Hot, Cool, Clean

Clean Heating and Cooling Opportunities for Massachusetts Municipalities

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Clean Energy Department
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MAPC
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About MAPC

The Metropolitan Area Planning Council (MAPC) is a regional planning agency serving the people who live and work in the 101 cities and towns of Metropolitan Boston. Our mission is to promote smart growth and regional collaboration.

We work toward sound municipal management, sustainable land use, protection of natural resources, efficient and affordable transportation, a diverse housing stock, public safety, economic development, an informed public, and equity and opportunity among people of all backgrounds. Our regional plan, MetroFuture, guides our work as we engage the public in responsible stewardship of our region's future.

MAPC's Clean Energy Department provides a range of services to communities, including comprehensive local energy and climate planning, energy-related technical assistance, and regional energy procurements. Our goal is to advance markets for clean technology while reducing greenhouse gas emissions and dependence on fossil fuel consumption in the Commonwealth.

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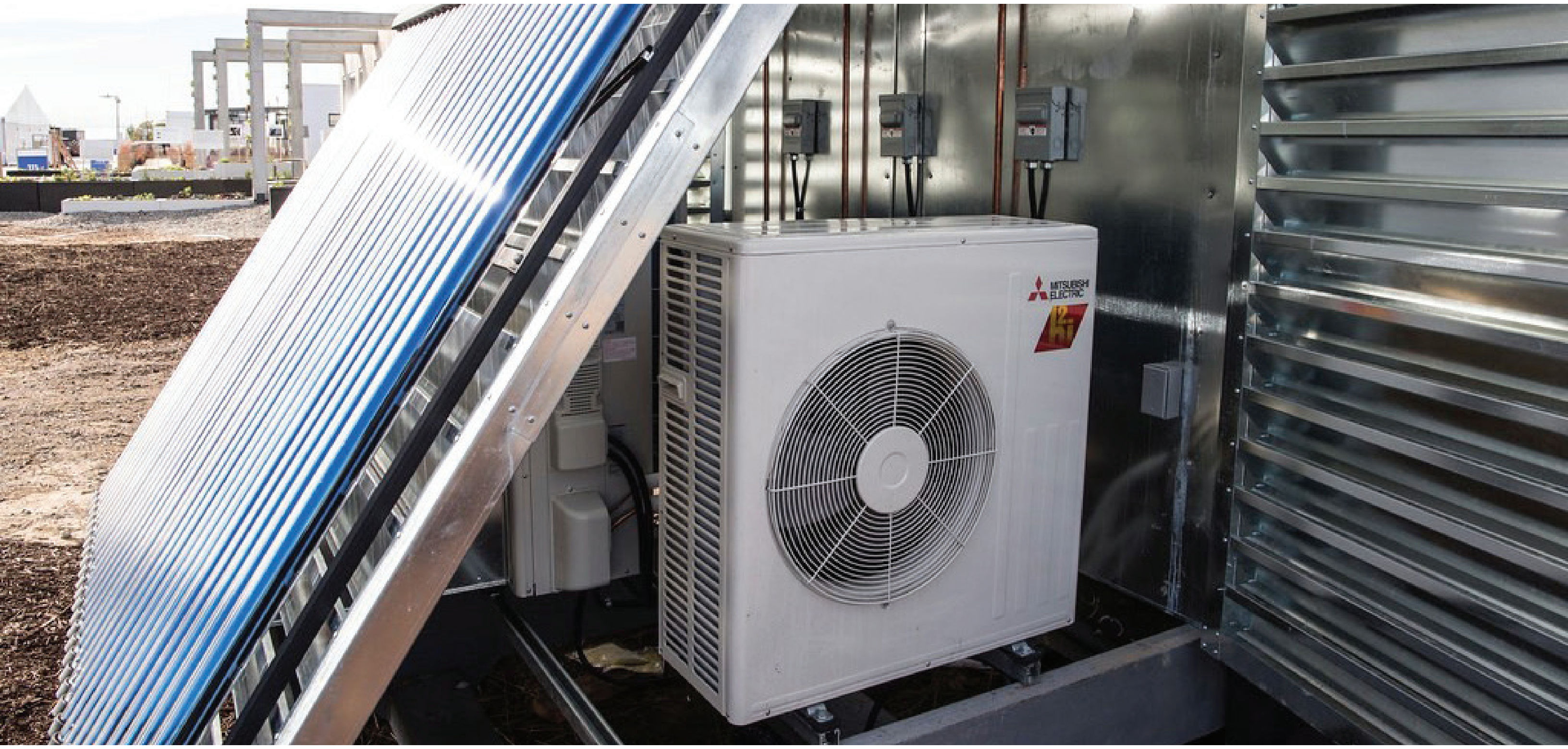

Solar thermal and an air-source heat pump. Source: National Reneweable Energy Lab.

Introduction

This white paper seeks to help Massachusetts cities and towns take advantage of clean heating and cooling (CH&C) technologies for their municipal facilities. CH&C, also often termed renewable thermal or renewable heating and cooling, utilizes renewable or highly efficient alternative heat resources to generate energy for space heating, space cooling, process heat, or hot water. Using technologies such as solar thermal, biomass thermal, and high-efficiency heat pumps reduces the role of traditional heating fuels, in turn often decreasing the amount of money spent on those fuels and the emissions associated with their combustion. There is significant opportunity and need to offset traditional heating fuels, as thermal energy consumption accounted for more than a third (39%) of Massachusetts' total energy consumption in 2016 and fuel oil and natural gas made up 92% fuel use in the thermal sector (Massachusetts Department of Energy Resources [MA DOER], 2018a).

Despite its significant contributions to Massachusetts' greenhouse gas emissions, the heating and cooling sector gets less attention from renewable energy investors and policy-makers than do the electricity and transportation sectors. Massachusetts' CH&C market has grown at a relatively slow pace despite some policy support, but growth in the sector has accelerated in recent years. Limited consumer awareness and education are consistently cited as the main barriers to CH&C deployment, as energy end-users simply do not know about these well-established, cost-competitive technologies or how to begin to acquire them (MA DOER and Massachusetts Clean Energy Center [MassCEC], 2012; MA DOER, 2014; International Energy Agency [IEA], 2017). This paper intends to enhance CH&C awareness with a particular focus on public facilities, introducing CH&C technologies and Massachusetts policies, describing the available incentives for each technology, highlighting pathways for local governments to utilize, and featuring case studies of local facilities that have benefited from CH&C technologies.

Utilizing Clean Heating & Cooling in Massachusetts

Technologies

According to the *Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study* (MA DOER & MassCEC, 2012), the CH&C industry could create between 1,600 and 5,900 jobs in Massachusetts and reduce the state's greenhouse gas (GHG) emissions by over two million tons in less than 10 years. In addition, CH&C displacements of fuel oil or electric resistance heating systems could lead to the greatest reductions in GHG emissions and provide the most lifecycle savings to customers of all carbon reduction measures. The potential is undeniably significant.

A subsequent report, the *Commonwealth Accelerated Renewable Thermal Strategy* (CARTS) (MA DOER, 2014), sought to identify ways to operationalize this opportunity. It focused on pathways to reduce GHG emissions, expand economic development opportunities, and reduce heating and cooling costs for consumers through CH&C. The Massachusetts Global Warming Solutions Act (GWSA) of 2008 mandates GHG emissions reductions, setting statewide limits on GHG emissions for both 2020 and 2050. CH&C plays a role in the *Massachusetts Clean Energy and Climate Plan for 2020* (Massachusetts Executive Office of Energy and Environmental Affairs [MA EOEEA], 2015), which seeks to delineate measures for meeting the mandated 2020 GHG limit. The plan recommends achieving a 1.1 percent reduction from growing the CH&C market in the state to expedite the decarbonization of the building sector's heating and cooling loads. The 2018 *Massachusetts Comprehensive Energy Plan* observes that, paired with energy conservation and improving building envelope efficiency, electrifying the thermal and transportation sectors will result in significant reductions in GHG emissions (MA DOER, 2018a).

The CARTS report identifies large commercial buildings (greater than 15,000 square feet) that use fuel oil or electric resistance heating as among the most important target market segments for CH&C. Numerous municipal buildings in the state fit this description and could be the first place a municipality looks to implement clean and highly-efficient heating and cooling systems. The report identified the most promising CH&C technologies for the Commonwealth as high-efficiency heat pumps (air-source and ground-source), solar thermal, and biomass thermal. These are described in more detail in *Table 1.*

Aging heating infrastructure in Massachusetts means that many buildings are ready for boiler replacements and upgrades. Building owners should take advantage of the cost-competitive renewable technologies described in Table 1. Non-electricity emissions from buildings accounted for approximately 30% of the state's greenhouse gas emissions in 2016, which is the second-largest source of GHG emissions in Massachusetts (Massachusetts Department of Environmental Protection, 2019). Additionally, the state has a relatively high proportion of oil-based heating, approximately 45% of commercial and industrial buildings in Massachusetts (MA DOER, 2014). These factors mean that addressing GHG emissions from heating can have a high impact on reducing the Commonwealth's carbon output. Switching to CH&C will also reduce fuel imports, on which Massachusetts depends for all of its natural gas and petroleum products. Fuel imports are susceptible to price fluctuations in the global market. Demand for out-of-state energy could also grow as air conditioning usage rises dramatically due to higher global temperatures (Davis and Gertler, 2015). As residents and businesses in Massachusetts without existing cooling systems install air conditioning for the first time, air-source and ground-source heat pumps, which are much more efficient than traditional window units, represent substantial opportunities to reduce carbon pollution.

Concerns about Biomass Thermal

Most biomass thermal systems burn wood and there are numerous concerns about wood and other biomass products as fuel sources for heating systems. While wood is a renewable resource, it is not carbon neutral (Pearce, 2017) and burning wood also releases other pollutants such as particulate matter which is known to cause health problems including respiratory disease. While biomass thermal may be a cost-effective heating option in some settings, municipalities looking to reduce greenhouse gas emissions and other pollution may want to consider different CH&C technologies.

Table 1: Clean Heating & Cooling Technologies

Technology	Description	Massachusetts Opportunities
Air-Source Heat Pumps (ASHPs) Types include ductless mini-splits or variable refrigerant flow (VRF) for larger buildings	ASHPs use a vapor compression cycle to move heat energy from the outside air to inside (or vice versa). The single system can provide both space heating and cooling to buildings depending on the season. ASHPs require electricity to operate, but much less than electric resistance heating, and operates at a lower cost than electric resistance, oil, or propane (Northeast Energy Efficiency Partnerships [NEEP], 2017).	The recent technology improvements of ASHPs have demonstrated better heating performance in low-temperature conditions (5˚F or less), which has significantly expanded the MA market.
Ground-Source Heat Pumps (GSHPs) Also called geothermal	Similar to ASHPs, GSHPs use energy from the earth to efficiently heat or cool a building. GSHPs use the temperature difference between the earth's ground temperature and a building's indoor air to provide space heating or cooling, depending on the season. GSHPs use electricity to move the heat, not to generate it, ultimately providing the same amount of heat much more efficiently than traditional electric heating would. Although installation can be expensive upfront, the savings and other benefits can be commercially attractive (MassCEC, 2017a).	MA bedrock has a higher capacity to provide heating and cooling than do other soil types in many other parts of the country. GSHP systems require trenches or wells to operate, so certain sites may not have sufficient space or geological conditions to support them.
Solar Thermal	Solar heat technologies absorb thermal energy from the sun and use that energy to provide hot water heating for all sectors (Solar Energy Industries Association, 2016). As with solar photovoltaics (PV), solar thermal collectors are not impacted significantly by snow; the angle of the collectors minimizes accumulation and maximizes the sun's rays for melting (MA DOER, 2017).	Solar hot water systems can reliably provide up to 80% of a building's total hot water needs in Massachusetts (MassCEC, 2017c). Rebates are available for Solar Hot Water through MassCEC for both residential and commercial systems. (MA DOER, 2018b)
Biomass Thermal	Biomass heating systems use organic matter, including wood pellets and wood chips, to heat homes, businesses, or other buildings. Biomass systems operate like traditional boilers or furnaces that use oil, propane, or natural gas. They can often integrate into existing heating systems to fulfill all of the heating needs of the building. Systems are typically fully-automated and require limited maintenance (MassCEC, 2017b).	Biomass systems must have a thermal efficiency of ≥85% for pellets and ≥75% for chips to qualify under the MA Alternative Energy Portfolio Standard (MA DOER, 2017b). Pellet delivery is available in most parts of MA and systems can be designed to require only three deliveries per year.

= Space Heating

= Space Cooling

= Hot Water

Clean Heating & Cooling for Municipalities

Opportunities

Municipalities are well-positioned to utilize clean resources for heating and cooling and benefit from these technologies. With CH&C, municipalities can:

- **Reduce energy use:** Space heating and hot water generation together make up approximately 50% of energy consumption in local government-owned buildings, and cooling accounts for an additional 11% of building energy use. Using CH&C technologies for space and water heating can optimize the energy, economic, and environmental impacts of building energy usage (U.S. Environmental Protection Agency [EPA], 2011). Also, systems that combine heating and cooling are more efficient than separate systems for both functions are.
- **Reduce energy costs:** According to the EPA, energy costs can account for as much as 10% of a local government's annual operating budget (EPA, 2011). This number is likely to grow as energy prices rise, leaving local governments more vulnerable to the unpredictable and variable costs of imported fuel, unless they diversify and generate their own clean energy sources. Increased efficiency and reduced energy usage can lead to reduced energy costs. ASHPs, GSHPs and solar thermal also do not require fuel delivery, increasing their economic value.
- **Increase comfort:** Technologies like air-source heat pumps can maximize building comfort by providing heating and cooling through the same system and enabling users to customize their comfort by separate zones.
- **Foster long-term thinking:** Municipalities own and operate their buildings for long periods of time, especially when compared to commercial and residential property owners. Municipalities are well positioned to consider a longer-term payback period, which may be associated with CH&C. However, they may also see other financial benefits of CH&C technologies including consistency in operation and maintenance costs over the life of the asset (EPA, 2017).
- **Lead by example:** Municipalities can set an example for their residents and businesses – and other communities – by leading on the adoption of CH&C technologies as another tool in their climate action toolboxes.
- **Generate economic growth:** Deploying CH&C technologies can foster economic development and job training opportunities by supporting the local clean energy economy and creating new job opportunities. The 2018 Massachusetts Clean Energy Industry Report shows that the clean energy industry grew by almost 84% between 2010 and 2018, an increase of 50,500 jobs (MassCEC, 2018).
- **Increase climate preparedness**: As more cooling centers are developed to manage rising temperatures and enhance community resiliency, these centers can utilize heat pumps without adding to the community's carbon footprint.

The myriad benefits of CH&C make it an attractive suite of technologies to consider for municipalities interested in bolstering their efforts to achieve GHG emissions reductions, reduce energy use, lower energy costs, and stimulate growth of cutting-edge technologies.

Policies and Programs

Massachusetts policymakers have recognized the importance of CH&C technologies for GHG and energy reductions, as well as the many co-benefits listed above. The Commonwealth has sought to be a leader in this space through policies and programming.

Rebates

MassCEC offers funding opportunities and informational resources for municipalities pursuing CH&C. MassCEC has supported solar hot water installations since 2012, when it authorized $10 million for rebates to the residential, commercial, and government/non-profit sectors through 2020. In 2015, MassCEC expanded its CH&C support in partnership with the Massachusetts Department of Energy Resources (DOER), announcing a five-year, $30 million commitment to high-efficiency CH&C systems. The program provided rebates for the installation of air- or ground-source heat pumps, solar hot water systems, and central biomass boilers. MassCEC's incentives for commercial ASHPs and VRF systems, GSHPs, and biomass thermal systems ended in 2019. However, the MassCEC solar hot water program is still operating and statewide energy efficiency program Mass Save offers commercial rebates for some heating systems.

Outreach Support

For communities interested in encouraging the adoption of CH&C technologies in homes, MassCEC also offers funding through its HeatSmart Mass Program (MassCEC, 2019a). Modeled after the popular Solarize Massachusetts program, HeatSmart Mass uses a group purchasing model to drive down the cost of installation and increase awareness of CH&C technologies among residents. HeatSmart Mass provides outreach and marketing support and grants of $5,000 with adders for engaging low and moderate-income residents ($2,500) and promoting more than one CH&C technology ($1,000 per additional technology) as well as an adder for communities with more than 10,000 residences (up to $2,500) (MassCEC & MA DOER, 2018). MassCEC's Solarize Plus program also includes support for communities interested in promoting CH&C technologies alongside solar PV (MassCEC, 2019b).

Alternative Energy Portfolio Standard

In addition to helping finance and fund CH&C technologies, the Commonwealth's policies also include regulation to incorporate these technologies into utilities' generation requirements. The MA Renewable Portfolio Standard (RPS) and Alternative Energy Portfolio Standard (APS) require that utilities meet a certain percentage of their electricity load using specified renewable and alternative energy technologies. Legislation passed in 2014 added CH&C technologies to the APS (Chapter 251 of the Acts of 2014), which means that utilities may use air-source heat pumps, ground- and water-source heat pumps, deep geothermal heat exchange, solar thermal, woody biomass, biogas, and liquid biofuels, among other non-CH&C technologies, to meet the required percentage of alternative energy sources in total electricity generation. The APS requirement, from the aforementioned sources, is 4.75% by 2019, and increases by 0.25% annually. Clean heating technologies calculate their contribution through a prescribed conversion from British Thermal Units (BTUs) to Megawatt Hours (MWhs) of electricity.

The APS supports CH&C investors by allowing utilities to purchase "credits" from system owners, such as homeowners or municipalities, rather than invest in and install the technology themselves. Therefore, a heat pump or solar thermal collector can generate multiple benefits for the system owner: the physical heat energy as used directly in the building, and the Alternative Energy Credit (AEC) as sold to the utility.[1] The APS acts as a production-based incentive, yielding higher returns for greater heat generation. The regulations (225 CMR 16.00) were promulgated in December 2017 and provide grant eligibility to CH&C technologies installed on or after January 1, 2015.

Other Programs

The MA DOER's Green Communities program provides grants of up to $250,000 to municipalities to implement clean energy projects including CH&C system installations. Municipalities may also be able to take advantage of the federal government's Modified Accelerated Cost-Recovery System (MACRS) if they are working with a third-party vendor who owns the CH&C system. See Table 2 below for more detail on all of these programs.

The longevity and variety of CH&C policies in Massachusetts indicate a momentum in the Commonwealth that could significantly benefit municipalities. Within this policy environment, there are numerous reasons for cities and towns to take advantage of CH&C technologies and several ways that they can reap the benefits.

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[1] Heat pumps will earn AECs only when operating in heating mode, not cooling.

Table 2: Available CH&C incentives, either explicitly for government/non-profit or more broadly for commercial scale. All incentives are specific to MA unless otherwise noted as federal. Incentive and program details are current as of July 2019 and may change.

Technology	Incentive Name	Incentive Value	Municipal Eligibility
Air-Source Heat Pumps	Alternative Energy Credits[2]	Financial incentives provided by the Alternative Energy Portfolio Standard[3]	Yes
	DOER Green Communities Grant Program[4]	Up to $250,000 for competitive grants	Yes*
	Mass Save Technical Assistance[5]	50% of engineering study/consulting; up to 75% of incremental cost of installed equipment	Yes**
	Mass Save Commercial & Industrial HVAC Rebates[6]	$50-$100 per ton for ductless mini- and multi-split systems; $125 per ton for VRF systems	Yes**
Ground-Source Heat Pumps	Alternative Energy Credits[7]	Financial incentives provided by the Alternative Energy Portfolio Standard[8]	Yes
	DOER Green Communities Grant Program[9]	Up to $250,000 for competitive grants	Yes*
	Mass Save Technical Assistance and Equipment Subsidization[10]	50% of engineering study; up to 75% of incremental cost of installed equipment	Yes**
	Modified Accelerated Cost-Recovery System (Federal)[11]	Bonus depreciation	Only if using a 3rd party
Solar Hot Water	MassCEC Solar Hot Water Rebate[12]	Up to 65% of project costs	Yes***
	Alternative Energy Credits[13]	Financial incentives provided by the Alternative Energy Portfolio Standard[14]	Yes
	DOER Green Communities Grant Program[15]	Up to $250,000 for competitive grants	Yes*
	Modified Accelerated Cost-Recovery System (Federal)[16]	Bonus depreciation	Only if using a 3rd party
Biomass Heating	Alternative Energy Credits[17]	Financial incentives provided by the Alternative Energy Portfolio Standard[18]	Yes
	DOER Green Communities Grant Program[19]	Up to $250,000 for competitive grants	Yes*
	Modified Accelerated Cost-Recovery System (Federal)[20]	Bonus depreciation	Only if using a 3rd party

* For municipalities that are becoming designated Green Communities, funding amounts depend on DOER's grant formula. Reach out to the DOER Green Communities Regional Coordinators for details.

** Municipal light plants (MLPs) are not eligible for Mass Save incentives; only customers in investor-owned utility (IOU) territories may receive Mass Save incentives. Individual MLPs may offer their own incentives. Contact your MLP for more information.

*** MassCEC awards may only be granted to project sites that receive electrical service from National Grid, Eversource, Unitil, and municipal light plant communities that participate in the Renewable Energy Trust (currently Ashburnham, Holden, Holyoke, Russell, and Templeton).

[2] https://www.mass.gov/alternative-energy-portfolio-standard
[3] https://www.mass.gov/service-details/alternative-portfolio-standard-rulemaking
[4] http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities
[5] http://www.masssave.com/en/business/services-financing/financing-for-business
[6] https://www.masssave.com/en/saving/business-rebates/upstream-electric-hvac-program
[7] https://www.mass.gov/alternative-energy-portfolio-standard
[8] https://www.mass.gov/service-details/alternative-portfolio-standard-rulemaking
[9] http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities
[10] http://www.masssave.com/en/business/services-financing/financing-for-business
[11] http://programs.dsireusa.org/system/program/detail/676
[12] http://www.masscec.com/get-clean-energy/government-and-non-profit/solar-hot-water
[13] https://www.mass.gov/alternative-energy-portfolio-standard
[14] https://www.mass.gov/service-details/alternative-portfolio-standard-rulemaking
[15] http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities
[16] http://programs.dsireusa.org/system/program/detail/676
[17] https://www.mass.gov/alternative-energy-portfolio-standard
[18] https://www.mass.gov/service-details/alternative-portfolio-standard-rulemaking
[19] http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities
[20] http://programs.dsireusa.org/system/program/detail/676

Overcoming Barriers to Clean Heating & Cooling

While possessing a unique set of opportunities for CH&C adoption, municipalities may face particular challenges in accessing these technologies. These challenges can be managed and should not impede a municipality from investing in CH&C. The following section describes some potential hurdles municipalities may experience and potential solutions to help address them.

Challenge: High upfront costs can be limiting for municipal budgets.

Potential Solution:

In many cases, CH&C upgrades and installations are paid for as part of a broader renovation or recapitalization of a facility. Depending on the technology, the costs for CH&C may be comparable or higher than traditional heating and cooling systems. These upgrades will likely be paid for by the municipal capital plan budget and will be net positive financially before the system's end of life.

A municipal government may also be able to finance projects using an energy services company (ESCO) or third-party ownership option that reduces or removes the upfront capital cost of a CH&C project. For example, when a municipality enters into a performance contract with an ESCO, the ESCO is responsible for purchasing and installing the system – an air-source heat pump, for example – along with other efficiency projects. The municipality continues to pay all or a majority of its original utility bill while the ESCO pays off the investment cost through the energy savings. At the end of the contract, the equipment ownership and energy savings transfer to the municipality.

In another model, a third-party company could take on the risk and responsibility for either part or all of a ground-source heat pump system. In this arrangement, either the company purchases and operates the geothermal well field and the building operator purchases the heating, ventilation, and air conditioning (HVAC) equipment, or the company purchases and operates the entire geothermal HVAC system on behalf of the customer. The company could then enter into a long-term contract with the building owner or manager to supply thermal energy from the well field or to operate the full HVAC system, depending on the ownership arrangement. The value of tax attributes and AECs would offset the cost of the contract, and the facility owner could have the option to buy the system at the end of the initial contract term.

Challenge: As non-profit entities, municipal governments cannot directly benefit from tax credits or depreciation schedules.

Potential Solution:

The same third-party ownership models described above could allow cities and towns to benefit from tax incentives. By collaborating with a tax-liable entity, such as a private developer that technically owns the system on behalf of the municipality, the private partner can help pass on and share the tax benefits with the municipality.

Challenge: Since there are many different CH&C technologies, a municipality may not know which to pursue.

Potential Solution:

Prospective CH&C investors can find educational resources and support from a wide range of energy advisors, including MassCEC, the U.S. Department of Energy, the Northeast Energy Efficiency Partnership (NEEP), UMass Amherst Clean Energy Extension, Mass Save, utilities, and other organizations. An ESCO might also be willing to provide a no-risk, upfront assessment in order to determine which technologies might be right for a particular property. The ESCO would ask for details about the site and undertake a building audit to understand which clean energy options are most suitable.

Challenge: Municipalities may not have the staff capacity to explore CH&C resources or expertise to analyze the technology, potentially limiting their ability and initiative to undertake these projects.

Potential Solution:

Regional planning agencies, such as MAPC, can be a resource to municipalities needing supplemental assistance. In addition to leading municipal clean energy education efforts via white papers, toolkits, workshops, and webinars, MAPC can provide direct technical assistance to municipalities interested in beginning or strengthening a CH&C project.

MassCEC and the Massachusetts Department of Energy Resources also offer CH&C resources and incentives. MassCEC's CH&C program details can be found at http://www.masscec.com/government-non-profit/clean-heating-and-cooling and MA DOER's CH&C program details can be found at http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/renewable-thermal.

Municipal Case Studies

Air-Source Heat Pumps (ASHPs) in Public Housing Across Massachusetts

Bruce Ledgerwood, Program Manager, Alternative Energy Program, Low-Income Energy Affordability Network (LEAN) at Action for Boston Community Development (ABCD)

Locations: 706 apartments at 21 housing authorities across 14 municipalities in MA (Pittsfield, Southwick, Acton, Boston, Attleboro, Orleans, Warren, Marlborough, Kingston, Cambridge, Dedham, Newton, Martha's Vineyard, Sharon)

Building Type: State-funded public housing: low rise, garden style buildings, with some sites serving elderly in one-bedroom apartment units.

Unit and ASHP System Size: 450-500 square feet units; 12,000 BTU capacity per unit.

Date of Project Installations: 2014 - 2016

Energy Savings and Performance Benefits:
In a sampling of 250 installations, ASHP recipients saw their HVAC energy consumption and costs reduced by approximately half. Since HVAC had previously accounted for about half of the total electricity bill, recipients saw overall energy and cost savings of about 25% on their electricity bills. In addition, there was a significant reduction in electricity capacity charges for the winter peak and a moderate reduction in summer peak demand charges. Most projects had approximately a 10-12 year payback. Residents have reported being pleased with the ASHP systems. The window AC units used prior to the ASHP installation were noisy, blocked natural light, and had to be installed and removed seasonally. Some residents have reported improved air-quality and wellness because ASHPs also filter indoor air.

Motivation and Technology Choice:
All installation sites had electric baseboard resistance heating or electric storage heaters, and over half had window AC units. ASHPs offered the greatest savings on electric heating bills. GSHPs were not appropriate because they would have been more expensive and work-intensive for these sites.

Incentives: As a pilot project, MassCEC grants covered almost 100% of ASHP installation costs in each LEAN/ABCD project. In two cases, Eversource and Cape Light Compact funded 50% and 30%, respectively, of a site's installation costs and MassCEC funded the remaining balance.

Process and Key Steps:

System Specifics: All electric baseboard or storage heat systems were removed except in bathrooms and hallways. If energy efficiency measures were not already in place in these housing units, they were added. The most common energy efficiency measures added were insulation and lighting.

Challenges and Solutions: The greatest initial challenge for LEAN/ABCD was finding contractors who could do quality work at a reasonable price. Today, there are more experienced ASHP contractors, resulting in faster completions and more competitive pricing.

Key Takeaways: ASHPs have offered the greatest savings on traditional electric heating bills for low-income residents in public housing and have yielded cost savings and improved comfort. The installation workforce is rapidly gaining expertise, resulting in faster and less expensive installations. Energy efficiency has been incorporated into many of these LEAN/ABCD ASHP projects, even when buildings already had a high degree of efficiency.

Ground-Source Heat Pump (GSHP) at Walpole Public Library

David Wildnauer, Former Member of the Walpole Permanent Building Committee and Former Chairman of the Board of Trustees of Walpole Public Library

Location: Walpole, MA

Building Type: Newly-constructed Public Library

Building and System Size: The building has a total area of 31,600 sq. ft., of which 4,900 sq. ft. is heated and cooled exclusively by the geothermal system. The geothermal system has 144,000 BTU/hour of heat capacity and 12 tons of cooling capacity. The design was based on 53˚ F ground temperature with four geothermal wells, three heat pumps, and three air-handling units.

Date of System Installation: 2012

System Performance: Library staff members were pleased with the performance of the ground-source heat pump (GSHP system) and report that it keeps the areas comfortable in both winter heating and summer cooling months.

Motivation and Technology Choice:
The Town decided to pursue the US Green Building Council's Leadership in Energy and Environmental Design (LEED) certification for the library, and subsequently the library administration has used the building as an educational tool. Working with the design architects and engineers, the building committee chose a GSHP system as part of the overall strategy to achieve LEED certification. The small site does not offer space for many geothermal wells, so the technology was utilized for only a portion of the building, mainly a community room that was chosen partly for its visibility in order to be a demonstration of green building technology.

Buy-In: Sustainable design was not a part of the building committee's original mandate. Green features like the GSHP system became a realistic goal when Walpole learned about state incentives for LEED-certified construction of libraries.

Incentives: The Massachusetts Board of Library Commissioners (MBLC) supports new municipal library construction with grant funding. In addition, if a library building earns LEED accreditation, the MBLC offers an additional 5% incentive on top of the original grant value. The Walpole Public Library's GSHP and other green features earned it LEED Gold certification, and the resulting supplemental MBLC grant funding offset the cost of the technology and the certification process.

System and Operations: The GSHP system is dedicated mainly to conditioning only a portion of the library -- a community room area, which is a single-story appendage to the two-story main building. As a separate space, and with intermittent use and an operating schedule distinct from the library's, the area was a natural candidate for a discrete HVAC system. Extra geothermal capacity is also used to condition the library's administrative offices, which also have separate needs from the library's public spaces.

Solar Thermal at Worcester State University

Bob Daniels, Associate Director of Facilities at Worcester State University (WSU)

Location: Worcester, MA

Building Type: Newly-constructed Fitness and Wellness Center

Building Size: 100,000 sq. feet

Date of System Installation: 2016

Energy Savings and Performance Benefits:
To be determined. The project is expected to pay for itself in 10-12 years.

Motivation and Technology Choice:
As an educational institution, WSU aims to ensure that its solar thermal system not only helps meet energy and cost savings goals, but also serves as a campus teaching tool. The campus already hosts solar PV and a combined heat and power plant. WSU planned upfront to build a LEED Gold building, which would be the fourth of its kind on campus and have additional environmental features. WSU targeted heating technology because it anticipated that the athletic center would have high demand for hot water and space heating. The university considered GSHPs but site conditions were prohibitive. An internal design group considered the different options and decided that solar thermal technology would be best suited for the site.

Buy-In: Securing public buy-in was not a hurdle. No one disputed the desire for renewable energy, both in order to achieve LEED certification and to lead by example as an educational institution. Financial incentives were also a big selling point.

Incentives: WSU utilized MassCEC installation rebates.

Key Takeaways and Advice: WSU underscored the importance of working with a good engineering group that understands the integration of the solar hot water system with the building operation. WSU used the MA public procurement process, through which it selected a vendor that offered a viable design. Secondly, WSU suggested that building and energy managers be involved early in the design process for a new facility and work to integrate CH&C technologies with the external design and mechanical engineering experts.

Worcester State University Wellness Center | Photo by WillJayPA / Wikimedia Commons

Pellet storage hopper installed at Nortfield Town Hall

Pellet boiler installed at Northfield Town Hall

Biomass Thermal at Northfield Town Hall

Bob Pasteris, Former Chair of Northfield Energy Committee

Location: Northfield, MA

Building Type: Town Hall

Building Size: 13,609 sq. feet

Date Installed: 2016

Energy Savings and Performance Benefits:
Northfield anticipates that it will break even with this project. The town is confident that the biomass boiler will help hedge future fuel prices, as oil prices have traditionally been volatile compared to wood pellet prices, which have remained stable for a decade.

Motivation and Technology Choice:
The Northfield Energy Committee wanted to move away from oil, and fossil fuels in general, to more local and renewable sources of energy in its municipal buildings. MassEnergyInsight[21] helped the Town identify the Town Hall as a good building to target, as Northfield had already upgraded its library and streetlights. The Town Hall, a brick structure constructed in 1929, houses the town offices, police department, and senior center. Until fairly recently, an oil-fired boiler had been the only technically and economically feasible way to heat the building.

When considering new technology for Northfield Town Hall, GSHPs were too expensive and ASHPs seemed suboptimal for the many rooms of the Town Hall (though now the Town is funding new ASHPs for cooling and some "shoulder season" heating in the building). Wood pellets were deemed appropriate for Northfield's location in Western Massachusetts, as the pellets are sourced from fewer than 50 miles away.

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[21] MassEnergyInsight (MEI) is a free online tool provided by the MA Department of Energy Resources that enables Massachusetts communities to monitor the energy use of their municipal facilities. Using raw utility data already loaded into the MEI platform for each community, cities and towns can plan renewable and efficient energy programming and communicate their efforts to reduce their community's carbon footprint and save taxpayer dollars (MassEnergyInsight, 2017).

Buy-In: The Energy Committee needed to convince the Select Board to pursue this project; they toured other installations in the area and saw great economic value for the project because oil prices were high at the time. While some raised concerns about the aesthetics of installing an aluminum silo out back for pellet storage, the silo is not visible from the road and is generally inconspicuous in the rural farming community.

Incentives: Northfield was able to leverage significant funding from its Green Communities grant, having become a designated MA Green Community in 2012. Northfield funded both its initial project feasibility study and part of the installation itself with Green Communities funding. The Town also used MassCEC and DOER grants for 75% of the project installation cost.

System Specifics: Northfield Town Hall underwent a heating system upgrade just before the biomass installation. This added the ability to control building heating zones and specify days of the week and times for heating individual offices. Through the heating upgrade and other energy efficiency measures, including air-sealing the attic and constructing plastic inserts for the old, historic arched windows, the Town managed to reduce energy consumption 13-14% at the Town Hall. These energy efficiency upgrades improved the new boiler's performance because the building requires less heat energy to achieve comfortable indoor temperatures. The Town has also maintained its old oil boiler, as the wood pellet boiler is sized to provide approximately 95% of the energy needed during the heating season in order to optimize its size, cost, and efficiency, while allowing the fuel oil boiler to be exercised periodically. During the coldest days, the Town meets its peak heating load with the oil boiler. The pellet boiler system communicates through email with the facilities staff if a switch back to oil is required.

Key Takeaways and Advice: Northfield advises that municipalities initiating a biomass thermal project conduct a thorough feasibility study. Northfield's study was very basic, at a cost of $5,000. The Town strongly suggests that municipalities make their feasibility study more of an involved proposal to get solid numbers and more fully know what the project will cost. The feasibility analysis conducted for Northfield underestimated the construction costs, which led to subsequent challenges. Northfield applied for grant money based on that analysis and then the design and construction bids came back much higher than they had budgeted. It was extremely challenging to make up the difference and the Town highly recommends that municipalities conduct a thorough feasibility assessment to get an accurate project construction cost before applying for a grant. It is very important to have reliable construction cost estimates before looking for project funding.

Deploying Clean Heating and Cooling

A Checklist for Municipalities

While designing or retrofitting a heating and cooling system requires planning and commitment, it can reap many benefits for municipal facilities. The list below includes recommendations for how to make this process as simple and successful as possible:

- [ ] **PLAN AHEAD**

Plan ahead for a boiler/furnace failure, considering the age of the existing boiler/furnace system. The average operating lifespan of a boiler is around 20 years (ASHRAE, 2013). When replacing the current heating system, whether scheduled or emergency, be prepared to use clean technologies, such as ASHPs, GSHPs, or solar thermal. Research providers, incentives, and structural limitations in advance.

- [ ] **CONSIDER THE BUILDING**

When identifying a facility for CH&C technologies, consider the size and energy intensity of the building, the geographic characteristics, and the current heating fuel type. Keep in mind that air-source and ground-source heat pumps can meet cooling as well as heating needs, enabling the removal of existing window AC units or avoiding them entirely for new cooling applications.

- [ ] **VISIT MASSCEC AND MASS SAVE WEBSITES**

Visit the MassCEC and Mass Save websites for information on the different technologies and instructions on how to find and evaluate installers. If still unsure about the appropriate technology and project size for a given facility, consider contacting a vendor, such as an HVAC installer ESCO, for evaluation and price quotes, potentially for no fee.

- [ ] **EXPLORE AEC OPPORTUNITIES**

Explore opportunities to qualify for Alternative Energy Certificates (AECs) under the Massachusetts Alternative Energy Portfolio Standard (APS). Qualifying CH&C systems generate Alternative Energy Credits which can be sold to electricity suppliers similar to Renewable Energy Certificates (RECs). Learn more about the APS and AECs at https://www.mass.gov/alternative-energy-portfolio-standard.

- [ ] **OPTIMIZE IMPLEMENTATION**

Optimize your investment by incorporating energy efficiency upgrades before or at the same time as your CH&C system installation, or implement CH&C in places with existing efficiency improvements. If your building is tightly sealed, it will better hold heating and cooling, significantly improving your system’s performance for both energy savings and comfort.

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