Non-Residential Building Electrification Overview

October 14, 2021 Sustainability and Climate Action Plan Ad Hoc Committee

Summary

At the April 19th 2021 City Council meeting, Council directed staff to develop a plan for earlier adoption of non-residential electrification retrofits. There is significant decarbonization opportunity in the non-residential building sector, especially in buildings with mixed-fuel rooftop packaged units (RTUs). Although the retrofit costs of these units are only slightly higher compared to like-for-like replacements, there remain a number of barriers to the electrification of RTUs, including landlord-tenant split incentives, lack of awareness with efficient electric alternatives, and contractor's preference to recommend a like-for-like replacement that follows the same equipment specifications as the existing equipment. For water heaters and cooking equipment, there are additional electrification barriers including physical constraints and staff training. To date, the City has adopted an all-electric preferred reach code for non-residential new construction projects. However, given that new construction projects each year represent less than 1% of the total commercial floor area, the City will be launching new initiatives to facilitate voluntary electrification efforts in existing buildings and address the electrification barriers. Over the next six months, the Utilities Department will launch new non-residential electrification incentives and a Commercial Electrification Assistance Program to provide technical assistance to building owners and facility managers with electrification projects. Staff will also engage with key account customers to get their input on the City's Sustainability/Climate Action Plan (S/CAP). The City will also explore policy options that can effectively curb greenhouse gas (GHG) emissions; such policies will serve as a backstop to ensure that the City will meet its aggressive GHG emissions reduction goal.

Background/Market Assessment

City of Palo Alto Utilities provides natural gas services to 23,600 customer accounts, of which 22,000 (93%) are residential and 1,600 (7%) are non-residential. In multi-family buildings and commercial buildings, a gas master meter account often times serves multiple households or commercial tenants, so the actual number of households and businesses is higher than the number of accounts. Of the roughly 28 million therms of natural gas consumed within Palo Alto each year, residential usage represents about 45% while non-residential usage represents 55%. Gas usage by key account customers, or the top 50 largest non-residential customers, makes up about half of the non-residential gas consumption.

Based on 2019 Santa Clara County Assessor records, there are 2,330 non-residential parcels and 3,030 non-residential buildings in Palo Alto. Total non-residential floor area is around 29,000,000 sf. Non-residential buildings over 50,000 sf represent over 60% of the total commercial floor area.

Within California Climate Zone 4, in which Palo Alto is located, non-residential natural gas use consists of space heating (38%), water heating (35%), cooking (20%), process (6%) and miscellaneous (1%).[1]

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[1] 2006 California Commercial End User Survey, California Energy Commission.

Overview of Space Heating Technologies in Non-Residential Buildings

The space heating/cooling systems in non-residential buildings vary depending on the size of the building. The key functions of a heating, ventilation, and air conditioning (HVAC) system are to provide space heating, space cooling, dehumidification (20-50%) and ventilation to meet indoor air quality standards.

The most common HVAC system in small to medium commercial buildings in the Bay Area is a mixed-fuel packaged unit (also known as “gas-fired packaged unit”, or “gas pack” in short), which includes a direct expansion (DX) air conditioner system for space cooling and a gas furnace for space heating. Gas packs are typically mounted on the building rooftop, and therefore are also known as “rooftop units” (RTUs). For large commercial buildings with forced air distribution, a variable air volume (VAV) system that uses hot and cold water coils to control the temperature of the supply air is more commonly found. For these systems, the hot water is produced by a gas-fired boiler, and the cold water is supplied by an electrically-driven chiller system. Air is blown across hot and cold water coils to deliver desired temperature to different zones within the buildings.

Gas packs under 30 tons can be easily replaced with a packaged heat pump unit, with the latter system being all electric and can operate in both heating and cooling modes. It is straightforward to retrofit an existing gas pack with a packaged heat pump unit, as the footprint of both systems is similar. The equipment cost of a packaged heat pump system is estimated at 20% higher than a gas pack of the same capacity; the installation cost and maintenance cost for a packaged heat pump system are similar to that of a gas pack.

On the other hand, it is more difficult to retrofit a chiller-boiler system with a heat pump system. The temperature of hot water is around 170^{O}F in typical boiler systems. This temperature is difficult to achieve using heat pump systems, which typically produce hot water of up to 140^{O}F. HVAC engineers are currently testing the deployment of heat pump systems as a retrofit solution in buildings to determine whether the lower temperature hot water can meet the space heating load. If this is not possible in a particular building, multiple components within the HVAC distribution system such as the heat exchangers and the pumps for hot and cold water may need to be replaced.

Overview of Water Heating Technologies in Non-Residential Buildings

Water heating is the second largest gas consuming application, behind space heating. However, the amount of hot water usage in non-residential buildings can vary widely depending on the industry type of the building. Office and retail buildings typically have much lower hot water consumption; hotels and hospitals, on the other hand, have much higher hot water demand with peak usage periods. Domestic hot water systems are designed to meet the hot water needs of the occupants across the floors within the building and various fixtures.

The most common domestic hot water (DHW) systems are water heaters with storage tank. The hot water is maintained at a temperature at between 140^{O}F to 160^{O}F, then cooled by a thermostatic mixing valve to between 110^{O}F to 120^{O}F to avoid scalding. The high temperature of the water prevents the growth of Legionella bacteria and also ensures that demand for hot water can be met during peak periods. In a typical electric or gas-fired hot water heater, the heating and storage happens at the same place. There are systems where the storage tank is separate from the heat source; these are known as indirect water heater. In an indirect water heater, there is a main boiler to heat a fluid that is circulated through a heat exchange in the storage tank. The energy stored by the water tank allows the boiler to turn off and on less often, which saves energy. A secondary closed water loop is used as a source for heating water in the storage tank. The closed loop never comes in direct contact with the water in the storage tank, hence the name ‘indirect’ water heater Typical boilers with storage tanks have efficiencies around 80%. With condensing boilers[2], the efficiencies can go above 90%.

For buildings with low hot water use, tankless point-of-use water heaters are becoming increasingly popular where each faucet has a resistance-based heating coil that heats water on demand. Heat pump water heaters (HPWHs) with tank size up to 80 gallons are widely available. On the other hand, large scale HPWHs that can meet daily domestic hot water consumption of 500 gallons or more, are offered only by a few manufacturers; there are challenges to retrofitting existing buildings with these heat pump units as they require significant clearance in order to generate adequate heat from the surrounding air to heat water.

Proposed GHG Reduction Goal for Non-Residential Buildings

Staff proposed a GHG emissions reduction goal of 40% for non-residential buildings from the baseline by 2030. Given that non-residential new construction projects each year represent less than 1% of the existing building square footage, the bulk of these reductions will come from reduction in natural gas use in existing buildings. To achieve this aggressive GHG reduction goal from the non-residential building sector, virtually all mixed-fuel rooftop packaged units on commercial buildings will need to be replaced with all-electric systems. In addition, facilities over 25,000 square feet will need to achieve a minimum GHG emissions reduction of 20%.

To date, staff have only been able to identify strategies to reach GHG emissions reduction of 71% from the 1990 level by 2030. To achieve the remaining 9% emissions reduction by 2030 will require further studies to identify additional decarbonization opportunities in the buildings sector, especially in large commercial buildings. To inform this process, staff will be gathering intelligence on the age and type of HVAC and water heating systems as well as monitoring technology developments for electrification retrofits in large commercial buildings.

Key Barriers to Non-Residential Electrification

To date, staff has identified the following key barriers to electrification in existing non-residential buildings:

- **Retrofit costs:** The cost of retrofitting existing mixed fuel HVAC system with a heat pump alternative is about 20% higher than a like-for-like retrofit. While this cost increase is not prohibitive, most building owners would prefer going with the lowest cost replacement system, especially when the utility bill is paid by tenants and the building owner does not benefit from the bill savings. This split incentive has also been a barrier to energy efficiency retrofit in commercial buildings.
- **Reluctance to replace equipment before end of equipment’s useful life:** Most rooftop packaged units remain in place for 20 to 25 years. From a building owner perspective, it is cheaper to keep an old HVAC unit with ongoing maintenance than to replace the entire unit.
- **Lack of awareness/familiarity with efficient electric technologies:** Building owners rely on their contractors to recommend a replacement system when existing equipment are no longer operable, and contractors typically recommend a like-for-like replacement with the same specifications as the existing system.
- **Reluctance to install unfamiliar equipment:** Contractors are disinclined to recommend the replacement of an existing gas equipment with an electric alternative; they do not want to take the

[2] Condensing boilers extract the latent heat out of the exhaust by condensing the water vapor from the exhaust in a secondary heat exchanger, hence adding to the heat supplied to the water. This is the reason condensing boilers can have an Annualized Fuel Utilization Efficiency (AFUE) higher than 90%.

blame for recommending a product that has not been tried and true. Similarly, building owners want to ensure that the building's energy systems provide adequate comfort or meet the heating needs of the tenants; they'd rather not take the risk of installing unfamiliar equipment.

- **Physical space constraints:** The efficient operation of heat pump equipment requires sufficient space around the compressor to ensure adequate air flow for heat exchange. In buildings where the water heating and space heating equipment is located in a mechanical room, there may not be adequate space to meet the needs of heat pump equipment.
- **Capital constraints:** Building owners may not have the cash flow to pay for the upfront cost of electrification projects; access to incentives and financing options can help overcome this barrier.
- **Staff training for operations and maintenance**: Building owners may not want to invest in the staff training to operate a new building system or even an induction cooktop.

Roadmap to Reducing GHG emissions in Non-Residential Buildings

The most cost-effective way to reduce GHG emissions in the non-residential building sector is through the adoption of a reach code to mandate all-electric new construction projects. The 2019 Reach Code Cost Effectiveness study shows that all-electric office and retail buildings are cost effective compared to their mixed fuel counterparts[3]. Based on building permit record, the number of commercial new construction projects each year ranges from 5 to 13 between FY 2016 and FY 2019; this represents less than 1% of the number of commercial buildings within Palo Alto. The City will therefore need to consider strategies to reduce GHG emissions in existing non-residential buildings in order to meet its GHG reduction target.

An immediate opportunity is to target rooftop gas packs that were installed prior to 2000. Many of these units are near the end of life. As of January 2020, R-22, a refrigerant often used in HVAC equipment, is no longer manufactured or imported into the U.S. While recycled R-22 is still available, the cost will continue to increase due to declining supply. Older leaky HVAC units that need periodic recharging of refrigerants will need to be replaced, and it is important to ensure that these gas packs are replaced with heat pump systems instead of other gas pack systems.

The top priority therefore is to support voluntary electrification of rooftop gas packs installed prior to 2000. In fall 2021, the Utilities Department (CPAU) will be rolling out new incentives for commercial electrification projects covering HVAC, domestic hot water, commercial kitchen equipment as well as other gas end uses. The incentive levels are designed to close the cost gap between the electric equipment and its gas equivalent, and therefore lower or remove the cost barrier for electrification projects.

Over the next 6 months, CPAU plans to launch a non-residential building electrification program to provide technical assistance to support voluntary electrification in the non-residential building sector. The program will be marketed to building owners, property managers and contractors to promote the environmental, health, safety and resilience benefits of all-electric buildings. In addition, CPAU will engage with our key account customers, including the Palo Alto Unified School District, to learn about their sustainability objectives and plans, solicit their feedback on the City's proposed S/CAP goals, key actions and policies for the non-residential building sector, and collaborate in the development of their decarbonization plan. For City facilities, the Public Works Department will be conducting an Electrification Assessment as part of the City's Facility Condition Assessment. The assessment will inventory the City's gas-fired assets, including the age and estimate of remaining life of the equipment, identify efficient

[3] 2019 Non-residential New Construction Reach Code Cost Effectiveness Study, California Statewide Codes & Standards Program – Reach Code subprogram, July 25, 2019

electric alternatives and the necessary upgrades to support electrification, and develop a plan to achieve an 80% reduction in natural gas consumption at City facilities by 2030.

It would be unrealistic to rely on voluntary actions to achieve 100% electrification of commercial rooftop gas packs. Therefore, in parallel, the City will also begin exploring policies that can effectively curb GHG emissions. Some examples of such policies include an end-of-life electrification mandate for targeted non-residential gas equipment, a building emissions standard for non-residential buildings over 25,000 sq.ft., an on-sale electrification mandate for non-residential buildings, and an adoption of an end date for gas service. The combination of a programmatic approach to encourage building electrification, coupled with regulatory actions to provide backstop, is necessary to ensure that the non-residential GHG emissions reduction target is met.

List of Goals and Key Actions Related to Non-Residential Electrification

Below is a list of goals and key actions targeting non-residential buildings between 2021 and 2024. Please refer to the proposed S/CAP Key Actions and Three-Year Work Plan for the full list. Note that additional funding and resources will be needed to pursue these proposed key actions.

Goals:

- Electrify most mixed-fuel rooftop packaged HVAC units on non-residential buildings
- Reduce gas use in major facilities by at least 20%
- Seek additional opportunities for commercial and multi-family electrification

Key Performance Indicators:

- Number of rooftop packaged HVAC units electrified
- Percentage of gas use reduction in major facilities and City facilities

Key Actions:

- E2. Launch non-residential program services and incentives for electrification of non-residential gas-fired space heating, water heating and cooking equipment. Services may include technical assistance, vetted contractor list, on-bill financing, and/or direct install services.
- E5. Adopt an all-electric reach code for non-residential new construction projects.
- E6. Conduct an Electrification and Planning Assessment of City facilities, which will be used to develop a plan for electrification that results in an 80% reduction in natural gas usage at City facilities by 2030.
- E8. Adopt city ordinance to require energy, water and emissions benchmarking for commercial and multi-family buildings over 25,000 sq.ft.
- C2. Work with major employers to develop custom emissions reduction plans that address commute, building and other emissions on an employer by employer basis.
- C5. Present options for Council consideration to accelerate EV, Mobility, and Energy emissions reduction activities through mandates or price signals, such as emissions targets, carbon pricing, on-sale or replace-on-burnout ordinance, parking rules in public and private spaces, and withdrawal of gas by a date certain.