high-value" opportunities within each sector.** For example, the market assessment concluded that there are 102 customers (gas accounts) that may be suitable sites for CHP in the greater than 1 MW system size category.

The four segments defined by equipment size also require different time for a complete installation based on the size of the capital outlay and the decision making process. A 75 kW internal combustion engine (ICE) to be installed at a 100 bed facility most likely will require less time for a developer to make the sell and to complete the install versus a 2 MW gas turbine at a university. **However, the sophistication and general knowledge of their thermal and electrical loads will be much higher for those larger installations than the smaller.** This has a significant effect on the level of effort required on the part of the PA implementers in supporting the installation process.

Table 7-1 Summary of Key Findings by Technology Size

Characteristics	60 to 150 kW	150 to 300 kW	300 kW to 1 MW	> 1 MW
Typical sites based on interviews	Nursing homes; 100-150 bed facilities; smaller apartment buildings	Hotels, heath clubs with pools; hockey rinks	Housing projects (including apartment buildings); small manufacturing, prisons, hospitals	Manufacturing; universities and colleges
Time to sell a system[38]	2 to 7 months	3 to 8 months	6 to 12 months	12 – 18 months
Time from signed contract to commissioning[39]	6 to 12 months depending on factors such as interconnection	6 to 12 months depending on factors such as interconnection	6 to 18 months depending on other factors	12 to 24 months depending on other factors
Influence of PA	Incentives and credibility, technical advice	Incentives and credibility, technical advice	Incentives and some support but site will have resident experts	Minimal, incentives and interconnection
Knowledge of CHP, thermal and electrical load by sites	Minimal knowledge of CHP and likely little of their facility loads	Some on CHP, better on their loads and operations	Good background overall on CHP and energy use	Experts in all facets of CHP, the physical plant and energy use
Technology[40]	ICE and MT	ICE and MT	ICE, smaller units often packaged instead of one larger unit.	GT, some ICE, potential for fuel cells
PA Marketing Strategy	Utilize developer channel	Utilize developer channel	Some developer channel and account executives	Direct outreach by Account Exec
”High-Value” Accounts	778	316	268	102

[38] Care should be taken in using the estimated time needed to sell CHP systems for planning purposes. During our interviews with the 9 developers (one interview was with a CHP center focused on providing the feasibility of CHP systems) ranges on time to sell ranged a fair amount particularly for those smaller systems. Time to sell was framed as time from beginning of negotiations to a signed contract.

[39] These are approximate timeframes developed from a small sample size and should be used carefully. Although interviews with Developers indicated time from contract to commissioning could be as little as 3-6 months, interviews with Sites indicated longer time periods were required. In addition, PAs indicate that interconnection times may extend this time period.

[40] GT = gas turbine; ICE = internal combustion engine; MT = micro turbine.

As shown in Table 1- the market assessment estimates there are 1,464 customers (gas accounts) that are considered 'high value' sites for CHP. Figure 7-1 presents the CHP opportunities by installed capacity and technology size segments. The two smaller technology size segments have many sites but limited total opportunity in terms of installed kW and the larger sites have fewer sites and larger opportunities.

Figure 7-1 CHP Opportunity – by Equipment Size Intervals

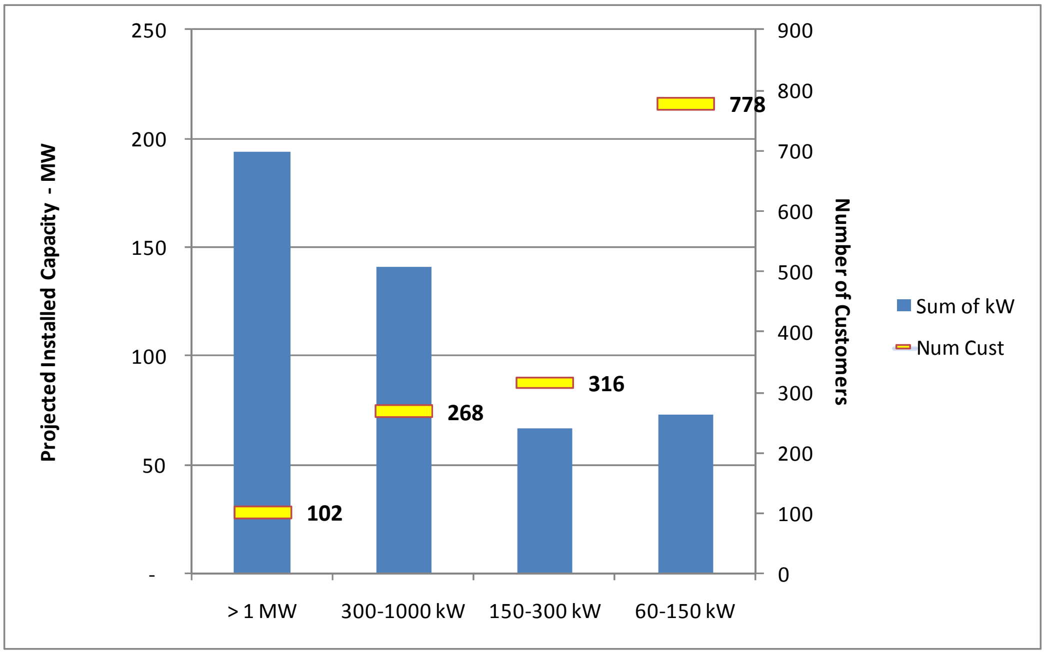


Figure 7-2 provides these same 1,464 high-value opportunities further segmented by PA service territory. Although NSTAR has the largest opportunity overall, the average system size is smaller than WMECO or National Grid. This may be due in part to the network in downtown Boston which restricts participation of some of NSTAR's largest customers, possibly driving the NSTAR average down.

Figure 7-2 PA CHP Opportunity by Equipment Size Interval

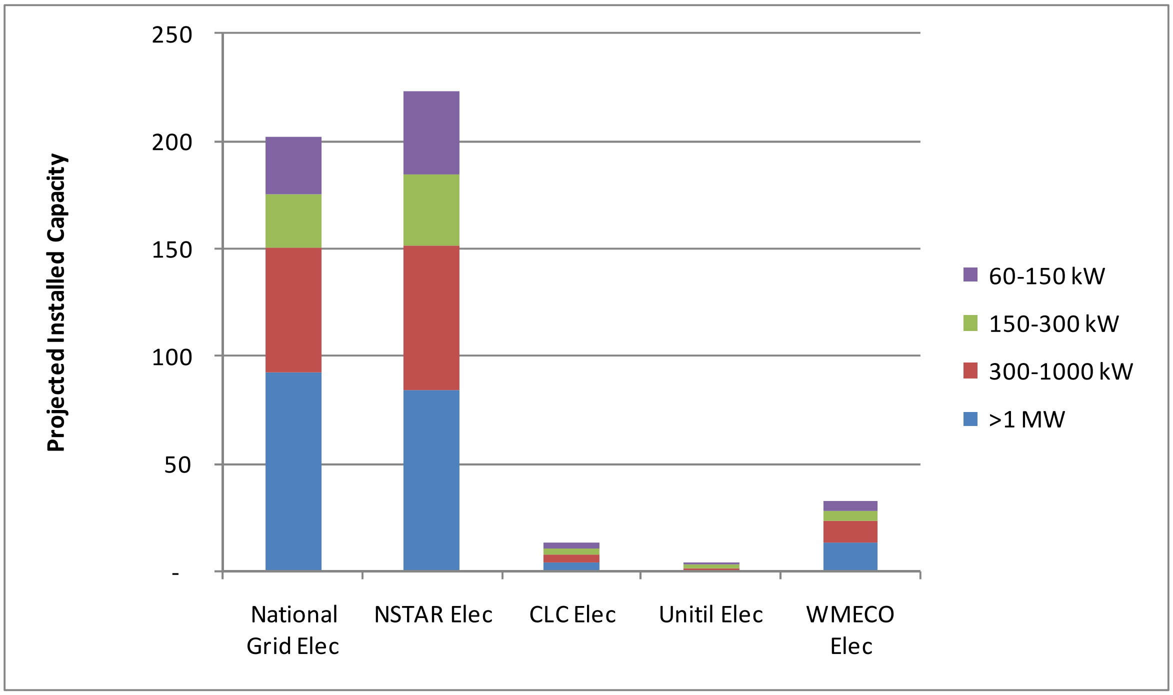


Table 7-2 provides a summary of CHP opportunities by PA. The opportunity is summarized by PA with estimates of the total capacity, generation, net fuel, installed cost, and budget. The quantitative market assessment methodology is built from the bottom up using individual gas account estimates, therefore factors that could not be attributed to an individual account were not incorporated into the final results. Two such factors, which are not included in Table 7-2, are about a 30% reduction in opportunity due to HVAC systems that are incompatible with CHP implementation (direct fired gas rooftops cannot easily use heat from CHP) and about a 7% additional opportunity represented by customers using oil. The table does not account for any impact on participation due to standby rates or limitations on system size due to mismatches between electric and gas loads, although these topics are explored in Appendix D.

Table 7-2 Summary of PA Opportunity

Electric PA	Accounts	Projected Installed Capacity (kW)	Generation (kWh)	Net Fuel (therms)	Customer Installed Cost	Incentive	Net Customer Annual Savings
Cape Light Compact	57	13,588	93,113,183	(4,427,841)	$24,485,494	$10,190,966	$5,355,860
National Grid	543	201,650	1,513,003,618	(69,276,951)	$350,826,451	$151,237,474	$73,908,145
NSTAR Electric	743	222,922	1,432,580,376	(66,143,217)	$389,478,438	$167,191,721	$83,679,013
Unitil Electric	23	4,345	21,997,572	(1,090,561)	$7,908,763	$3,258,963	$1,713,533
Western Mass Electric	98	32,662	257,940,342	(11,952,305)	$57,700,524	$24,496,242	$12,008,945
	1,464	475,167	3,318,635,091	(152,890,875)	$830,399,669	$356,375,367	$176,665,497

Average Installed Cost:	$ 2,498	per installed kW
Average incentive per kWh generated:	$ 0.11	$ / kWh
Net gas usage per kWh generated:	(4,607)	BTUs
Customer Annual Net Savings	$176,665,497	
Estimated PA net benefits:	$2,897,099,864	
BCR estimate:	2.4	
Estimated PA net benefits without heat recovery:	$192,378,820	
BCR estimate:	0.2	

As part of the quantitative market assessment, the LCIEC Team divided customers into four groups based on annual gas usage. Table 7-3 provides a summary of CHP opportunities by customer size categories based on annual fuel usage. We conclude:

- **Largest opportunity for CHP is in the 90,000 to 950,000 therms customer class.**
- **Large customers from the greater than 950,000 therms customer class are favorable candidates for CHP; however there are only 51 high-value accounts. The prevalence of existing generation reduces the opportunity for CHP at the largest customer sites.**
- **Minimal to no high-value opportunities in the smaller two size categories.**

- **CHP systems, if properly sized and operated with little or no thermal dumping, provide broad benefits to the customer and stakeholders as indicated by the BCR ratio. At the other extreme, however, systems which primarily generate electricity with little or no heat recovery can result in projects with a BCR ratio less than 1.**

Table 7-3 Summary of CHP Opportunities by Customer Size

Characteristics	Customer Gas Usage			
	>950k Therms	90k-950k Therms	16.5k-90k Therms	<16.5k Therms
Customer Types[41]	university campuses, large industrial and commercial sites, and large hospital complexes	housing authorities, larger hotels, senior housing, smaller community hospitals, colleges and university sub-accounts, bio-tech, and food processing operations	nursing homes, grocery stores, residential public and private housing, big box retail, YMCAs, and high volume restaurants (not fast food)	NA
Population (number of accounts)	96[42]	1,229	7,725	105,990
Average Annual Usage (population)	2,883,395	218,517	35,112	2,491
Passed CHP Screens	50%	70%	10%	Only 1 account
"High-Value Accounts"	51	828	584	1
Conclusions	Good but few candidates.	Largest opportunity.	Very small number of high-value sites. High cost of engagement.	No opportunities.

[41] This is not an exhaustive list.

[42] 24 customers confirmed to have on-site generation.

There is a common understanding among the market actors interviewed (Developers of CHP, Sites where CHP has been installed, and candidate sites) of the motivations for and the barriers to the installation of CHP. Table 7-4 presents the primary motivators and barriers to installing CHP in Massachusetts listed in order of importance. Reducing energy costs was the most common motivator followed by environmental benefits for the Developers, Sites and Candidates. The most cited barrier to the adoption of CHP is knowledge of the technology, followed by payback, interconnection or permitting issues.

Table 7-4 Motivations and Barriers to Installation of CHP

Motivations for Installation of CHP	Barriers to Installation of CHP
▪ Economics: Utility rates &Cost savings. ▪ Utility Incentives. ▪ Environmental. ▪ Supportive utilities.* ▪ APS program. ▪ Relaxed qualifying restrictions.* ▪ Power reliability. ▪ Emergency power capability.**	▪ Knowledge of CHP. ▪ Payback. ▪ Interconnection/permitting. ▪ Spot or street networks.*** ▪ Economy. ▪ Air emissions. ▪ Electric utility changing habits.*** ▪ Upfront cost. ▪ Metering.* ▪ Qualifying for program.
* Only mentioned by Developers. ** Not mentioned by Developers. *** Not mentioned by Current Users of CHP. Spot networks refer to electrical networks that serve a single site, whereas street networks refer to electrical service covering several city blocks.	

7.2 Recommendations

The Project 1C Team presents the following short-term and long-term recommendations to the PA implementers for consideration.

7.2.1 Short-term recommendations

1. **Determine realistically achievable targets.** Energy-saving goals of the Program are tied to the time it takes to sell, install and commission CHP systems. The PAs can help insure the Program achieves these goals by taking into account the project development timeframes and establishing a “pipeline” approach that associates the different market segments to the anticipated timeframes. For example, a high-value 2 MW gas turbine site being developed in spring of 2011 will realistically not be commissioned until the end

of 2012 at the earliest. Consequently, energy savings from this site will not be available until the latter part of 2012 or early 2013. Developing a pipeline approach will assist in identifying expected annual energy savings, prioritizing market segments that can deliver those energy savings and help focus marketing and implementation activities. Variables to consider in developing the pipeline are:

   a. Size of each segment
   b. Time for installation by segment
   c. Conversion percentages
   d. Yearly targets for leads, assessments, and installation segment

2. **Outreach to large sites**. The PAs should identify and reach out to high-value large sites using the account executive teams from the different utilities. These sites take the longest estimated time from signed contract to commissioning; they are also the most sophisticated. They do not need time to learn about CHP, they need to be educated about the incentive, which may be the final variable that helps a project exceed its internal hurdle rates. In addition, educating large sites and developers on the program now may assist in managing any ambiguity on attribution of the program.

3. **Focused outreach for under 300 kW.** For sites 60 – 300 kW, the PAs should work with partners to promote the incentive program. The PAs role with these customers is to build the credibility of CHP technology and act as the role of energy advisor by providing customers with an integrated solution of energy efficiency measures including CHP systems.

4. **Training Using Webinars.** The evaluation team understands that planning for webinar training sessions is currently underway via the PA Implementers' CHP Working Group. The evaluation team supports this endeavor and recommends training session in the following areas:

   a. Understanding of the CHP technology.
   b. Understanding of the services offered by the program.
   c. Interconnection process, issues and solutions.
   d. Identification of barriers to installation and steps to address barriers.
   e. Methods to reduce installation costs.
   f. Case studies of successful installations.

5. **Program Stability-Coordination.** The program should consider increased coordination with other CHP initiatives (i.e. Alternative Energy Portfolio Standards requirements) to

leverage overlapping requirements for cost-effective execution of both programs. Inconsistency and duplication across programs can lead to customer frustration and act as a barrier. Specific areas of consideration include the development of consistent metering approaches. The metering approach can and likely should vary by the size of the customer.

6. **Partners to collaborate.** The program should consider collaborations with existing groups such as trade groups, vendor associations, and customer groups with the goal of leveraging existing mass marketing efforts. Examples of collaboration activities include:

    a. Training and education to validate to effectiveness of the technology in specific applications (e.g. hospitals, nursing homes, college and universities).
    b. Coordination with but not endorsement of vendors.
        i. The approved vendor list being developed by one utility is a step in the right direction.
        ii. Partner with CHP vendors to conduct training on their technology. The focus should be on training and not selling the specific technology.

    c. Cooperation and collaboration with DOER on coordination of EE CHP and APS incentive programs.

7.2.2 Long term recommendations

The short-term recommendations outlined above will help to act as catalyst for more CHP adoption. The following long-term recommendations based on our analysis require a longer time horizon.

1. **Network Interconnects.** The challenges of spot networks have been addressed by a number of metropolitan areas (e.g. Manhattan). Changing the policies by the utilities in Massachusetts to allow for CHP interconnection on a distribution spot network like Boston will take time. However, not addressing this issue is resulting in not capturing 23 MW of identified capacity.

2. **Interconnection process**. In addition to spot networks, the utilities could focus on more long term interconnection issues such as simplifying the forms or harmonizing them within the state to make it easier for developers working with different utilities.

3. **Refinement of targeting under 300 kW.** After the initial push to educate and inform those sites under 300 kW in 2011, the PAs should consider using metrics to determine their success rates and look to refine any processes to help hit the targets in 2012 and beyond. This process of measurement, review and continuous improvement has proven to be successful in many industries.

4. **Incentive Types.** CHP programs across the country are considering capacity-based incentives paid up front, performance-based incentives paid over time and hybrid structures where a portion of the incentive is paid up front and the remainder is paid out as a performance incentive. There is no single approach that is being adopted across the board. CHP project developers prefer upfront incentives which help defer capital costs and reduce financial risk. Prospective CHP sites also prefer the financial benefits associated with upfront, lump sum incentives, but like the reassurance of project developer and manufacturer involvement that is tied to performance payments. From an implementation perspective, performance incentives represent additional complexity and transaction costs. By requiring system warranties on incented projects, the Massachusetts Program has taken steps to help insure sustained CHP system performance. Consequently, using upfront incentives tied with system warranties may be the best way to help motivate CHP project development under the Program and insure high sustained performance. We recommend the continued use of upfront incentives.

A. Literature Review Sources

Literature Review Sources	
State/Organization	**Website**
CA	http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/
CT	http://www.ctcleanenergy.com/default.aspx?tabid=95
NY	http://www.nyserda.org/Programs/dgchp.asp
	http://www.nyserda.org/programs/Existing_Facilities/chp.html
	http://www.nyserda.org/programs/New_Construction/default.asp
WI	http://www.we-energies.com/business/altenergy/dirfinance_incent.htm
	http://www.alliantenergy.com/wcm/groups/wcm_internet/@int/documents/contentpage/024302.pdf
	http://www.we-energies.com/pdfs/etariffs/wisconsin/ewi_sheet190-192.pdf
	http://www.focusonenergy.com/Incentives/Business/renewable_incentives.aspx
VT	http://www.cvps.com/cowpower/
	http://publicservice.vermont.gov/energy/ee_cleanenergyfund.html
OH	http://www.gridsmartohio.com/savingWork/CIPrograms/CICustom.aspx
WA	http://www.chelanpud.org/snap.html
	http://www.okanoganpud.org/consSNAP.htm
US Environmental Protection Agency	http://www.epa.gov/chp/index.html
US Department of Energy	http://www1.eere.energy.gov/industry/distributedenergy/chp_projects.html
CHP Database	http://www.eea-inc.com/chpdata/index.html
Association for Energy Efficiency Economy (ACEEE)	http://www.aceee.org/sector/state-policy/toolkit/chp
Northeast CHP	http://www.northeastchp.org/nac/index.cfm
DSIRE	http://www.dsireusa.org/summarytables/finee.cfm
	http://www.dsireusa.org/summarytables/finre.cfm
US Clean Heat and Power Association	http://www.uschpa.org/i4a/pages/index.cfm?pageid=1
Midwest CHP Application Center	http://www.chpcentermw.org/home.html

B. Vendor Interview Guide

INTERVIEW GUIDE/PLAN FOR CHP PROJECT DEVELOPERS AND CHP TECHNOLOGY PROVIDERS

MA LCIEC CHP TASK #1C – December 2010

[This interview guide presents questions our evaluation team plans to ask of CHP project developers or CHP equipment providers. The goal of the interview is to determine: 1) knowledge of the interviewee with the current CHP program; 2) knowledge of the demand of CHP in the utility service areas including types of applications and targeted segment,; 3) the extent of the interviewee's knowledge of decision makers at facilities for CHP installation; and 4) the interviewees knowledge of hurdles and drivers for the CHP market including technology applications, air quality, pricing, tariffs, regulatory and the incentive program.]

Name ____

Company Name ____

E-Mail ______________________________________

Phone ____

Date ____

Introduction – For Phone and Face to Face if necessary

My name is **<NAME>** and I work for Itron's Consulting and Analysis Group. We have been hired by the Massachusetts Energy Efficiency Program Administrators **<mention their likely utility>** to assess the market potential for combined heat and power (or CHP) in Massachusetts.

An important element in this process is to discuss the Massachusetts CHP program and market with equipment manufacturers and project developers. The information gathered from our research may directly benefit you and your industry, as the results of this study will help identify the specific drivers and limitations to expanding CHP in Massachusetts. However, the specific responses provided by you will be treated as confidential. Only the overall results will be made public.

I have a carefully planned out questionnaire and would like to spend 30 minutes to an hour gathering your opinion on the CHP market in Massachusetts. Are you an appropriate person at your firm to discuss this matter with us?

Throughout this survey, to the extent possible, provide answers to our questions as they relate directly to CHP efforts by your firm in the State of Massachusetts.

Screening

S1. Does your firm sell CHP products or services in Massachusetts?

S2. Over the past two years how many CHP systems has your firm sold in Massachusetts, Less than 5, Between 5 and 15, greater than 15?

S3. Over the past two years how many CHP systems has your firm installed in Massachusetts, Less than 5, Between 5 and 15, greater than 15?

S4. What percent of your business is located in Massachusetts?

Background and Process of CHP Customer Selection

B1. What is your exact job title?

B2. Could you briefly describe your job responsibilities and roles in the development of CHP projects or installation of CHP equipment?

B3. Do you serve a specific sector of customers (e.g. geographic region or customer segment such as industrial, commercial, etc)?

B4. Which CHP technologies does your firm generally represent or typically specify for projects?

B5. What other services does your firm provide as part of the installation/development of a CHP project (e.g. energy efficiency audits, Power Purchasing Agreements (PPAs), energy management software)?

B6. If your firm is a CHP technology developer, do you provide additional operation and maintenance services with your product or is that provided by a third party?

B7. Does your firm provide CHP performance metering, measurement and/or analytics as part of the installation? (if yes, please identify which of these services are offered)

B8a. How does your firm typically identity prospective CHP projects (e.g., through your own market research, through the utility, etc.)

B9a **If they do not mention thermal or electrical load prompt.** Do you consider the sites electrical or thermal load?

B9b **If Thermal load /characteristics**– Is the thermal amount the minimum amount of thermal load occurring throughout the year and what is generally that minimum amount? In addition, do you consider the match between electrical and thermal load in selecting candidate CHP projects?"

B9c. **If thermal -** What type of information does your firm use in assessing the thermal load at prospective facilities (e.g., billing data from the customer, metered data that you have collected on similar facilities, etc.)?

B9d. **If not thermal ask if electrical or document other means that the developers uses to identify sites not covered in B8**

Program Awareness and Customer Application

P1. Are you aware of the Combined Heat and Power (CHP) Program incentives as part of the utility Energy Efficiency program in Massachusetts?
PROMPT – if unfamiliar with program - As a result of the Green Communities Act of 2008, Combined Heat and Power Projects are now eligible for funding as an electric energy efficiency measure by Electric Program Administrators ("PA") in Massachusetts. While gas utilities offered some CHP incentives in the past, the current Program Administrators responsible for administering incentives for CHP Programs are NSTAR (electric), National Grid (electric), Western Massachusetts Electric Company, Unitil (electric), and Cape Light Compact. Generally, equipment qualifying for CHP incentives include reciprocating engines, gas and micro turbines (also commonly referred to as combustion turbines), and back pressure steam turbines which recover waste heat for useful purposes. . It is important to note that for the purposes of receiving an incentive under this program, a CHP system must directly produce electricity, recover and use thermal energy produced from the system; and not simply offset the use of electricity. An example of equipment excluded from this definition would be a gas-fired engine

directly coupled to a compressor which indirectly reduces electricity by reducing or eliminating the use of a motor to drive a compressor. The CHP system can use any fuel type.

P2. How did you learn about the current CHP incentives and services offered in Massachusetts?

P3. Is your firm involved in the current electric CHP incentive program offered in Massachusetts? If so how is your firm involved and approximately how many projects or customers have you worked with for these efforts?

P4. Have you worked with clients who qualified for incentives or services under the CHP program but chose not to participate? Do you know the primary factors that led them not to participate in the program?

P5. Have you worked with clients who did NOT qualify for incentives or services under the CHP program but chose to move forward? Do you know the primary factors that led them not to qualify in the program?

P6. Do you have clients who installed CHP systems prior to the current CHP program? If so, why did those clients choose to implement these projects? Did they receive an incentive from the gas utility?

Knowledge of Segments and Technology Fit

K1. We are interested in your opinions regarding which market segments are best suited for CHP program participation in Massachusetts. Examples of possible market segments are hospitals, hotels, supermarkets, college campuses, etc. Are there market segments you think are a natural fit for CHP? Why do you say that and what are the key drivers in those segments?

K2. When do you typically get involved with facilities that are considering installing CHP equipment (e.g., you initiate the process by contacting them; you are contacted after they have made a decision and are involved in feasibility studies; you are contacted when they have made the decision and are looking for cost estimates, etc.)?

K3a. What are the primary customer requirements that seem to drive your clients to install a CHP system?

K3b. Why do you say that?

K4a. What other considerations influence your perspective on the site's value as a prospect for installing a CHP system (e.g., the size of the CHP that would be installed; having an energy manager on site; having someone on site qualified to run the CHP equipment)

K4b. Why did you say that?

K5. How sophisticated do you think your clients are in examining the importance of utilizing waste heat to offset thermal loads? PROBE (Do they examine the economics using sophisticated tools and models and is their ultimate decision making surrounding technology selection sound?)

K6 How much of the economic analysis and associated CHP technology selection do you do for clients; or do you work with other companies who provide these services?

K7. Based on conversations with potential customers who have expressed interest in CHP, are you seeing interest in CHP systems that are more electrical load following or more electrical base load or is the interest in thermal load following or thermal base load?

K8. Based on applications to the program or on conversations with clients who have expressed interest in CHP technologies, do you see a typical size or range of sizes for electrical output?

K9. Is the size of electrical output typically determined by the waste heat needs or the electrical needs of the facility?

K10. What are some common thermal loads that clients are able to offset using CHP waste heat (e.g. domestic hot water, heating, cooling using absorption chillers)?

Decision Makers and Marketing & Recruiting

D1. When a customer wants to install a CHP system, who is the primary stakeholder at the facility you interact with? [IF NEEDED: What are the client job titles of the decision makers that you normally work with, and who are the staff that you might work with when installing equipment?]

D2. Do you use the CHP rebates that are available in Massachusetts as a means of recruiting new clients? Why or why not?

D3. **If yes to D2**, in your experience how important are Massachusetts utility incentives in leading to CHP installations?

D4. Have you ever seen marketing materials, such as brochures or fact sheets, describing the CHP program in Massachusetts? Did you provide them to your clients? Were they useful?

D5. Would you say that your customers in Massachusetts typically know about these CHP incentives?

D6. What other CHP-related services are customer's interested in? (IF NEEDED PROBE: Power Purchasing Agreements (PPAs), energy management, running the CHP device, services and maintenance, audits, retro-commissioning)

D7. At what point in the project process do you begin to talk about energy efficiency or the other utility programs with your clients? [PROBE THE INTERVIEWEE FOR A TERM TO

DESCRIBE THE PHASE OF THE PROCESS. POSSIBLE TERMS THEY MIGHT USE: RFP/PROPOSAL, DESIGN DEVELOPMENT, TERM SHEET]

Other Questions

Q1. What primary barriers do you perceive in the adoption of CHP in Massachusetts? Are costs the primary burden? How do air quality regulations impact adoption? Any utility requirements like interconnection or ability to export influencing adoption?

Q2. To minimize these barriers, are there activities the Program Administrators for the CHP program to take to address the barriers and what do you believe should be the priority of these actions?

Q3. What primary drivers to growth do you see for CHP in Massachusetts?

Q4. What tools or information would help you identify CHP projects that meet the eligibility requirements of the CHP program?

Q5. How well do the CHP program requirements mesh with your normal development process for CHP systems in Massachusetts?

Q6. For a typical project, how much additional time does the CHP program process in Massachusetts require from your firm? [TO NORMALIZE RESPONSES, TRY TO GET ESTIMATES IN TERMS OF % INCREMENTAL TIME FOR CHP INCENTIVE PROJECTS VS. NON-CHP INCENTIVE PARTICIPATION]

Q7. Are there any modifications to the programs that Massachusetts utilities might make to better support the design and construction of CHP systems?

General Thoughts

G1. What are your general thoughts about the CHP program in Massachusetts?

G2. What are the greatest strengths of the CHP program at this time?

G3. What are the greatest weaknesses of the CHP program at this time?

C. Site Interview Guide

INTERVIEW GUIDE FOR COMBINED HEAT AND POWER SITES

MA LCIEC CHP TASK #1C – December 2010

[This interview guide presents questions our evaluation team plans to ask of businesses that have installed a CHP system. The goal of the interview is to determine: 1) why did they choose to install a CHP system and their decision making process, 2) what did they learn during the process and what did they wish they knew at the beginning, 3) what challenges and opportunities do they see for CHP sites and other aspects of CHP – utility hook up, metering, etc]. This will not be a cold call, an email will be sent in advance to the location contact and the utility account representative may or may not be involved in the set up of the call.

Name ____________________________________

Company Name ____________________________________

E-Mail ___________________________________

Phone ____________________________________

Date _____________________________________

Introduction – For Phone and Face to Face if necessary

My name is **<NAME>** and I work for Itron's Consulting and Analysis Group. We have been hired by the Massachusetts Energy Efficiency Program Administrators **<mention their likely utility>** to conduct a market assessment of the combined heat and power, or CHP market in Massachusetts.

An important element in this process is to discuss the current Massachusetts CHP program and market with sites that have already installed CHP systems prior to the current program as well as those that have participated and installed their equipment in the current program. We are specifically contacting you because you have installed CHP 'prior to' or 'under' the current Massachusetts CHP program. The information discussed during this interview is for research purposes only and your responses to our questions will treated as confidential.

I have a carefully planned out questionnaire and would like to spend 30 minutes to an hour gathering your opinion on the CHP installed at your location. Are you an appropriate person at your firm to discuss this matter with us?

Throughout this survey, to the extent possible, provide answers to our questions as they relate directly to CHP installed at your facility.

Screening/Site Information

S1. According to Utility records you installed [Insert type and size of CHP]? Is this correct?

S2. What other CHP-related services did you pursue as part of your system installation? (IF NEEDED PROBE: Power Purchasing Agreements (PPAs), energy management, metering services, running the CHP device, services and maintenance, audits, retro-commissioning)

S3. On a scale of 1 to 10, 10 meaning a significant amount of reliance, how much did you rely on the project developer for advice on the equipment installed?

Background and Process of Participant Recruitment

B1. What is your exact job title?

B2. What is your company's primary business? (e.g Prison, food handing, consumer package goods)

B3. What type of facility is the CHP device located at (manufacturing, hotel, office space?)

B4. Could you briefly describe your job responsibilities and roles in the installation and operation of the CHP equipment?

B5. Is this the first CHP system you have been involved with at this company or other companies?

System Decision Making

D1. Why did your organization investigate the installation of a CHP system at your facility? Probe: (Was the idea initiated internally as part of a study, did a CHP developer contact you, was it from a conference or a trade show?) [WE ARE LOOKING TO DETERMINE HOW PEOPLE CHOOSE TO SELECT A CHP SYSTEM, IS IT DUE TO THE CHP VENDOR, AN AUDIT, OR INTERNAL EFFORTS/PAST EXPERIENCES WITH CHP]

D2. What was the primary factor driving the desire to install a CHP system at your facility (e.g. use of the waste heat, lower electricity costs, ability to be independent from the grid and/or run as back-up power)

D3. How familiar were you with the electrical loads at your facility prior to investigating the selection of a CHP system. Did your knowledge increase after the CHP system was installed?

D4. How familiar were you with the thermal loads at your facility prior to investigating the selection of a CHP system. Did your knowledge increase after the CHP system was installed?

D5a. Did you select pursuing a technology based on a minimum amount of thermal load occurring throughout the year? (Interviewer If yes D5b, if no D5c)

D5b. What is generally that minimum amount? Probe(did you consider the match between electrical and thermal load when pursuing a CHP system)?

D5c. Did you pursue a technology to meet the electrical needs of the location? Probe(did you consider the match between electrical and thermal load when pursuing a CHP system)?

D6. How did you measure the thermal load at the facility where CHP was installed (e.g., billing data, metered data that you have collected on similar facilities, you do not know the thermal load.)?

D7. Does the CHP system you installed modulate based on the electrical demand of the facility, does it modulate based on the thermal requireiments or does it not modulate at all?

D8. At any point in the project process did you or the CHP developer talk about energy efficiency or the other utility programs? [PROBE THE INTERVIEWEE FOR A TERM TO DESCRIBE THE PHASE OF THE PROCESS. POSSIBLE TERMS THEY MIGHT USE: RFP/PROPOSAL, DESIGN DEVELOPMENT, TERM SHEET]

D9. When deciding to install a CHP system, did you need to account for an increase in human resources (e.g. another energy manager, someone to operate the system) to operate the equipment -- did you already have staff on hand that could operate the system or did you out source this to a contractor?

D8. Prior to pursuing the installation of CHP did you examine the importance of utilizing waste heat to offset thermal loads? Did you examine the economics of CHP using analytical tools and models?

D9. What steps and analysis needed to take place before pursuing the installation of the CHP devices and who was the ultimate decision maker?

D11. Did the CHP developer or equipment manufacturer help provide data and information to you to assist in obtaining project acceptance?

D12. Is there anything you wish you had asked or pursued differently in the decision making/project acceptance process now that the system is running?

D14a. Do you currently monitor the output from your CHP system?

D14b. If yes, what type of information and from whom?

D14c. If no, would you be interested in obtaining the data?

Knowledge of CHP Program

P1. Are you aware of the Combined Heat and Power (CHP) Program incentives as part of the utility Energy Efficiency program in Massachusetts?
PROMPT – if unfamiliar with program - As a result of the Green Communities Act of 2008, Combined Heat and Power Projects are now eligible for funding as an electric energy efficiency measure by Electric Program Administrators ("PA") in Massachusetts. While some gas utilities previously had some incentives for CHP, the Program Administrators who are responsible for administering incentives for CHP Programs are NSTAR (electric), National Grid(electric), Western Massachusetts Electric Company, Unitil(electric), and Cape Light Compact. Generally, equipment qualifying for CHP incentives include reciprocating engines, gas turbines (also commonly referred to as combustion turbines), and back pressure steam turbines which recover waste heat for useful purposes. It is important to note that for the purposes of receiving an incentive under this program, a CHP system must directly produce electricity and not simply offset the use of electricity. An example of equipment excluded from this definition would be a gas-fired engine directly coupled to a compressor which indirectly reduces electricity by reducing or eliminating the use of a motor to drive a compressor. The CHP system can use any fuel type.

P2. Was an incentive received for the installed CHP device? From what utility (gas or electric)?

P3. Were you familiar with the incentive or were you informed of it through your developer or through a utility account representative?

P4. If installed with an incentive at what point in the process did the CHP Program Administrators become involved?

P5. Did you receive any services from the PAs such as technical assistance for the CHP installation?

P6. Have you ever seen marketing materials, such as brochures or fact sheets, describing the CHP program in Massachusetts? Were they useful?

Installation and Post Commissioning

Q1. Were you engaged in the installation and commissioning process?

Q2a. On a scale of 1 to 10, 10 being the most satisfied how satisfied with the installation and commissioning process?

Q2b. What was the primary reason for satisfaction?

Q2c. What was the primary reason for any dissatisfaction?

Q3a. On a scale of 1 to 10, 10 being the most satisfied how satisfied are you with the interconnection and gas upgrade process with the utilities?

Q3b. What was the primary reason for satisfaction?

Q3c. What was the primary reason for any dissatisfaction?

Q4. From a signed contract to commissioning of the CHP system, how long did this process take (answer in months)?

Q5a. On a scale of 1 to 10, 10 being the most satisfied were you satisfied in the time it took to install?

Q5b What was the primary reason for satisfaction?

Q5c What was the primary reason for dissatisfaction?

Q6a. On a scale of 1 to 10, 10 being the most satisfied how satisfied are you in the performance of your CHP system?

Q6b What is the primary reason for satisfaction?

Q6c What is the primary reason for dissatisfaction?

Q7a Do you plan on installing any more CHP systems at this site or others?

Q7b Why or why not?

Q8. What in your opinion is preventing a greater adoption of CHP in Massachusetts today if at all?

Q9. If you believe there are barriers, to minimize these barriers, are there activities you can think of that the Program Administrators could undertake to address them and what do you believe should be the priority of these actions?

Q10. What primary drivers to growth do you see for CHP in Massachusetts? (EXAMPLES Incentives, reducing peak demand, energy reduction, the environment)

Q11. Are there any modifications to the programs that Massachusetts utilities might make to better support the design and construction of CHP systems?

General Thoughts

G1. What are your general thoughts about the CHP program in Massachusetts?

G2. If you could share one piece of advice to another facility looking to install a CHP system, what would you tell him or her?

G3a. On a scale of 1 to 10, 10 being the most satisfied what is your level of satisfaction with your gas and electrical utility providers?

G3b. Why did you say that?

D. Detailed Methodology: Quantitative Market Assessment

This appendix presents a detailed description of the quantitative market assessment methodology, algorithms and assumptions. It is organized as follows:

- Section D.1 Estimating Account Opportunity
- Section D.2 Filtering and Aggregating Market Segments
- Section D.3 Step by step Calculations
- Section D.4 Base load profiles
- Section D.5 Partial list of confirmed Generation

D.1 Estimating Account CHP Opportunity

This section describes the approach to modeling the individual gas customer's opportunity for a CHP system and the assumptions made during the analysis.

The power of the model is in the quality of the thermal characterization provided by the customer's billed gas usage. The gas distribution companies provided individual gas billing account information for all of their commercial accounts. The data includes an account number and twelve months of billed gas usage. This usage data characterizes the customer's thermal load with a high level of certainty and sets an absolute upper bound on the CHP opportunity for that location, at that point in time. In addition, all the gas companies except for Columbia Gas provided customer name, service address, and SIC codes. These data were used to further characterize the customer's thermal profile and improve the estimate of CHP opportunity.

The computations produced an estimate of an optimally sized CHP unit and its performance for each account. CHP systems that are in the size range of commercially available products and meet financial criteria are considered 'high-value. The final compilation of high-value accounts might be considered a 'lead list', and should, theoretically, include all of the best candidates for CHP, but also a number of false positives. For example, about 30% of the lead list will probably have gas-fired heating systems that cannot be displaced by CHP or the physical layout of the facility eliminates the site, as noted during the **Developer** interviews.

D.1.1 Account estimation methodology

The model takes advantage of the fact that high efficiency CHP systems are almost always limited by the thermal load profile of the host site. If a CHP unit runs and the heat production is not used by the facility, it is strictly a generator with an operating electrical efficiency of 29% to 33%. Therefore good CHP sites can best by identified by their thermal load, not electric load.

The underlying assumption of the model is a customer's gas usage is a good proxy for the facility thermal loading and that some portion of that thermal loading can be displaced by CHP. Using gas bills is a similar methodology that the ***Developers*** shared with us during the interviews on how they prospect for potential sites.

D.1.1.1 Modeling of CHP Characteristics

A cost-effective and energy efficient CHP system requires the confluence of a number of factors. The model estimates opportunity, assuming a system purchased, installed and operating will meet these requirements:

- The magnitude of the thermal usage must be large enough to support the installation of a commercially high-value CHP unit. The model uses 60 kW as minimum size of a high-value CHP unit. The 60 kW threshold was chosen because it reflects commercially available equipment.

- The unit is operated as a thermal following system. The model assumes that units are sized to meet the thermal load and operated to match the thermal requirements of the facility. This will maximize the system efficiency. The model also assumes that all the electricity generated is consumed by the facility. The thermal load heats hot water or steam. A CHP unit cannot displace direct-fired heating used for, cooking or process, for example. Larger unit applications (1MW+) can displace steam production. It is assumed some portion of the base usage cannot be displaced by CHP depending upon the building type.

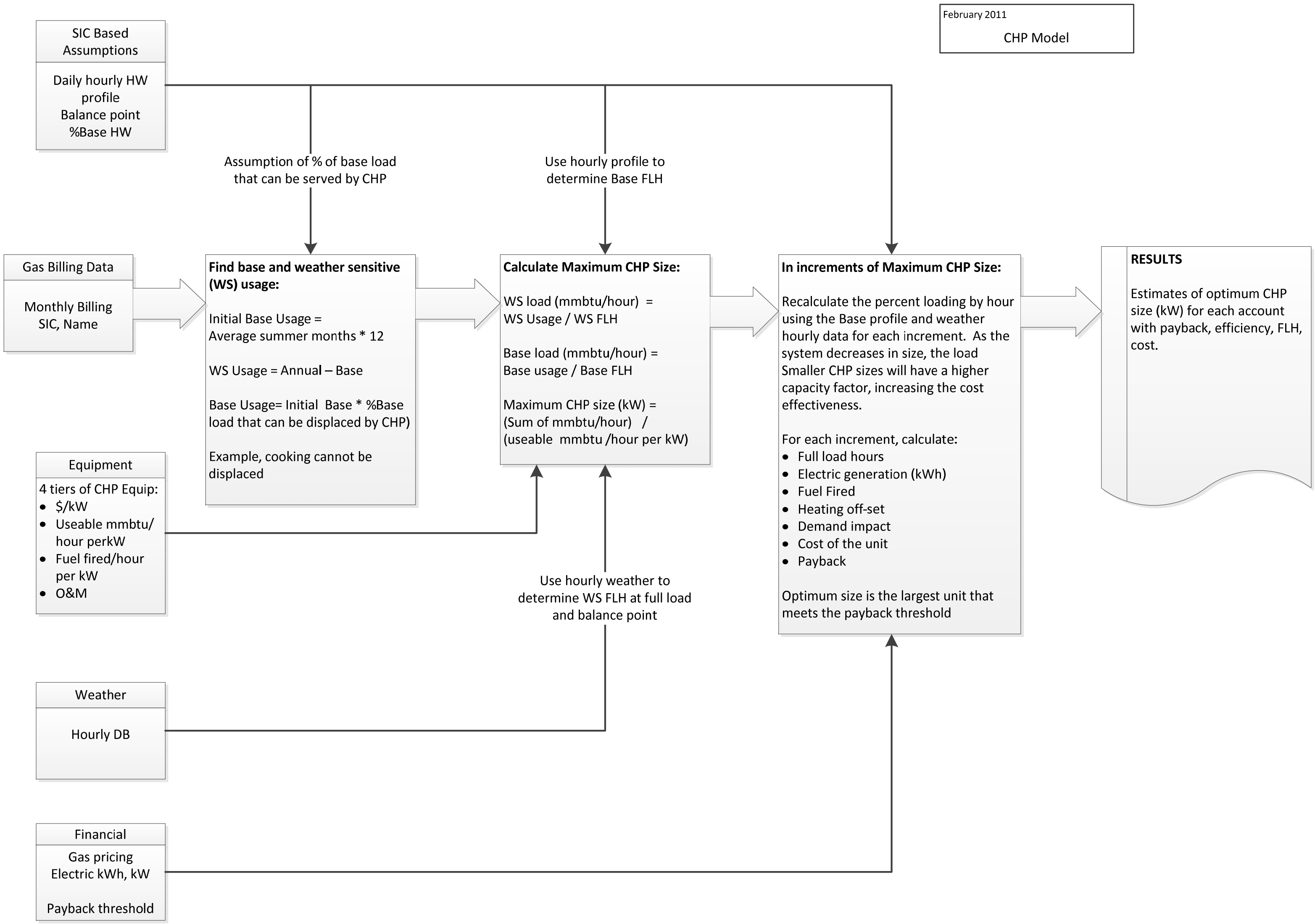
- Typically, the full load operating hours of the unit must meet or exceed about 6,000 hours per year to be cost effective. The actual threshold varies by installation. Typically, in order to meet the full load hours threshold, a portion of the thermal load must come from a year round base load that is required for extended periods each day. Downsizing a CHP unit can increase the effective full load hours and improve cost effectiveness in some scenarios.

D.1.1.2 Calculation Descriptions

This section identifies and discusses the inputs and basis of the calculations used by the model. Figure D-1 illustrates the computations overall. A step-by-step example of a single account calculation is shown in Section D-3 Step-by-Step Calculations with additional detailed rationales for the steps.

In summary, the model estimates the customer's base usage components using billed summer usage as a measure of non-weather sensitive loads. The weather sensitive load is the difference between the annual billed usage and the calculated base usage.

Figure D-1 Flow Chart for Gas Customer CHP Calculations



The model then distributes the thermal load through all hours of the year. The account specific weather sensitive load is distributed using a weather driven hourly profile; the account specific base thermal usage using a building type hourly profile. While the *shape* of the profile is not wholly unique to a customer (profiles are weather and building type determined) – the sum of the hourly usage must equal that particular customer's billed usage which provides a very specific results for each account.

An initial CHP system size is selected that has sufficient thermal capacity to meet the peak thermal load. Its load performance is assumed to vary with the load through all hours of the year. Typically a system sized to meet the maximum thermal load of a facility is not cost-effective, so the model tests the performance of CHP systems sized at a series of fractions of the maximum size. The optimum size is the maximum sized unit that meets a customer payback threshold.

Inputs

The inputs utilized in each CHP opportunity calculation are as follows:

- Customer monthly billed gas usage. Also, for all but Columbia Gas customers: customer name, service address, and SIC code.
- Building characteristic – selected by the customer's SIC. Defaults to "Office" building type for un-coded accounts. The building characteristics define the balance point, the percent of the base load which cannot be displaced by CHP (for example, gas used for cooking cannot be displaced by CHP), and a base load hourly profile (the model utilizes 12 profiles which are listed in Section D-4 Base Load Profiles).
- 8760 weather data – selected by PA (WMECO:Pittsfield, National Grid and Unitil: Springfield, NSTAR: Boston, Cape Light: Hyannis). The actual hourly weather used is historical data for the time period of the gas bills used in the analysis.
- Electric and gas rates – a single statewide gas rate is used; however, the electric rates are implemented by electric distribution company.
- Equipment operating characteristics. Typical equipment characteristics, including fuel fired and maximum recoverable heat per kWh and O&M and installed costs.

Calculations

This section presents a rational for the calculation methods.

Defining Weather Sensitive and Base Thermal Usage

The model defines the customer's non-weather sensitive base gas usage as the average usage in the months of June, July and August extrapolated to a full year. The weather sensitive annual gas usage is calculated as the difference between the base and annual billed usage.

This is a standard method for differentiating between the billed usages serving the space heating versus other base requirements of the building.

The annual gas usage is adjusted further in the calculations to account for the existing boiler efficiency and also that portion of the base load that cannot be served by CHP. The existing boiler is assumed to be 80% efficient. The base load that cannot be served by CHP (cooking load for example) is specified by building type.

Thermal Load Profile

The size, generation, net gas benefits and cost-effectiveness of CHP depends upon the annual size of the thermal load that can be displaced by CHP, but also very importantly upon seasonal and daily hourly usage pattern or thermal profile. A system sized to meet the heating requirements for a typical commercial space will run the equivalent of about 2000 full load hours, which reflects the hour to hour variation in weather and the percent of full load required to meet the subsequent building thermal load. CHP systems must operate in the order of 5000 to 6000 hours a year to be cost-effective. A CHP system can log extended hours of operation with a near continuous base load and/or by downsizing the unit.

The model assumes the weather sensitive portion of the annual usage operates under a load profile determined by the hourly dry bulb temperature variation. Historical hourly weather files are used to determine the hourly load profile for the weather sensitive portion of the load.

The model assumes the base load portion of the annual usage operates under a profile determined by building type, which is assigned based on the SIC coding of the account, and is characterized by an average daily profile expressed in percent of maximum load per hour.

CHP maximum size

The unit is initially sized to meet a theoretical design load based on the relationship of:

Maximum CHP size = WS maximum load per hour + Base maximum load per hour

where:

WS max mmbtu/hour = WS annual usage / WS full-load-hours

Base max mmbtu/hour = adjusted base annual usage / base full-load-hours

These equations are more familiar as the relationship often used in rules of thumb for heating and cooling equipment.

Annual usage = maximum capacity x full-load-hours

CHP systems are not often sized to meet the heating requirements for a facility for all loads, for all hours of the year, unless the thermal load is fairly constant year around, which might occur for an industrial site. Instead, CHP units are sized to meet the portion of a variable thermal load which increases the full load hours (FLH) and the cost-effectiveness of the unit.

The model simulates downsizing by recalculating the combined WS and base FLH at ten different size points selected as a percentage of the Maximum CHP Size for that particular account (1%, 8%, 15%, 20%, 30%, 40%, 50%, 60%, 80%, 100%). Under each size scenario, the system calculates the loading percentage of the reduced sized CHP unit for each hour of the year.

Results

Once each scenario FLHs are calculated, the results are computed as follows:

*Generation (kWh) = Scenario FLH * CHP scenario size (kW)*

Summer/Winter Demand impact = Summer/Winter average peak reduction/8760
** CHP scenario size (kW)*

Note: summer and winter demands are independently calculated

*Fuel fired (mmbtu) = Generation (kWh) * Fuel fire rate per kW*

*Fuel off set = Generation (kWh) * Heat available rate per kW / boiler efficiency*

*O&M costs = Generation (kWh) * O&M ($/kWh)*

*Installed cost = CHP scenario size (kW) * installed cost per kW*

Annual benefit = sum of the financial effects of avoided retail electricity consumption, demand impact, and net gas consumption and O&M costs.

Payback = Installed cost / Annual benefit

D.1.2 Model Assumptions

This section reviews the assumptions used in the model and include:

- Building characteristics
- Equipment operation characteristics
- Cost of electricity and gas
- Cost-effectiveness screening: simple payback

D.1.2.1 Building Characteristics

A building type is assigned to each account based on the SIC coding of the account. Three factors used in the model to characterize the building thermal operation are:

- Base load profile, an average day hourly usage profile expressed as a percentage of maximum loading for each hour
- Percent of the base load that cannot be displaced by CHP (such as cooking), for adjusting the annual base load
- Building balance point, degrees F, for computing the weather sensitive load profile

The primary source for both load profiles and percentage of base load that cannot be displaced by CHP is the California Commercial End-Use Survey (CEUS). CEUS is a comprehensive study of commercial building sector end-use energy use. Itron performed the survey under contract to the California Energy Commission (CEC), and with the support of the California electric distribution companies. The survey captures detailed building systems data, building geometry, electricity and gas usage, thermal shell characteristics, equipment inventories, operating schedules, and other commercial building characteristics. A stratified, random sample of 2,800 commercial facilities was targeted and a sample of 2,790 were actually completed. Commercial premises are weighted and aggregated to building segment results. Available study results include floor stocks, fuel shares, electric and natural gas consumption, energy-use indices (EUIs), energy intensities, and 16-day hourly end-use load profiles were estimated for twelve common commercial building type categories.

While the California and Massachusetts weather conditions are very different, the characteristic use of service hot water, cooking and miscellaneous loads are much more dependent upon building types and not weather and, therefore, are considered useful for this analysis.

The percent of base load that cannot be displaced by CHP is also a characteristic of the building type (i.e. office, hospital, and restaurant). T he US EIA Commercial Building Energy Consumption Survey (CBECS)[43] and CEUS were both used to estimate the portion of gas consumption that could not be supplied by CHP.

The balance point is the neutral point in a building where neither heating nor cooling is required. A building with a higher balance point (60 F vs. 50 F) has more hours in the year where heating is required, therefore the CHP should operate longer and be more cost-effective is building with a higher balance point. Generally, buildings with higher internal heat gains have a lower balance point. Balance points were assigned using engineering judgment by SIC code.

D.1.2.2 Equipment Operation Characteristics

Table D- summarizes the equipment performance and cost parameters used in the model. The pricing is intended to represent a typical cost for a fully installed CHP unit. The performance and cost data reflects the findings of cost-effectiveness work done in California by the team and would be applicable to the performance of systems in Massachusetts. The fuel fired rate and available heat represent rated rates and not necessarily average observed rates.

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[43] http://www.eia.doe.gov/emeu/cbecs/

Table D-1. Model Equipment Performance and Cost Parameters

CHP Size Range (kW)	Unit modeled	Fuel fired mmbtu/kWh	Heat Available mmbtu/kWh	Cost	O&M $/kWh
0	100 recip	0.011488	0.004488	$ 2,685	0.0013
60	300 recip	0.011006	0.005067	$ 2,552	0.0013
150	300 recip	0.011006	0.005067	$ 2,552	0.0013
300	300 recip	0.011006	0.005067	$ 2,552	0.0013
1000	3.5 MW turbine	0.010339	0.005000	$ 2,327	0.0059

Equipment has been considered that is commercially available in a competitive setting. Currently, there is not a widely available CHP unit under 60kW in size. However, as the market advances, it is likely smaller units will become available. An estimate of the opportunity for systems in the 30 to 60 kW range is provided in Table D- using a $750/kW incentive, a five year payback threshold and the unit performance for 100 kW.

Table D-2. Opportunity for Cost-effective Units in the 30-60 kW Range

Electric PA	Num Accts	Capacity (kW)	Annual Therms	Generation	Cost
CLC Elec	13	598	711,010	4,290,719	1,077,748
NGRID Elec	267	11,581	16,492,415	93,496,045	20,869,751
NSTAR Elec	393	17,302	17,709,786	119,689,437	31,178,372
NSTAR Network	35	1,525	1,688,049	10,365,281	2,748,465
Unitil Elec	20	825	372,193	5,145,091	1,596,629
WMECO Elec	45	1,949	2,734,736	16,215,120	3,511,495
		33,781			

D.1.2.3 Cost of electricity and gas

Retail customer pricing for both electricity and gas is used to compute the value of both the electrical benefits and net gas costs. Ultimately, the relationship of the retail price of electricity and gas – or the spark gap – impacts the optimum CHP size and whether the unit will meet the customer's financial criteria. This was confirmed during our interviews with ***Developers*** and ***Sites.***

The components of the retail cost of energy include:

- Electric generation price – this is the commodity price for electricity and corresponds the generation charge on a customer bill;
- Gas commodity price – this is the per therm charge for the fuel transported to the city gate;
- Electric distribution energy price – this is the per kWh charge assessed by the electric distribution company for distribution related services.
- Electric distribution demand price – this is the per kW monthly charge assessed by the DISCO for distribution related services. A standby charge may be incorporated factored into this charge for those electric distribution companies with a standby tariff;
- Gas distribution price – this is the distribution company charge per therm delivered for distribution related services.

The gas commodity and electric generation charges constitute the largest portion of a customer's bill and are the most volatile. Generation and gas commodity prices are impacted by global and unpredictable events like hurricanes and political upheaval. The key price inputs for gas commodity and electric generation charges were derived from the Massachusetts avoided cost model which is based on the report by Synapse Energy Economics entitled "Avoided Energy Supply Costs in New England – 2009 Final Report, August 21, 2009. Although, the AESC prices were not intended to be used directly as retail prices, they were derived in a consistent manner, and therefore correctly represent the spark spread, a driver of CHP economics.

As a further validation for their use in this report, the AESC prices were compared with pricing data from the U.S. Energy Information Agency (EIA) and also to current retail rates in Massachusetts.

Figure D-2 compares projections of generation prices by the EIA, AESC, and current retail generation rates. The EIA prices are national average projections[44], while the avoided costs

[44] http://www.eia.doe.gov/forecasts/aeo/index.cfm

prices have been tailored to Massachusetts and are quite close to the current actual retail price of electricity purchased under the Basic Service default rate.

Figure D-2. Comparison of Cost Projections of Electricity

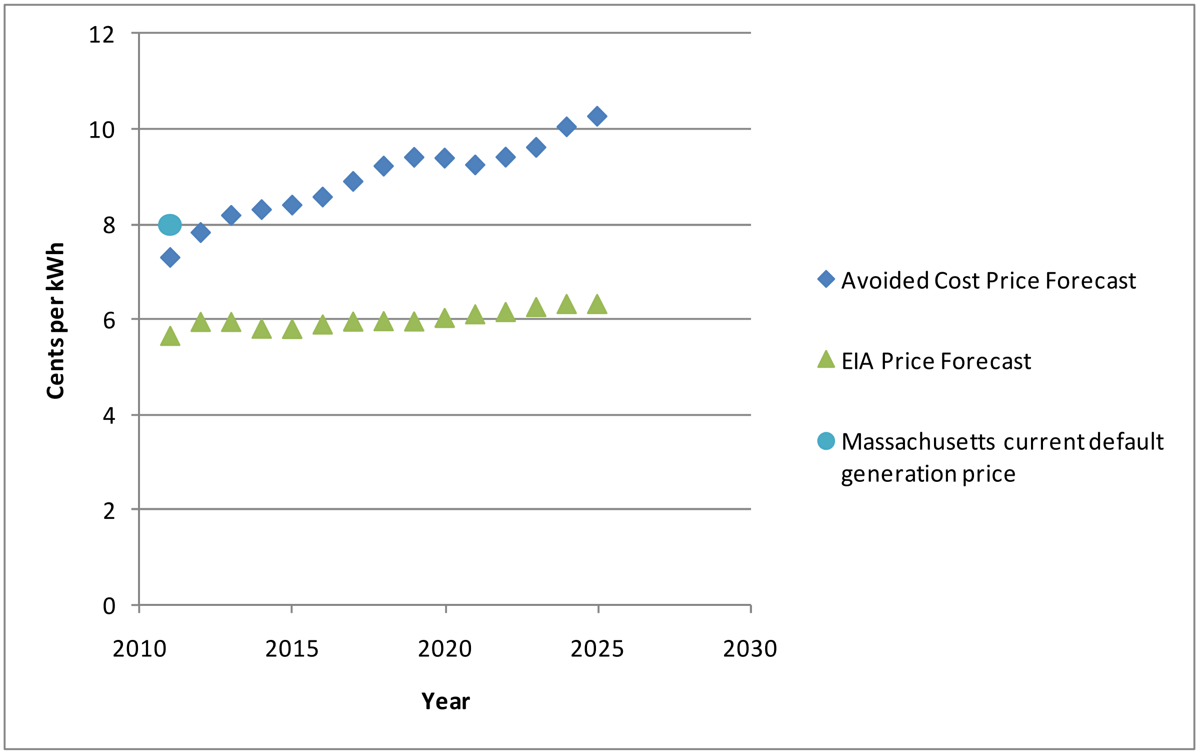
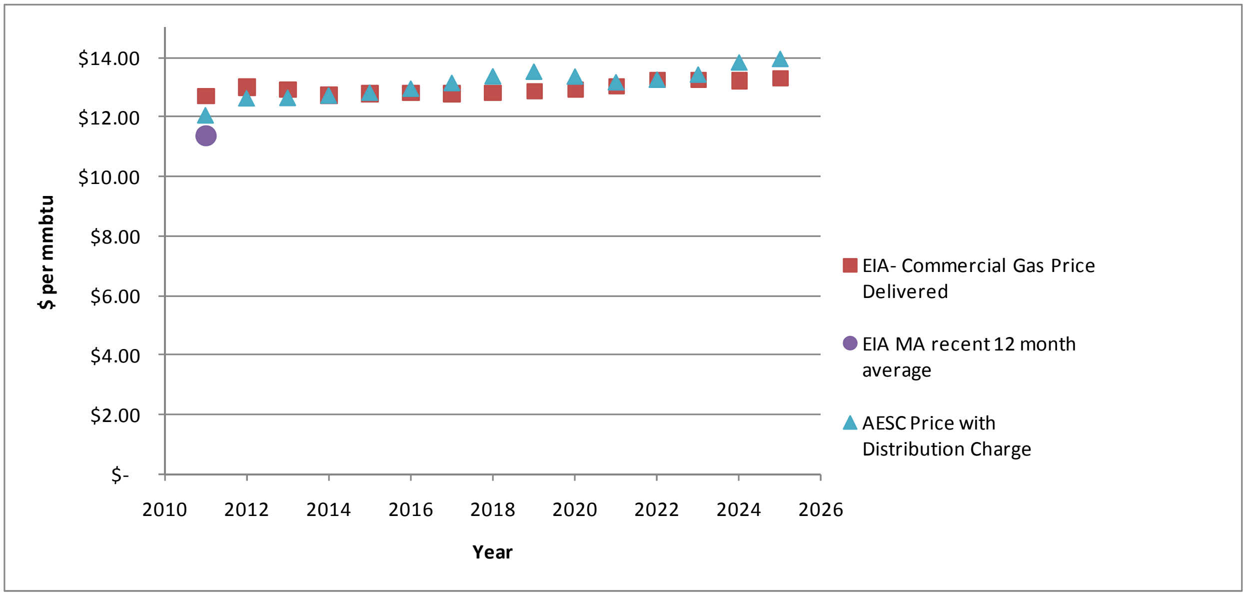


Figure D-3 presents the EIA[45] and avoided cost model projections for retail prices for gas. The EIA values include distribution charges; therefore a distribution charge of $2.50 per mmbtu was added to the avoided cost model prices.

[45] http://www.eia.gov/oiaf/archive/aeo10/aeoref_tab.html

Figure D-3. Comparison of Cost Projections of Gas



Customer retail commodity prices are modeled as an average of the projected prices for generation and the commodity cost of gas from 2011 to 2015, consistent with the five year payback screening scenario (with incentives).

The final electric generation and gas commodity and distribution charges used for screening from the customer perspective are shown in **Error! Reference source not found.**

Table D-3 Price of Generation and Natural Gas

		Units
Electric generation	$ 0.07865	$ / kWh
Commercial NG Commodity	$ 1.01	$/therm
NG delivery	$ 0.25	$/therm

In addition to the commodity charge, there is an electric distribution company energy ($/kWh) and demand ($/kW per month) charge. Because the electric pricing structures vary by distribution company, with more or less emphasis on demand vs. energy based charges, unique rate models were set-up for each electric distribution company based on G3 time-of-use tariff, as shown in Table .

Table D-4. Distribution Company Rates

		NSTAR	WMECO	National Grid	Unitil
Peak	kWh	0.0125	0.0213	0.0297	0.0584
Off	kWh	0.0125	0.0132	0.0222	0.0495
Energy	kWh	0.0125	0.0159	0.0247	0.0525
Win Demand	kW	17.74	8.12	3.92	7.69
Sum Demand	kW	23.71	8.12	3.92	7.69
Standyby	kW	20.83			

Cape Light Compact is served by NSTAR and subject to NSTAR rates.

NSTAR is the only Massachusetts company with a standby rate at this time. Accounts with generation installed capacity greater than 250 kW and providing 30% or more of site power is subject to the rate. The rate charge is applied to peak demand contribution to the building load as measured on a separate installed on the generator. About 25% of the locations accounting for 70% of the installed capacity opportunity would be subject to the tariff. The standby charge does potentially have a substantial impact on customer economics.

Table D-5 Impact of Standby Charge

Standby Rate Analysis		
Tariff charge	$20 per metered monthly peak kW	
Systems >250 and serving 30% or more load are subject to the tariff		
	Number of Accts	Projected Capacity
Total NSTAR Sites withViable CH	742	222,922
Sites > 250 kW	192	159,219
Potential stand-by charge		$20,077,440
Current total annual $ benefit at sites subject to standk		60,794,696
Current total cost, net of incentives		274,698,479
Current average payback in years		4.5
Average payback with standby factor		6.7

D.1.2.4 Cost-effectiveness Screening: Simple Payback

The model uses a maximum simple payback of 5 years assuming incentives of $750 per kW for economic screening from a customer's perspective. The economic screening is used to identify the unit's optimum size and as a final screen for identifying high-value sites. Simple payback is a commonly used measure of cost-effectiveness from a customer's point of view. Many energy efficiency projects are expected to have paybacks in the two year ranges. For a large capital project like a CHP system, a customer may accept a four to five year payback. This range was confirmed in the CHP market assessment surveys.

The purpose of this particular study is to define the attributes "of the CHP market in enough detail that the program planners and administrators can use the information for improving program implementation." To that end, the financial screening is designed to model customer decision making. If the purpose of the study was to identify statewide CHP potential, it would be appropriate to use the state screening tool methods for screening rather than customer payback.

The model's sizing algorithm selects the largest cost-effective CHP system using customer payback as the measure of cost-effectiveness. The simple payback is the installed cost minus the incentives divided by the net annual customer benefits (in dollars) and is measured in years. Net annual benefits include the electric generation and demand benefits, the net fuel cost and also the cost of annual operation and maintenance (O&M).

The incentive level has a significant impact on the size of the opportunity. Assuming a five year payback threshold, a larger incentive will not only make the systems more affordable for additional customers, but it will also permit customers to increase the size of their system. As can be seen in Table , not only does the number of eligible customers increase with incentive, but the average system size generally increases as well.

Table D-6 Sensitivity to Incentive Levels

Incentive per kW installed	Num Accts	Pct Change from Baseline	Capacity (kW)	Pct Change from Baseline	Average System Size kW
$250 / kW	1,051	-28%	306,780	-35%	292
$500 / kW	1,239	-15%	389,941	-18%	315
Baseline $750 / kW	1,464	0%	475,167	0%	325
$1000 / kW	1,829	25%	587,492	24%	321
$1250 / kW	2,268	55%	738,721	55%	326

Table shows how the opportunity will change with different payback threshold changes:

Table D-7 CHP Opportunity Scenarios by Payback Threshold

Payback - Years	Num Accts	Pct Change from Baseline	Capacity (kW)	Pct Change from Baseline	Average System Size kW
Payback <3	199	-86%	157,644	-67%	791
Payback <4	1,153	-21%	378,265	-20%	328
Baseline for payback <5 years	1,464	0%	475,167	0%	325
Payback <6	1,882	29%	556,145	17%	295
Payback <8	2,515	72%	660,168	39%	263

Note the incentive is a constant $750 per kW in all the scenarios.

In this case we see the average system size increases with faster payback periods.

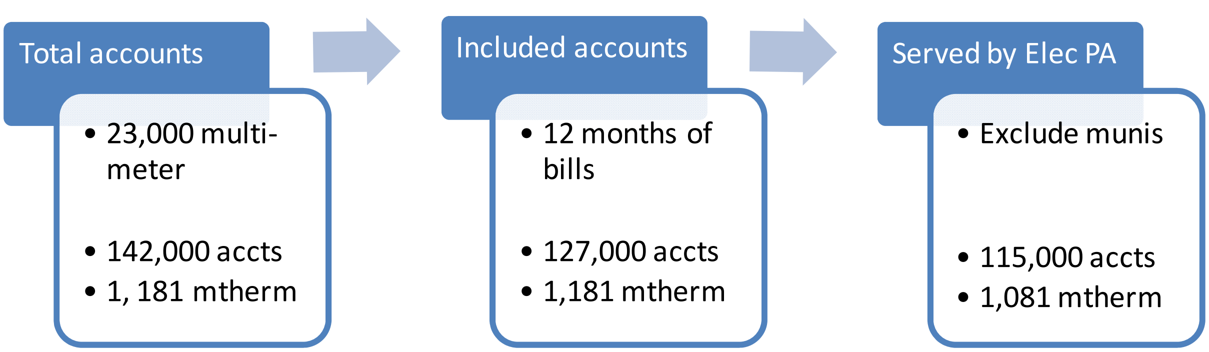
D.2 Filtering and Aggregating Market Segments

The individual account estimates of CHP opportunity were filtered and in some cases adjusted to create the different market segmentation views. This section presents the rational for applying those filters and adjustments and additional analysis around those choices.

D.2.1 Defining the population frame

This section describes the steps taken to create the initial population set beginning with the initial set of records provided by the gas distribution companies. This process is illustrated in Figure D-4

Figure D-4. Screening Process for Defining the Population

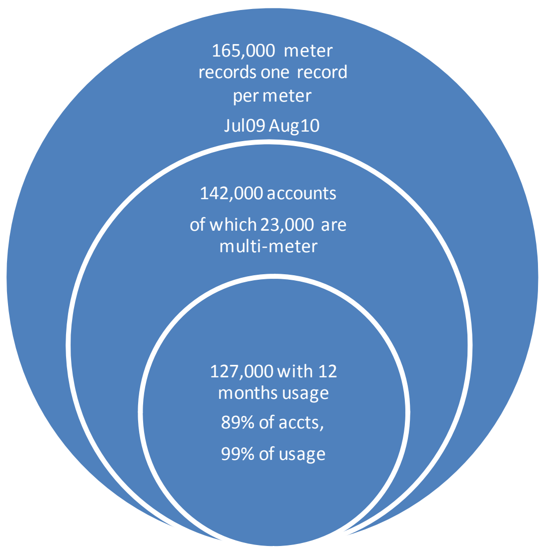


D.2.1.1 Preparation and cleaning of the gas billing data

Customer identification and monthly billing data was provided by five of the six gas distributors. New England Gas was unable to provide the data.

The data sets were cleaned, calendar-normalized and checked for consistency and reasonableness. The disposition of the records is illustrated in Figure D-5. The final data set consists of monthly billed usage for the period of August 2009 through July 2010.

Figure D-5. Billing Record Disposition



Individual meter records were aggregated by account. Of the 23,000 accounts that have multiple meters, 46 accounts have 10 or more meters. Most of those accounts where names are provided appear to be housing authority or condominium residential housing. Another 600 accounts have 3 to 9 meters. The rest of the multi-meter accounts have two meters and probably represents accounts with two meters billing at two rates.

Next, accounts were screened for new accounts which had not been billed for a full year. Any account with zero usage for twelve months prior to November 2009 was considered incomplete and was screened out. Table summarizes the number of accounts included and excluded by gas distribution company. While about 11% of the accounts were excluded, the total excluded gas usage was less than 1% of the total.

Table D-8 Included and Excluded Accounts by Gas Distribution Company

Gas Disco	Num of Accts	Annual Usage - therms	Total Accts	Total Usage - therms
Included				
Columbia Gas	36,474	323,628,563		
Berkshire Gas	4,231	33,940,280		
National Grid Gas	63,224	599,715,382		
NSTAR Gas	22,183	218,192,610		
Unitil Gas	934	5,661,518	127,046	1,181,138,353
Excluded				
Columbia Gas	6135	6498211		
Berkshire Gas	7220	3078191		
National Grid Gas	216	324553		
NSTAR Gas	1677	3051646		
Unitil Gas	158	39381	15,406	12,991,982
Total			*11%*	*1%*
Columbia Gas	42,609	330,126,774		
Berkshire Gas	11,451	37,018,471		
National Grid Gas	63,440	600,039,935		
NSTAR Gas	23,860	221,244,256		
Unitil Gas	1,092	5,700,899	142,452	1,194,130,335

D.2.1.2 Accounts Served by an Electric PA

Each of the included accounts was mapped to a serving electric PA by town using the account zip code. Table D- summarizes the distribution of customers by electric PA. The gas distribution companies also serve municipal distribution companies which are indicated as ‘Other’. About 99% of the gas sold is served by an electric PA.

Table D-9 Gas accounts by Electric PA

Electric PA	Num of Accts	Annual Usage	Total Accts	Total Usage
Included				
CLC Elec	7,464	28,451,109		
National Grid Elec	53,784	455,299,324		
NSTAR Elec	39,927	391,589,535		
NSTAR Network	2,909	44,486,823		
WMECO Elec	10,242	157,258,552		
Unitil Elec	716	3,622,732		
Municipal Elec	11,998	100,404,476	127,040	1,181,112,551

D.2.1.3 Locations Served by an Electric Network Distribution Design

Locations served by an electric network distribution system cannot be served by generation without elaborate and expensive electrical isolation which adds substantial cost. The downtown Boston distribution system is network. Customers in zip codes 02108 to 02116 are assumed to be on the network and are assumed to have no opportunity for CHP. Other electric distribution companies have networks that are small and were not factored in to the analysis.

Table D- summarizes the within network and off network NSTAR and Boston CHP opportunities. The NSTAR Network accounts were not included as high-value accounts.

Table D-10 NSTAR CHP Opportunities

Electric PA	Accounts	Projected Installed Capacity (kW)	Generation (kWh)	Customer Net Cost
NSTAR Electric	743	222,922	1,432,580,376	389,478,438
NSTAR Network	94	44,418	258,934,067	74,817,047
	837	267,340	1,691,514,443	464,295,485

D.2.1.4 Existing Generation

If an account serves an existing generation system, the model will mistake the generation load as an additional thermal load and overstate the opportunity. In addition, sites with existing generation have already captured some if not all of the potential available at a site. For that reason, accounts with confirmed generation are not included as high-value accounts.

The resources listed in Table D- identified sites with existing generation by name and location. An attempt was made to match the customers listed in the sources to a particular gas account by name and service address. In addition to the list, customer names were searched using keywords (such as “co-gen” and “gen”). The lists substantially overlap and may represent about 250 unique sites.

Table D-11. Lists of Existing Generators

Source of Generator Lists	Generator Sites	Listed Capacity (kW)
National Grid Interconnect List	156	59811
NSTAR Interconnect List	59	39885
DEP Permitting Call List	262	None
Identified by Customer Name	13	NA

It was only possible to match about a third of listed generators with a gas account. First, customer names were not provided by all the gas companies and secondly, businesses are referred to in multiple ways making it impossible to deduce the match in all cases. In seven cases, CHP is suspected because of the magnitude of the gas purchased and the existence of generation in the locality, but either the customer name may be missing or ambiguous. Suspected accounts were included as high-value accounts. The final numbers of confirmed and suspected generators are summarized in Table D-.

Table D-12 Summary of Confirmed and Suspected Generation

Dispostion of Generation	Number of Accts	Model Est of CHP - kW	Listed Capacity of Generation - kW
Confirmed match with mapped capacity	32	28,552	27,779
Outlier with mapped capacity	1	57	21,500
Confirmed generation, no mapped capacity	43	407,445	
Confirmed generation total	76	436,054	
Suspected genertion, included as high value	10	44,245	

The model estimates of CHP installed capacity can be compared to the actual installed capacity for those accounts where existing CHP has been mapped to a gas account. Section D-5 contains a table of accounts with both the estimated and actual installed capacity. While account to account, there is considerable divergence between the estimated and actual values, the overall sums match quite well. This provides some level of corroboration of the model's ability to estimate CHP size.

D.2.2 Other Factors Impacting CHP Opportunity

The gas customer data set provides good basis for identifying CHP potential, although the approach does not account for factors that could impact the overall magnitude of the opportunity. Since this methodology is built from the bottom up using individual account estimates, factors which could not be attributed to an individual account were not incorporated into the final results. There are other sources of CHP opportunity and factors that influence a larger market that have been factored into the PA totals. These factors have not been applied to the market segments because the account-by-account, bottom up development of the segment does not integrate cleanly with these broader market indicators.

D.2.2.1 Incompatible Heating Equipment

According to CBECs data, about 30% of the commercial space is heated by equipment other than a boiler, including heat pumps, packaged direct fired units, and unit heaters. A CHP unit generates steam or hot water which can be piped in series with the house boiler, either supplementing or supplanting the production of the boiler. However, if the building does not have a hot water or steam distribution system, which is the case for air-source heat pumps, packaged units and unit heaters, the CHP hot water production cannot be distributed without an extensive redesign of the existing systems.

This implies that the overall estimated opportunity could be reduced by 30%.

D.2.2.1.1 Mismatched Electric and Gas Usage

It is rarely cost-effective for a site to export electricity because the price paid to the customer for exported electricity is much lower than the retail value of electricity offset by CHP generation. In some cases where the electric usage is relatively low compared to the thermal load, the CHP system size will be limited by the site's peak electrical consumption rather than by the thermal load.

This mismatch between thermal and electric load was investigated in building types where it is more likely to occur: residential, schools, lodging and athletic clubs. An example of where this might occur is a residential building with a central boiler for hot water and heating, but with individual tenant electric meters. The house meter may only serve common area lighting and auxiliary heating equipment. A CHP system sized to meet the thermal load will generate more electricity than can be used by the facility resulting in exporting to the grid.

NSTAR and NGRID serve both electric and gas accounts and were able to provide both electric and gas usage for customers. This is not an easy task, since the data must be manually matched using customer name and service address, therefore only a limited number of accounts could be examined.

An analysis was conducted of the 127 accounts with both gas and electric billing usage. Each account was rated on the likelihood that the electric generation would exceed the facility's electric load based on a comparison of the maximum billed demand and the estimated CHP size for that location. This analysis has limitations since it the facility peak demand may not be very indicative of the facility electrical load during a winter evening when the CHP may be producing maximum output. That being said, the data strongly indicates that the Residential sector (public housing, condominiums, and apartment buildings) may not have sufficient electric load about 50% of the time.

D.2.2.2 Opportunities for Non-Gas CHP

D.2.2.2.1 Gas and Oil Usage by Massachusetts Businesses

As a first step, the number, type, and thermal energy use of Massachusetts C&I were characterized using data from the US Census Bureau County Business Patterns[46], the US Energy Information Administration (EIA)[47], supplemented by data derived from the gas distribution company customer billing data. The Census Bureau and EIA most recent information was from 2008.

Table D- summarizes the number of C&I customers in MA from different sources. The US Census Bureau values best represent the number of businesses establishments in the state. An establishment represents a unique instance of a business at a particular location. Therefore, a national chain that had fifty locations in the state would count as fifty establishments.

Table D-13 Summary of Number of MA C&I Customers

Number of Businesses	Commercial	Industrial	Total
US Census Bureau County Patterns - 2008	134,771	30,444	165,215
EIA Reported Electric Customers - 2008	375,507	16,173	391,680
EIA Reported Gas Customers - 2008	129,560	13,390	142,950
Gas Company Billing Data Set -	+	+	141,360

46 http://www.census.gov/econ/cbp/

47 http://www.eia.gov/

Both the gas and electric billing data represents number of billing accounts in the state. It is extremely common to have multiple electric accounts per business establishment, less common to have multiple gas accounts per business. The gas account is a reasonable proxy for a business establishment. It is expected that the gas company and census bureau would not agree, because not all regions of the state are served by natural gas. This analysis uses the following figures in the analysis:

Referencing EIA data, about 81% of C&I thermal requirements are met with natural gas, as compared to oil, as shown in Table D-. The gas use represented in the billing data set provided by the gas LDCs is about 14% more than reported by EIA. It is possible that the difference is in how gas used for generation is reported. The year-to-year variation in total gas delivery is about 4%.

Table D-14 Massachusetts C&I Oil and Gas Usage Profile

Number of Businesses	Commercial	Industrial	Total
US Census Bureau County Patterns - 2008	134,771	30,444	165,215
EIA Reported Electric Customers - 2008	375,507	16,173	391,680
EIA Reported Gas Customers - 2008	129,560	13,390	142,950
Gas Company Billing Data Set -	+	+	141,360
Fuel Serving Massachusetts - EIA 2008	Commercial	Industrial	Total
Oil Sales - Distillate kgal, EIA 2008	103,001	9,903	112,904
Oil Sales - Residual kgal, EIA 2008	34,044	13,848	47,892
Gas Sales (million CF) EIA 2008	56,568	47,489	104,057
Total ALL Fuels	76,784,310	50,913,170	127,697,480
Total per customer - mmBTU per year	570	1,672	773
Gas Sales (mmCF) Gas LDC billing 09/10			118,840,363
Oil Sales - Distillate	12%	1%	
Oil Sales - Residual kgal, 140,000 btu	4%	2%	19%
Gas Sales (mmCF)	44%	37%	81%

D.2.2.2.2 Estimating the Displacement of Oil-fired Thermal Load with CHP

The model uses a site specific process for determining CHP opportunity for all C&I gas customers in the state, but there is no similar information for oil customers. The model assumes that on average, a oil-fired customer has a similar thermal profile to a gas-fired customer and that an average kW per mmbtu can be applied to oil usage to estimate statewide CHP opportunity for oil-fired customers. This statewide estimate is subject to the following conditions:

- Dual fuel fired locations – gas customer bills were analyzed to estimate due-fuel fired locations. A dual fuel customer, typically a larger customer, will switch boilers to oil during the winter months when the LDC distribution charge can increase from $2 per mmBTU to $5 per mmBTU. The estimates was made by identifying those accounts that had high usage March through November, followed by a sharp curtailment beginning in December. Estimates were made of the thermal load for the curtailment period and accounts for about a third of the statewide C&I oil consumption or about 7.5 million mmBTUs with about 1000 customers.

- The balance of the heating oil serves about 21,000 customer consuming about 16.1 million mmBTUs. These customers could be located in areas served by a gas distribution company or not.

- Based on the average mmBtu of usage per kW installed, there should be about 37 MW of potential from oil served customers.

D.3 Step by Step calculations

D.3.1 Extract Key Account Information

Gas Customer Account Information

Account	# Meters	Customer	Zip	SIC Code
NSxxxx	1	Hospital Name	02138	8062

Map to PA
NSTAR is the
PA in this case.
Also use to ID
networks

Map to: Hospital
30% of base can't be
displaced by CHP
65 Balance point

The percentage of base that cannot be displaced by CHP for a hospital includes cooking and process loads. It is assumed that all other loads can be displaced by CHP, which means they are hot water or steam loads of some kind.

The usage in therms

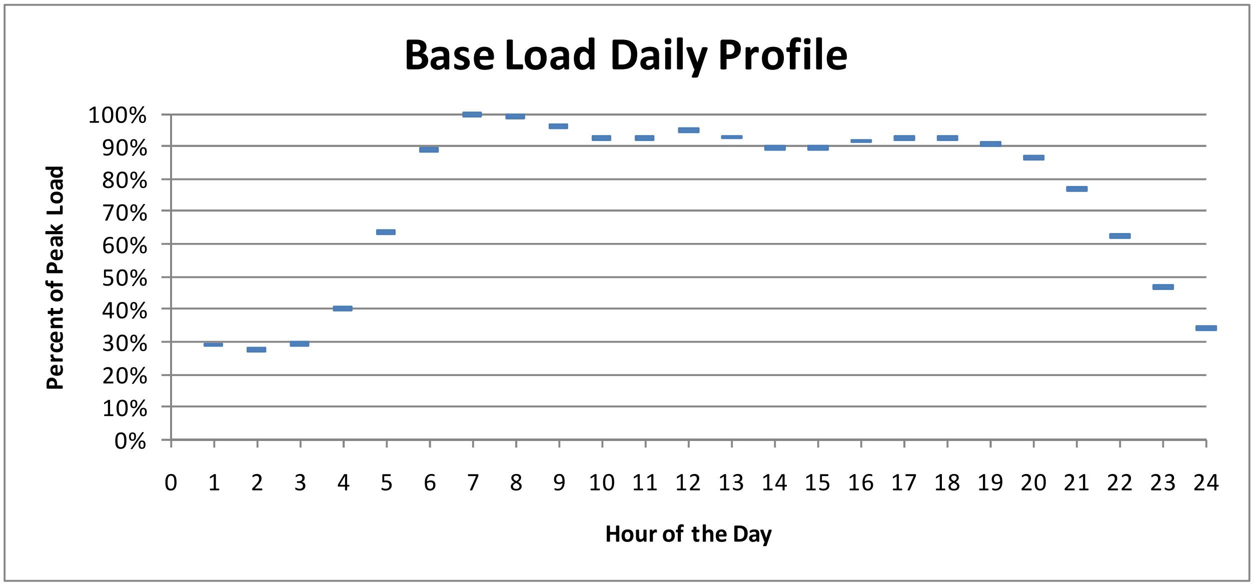
Sep2009	Oct2009	Nov2009	Dec2009	Jan2010	Feb2010	Mar2010	Apr2010	May2010	Jun2010	Jul2010	Aug2009
68,659	102,161	92,510	152,750	144,448	129,401	109,935	100,780	75,686	67,400	65,893	66,777

Base is the minimum of
(average of June, July, August * 12) OR
Total annual usage.
800,280 therms in this case

Annual usage = 1,176,400 therms
Weather sensitive usage = annual usage – base usage = 376,120 therms or 37,612 mmbtus
Adjusted base usage = base usage * (1-30%) = therms or 56,020 mmbtus

D.3.2 **Find the Full Load Hours for Base Load**

Hospitals are assigned the CEUS domestic hot water health care profile which is shown in the following graph. There are a total of 11 profiles used in the model and this is an example of one of them.

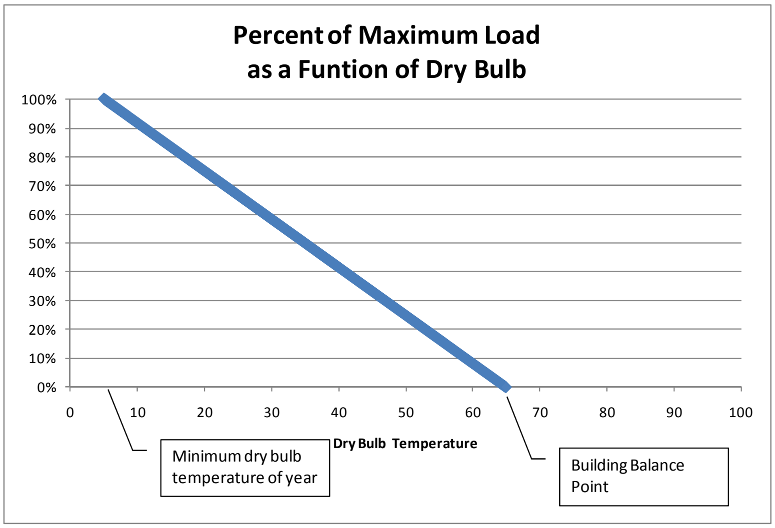


Base full load annual hours is equal to the sum of the hourly percentages * 365 hours per year.

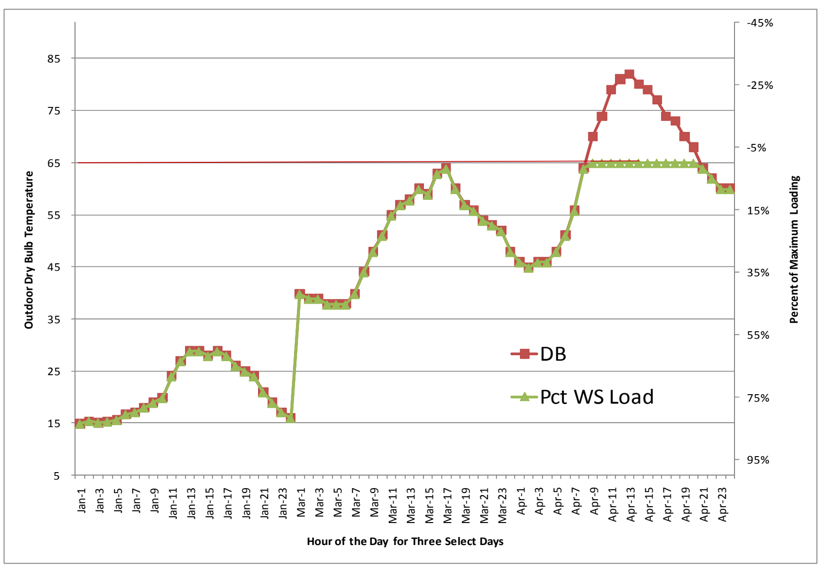
This curve is independent of equipment sizing and represents hourly usages in relationship to the peak hourly usage. The peak hour is the 100% hour, all other hours are in relationship to this hour. The sum of the percentages in any day is equal to the number of equivalent full load hours of runtime for a system sized to meet that peak hour load. Since the profile represents a daily profile, the results is multiplied by 365 to arrive at the annual full load hours. In this case the base full load hours are 6572 hours per year for the base load. This profile will be used later in the annual analysis.

D.3.3 Find the full load hours for the weather sensitive load

The building weather sensitive thermal load is assumed to vary linearly with dry bulb temperature between the minimum observed dry bulb temperature and the building balance point.



The graph below shows three non-contiguous 24 hour days the hourly dry bulb and the thermal load as a percent of maximum loading. Note how the percent load on the right hand axis is in reverse order. As the dry bulb temperature decreases, the loading increases. The two y-axis have been selected so that the graphs overlay one another. Note how the percent loading is zero at the balance point. Similar to the base load full load calculations, the sum of the percent loading for all hours of the year is equal to the full load hours at the maximum load hour. The full load hours are independent of equipment sizing.



D.3.4 Calculate the initial condition for maximum sized CHP unit

The maximum sized CHP unit that is operated in a thermally following manner will have an adequate thermal production capacity to meet the sum of the adjusted base and weather sensitive loads. If the loads do overlap, then the maximum load may be less than the sum of the two loads, however, for the purpose of this initial condition size, the loads are simply added.

It is at this point that the thermal efficiency of the existing system is taken into account. The weather sensitive and base usages are derived from an examination of the gas usage – but the actual building load is less since the heating system efficiency is less than 100%.

The model assumes an average existing system efficiency of 80%.

The case example figures are used in the equations:
Weather sensitive maximum load =

*Weather sensitive annual load / WS full load hours * existing thermal system efficiency*

*37, 612 mmbtu /2162 * 80%*

= 13.9 mmbtu / hour maximum building thermal load in any one hour

Adjusted base maximum load =

Base load full load hours / base load full load hours

56,020 mmbtu / 6572

= 6.8 mmbtu/hour maximum base load in any one hour

Note that although the annual base usage is about double the weather sensitive usage, its maximum load is less because it has much longer full load hours. The maximum CHP size thermal load served is the sum of the two or: 20.7 mmbtu/hour

D.3.5 Select CHP Size and the CHP Equipment Parameters

Once the maximum thermal load has been determined, the size of the CHP unit that can serve that load can be selected.

For the purposes of this analysis, four equipment types have been established to represent typical performance and cost points, each serving a different range of thermal loads. The equipment parameters are provided in the table below.

Equip at least mmbtu/hr	Modeled by	mmbtu/kWh Fuel fired HH\	mmbtu/kWh Heat avail	$/kW Cost	O&M per k	Elec Eff	Ht Eff
-	100 recip	0.011488	0.004488	$ 1,935	0.0013	29.71%	39.07%
0.3040	300 recip	0.011006	0.005067	$ 1,802	0.0013	31.01%	46.04%
0.7601	300 recip	0.011006	0.005067	$ 1,802	0.0013	31.01%	46.04%
1.5201	300 recip	0.011006	0.005067	$ 1,802	0.0013	31.01%	46.04%
10000	3.5 MW turbine	0.010339	0.005	$ 1,577	0.0059	33.01%	46.04%

The initial load is used as an index into the equipment type to identify an initial CHP equipment size. In this case, the load drives the selection to the last line of the table. Now, the corresponding CHP size can be computed:

Initial condition CHP size in kW units of capacity=

maximum CHP size thermal load / mmbtu per kWh heat available

20.7 mmbtu/hour / .005 mmbtu/kWh

= 4,093 kW

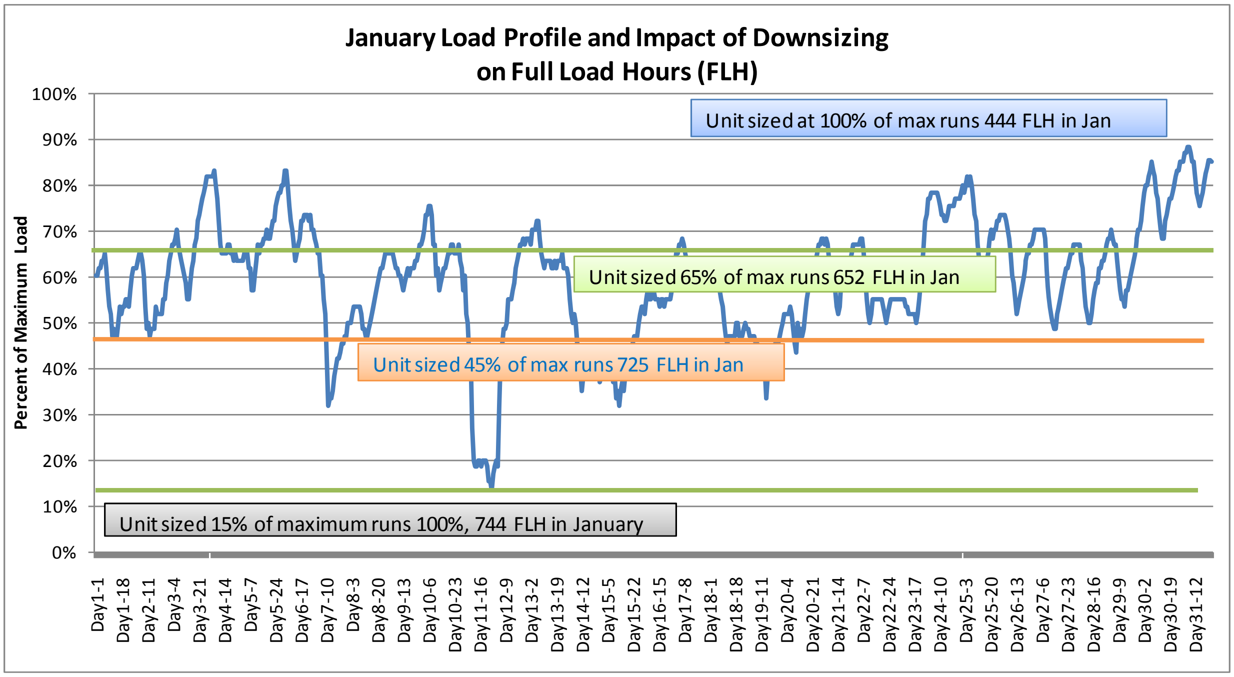
D.3.6 Right Sizing the CHP Unit

The maximum sized unit calculated previously is rarely the right sized unit. The next step in the model is to calculate results for a range of CHP units which are a fraction of the maximum sized unit to meet the thermal load. The calculations are completed for the fractions shown below. The fractions are somewhat arbitrarily selected, but include more small increments unit because the cost-effectiveness break-point is usually for the lower fractions.

Downsize unit	1.0%	8.0%	15.0%	20.0%	30.0%	40.0%	50.0%	60.0%	80.0%	100.0%
Downsized combo - kW	41	327	614	819	1,228	1,637	2,046	2,456	3,274	4,093

Note the highlighted cell. Equipment cost and performance characteristics indexed by this unit size are used in all the calculations. A single equipment selection is utilized for each of fractional load point so that the transition from one fraction point to the next is a result of the change in sizing and not an artifact of an equipment selection transition.

Next, system loading is calculated for each fractional load. While the building load will not change, the ability of the CHP system to meet the load is reduced as the system size is lowered. While less thermal load is provided by the CHP in absolute terms, a smaller system will run more hours fully loaded. This concept is illustrated below.


January Load Profile and Impact of Downsizing
on Full Load Hours (FLH)
Unit sized at 100% of max runs 444 FLH in Jan
Unit sized 65% of max runs 652 FLH in Jan
Unit sized 45% of max runs 725 FLH in Jan
Unit sized 15% of maximum runs 100%, 744 FLH in January
Percent of Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Day1-1
Day1-18
Day2-11
Day3-4
Day3-21
Day4-14
Day5-7
Day5-24
Day6-17
Day7-10
Day8-3
Day8-20
Day9-13
Day10-6
Day10-23
Day11-16
Day12-9
Day13-2
Day13-19
Day14-12
Day15-5
Day15-22
Day16-15
Day17-8
Day18-1
Day18-18
Day19-11
Day20-4
Day20-21
Day21-14
Day22-7
Day22-24
Day23-17
Day24-10
Day25-3
Day25-20
Day26-13
Day27-6
Day27-23
Day28-16
Day29-9
Day30-2
Day30-19
Day31-12

D.3.7 Calculating the combined WS and Base Full Load Hours

The load facing the CHP unit in any hour is the sum of the weather sensitive load and the base load for that hour. The model computes the percent loading for each hour of the year as the sum of the weather sensitive load and the base load. The table shows percent loadings for 24 hours for Dec 21 for the Example Case.

Month	Day	Hour	DB	Heating Temp Load	Pct of max w Balance Point	Pct of max of Base Load	Combined Load	1%	8%	15%	20%	30%	40%	50%	60%	80%	100%
12	21	1	21.20	44	75%	29%	60%	100%	100%	100%	100%	100%	100%	100%	100%	75%	60%
12	21	2	21.11	44	75%	28%	59%	100%	100%	100%	100%	100%	100%	100%	99%	74%	60%
12	21	3	21.20	44	75%	29%	60%	100%	100%	100%	100%	100%	100%	100%	100%	75%	60%
12	21	4	21.20	44	75%	40%	63%	100%	100%	100%	100%	100%	100%	100%	100%	79%	64%
12	21	5	21.11	44	75%	64%	71%	100%	100%	100%	100%	100%	100%	100%	100%	89%	71%
12	21	6	21.20	44	75%	89%	80%	100%	100%	100%	100%	100%	100%	100%	100%	100%	80%
12	21	7	24.80	40	69%	100%	79%	100%	100%	100%	100%	100%	100%	100%	100%	99%	79%
12	21	8	24.44	41	69%	99%	79%	100%	100%	100%	100%	100%	100%	100%	100%	99%	79%
12	21	9	26.60	38	66%	96%	76%	100%	100%	100%	100%	100%	100%	100%	100%	95%	76%
12	21	10	28.40	37	63%	93%	72%	100%	100%	100%	100%	100%	100%	100%	100%	91%	73%
12	21	11	29.12	36	61%	93%	72%	100%	100%	100%	100%	100%	100%	100%	100%	90%	72%
12	21	12	30.20	35	60%	95%	71%	100%	100%	100%	100%	100%	100%	100%	100%	89%	71%
12	21	13	30.20	35	60%	93%	70%	100%	100%	100%	100%	100%	100%	100%	100%	88%	71%
12	21	14	30.56	34	59%	89%	69%	100%	100%	100%	100%	100%	100%	100%	100%	86%	69%
12	21	15	30.20	35	60%	89%	69%	100%	100%	100%	100%	100%	100%	100%	100%	87%	70%
12	21	16	30.20	35	60%	92%	70%	100%	100%	100%	100%	100%	100%	100%	100%	88%	70%
12	21	17	30.11	35	60%	93%	71%	100%	100%	100%	100%	100%	100%	100%	100%	88%	71%
12	21	18	28.40	37	63%	92%	72%	100%	100%	100%	100%	100%	100%	100%	100%	91%	73%
12	21	19	28.40	37	63%	91%	72%	100%	100%	100%	100%	100%	100%	100%	100%	90%	72%
12	21	20	28.22	37	63%	86%	71%	100%	100%	100%	100%	100%	100%	100%	100%	89%	71%
12	21	21	26.60	38	66%	77%	69%	100%	100%	100%	100%	100%	100%	100%	100%	87%	70%
12	21	22	26.60	38	66%	63%	65%	100%	100%	100%	100%	100%	100%	100%	100%	81%	65%
12	21	23	26.78	38	65%	47%	59%	100%	100%	100%	100%	100%	100%	100%	99%	74%	59%
12	21	24	24.80	40	69%	34%	57%	100%	100%	100%	100%	100%	100%	100%	96%	72%	58%

The “Pct of Max w Balance Point” column is the weather sensitive heating load derived from Figure A1 and is a function of the dry bulb temperature. The “Pct of Max Base Load” is the percentage for the hour derived from Figure A2. The Combined Load is the sum of the two loads proportional to their maximum loads. For example, for the first hour:

Previously calculated:

WS max load = 13.9, base load = 6.8, combined = 20.7 mmBTU/hour

WS load at 29 DB = 60%; Base load from graph = 19% for the first hour of the day

*Combined load = 75% * 13.9/20.7 + 29% * 6.8/20.7 = 60%*

In the example, the minimum load in the period is 57%. Therefore any unit that is sized less than 57% of the maximum sized unit will run 100% of the time. However, any unit sized larger than that will run part loaded for some hours when its capacity exceeds the needs of the combined thermal load. The resulting part loads by hour are shown in the table for the ten fractional size points.

D.3.8 Performance Calculations

These calculations are completed at the ten fractional loads:

Row	Parameter		Value	Calculation Explanation
2	**Full Sized**		100%	
3	Total Annual MMBTU - adjusted for boiler eff:		74,905	Row 6 + Row 7
4				
5	Factor in split & blr eff%			
6	WS Req'd, mmbtu		30,090	Adjusted WS usage * boiler efficiency in mmbtu per year
7	Base Use, mmbtu		44,816	Adjusted Base usage * boiler efficiency in mmbtu per year
8				
9	Htg Max, mmbtu/hr: WS Load / FLH		13.920	Row 6 / heating full load hours, from previous page
10	DHW Max, mmbtu/hr: Base load / FLH		6.819	Row 7 / base load full load hours, from previous page
11	System Size (kW):		4,093	(Row 6 + Row 7) / equipment mmbtu heat available per kW
12				
13	**Fractional Size**		**60%**	One of 10 fractional sizes
14	Downsized combo - kW		2,456	Row 13 * Row 11
15	Max heat offset rate mmbtu/hr		12.279	Row 13 * (Row 9 + Row 10)
16	Pct htg/base offset		96%	From hourly analysis
17	System FLH		5,792	From hourly analysis
18				
19	Monthly Ave Demand (kW)		2,456	Row 14 * Row 17 / 8760
20	Elec gen (kWh)		14,224,377	Row 14 * Row 17
21	Gas fired (mmbtu)		(147,066)	Row 20 * fuel fired per kWh from equipment table
22	Gas offset (mmbtu), adjd for blr eff		89,854	Row 3 * Row 16 / boiler efficiency
23	Customer Annual net savings	$	906,145	See below
24				
25	Installed Cost	$	3,872,793	Row 14 * installed cost per kW from equipment table
26	Payback - Years		4.3	Row 26 / Row 24
27	System efficiency		82%	(Row 20 * 3413/m + Row 22) / Row 21
28				
29	Possible Electric FlwHrs		2,968	8760 - Row 17
30	Elec gen (kWh)		21,512,790	Row 35 * 8760
31	Gas fired (mmbtu)		(222,421)	Row 32 * fuel fired per kWh from equipment table
32	Gas offset (mmbtu)		89,854	Does not change from thermal following case
33	customer Annual net savings	$	828,110	See below
34	Payback - Years		3.897	Row 26 / Row 36
35	Elec Follow %		69%	(Row 32 * 3413/m + Row 34) / Row 33

The monthly demand is the ratio of the system FLH and the total hours in a year. However the benefit is calculated as follows:

Summer Demand Impact = The average percent system load for the hour of 12 to 6pm for the months of June through September
Summer demand value = Summer Demand Impact * the summer demand charge * 4 months
Winter Demand Impact = The average percent system load for the hour of 12 to 6pm for the months of January – May and October - December

D.3.9 Selecting the Right Sized Unit

Parameters are calculated for each fractional sized unit. The optimally sized unit is the largest unit that has a payback less than the threshold. In this case, a seven year payback was the threshold. [The table below does not include the mid-fractional loads.]

Actual weather=>	FLH Htg	WS Fuel Use	Base Fuel Use	FLH HTG	FLH Base	
Actual weather=>	FLH Base	37,612	56,020	2,162	6,572	0.375

Downsize unit	1.0%	30.0%	40.0%	60.0%	80.0%	100.0%
Total Annual MMBTU - adjusted for boiler eff:						74,905.28
Factor in split & blr eff%						
WS Req'd, mmbtu						30,090
Base Use, mmbtu						44,816
Htg Max, mmbtu/hr: WS Load / FLH						13.920
DHW Max, mmbtu/hr: Base load / FLH						6.819
System Size:						4,093
DHW Size - kW						
Downsized combo - kW	41	1,228	1,637	2,456	3,274	4,093
Max heat offset rate mmbtu/hr	0.205	6.139	8.186	12.279	16.372	20.465
Pct htg/base offset	2%	67%	81%	96%	100%	100%
System FLH	8,760	8,138	7,314	5,792	4,516	3,621
Monthly Ave Demand (kW)	41	1,228	1,637	2,456	2,625	2,625
Elec gen (kWh)	358,547	9,992,426	11,975,148	14,224,377	14,788,804	14,822,473
Gas fired (mmbtu)	(3,707)	(103,312)	(123,811)	(147,066)	(152,901)	(153,250)
Gas offset (mmbtu), adjd for blr	2,265	63,121	75,645	89,854	93,419	93,632
Total $ Value w demand & O&M	$ 22,151	$ 637,218	$ 761,607	$ 906,145	$ 941,004	$ 942,483
O&M						
Installed Cost	$ 64,547	$ 1,936,397	$ 2,581,862	$ 3,872,793	$ 5,163,725	$ 6,454,656
Payback - Years	2.914	3.039	3.390	4.274	5.487	6.849
System efficiency	82%	82%	82%	82%	82%	82%
Possible Electric FlwHrs	-	622	1,446	2,968	4,244	5,139
Elec gen (kWh)	358,547	10,756,395	14,341,860	21,512,790	28,683,720	35,854,650
Gas fired (mmbtu)	(3,707)	(111,210)	(148,280)	(222,421)	(296,561)	(370,701)
Gas offset (mmbtu)	2,265	63,121	75,645	89,854	93,419	93,632
Total $ Value w demand	$ 23,800	$ 653,362	$ 764,153	$ 849,518	$ 801,160	$ 710,677
Payback - Years	2.712	2.964	3.379	4.559	6.445	9.082
Elec Follow %	82%	78%	74%	65%	58%	53%

In this case, the site supports a unit sized at 60% of the initial estimate, since it is the largest sized unit with less than a five year payback. Note how the full load hours decrease as the load increases. It can also be seen that as the unit size increases, the payback increases.

D.4 Base load profiles

Table D-5 Base Load Profiles

Lodging-2	Apt-3	Nhome-4	Industrial -5	Office-6	Grocery-7	Health-8	Restaurant-9	2Shift-10	Retail-11	Education-12
22%	55%	55%	100%	59%	27%	29%	16%	40%	23%	26%
18%	52%	52%	100%	59%	21%	28%	14%	40%	22%	25%
17%	41%	41%	100%	59%	23%	29%	13%	40%	23%	25%
25%	45%	45%	100%	59%	34%	40%	17%	40%	27%	26%
44%	41%	41%	100%	62%	57%	64%	22%	40%	35%	30%
76%	41%	41%	100%	69%	81%	89%	27%	40%	52%	37%
99%	52%	52%	100%	82%	95%	100%	32%	100%	70%	51%
100%	62%	62%	100%	94%	100%	99%	40%	100%	79%	69%
92%	100%	100%	100%	100%	100%	96%	55%	100%	87%	88%
78%	86%	86%	100%	99%	98%	93%	72%	100%	94%	100%
73%	79%	79%	100%	99%	97%	93%	85%	100%	98%	99%
77%	69%	69%	100%	99%	96%	95%	91%	100%	100%	93%
73%	69%	69%	100%	98%	96%	93%	93%	100%	99%	89%
68%	62%	62%	100%	96%	96%	89%	94%	100%	98%	86%
69%	52%	52%	100%	93%	97%	89%	97%	100%	96%	84%
73%	48%	48%	100%	88%	98%	92%	100%	100%	92%	83%
77%	48%	48%	100%	79%	99%	93%	100%	100%	85%	82%
78%	62%	62%	100%	68%	100%	92%	97%	100%	74%	81%
77%	79%	79%	100%	61%	99%	91%	93%	100%	61%	80%
73%	86%	86%	100%	59%	95%	86%	84%	100%	45%	77%
64%	76%	76%	100%	59%	88%	77%	65%	100%	34%	72%
52%	62%	62%	100%	59%	78%	63%	43%	100%	31%	61%
38%	55%	55%	100%	59%	62%	47%	28%	40%	29%	49%
29%	69%	69%	100%	59%	42%	34%	20%	40%	25%	35%
14.93	1493%	1493%	24.00	18.19	18.79	18.00	13.98	19.20	14.77	15.45
62%	62%	62%	100%	76%	78%	75%	58%	80%	62%	64%
5,450	5,450	5,450	8,760	6,640	6,857	6,572	5,103	7,008	5,392	5,639

D.5 Partial List of Confirmed Generation

Table D-6 Partial Listing of Confirmed Generation with Model Estimates of Potent

Business Type	Listed Size	Estimated Size - kW	RR%
Manufacturer	13000	16,931	130%
College	6500	2	412681%
Hospital	1050	1,779	59%
College	475	101	472%
Manufacturer	425	26	1659%
Manufacturer	425	26	1659%
VoTech	320	271	118%
Business	300	22	1390%
High School	300	293	102%
Manufacturer	300	1	25459%
Condo	280	29	956%
Pharma	250	467	53%
VoTech	250	338	74%
High School	250	346	72%
School	250	150	166%
College	195	496	39%
School	150	17	906%
Club	150	53	280%
Residence	150	84	179%
School	124	327	38%
Food Processir	105	121	87%
Office	85	1	5883%
Residence	75	133	56%
Mixed Use	75	148	51%
Office	75	0	16288%
Nursing Home	75	441	17%
Residence	75	50	151%
Residence	75	195	39%
Residence	75	136	55%
Nursing Home	75	1,084	7%
Unknown	60	115	52%
YMCA	60	706	9%
Nursing Home	60	1	4781%
Residence	60	244	25%
Residence	60	104	58%
Total	27,779	28,552	97%

E. Interview guide Potential Sites Cover Letter

INTERVIEW GUIDE FOR POTENTIAL COMBINED HEAT AND POWER SITES

MA LCIEC CHP TASK #1C – March 2011

[This interview guide presents questions our evaluation team plans to ask of businesses and institutions that are considered potential candidates for Combined Heat and Power (CHP) installations. The goal of the interview is to determine: 1) why customers have not chosen CHP, 2) what factors would lead them to pursue CHP, 3) and identifying barriers that could be mitigated through a CHP program. This will not be a "cold call", an email will be sent in advance to the location contact and the utility account representative may or may not be involved in the set up of the call].

Name ____________________________________

Company Name ____________________________________

E-Mail ____________________________________

Phone ____________________________________

Date ____________________________________

Introduction – For Phone and Face to Face if necessary

My name is **<NAME>** and I work for Itron's Consulting and Analysis Group. We have been hired by the Massachusetts Energy Efficiency Program Administrators **<mention their likely PA>** to conduct a market assessment of the combined heat and power, or CHP market in Massachusetts. Customers with CHP generate some of the electricity they use on site and capture the waste heat from the generator for use in systems needing heat.

An important element in this process is to discuss the current Massachusetts CHP incentive program with sites considered potential candidates for CHP under the current program. We are contacting you because your site has been identified by a PA sponsored market study as having the potential for implementing CHP under the current Massachusetts CHP program. The information discussed during this interview is for research purposes only and your responses to our questions will treated as confidential. The results of this interview are very important in improving the PA incentive program and promoting the economic and environmental benefits of CHP.

I have a carefully planned out questionnaire and would like to spend 30 minutes to an hour gathering your opinions on CHP and its potential at your facility. Are you an appropriate person at your facility to discuss this matter with us?

Throughout this survey, to the extent possible, please provide answers to our questions as they relate directly to your facility.

Screening/Knowledge of CHP Technology

S1. To clarify, I am calling regarding the facility located at __________. Are you currently operating a combined heat and power (CHP) system at this facility or are you currently planning to install a CHP system?

Response: If yes, transition away from interview and thank them for their time.

S2. How would you categorize your familiarity with Combined Heat and Power or CHP? [READ LIST]

Knowledgeable of CHP systems, hardware and how it operates.

Heard of CHP but not familiar with the hardware or how it operates.

Have not heard of CHP.

Response:

If (1) or (2) skip to heading: Screening Continued: Customer and Facility Background

If (3) – Probe further: Is there another individual at the organization or location who might be more familiar with CHP and its potential at your site?

Response: If yes – get name/contact information and continue with that person.

If no, continue to heading: Do Not Conduct Full Interview (No knowledge of CHP)

Do Not Conduct Full Interview (No knowledge of CHP)

D1. INFORM THEM OF WHAT CHP IS AND AGAIN WHAT WE ARE TRYING TO FIND REGARDING CHP AND THEIR FACILITY. STATE YOU WOULD LIKE TO ASK A FEW MORE QUESTIONS TO HELP US IN EDUCATING SIMILAR CUSTOMERS.

D2. So I can better understand your perspective, what is your exact job title?

D3. What is your company's primary business/facility type?

- (e.g. hotel, assisted living, housing, office, manufacturing, school, prison)

D4. On a scale of 1-10, how familiar are you with the electrical and thermal loads at your facility, 10 being most familiar?

D5. What are your primary electrical loads?

D6. What are your primary thermal loads?

D7. How do you measure or quantify the amount of electrical and thermal loads at your facility?

- (e.g., billing data, metered data, relation to similar facilities)

D8. Are you the only one dedicated to or knowledgeable of the energy measures onsite, or does your facility have a team or department dedicated to such matters?

D9. Are you familiar with the utility incentives for energy conservation? If so, how do you keep current with the electrical utility's energy efficiency programs?

- (e.g., account manager, web sites, marketing materials)

D10. For electrical efficiency investments, what type of payback or financial hurdle rate do you require to pursue the investment?

D11. What would be the best way for the program administrators to introduce CHP to companies (organizations) in your industry?

- (e.g., Direct Mail, Local member organizations (get organization name(s), local business periodicals (find out names), energy efficiency staff at program administrator, vendors make direct calls).

TRANSITION AWAY FROM INTERVIEW AND THANK THEM FOR THEIR TIME.

Screening Continued: Customer and Facility Background

SC1. So I can better understand your perspective, what is your exact job title?

SC2. What is your company's primary business/facility type?

- (e.g. hotel, assisted living, housing, office, manufacturing, school, prison)

SC3. Are you the only individual dedicated to or knowledgeable of the energy measures onsite, or does your facility have a team or department dedicated to such matters?

SC4. On a scale of 1-10, how familiar are you with the electrical and thermal loads at your facility, 10 being most familiar?

SC5. What are your primary electrical loads?

SC6. What are your primary thermal loads?

SC7. How do you measure or quantify the amount of electrical and thermal loads at your facility?
- (e.g., billing data, metered data, relation to similar facilities)

SC8. What technologies/hardware do you see associated with CHP?

SC9. What applications/ thermal uses do you see fit for CHP?

SC10 What types of facilities do you see being a good fit for CHP?

CHP Considerations/Decision Making

DM1. When did you first hear about CHP?

DM2 How did you hear about CHP?
a. Word of mouth:
b. Energy audit:
c. Conference or trade show:
d. CHP developer:
e. Studies:
f. PA's/Utilities:
g. Trade magazines
h. Other:

DM3. Have you or your organization ever considered or investigated the installation of a CHP system at your facility?

a. Yes/No:

If (No) skip to section: Did Not Consider or Investigate CHP
If (Yes) continue below:

DM4 – What calendar year did you consider installing a CHP system?

DM5. What initially instigated the idea or consideration of installing CHP at your facility? (e.g. initiated internally as part of a study, contacted by a CHP developer, conferences or a trade shows)

DM6. Are you still deciding to pursue or not pursue the installation of CHP at your facility?

If YES - DYa. What technology and size CHP system are you thinking of installing?

DYb. Who is the developer you are working with?

DYc. How much have you relied on them for guidance; and on what matters?

DYd. How is your prospective system being sized? (e.g. electric base/follow, thermal base/follow)

DYe. What electrical and thermal loads will the CHP offset?

DYf. When are you thinking of making the final decision?

DYg. Approximately what date did you begin talking to contractors/developers?

If No - DNa. What technology and size CHP system were (are) you considering?

DNb. Did you work with any outside CHP developers when considering CHP? Describe your interactions with them and your level of reliance on them for guidance.

DNc. How would your system have been sized? (e.g. electric base/follow, thermal base/follow)

DNd. What electrical and thermal loads would the CHP have offset?

DNe. Did you consider any PA rebates for the system?

DNf. Did you have any interaction with the utilities while considering CHP? (If yes, please provide details and identify whether electric or gas)

DNg. Please rate the influence on a scale of 1 to 10 of the utilities including the incentive (if received one) on your decision not to install the CHP system.

DNh. Describe your satisfaction with the utilities, related to CHP, on a scale of 1 to 10.

DM6. What steps did you go through to determine whether or not to install CHP? (examples may be what type of analysis or variables were considered when making the decision to install or not install CHP?)

DM7 Ultimately who are the decision makers for installing a CHP system at your facility?

DM8. At what point in that process was it determined that you would or would not move forward with the installation of CHP? And what were the main factors behind that decision?

DM9. Please rank the following motivators for installing CHP at your facility from 1 to 10, 10 being the highest.

a. use of the waste heat _______
b. environmental__________
c. lower electricity or energy costs_________
d. ability to be independent from the grid and/or run as back-up power)_________
e. Other (list by name) ______

DM10. Please rank the following barriers for installing CHP at your facility from 1 to 10, 10 being the highest

a. capital cost______
b. confidence in CHP technology_____
c. footprint______
d. human resources________

e. interconnection__________
f. demand charges/standby rates______
g. Other (list by name)___________

DM11. Do other energy efficiency projects take precedent over the CHP projects? If yes, why?

DM12. For energy efficiency investments, what type of payback or financial hurdle rate do you require to pursue the investment?

DM13. In your opinion, what is preventing a greater adoption of CHP in MA? (e.g. incentives, reducing peak demand, energy reduction, the environment, complexity of CHP, etc)

DM14. To minimize any barriers to installation of CHP, are there activities you think the Program Administrators could undertake to mitigate them, and what do you believe should be the priority of these actions?

DM15. Who was or would be the final decision maker/approver for installing CHP at your facility?

SKIP TO HEADING: Knowledge of the CHP Program

Did Not Consider or Investigate CHP

NC1. What are the main reasons your company has not **considered** the installation of a CHP system? (No funding/upfront costs, not enough knowledge of CHP, lack of loads, human resources, other energy efficiency projects, payback not high enough etc.)

NC2. Please rank the following barriers for installing CHP at your facility from 1 to 10, 10 being the highest

a. capital cost______
b. confidence in CHP technology_____
c. footprint______
d. human resources________
e. interconnection__________
f. demand charges/standby rates______
g. Other (list by name)___________

NC3. To minimize these barriers, are there activities you think the Program Administrators could undertake to address them or to help you become more knowledgeable about CHP?

NC4. Please rank the following motivators for installing CHP at your facility from 1 to 10, 10 being the highest

a. use of the waste heat _______
b. environmental__________
c. lower electricity or energy costs_________
d. ability to be independent from the grid and/or run as back-up power)_________
e. Other (list by name) ______

NC5. What are the primary thermal load applications you have onsite that would have been offset by a CHP?

NC6. How would the CHP have been operated? (e.g. base electrical, base thermal, electrical or thermal following, or load technologies)

NC7. Has your facility recently pursued any other energy efficiency measures onsite?

NC8. How did these energy efficiency measures relate, if at all, to the consideration of CHP?

NC9. For efficiency investments, what type of payback or financial hurdle rate do you require to pursue the investment?

NC10. Who was or would be the final decision maker/approver for installing CHP at your facility?

Knowledge of CHP Program

P1. Are you aware of the new electric Combined Heat and Power (CHP) Program incentives as part of the PA Energy Efficiency program in Massachusetts? *PROMPT – if unfamiliar with program - As a result of the Green Communities Act of 2008, Combined Heat and Power Projects are now eligible for funding as an electric energy efficiency measure by Electric Program Administrators ("PA") in Massachusetts. While some gas utilities previously had some incentives for CHP, the Program Administrators who are responsible for administering incentives for CHP Programs are NSTAR (electric), National Grid(electric), Western Massachusetts Electric Company, Unitil(electric), and Cape Light Compact. Generally, equipment qualifying for CHP incentives include reciprocating engines, gas turbines (also commonly referred to as combustion turbines), and back pressure steam turbines which recover waste heat for useful purposes. It is important to note that for the purposes of receiving an incentive under this program, a CHP system must directly produce electricity and not simply offset the use of electricity. An example of equipment* *excluded from this definition would be a gas-fired engine directly coupled to a compressor which indirectly reduces electricity by reducing or eliminating the use of a motor to drive a compressor. The CHP system can use any fuel type.*

P2. How and when did you become aware of the new MA CHP rebates?

How:

When:

P3. Are there any modifications to the programs that Massachusetts utilities might make to better support the design, construction, and commissioning of CHP systems?

P4. Have you seen any marketing materials, such as brochures or fact sheets, describing the CHP program in Massachusetts? Were they useful?

P5. What type of PA marketing for CHP and the incentives would be most effective in reaching potential customers such as yourself? (e.g. bill inserts, conferences, case studies)

General Thoughts

G1. What are your general thoughts about CHP in Massachusetts?

G2. Is there anything you wish you would have done differently in considering, pursuing, or installing CHP at your facility?

G3. What are the main things that would have helped or would help you consider CHP at your facility?

G4. What are the main things that would help you move forward with installing CHP?

G5. What are the main things that would help you finalize the installation and commissioning of a CHP?