DECARBONIZATION OF PUBLIC BUILDINGS : FROM BOILER TO HEAT PUMP

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Content

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Path to Decarbonization: Initiating the Conversation

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Decarbonization is a crucial strategy to tackle the adverse effects of climate change and work towards a sustainable future. Buildings play a significant role in this low-carbon transition, contributing nearly 40% of global energy-related carbon dioxide (CO_2) emissions and even up to 70% in large cities. To combat this, decarbonizing buildings, especially older ones, becomes essential by implementing energy efficiency improvements and adopting renewable energy sources. This not only reduces carbon emissions but also brings about additional benefits like improved health, enhanced energy affordability, and positive impacts on the labor market.

In the United States, the urgency for decarbonization is evident from the country's substantial carbon footprint. In 2019, the Environmental Protection Agency (EPA) reported approximately 5.4 billion metric tons of carbon dioxide equivalent emitted by the US, primarily due to fossil fuel combustion in electricity generation, transportation, and industrial processes. To achieve decarbonization, it is vital to go beyond new construction, focusing on renovating existing buildings and reducing their life-cycle carbon emissions.

Turning our attention to Michigan, the power sector is responsible for about 30% of the state's total greenhouse gas emissions. In 2020, coal and natural gas, being the primary emission sources in this sector, accounted for 59% of the state's electricity generation. Achieving climate goals set by East Lansing and addressing Michigan's emissions requires a significant increase in adopting renewable energy sources like wind and solar, while ensuring that these actions are in line with environmental justice considerations.

Government policies play a significant role in decarbonization efforts, particularly by establishing energy efficiency requirements for new constructions. Michigan has already adopted the International Energy Conservation Code (IECC) as its statewide building energy code. States have the flexibility to modify and amend the code to align with their specific needs and goals. Some states even mandate higher energy efficiency standards for public buildings, including certifications like LEED or zero-net-energy building standards.

Another crucial step is identifying and retrofitting the most inefficient buildings when it comes to energy savings. Governments can prioritize retrofitting efforts by benchmarking energy and water usage and collaborating with service companies through energy performance savings contracts. These contracts allow the government to fund retrofits using the utility savings generated after the project's completion. Implementing energy-conservation technologies in the public sector not only saves taxpayer money and supports economic development but also demonstrates the effectiveness and indispensability of efficiency measures.

In conclusion, decarbonization is a pressing need to mitigate climate change impacts, enhance air quality, reduce dependence on fossil fuels, and foster the development of renewable energy sources. The carbon emissions figures in the United States underscore the urgency of decarbonization efforts both nationally and locally. By prioritizing energy efficiency, transitioning to clean energy sources, and retrofitting inefficient buildings, we can pave the way towards a more sustainable and resilient future.

Stakeholder Interview

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In order to gain insights into decarbonization and electrification of public buildings at East Lansing, a series of interviews were conducted with key individuals representing various stakeholder groups. The interviewees ranged from government officials serving East Lansing, representatives from Lansing Board of Water and Light, contractors of companies who provide HVAC solutions and clean energy specialists. These interviews aimed to gather information about their interests, concerns, expectations, and suggestions related to the project.

Key questions that were asked during the interview were :

- What does decarbonization in East Lansing look like to you?
- In your view, what would make a retrofitting of HVAC to Heat Pumps successful?
- What aspects of the current infrastructure present do you feel need improvement?
- Who do you see as the key partners and decision makers in the process of retrofitting with the intention of decarbonization?
- What are the bottom line “must-haves” while executing a project like such?

Summary and takeaways of findings from the interviews were :

- Challenges with Existing Buildings: The age and condition of buildings, such as City Hall and the Hannah Community Center, pose challenges for retrofitting efforts. Decisions need to be made regarding whether to retrofit the current building or consider moving to a different one. This highlights the need to address structural and logistical challenges associated with retrofitting.
- Complexities of Retrofitting: Retrofitting community centers, schools, and libraries is expected to be challenging due to specific requirements and existing infrastructure in these buildings. There is existing infrastructure that is being underutilized. This implies that retrofitting strategies need to be tailored to the unique characteristics and functions of different public buildings. This emphasizes the importance of improving efficiency and considering current infrastructure standards and utility loads to optimize energy consumption.
- Key Partners and Decision Makers: Achieving successful retrofitting requires collaboration with various stakeholders, including new city leadership, the current city council, finance departments, and boards and commissions related to the environment, planning, parks and recreation, and historical district. Additionally, utility companies like BWL and their contractors are important partners in the process.
- Building Envelope Considerations: Addressing issues related to the building envelope, such as air leakage, efficiency, weatherization, and insulation values, is crucial for achieving decarbonization goals. These aspects contribute to energy efficiency and the reduction of carbon emissions.

- Site-Specific Retrofitting Needs: The retrofitting requirements vary across different sites. Prioritizing critical areas, such as addressing leaks and improving energy efficiency, based on the specific needs of each site is necessary for effective retrofitting.
- Identifying Blockers and Concerns: Potential blockers to success should be identified and addressed during the retrofitting process. Specific areas of concern, including assessing the insulation, plaster, concrete, vestibules, and the condition of air curtains, need to be assessed to determine necessary improvements.

To access the full list of the stakeholder interview questions, see Appendix : 1

Case Studies

Skokie Courthouse, Cook County, Illinois

Image by Dana Samargiu

Background

The Skokie Courthouse, constructed in 1980, is a three-floor masonry facility. Initially the courthouse was designed as a shopping center with abundant windows, spacious interiors, and an all-electric power system. Occupying an impressive area of 345,783 square feet, along with a 483,451-square-foot parking garage, the 26 roomed courthouse was selected due to its distinctive energy profile and potential for alternative power sources.

Cook County, being the second-largest county in the country, understood the significance of adopting sustainable energy practices to reduce its overall environmental impact. In alignment with their commitment to achieve an 80 percent reduction in greenhouse gas emissions by 2050, Cook County undertook a comprehensive plan to implement energy efficiency projects over the next two decades.

The Skokie Courthouse catered to the needs of District 2 for court proceedings and serves the northern suburbs of Cook County, encompassing areas such as Deerfield, Des Plaines, Evanston, Glencoe, Glenview, Golf, Kenilworth, Lincolnwood, Morton Grove, Niles, Northbrook, Northfield, Park Ridge, Skokie, Wilmette, and Winnetka, as well as three townships.

Recognizing the need for energy efficiency improvements and upgrades to its aging equipment, the Skokie project was included in an energy service contract, which covered three other suburban County courthouses and five Department of Transportation and Highways buildings, all geared towards promoting energy efficiency and sustainability within the region.

Strategies Implemented

The implementation of energy efficiency measures at Skokie Courthouse was projected to result in approximately 59 percent savings in utility costs. Specifically, the decision to install a geothermal heat pump system at Skokie Courthouse was influenced by several factors, including higher heating load requirements due to leaking windows and insufficient perimeter heating, outdated controls, and the site's geographical suitability for geothermal solutions.

As a result of these energy efficiency initiatives, Cook County expects to achieve a significant reduction in greenhouse gas emissions, estimated at around 3,569 tons per year. Given that the existing equipment was nearly three decades old, the installation of modern, energy-efficient systems, such as the geothermal heat pump system complemented by natural gas boilers and chillers, promised operational savings but also enhanced safety standards at Skokie Courthouse.

Gillette City Hall, Campbell County, Wyoming

Image by J. Stephen Conn

Background

With the commitment of managing City facilities efficiently, responsibly handling taxpayer resources, the leadership of the City of Gillette introduced a policy to upgrade and replace outdated and inefficient HVAC equipment with more energy-efficient systems. To kickstart this HVAC upgradation program, they chose City Hall as the first site due to its central role in City operations and frequent visits from community residents, making it a visible showcase of their dedication to energy efficiency.

Gillette City Hall, constructed in 1984, spans an area of 85,527 square feet and houses various facilities like offices, conference rooms, utility billing services, a gym, locker rooms, a server room, and the police department. The building is occupied from 7 am to 5 pm Monday through Friday, and the police department operates 24/7, year-round.

The City Council allocated funding of over $900,000 for the initial phase of the project, with subsequent phases expected to receive funding through a five-year capital improvements budget. The administrative services department was assigned at overseeing the project, focusing on long-term investments in efficiency.

Solution

For Phase I, the city collaborated with a service provider to conduct a retro-commissioning project at City Hall.

The resulting report highlighted opportunities for HVAC system improvement and efficiency, including upgrading the controls system and sequenced equipment replacements.

During Phase I, the city replaced outdated controls and thermostats with more efficient ones, resulting in better temperature regulation throughout the building. Additionally, they replaced a cooling tower that had surpassed its useful life by 5 to 10 years.

Phase II, which was completed in the summer of 2015, involved the replacement of two boilers with higher efficiency units.

Apart from the immediate benefits of improved energy efficiency and cost savings, the new control system and sub-meters enhanced reporting capabilities and data tracking for City administrators and elected officials. The staff could now report more accurately on energy performance.

Furthermore, the success of the project has motivated the staff to plan for similar equipment replacements in another building, replicating the positive outcomes achieved at City Hall.

Road to Electrification : Heat Pump Upgradation

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The reduction of fossil fuel use in heating is of paramount importance for addressing energy security risks, mitigating the effects of volatile energy prices, and achieving climate objectives. Currently, approximately half of global buildings-related energy consumption is dedicated to heating, with natural gas being the predominant energy source, accounting for an annual consumption of 760 billion cubic meters.

Heat pumps play a crucial role in decarbonizing space and water heating in buildings. The installed capacity of heat pumps in buildings currently exceeds 1000 GW(GigaWatts). In 2022, the International Energy Agency (IEA) released its World Energy Outlook to map the trajectory of what it would look like if governments meet all aspirational climate targets on time. In the publication ,under the Announced Pledges Scenario, which assumes the fulfillment of national climate and energy security targets, this capacity is projected to increase to 2600 GW by 2030. Consequently, the share of total heating needs in buildings supplied by heat pumps is anticipated to rise from almost 10% in 2021 to 20%. It is worth noting that many of these heat pumps are reversible, enabling them to provide cooling as well. By adopting heat pumps, natural gas demand can be reduced by more than 80 billion cubic meters and heating oil demand by 1 million barrels per day, while the use of coal diminishes to negligible levels. Furthermore, the increased demand for electricity resulting from heat pump usage contributes to around 9% of the overall electricity demand growth by 2030, without significantly adding to system-wide peak loads during winter. As a result, heat pumps possess the potential to decrease global carbon dioxide emissions by at least 500 million metric tons in 2030.

The transition to heat pumps not only curtails greenhouse gas emissions but also contributes to improvements in air quality. Despite the fact that unintended leaks of potent greenhouse gasses like F-gas refrigerants, can diminish their positive climate impact, heat pumps still exhibit a minimum reduction of 20% in greenhouse gas emissions compared to gas boilers, even when powered by emissions-intensive electricity. In countries with cleaner electricity generation, this reduction can be as substantial as 80%. Moreover, the global emissions of major air pollutants associated with combustion heating in buildings decrease, resulting in a reduction of hazards associated with fuel combustion for heating purposes.

Heat Pump Factsheet

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Heat Pump : Considerations for Retrofits

Introduction

A heat pump is an energy efficient heating and cooling system that can heat buildings by moving heat from outdoors to indoors (during winter) and cool buildings by moving heat from indoors to outdoors (during summer). As a heat pump moves heat rather than generating it, they have typical efficiencies between 200 and 400 percent. In addition to efficiency, a key health and safety benefit of heat pumps compared to fossil fuel-based heating is the lack of any indoor combustion emissions, such as carbon monoxide (CO), nitrogen dioxide (NO2), fine and ultrafine particles, polycyclic aromatic hydrocarbons (PAHs), and formaldehyde.

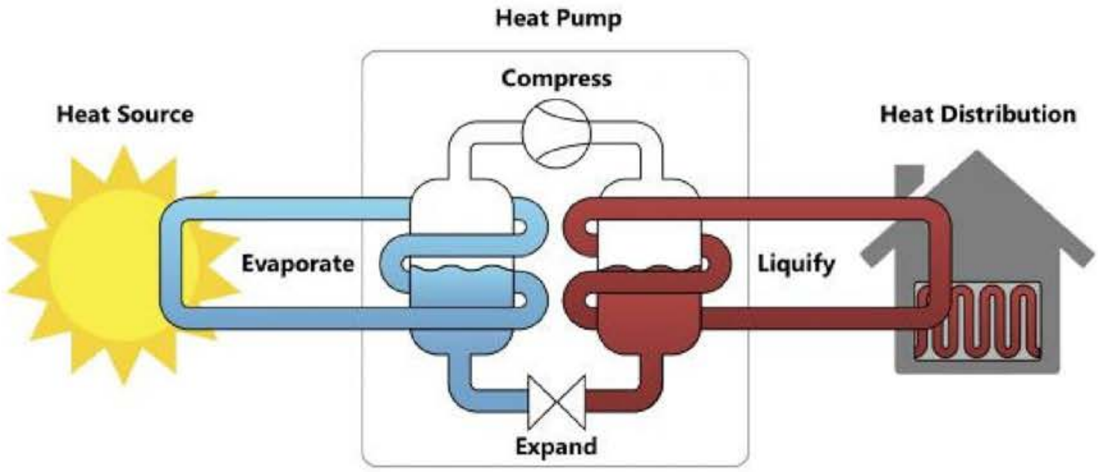

Photo Source : EPA

How does a heat pump work ?

A heat pump utilizes technology similar to that found in refrigerators and air conditioners. It extracts heat from various sources like the surrounding air, geothermal energy stored underground, water sources, or waste heat from industrial processes. By amplifying and transferring the extracted heat, it effectively meets heating requirements. Compared to traditional heating methods like boilers or electric heaters, heat pumps are significantly more efficient and cost-effective. They transfer heat rather than generating it, resulting in a higher output of heat energy relative to the electrical energy input. For instance, the coefficient of performance (COP) for a typical household heat pump is around four, indicating that the energy output is four times greater than the electrical energy consumed. This makes current models three to five times more energy-efficient than gas boilers. Heat pumps can also be integrated with other heating systems, often in hybrid configurations alongside gas systems.

What are the different types of heat pumps available ?

Heat pumps are often classified by their heat source (e.g., air-, water-, and ground-source) and thermal distribution method in the building (e.g., air for packaged rooftop units, water for hydronic heat pumps, and refrigerant for variable refrigerant flow solutions). The commercially classified heat pumps currently available are :

- Air-Source Heat Pumps: These are the most common and affordable type of heat pumps. They extract heat from the outdoor air and transfer it indoors during the winter for heating, and vice versa during the summer for cooling. Air-source heat pumps are easy to install and can be used in various climates, although their efficiency is affected in extremely cold regions. The equipment looks very similar to traditional air conditioning equipment.
- Ground-Source Heat Pumps (Geothermal) : These heat pumps utilize the stable temperature of the ground or a nearby water source as a heat exchange medium. They are installed with a well field or closed-loop equipment. The well field typically consists of a series of vertical boreholes drilled into the ground, while the closed-loop equipment involves a network of horizontal or vertical pipes buried underground. These systems enable the geothermal heat pump to extract heat from the ground during winter, transferring it indoors for heating purposes. Similarly, during summer, heat is extracted from the indoor air and released into the ground for cooling. Geothermal heat pumps offer remarkable energy efficiency and substantial cost savings over time. However, their installation process involves significant excavation and meticulous planning.
- Water-Source Heat Pumps: Similar to geothermal heat pumps, water-source heat pumps use a water body as a heat exchange medium. They extract heat from a water source, such as a lake or pond, for heating, and release heat into the water during cooling. Water-source heat pumps are more efficient than air-source heat pumps but less efficient than geothermal systems.
- Absorption Heat Pumps: Unlike conventional heat pumps that use compressors, absorption heat pumps use heat and a refrigerant to generate cooling or heating. These heat pumps are often fueled by natural gas, solar energy, or waste heat. Absorption heat pumps are primarily used in industrial and commercial applications due to their larger size and higher cost.

How will transitioning to heat pumps impact the building's utility bills?

Although heat pumps may have higher upfront costs compared to conventional systems, their energy efficiency and reduced operating expenses result in long-term cost savings. Evaluation of the benefits of a heat pump system is usually done on an individual building basis. Over the lifespan of a heat pump, the energy savings can offset the initial investment, leading to lower utility bills and improved financial sustainability for public buildings. By embracing heat pump technology, buildings can not only contribute to decarbonization but also realize significant cost savings in the long run.

How is the efficiency of heat pumps evaluated ?

The efficiency of a heat pump depends critically on the source of the heat. In winter, the ground and external water sources typically remain warmer than the ambient air, so ground source and water-source heat pumps consume less electricity than air-source ones, yielding a higher coefficient of performance (COP).

This is particularly the case in cold climates where defrosting the outside components of air-source heat pumps can consume additional energy. However, ground source heat pumps are more expensive to install, as they require an underground heat exchanger – a deep vertical borehole or a large network of pipes buried at least one meter below the surface of the ground. Connecting a water-source heat pump to a nearby river, groundwater or wastewater can also be costly.
For these reasons, ground- and water-source heat pumps are generally less common than air-source pumps. Worldwide, almost 85% of all heat pumps sold for buildings are air-source, as they require the least effort to be installed. Many of these are air-to-air units, while in heating-dominated regions air-to-water (or hydronic) units are growing in prevalence. Ground-source heat pumps and hybrid heat pumps that combine a heat pump with another heating source, like a gas boiler, are a small portion of global sales today, but make up a substantial share of the market in some countries.

What factors should be considered in comparing a heat pump to other types of heating systems?

Factors like efficiency, fuel availability and cost, climate compatibility, installation requirements, and environmental impact should be considered to make an informed decision when comparing a heat pump to other types of heating systems. Understanding these aspects will help determine the most suitable heating system for a specific application.

Efficiency: Assessing the efficiency of heating systems is crucial for energy savings and cost-effectiveness. Heat pumps are known for their high efficiency, as they transfer heat rather than generating it through combustion. Comparing the Coefficient of Performance (COP) of a heat pump to the Annual Fuel Utilization Efficiency (AFUE) of other systems, such as furnaces or boilers, provides insight into the energy efficiency of each system.

Fuel availability and cost: Consider the availability and cost of different fuel sources in the region. Heat pumps typically rely on electricity, which is widely available. However, the cost of electricity and other fuels like natural gas, oil, or propane can vary. Assessing the long-term price trends and availability of fuels helps evaluate the economic feasibility of various heating systems.

Climate Compatibility: The climate plays a significant role in determining the performance of heating systems. Heat pumps are highly efficient in moderate climates but may experience decreased efficiency in extremely cold regions. In such cases, supplemental heating may be required. Comparatively, combustion-based systems like furnaces and boilers are less affected by climate conditions.

What are the maintenance and servicing requirements for heat pumps ?

Proper maintenance plays a vital role in ensuring efficient operation for all heating and cooling systems, including heat pumps. Neglecting maintenance can result in a significant difference in energy consumption, ranging from 10% to 25%, between a well-maintained heat pump and one that is severely neglected. Therefore, it is crucial to prioritize regular maintenance activities to optimize energy efficiency and extend the lifespan of the heat pump.

Here is a general description of heat pump maintenance:

- Filters: Clean or replace air filters every 1-3 months to maintain efficient airflow and prevent dust accumulation.
- Coils: Regularly inspect and clean both the indoor evaporator and outdoor condenser coils to remove dirt, debris, and other obstructions. This enhances heat transfer efficiency.
- Refrigerant levels: Check refrigerant levels annually and adjust as necessary. Improper refrigerant levels can lead to reduced efficiency and potential damage to the compressor.
- Ductwork: Inspect ducts for leaks, gaps, or obstructions that can impair system efficiency. Seal any leaks and ensure proper insulation.
- Thermostat calibration: Verify that the thermostat is accurately calibrated to maintain desired temperatures and optimize energy consumption.
- Lubrication: If required, lubricate the system's moving parts, such as motors and bearings, according to the manufacturer's recommendations.
- Electrical components: Inspect electrical connections, wiring, and terminals to ensure they are secure and free from corrosion or damage.
- Outdoor unit: Keep the outdoor unit clear of debris, vegetation, and obstructions to allow adequate airflow.
- Professional inspection: Schedule annual maintenance by a qualified HVAC technician who can perform comprehensive system checks and address any potential issues.

Steps required while considering heat pump installation and whom to contact according to heat pump type

Steps for heat pump installation	Whom to Contact	Heat pump type
Sizing and heat pump system design		
On-site assessment of existing heating infrastructure and property insulation	General construction worker, heat pump installer	All
Heat losses and heating load calculations	Heat pump installer	All
Design, choice of materials and system layout	Heat pump installer	All
Pressure drop calculations, thermal conductivity assessment	Heat pump installer	All
Installation		
Trenching and drilling	Certified drilling professional	Ground-source
Pipe joining and plumbing	Plumber, pipefitter, heat pump installer	All
Handling refrigerants	Heat pump installer with F-gas certification Heat pump installer qualified to handle flammable materials	Systems with onsite F-gas refrigerant handling Systems with on-site hydrocarbon refrigerant handling
Electrical work		
Electrical wiring	Electrician, heat pump installer	All
System configuration		
Final system setup, refrigerant gas stabilization	Heat pump installer	All

Table from : The Future of Heat Pumps

Site Specific Requirements

Design Strategies
In the initial phase of building design, the design engineer seldom has sufficient information to render the optimum HVAC design for the project, and its space requirements are often based on percentage of total area or other rule of thumb. The final design is usually a compromise between what the engineer recommends and what the architect can accommodate. Total mechanical and electrical space requirements range between 4 and 9% of gross building area, with most buildings in the 6 to 9% range. This range includes space for HVAC, electrical, plumbing, and fire protection , as well as vertical shaft space for mechanical and electrical distribution through the building. For more information look into https://www.energy.gov/eere/buildings/zero-energy-buildings-resource-hub

Retrofit Strategies
Each heat pump system type can be more centralized or less centralized (more distributed). The direction to take depends partly on the technical difficulty of the transition and partly on the desired level of control by occupants and/or building owners and staff. A centralized system is more dependent on the building owners and staff, while a decentralized system is more dependent on occupants in the room. This dependence is both from a maintenance and a set point control/operations perspective.
For example, a hot water-heated building could replace the entire system with a central heat pump plant, which would be a similarly centralized system. This new system would require the building staff to maintain the central heat pumps and control the day-to-day operation of the heating system.
Alternatively, the building could decommission the hot water system, remove it, and install Packaged Terminal Heat Pumps(PTHPs) in each room, which would be a move from a centralized system to a decentralized system. The occupants of the building would have the day-to-day control of their heat pumps while building staff would be involved in more substantial work such as replacement and periodic maintenance.

Potential scenario at East Lansing : Retrofitting of Hannah Community Center

Photo by Caleb Kline

Retrofitting buildings with energy-efficient systems is a crucial step towards reducing carbon emissions and achieving sustainable operations. Before transitioning from fossil fuel based systems, there are certain energy efficient methods that can be implemented for better building performance. In the City of East Lansing Climate Sustainability Plan developed by the East Lansing Commission on the Environment, the projected energy reductions from the audit done on the Hannah Community Center building was 96,100 kWh/annually, resulting in an average savings of $7,150. Below are some recommendations that have been drawn after studying the existing conditions at Hannah Community center.

Envelope

Building envelope improvement for Hannah Community Center is crucial for enhancing the energy efficiency and thermal performance of the building. Below are some recommendations that can be implemented for adding insulation to the exterior walls:

Air Sealing around Doors and Windows:

- Replace existing weatherstripping around doors and windows to effectively seal gaps and prevent air leakage.
- Apply caulk to seal visible gaps or cracks around door frames, window frames, and other openings.
- Engage the services of a qualified contractor to inspect the exterior of the building thoroughly.
- Instruct the contractor to identify and seal any openings that compromise the airtightness of the building envelope.
- Be aware that abandoned mechanical penetrations, such as old flue pipes, are often sources of air leaks and should be sealed appropriately.

Exploring Exterior Wall Insulation Options:

- Consider implementing insulation improvements during interior renovations as an opportune time for the installation.
- Evaluate the construction of the walls to determine the feasibility of blowing insulation into the existing stud cavities.
- If viable, consult insulation professionals to assess the most suitable method for blowing insulation through strategically drilled holes in the interior surface of the walls.
- Adhere to recommended procedures and safety guidelines during the installation process to achieve desired insulation outcomes.

Roof Insulation Upgrade:

- When replacing the roof, prioritize increasing the insulation to meet the current code level. Consult local building codes and regulations to determine the required insulation R-value. Since East Lansing is Climate Zone 5 the ceiling R-value is 38.(Refer sections R502, R503 and R504 sections of 2015 Michigan Energy Code for further information)
- Select insulation materials that comply with the specified code requirements and are suitable for the roof structure.
- Install the chosen insulation material in accordance with the manufacturer's instructions and industry best practices.
- Ensure complete coverage of the roof surface, paying close attention to gaps, joints, and edges to minimize heat loss.

Schedules

To optimize energy efficiency and improve scheduling accuracy, it is important to follow these formal instructions regarding schedules when managing the automation system for the Hannah community center :

- Verify Occupancy Schedules for the Community Center:
- Ensure that the building automation system utilizes schedules to differentiate between occupied and unoccupied periods in the community center.
- During unoccupied hours, implement temperature setbacks to conserve energy and reduce unnecessary heating or cooling.
- Disable outside air ventilation during unoccupied hours, with the exception of the natatorium, where ventilation should remain operational.
- Upgrade Schedules for Sporadically Occupied Classrooms and Meeting Rooms:
- Enhance the building automation system's schedule for classrooms and meeting rooms that have irregular occupancy patterns.

- Sync the calendar used for room reservations with the building automation system to achieve accurate scheduling.
- Identify instances where the current system may have rooms set to occupied mode for extended periods, even when they are only sporadically used.
- Implement an upgraded system that synchronizes with the room reservation calendar, allowing the mechanical system to heat, cool, and ventilate the meeting room only during the reserved time slots. For example, if a meeting room is reserved from 10:00-11:30 AM and 2:00-4:00 PM on a Tuesday, the upgraded system should adjust the mechanical system to operate from 9:30 AM to 12:00 PM and 1:30 PM to 4:30 PM specifically for that Tuesday.

Variable Volume Pumps:

- Currently, constant volume pumps operate at a single speed at the community center. It is helpful to recognize that these pumps often run at full speed even when the building load is below the design maximum, resulting in wasted energy.
- Consider installing variable frequency drives (VFDs) on the pump motors to enable them to operate at lower speeds during periods of reduced demand. VFDs allow for better control of pump output, matching it to the actual building load and reducing unnecessary energy consumption.

Energy Recovery:

- When considering the pool dehumidification unit within the next year or two, it is worth exploring energy recovery options.The dehumidification process can be utilized to recover energy and use it to warm the pool water, enhancing energy efficiency.
- As air handling units are replaced, it will be helpful to assess the potential for incorporating energy recovery systems to precondition incoming outside air with energy from the exhaust air. Particularly, focus on spaces with significant ventilation requirements, such as the gym, meeting halls and kitchens, as they can benefit greatly from energy recovery.
- Note that energy recovery requirements may be dictated by local building codes depending on the specific space.(Look into ASHRAE 90.1-2013 for specific requirements.)

Options of Heat Pumps for upgrading from current systems at Hannah Community Center

It is essential to consider the environmental impact and sustainability goals of the Hannah Community Center. Reviewing the current conditions it is worth considering using heat pumps, which can efficiently produce temperatures closer to 115 °F to heat the building. By adopting heat pumps, the center can significantly reduce greenhouse gas emissions associated with traditional fossil fuel-based systems. Below are recommendations made for upgrading the existing systems at the community center.

<table>
<tr><th>Current System</th><th>Potential Upgrade</th><th>Benefits</th></tr>
<tr><td rowspan="2">
Current boilers have reached the end of their useful life and need upgrading in the next 2-3 years.</td><td>- Air Source Heat Pump System or a Ground Source Heat Pump System can be implemented to support the existing conditions
- If boiler systems are considered along with a heat recovery system higher energy efficiency can be achieved.</td><td>- Shift away from burning oil as an energy source and reduce carbon consumption.
- Possibility of integrating with clean electric energy.
- Energy conservation and potential cost savings. (BWL flats utility rates for peak hours)</td></tr>
<tr><td>- Heat exchanger installed from boiler water and domestic hot water. Energy recovery heat pump can be installed between chilled water and pool/domestic hot water.</td><td>- Energy will be saved and conserved as it gets exchanged between systems.
- If there is a plan to upgrade to a hybrid system, it will still be energy efficient.</td></tr>
</table>

Moving Forward

In April 2012, the City of East Lansing embraced a Climate Sustainability Plan to advance its eco-friendly initiatives. The plan highlights that based on recommended efficiency upgrades identified through energy audits, the City will develop a plan for implementing the highest energy and cost saving measures. The plan mentions the creation of an internal fund and/or tracking mechanism from utility savings realized from energy efficiency upgrades to fund energy efficiency projects for the 5 years after the completion of a project. The plan also mentions that all new equipment purchased must be ENERGY STAR compliant. The plan recommends implementation through the Commission on the Environment by drafting and working with Council to approve an Energy Star purchasing policy. It mentions that East Lansing Purchasing Department staff will only approve the purchase of Energy Star rated equipment for new office equipment purchases, unless approved by the Department Director.

From a policy perspective,transitioning to heat pumps as part of the decarbonization of public buildings in the United States especially in East Lansing offers numerous benefits, including reduced greenhouse gas emissions, improved energy efficiency, and lower utility bills.By embracing electrification, integrating renewable energy sources, and capitalizing on available incentives, public buildings of East Lansing can make a substantial positive impact on both the environment and their operational costs. It is crucial for stakeholders to collaborate, leverage funding opportunities, and prioritize the adoption of heat pumps to accelerate the decarbonization journey and build a sustainable future for public buildings in the US.

There needs be an alignment of decarbonization regulatory work across State and Local Agencies. The scale of transformation needed to eliminate building emissions will require a cohesive strategy across government. To maximize progress in meeting shared objectives, public utility commissions and other government bodies will need to align on a vision, clarify roles, and coordinate policies and programs.

The major challenges with retrofitting heat pump water heaters, from a design perspective are :

- Equipment Size : When designing a Heat Pump Water Heating(HPWH) system to match the previous heating capacity of the gas system, this usually results in more devices to provide the required amount of heating, and they are usually larger in size than gas boilers. In addition, centralized large HPWH systems require a lot more storage, so fitting the extra storage tanks and the heat pumps themselves in an existing mechanical room can be a challenge.
- Electrical capacity : The existing mechanical room electrical panels are sized for the electrical load of the boiler, and whatever miscellaneous loads are in this room, like lights and outlets, so often times a panel upgrade is needed, or one has to consider how many heat pumps can actually be installed based on the existing electrical capacity.

- Lower Heating Hot Water Temperature: It is important to evaluate the current heating hot water system. Currently the heating system heats the water to 180 °F in winter and 140 °F in summer. Reducing the winter heating temperature below 140 °F can significantly improve the efficiency of new condensing boilers. A feasibility report for assessing utilizing specific domestic hot water heat pumps to generate hotter water for domestic use has to be implemented. It would be necessary to evaluate the hot water coils in all heating equipment, including air handling units and VAV reheat coils, and replace them as necessary to accommodate the lower temperature requirements.

From a policy perspective :

- Fostering a Shared Vision among Diverse Stakeholders: Cultivating a collective vision is essential for cities and regions to engage a wide range of stakeholders in the pursuit of decarbonizing buildings. This involves forging collaborations and dialogue with various actors, while formulating a comprehensive, long-term policy framework that encompasses both public and private buildings.
- Formulating Effective Regulatory Frameworks for Building Decarbonization: To advance the decarbonization agenda, cities and regions should prioritize the development and implementation of robust regulatory frameworks. This entails enhancing the enforcement of mandatory building energy codes, establishing a clear roadmap for progressively stringent regulations, and piloting effective regulations specifically tailored to existing buildings.
- Implementing a Monitoring and Evaluation System for Policy Outcomes: It is crucial for cities and regions to evaluate the effectiveness of their policies aimed at decarbonizing buildings. This can be achieved by conducting a thorough assessment of the local policy landscape, while devising outcome-based indicators to track progress towards subnational targets. Such monitoring and evaluation schemes enable effective policy adjustments and ensure accountability in the decarbonization process.

Appendix

Heat Pump Retrofit Stakeholder Questions

General questions

1. What is your position and what are your responsibilities?
2. What does decarbonisation in East Lansing look like to you?
3. In your view, what would make a retrofitting of HVAC to Heat Pumps successful? What aspects of the current infrastructure present do you feel need improvement?
4. Are you aware of existing examples of communities that have done similar decarbonisation projects like East Lansing? What makes East Lansing unique in that aspect?

Site specific

1. How diverse are the needs of the sites ?
2. Looking at the uses of the existing uses of the site, which ones are the most critical and why ?
3. What are the areas of concerns that should be addressed while thinking about retrofitting at the sites?
4. Who do you see as the key partners and decision makers in the retrofitting process?
5. Are there blockers to success that should be looked out for?
6. What are the bottom line "must-haves"?

Technical

1. How old is the equipment? Which pieces will need to be replaced in what sequence?
2. What is the current heat distribution system? Similarly, what is the cooling distribution?
3. What are the current deficiencies with the HVAC system?
4. What sort of space is available and where? Will the equipment need to go on the roof? Is there extra available space outside? Is there space outside for ground source heat exchanger wells?
5. What are the deficiencies and what are the problems that people are facing currently in the building ?

Can you provide any words of advice?

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