South Coast AQMD

2022 AIR QUALITY MANAGEMENT PLAN

Draft Policy Brief

Residential and Commercial Building Appliances

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

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PURPOSE AND OBJECTIVE

This is one of five briefing papers intended to provide policy background information supporting adoption and implementation of the 2022 AQMP. This paper specifically addresses building electrification in achieving the 2015 Ozone standard.

Combustion sources in residential and commercial buildings are one of the many sources of NOx emissions in the region. California state and local agencies are developing pathways to high levels of building electrification in order to achieve California's carbon neutrality goal by 2045. South Coast AQMD staff understands collaboration with other agencies is the key to achieving emission reductions in the building sector. Staff assembled a Residential and Commercial Buildings Working Group to provide input in the development of control measures for the Draft 2022 AQMP. This briefing paper describes the background on emission inventory, relevant technologies for building energy efficiency, regulatory approaches by state and local agencies, and the recommended approach the South Coast AQMD may pursue as part of the 2022 AQMP.

OVERVIEW OF RESIDENTIAL AND COMMERCIAL SECTOR IN THE BASIN

The South Coast Basin (Basin) is home to approximately 17 million residents, representing 44 percent of the California population, who reside in close to six million housing units and utilize commercial space for shopping, entertainment, and places of employment. Structures making up the residential and commercial spaces within the Basin differ widely in their periods of construction, size, purpose, and locations within different climate zones. These factors, along with income variations, regulations, ordinances, economic sectors, and tenant or owner occupancy rates result in differences in the amount of energy and other resources needed to support these structures. The consumption of energy within the residential and commercial sectors is both a direct and indirect source of criteria pollutants and greenhouse gas emissions.

Over 63 percent of the residential structures in the Basin were constructed before the 1979 California Title 24 building energy standards were enacted (Figure 1 from Southern California Association of Governments (SCAG) Pre-Certified Local Housing Data, August 2020). There are barriers to adopting energy and emission saving measures. One of barriers is for rental and leased properties (Figure 2 from U.S. Census Bureau/AmericanFactFinder). Property owners would lack an incentive to install appliances with advanced technologies as tenants would reap the operational cost savings.

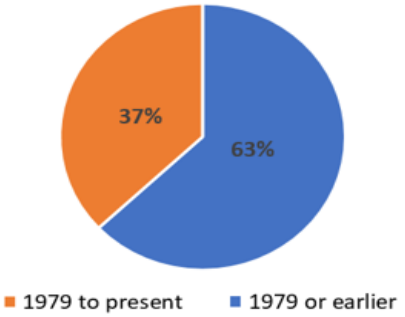


Figure 1

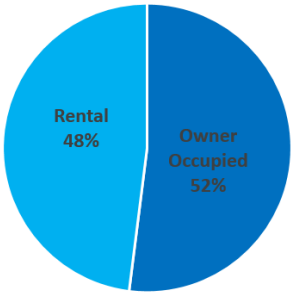
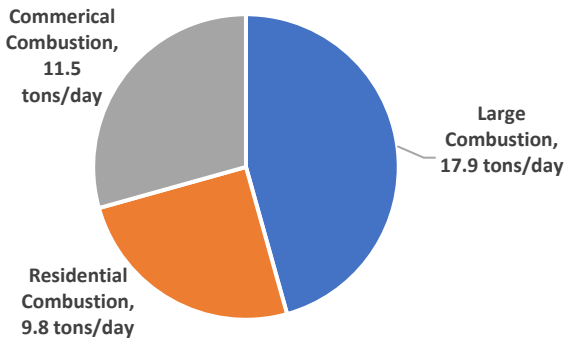


Figure 2

Some of these barriers have been reduced through regulations that require energy savings measures be employed within new construction, building retrofits, appliance energy standards, and incentive programs that help lower the capital cost barriers.



Total NOx: 39.3 tons/day

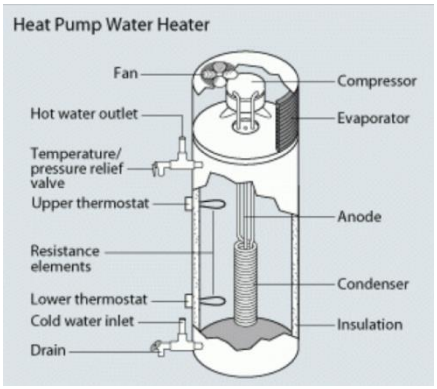
Figure 3

Residential and commercial buildings combustion sources include space and water heating, cooking, and other miscellaneous equipment, with emissions primarily from combusting natural gas. Those sources emit about 21.3 tons per day of NOx, constituting roughly 54 percent of 2037 NOx baseline emissions (Figure 3) from stationary and area sources, which is estimated to be approximately 39.3 tons per day.

OVERVIEW OF EMERGING TECHNOLOGIES FOR RESIDENTIAL AND COMMERCIAL

The primary emission sources of NOx in the residential and commercial sector are appliances for water and space heating, cooking, and others. The following discussion provides an overview of zero emission and low NOx technologies and the basis for the proposed residential and commercial building control measures in the Draft 2022 AQMP.

RESIDENTIAL WATER HEATING

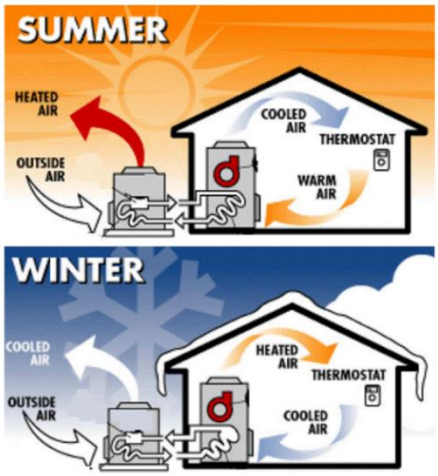


The primary zero emission residential water heating technology is an all-electric heat pump water heater. Development of heat pump water heaters involves expanding the number of available models, further improving unit energy efficiency, enhancing heat pump performance for colder weather, and developing a heat pump water heater that can operate from a 120-volt plug-in (residential standard). The low power 120-volt design can plug into existing wall outlets without requiring expensive panel upgrades and/or home rewiring that can be required for traditional heat pumps that require 240-volts, providing a more cost-effective solution for retrofit applications.

There are also low NOx water heating technologies, including fuel cell water heaters and gas heat pump water heaters. The South Coast AQMD has funded a fuel cell demonstration project in collaboration with the Gas Company. Residential fuel cells used for the generation of electricity and hot water have been commercially available in Europe since 2009. This technology is yet to be widely utilized in the United States market. The South Coast AQMD also funded a natural gas

heat pump water heater demonstration by Stone Mountain Technologies. These heaters are another lower NOx emission technology that use a natural gas fired engine, instead of electricity, to drive the heat pump compressor. This technology performs well in colder climates and would complement the use of all-electric heat pumps.

RESIDENTIAL SPACE HEATING



https://bertieair.com/maintain-hvac-efficiency-in-unpredictable-weather

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All-electric heat pumps for space heating and cooling offer an energy-efficient and zero emission alternative to natural gas furnaces. There are three types of heat pumps: (1) air-to-air, (2) water source, and (3) geothermal. The heat pump choice depends on whether the unit transfers heat between the building and outside air, water, or ground. The most common type is the air source heat pump. According to the United States Department of Energy, today's heat pump systems can reduce household electricity use for heating by approximately 50 percent compared to electric resistance heaters. High-efficiency heat pumps also dehumidify better than standard central air conditioners, resulting in less energy usage and more cooling comfort during the summer months. For homes without ducts, air source heat pumps are also available in a ductless version, referred as a split system. Heat pumps have been used for many years in nearly all areas of the United States and are even more energy-efficient and cost effective when utilized in warmer climate zones such as in the South Coast AQMD.

A new type of low NOx heat pump for residential systems is the absorption heat pump, also called a natural gas heat pump. Instead of using electricity to fuel the operation, a natural gas heat pump has a natural gas-fired engine to drive the heat pump compressor.

Current Rule 1111-compliant furnaces are certified to achieve a 14 ng/J NOx level; however, many of the compliant furnace models were tested below 10 ng/J for NOx emissions. Furthermore, lower NOx emission rates are expected as demonstrated by new burner development projects currently funded by the South Coast AQMD. For example, Lantec Products has completed the burner design, operational testing, and certification of residential condensing and non-condensing furnaces that emit less than 7 ng/J NOx. They are seeking to commercialize that burner in the near future. Low NOx space heating technologies would provide an alternative or off-ramp for situations when zero emission requirement is deemed infeasible. Examples include buildings in cooler climate zones or structures with special designs or functions.

RESIDENTIAL COOKING

Natural gas and electricity are the two main types of energy sources used in residential cooking. Gas cooking devices emit criteria pollutants such as NOx, particulate matter, and CO through

incomplete combustion and oxidation processes. In the South Coast Air Basin, over 75 percent of households use gas appliances for cooking, which accounts for about 11 percent of total residential combustion emissions in 2018. Pollutant emissions from residential cooking devices are not currently regulated by South Coast AQMD or any other agencies

The transition from conventional gas burners to zero and low-NOx emission technologies would improve both indoor and outdoor air quality. Electric and induction cooking devices that utilize electricity rather than gas offer the most reductions with no emissions on site and have been commercially available for years. Electric cooking devices include a coil or infrared heating element that generates heat by electric current and are often inexpensive due to their simple design. High efficiency induction cooktops do not have an open flame and transfer heat directly through magnetic cookware which minimizes heat loss to ambient air. Consequently, this reduces cooking times and NOx emissions and adds extra safety in food preparation.

Low NOx gas burners can also provide NOx reductions opportunities compared to conventional burners. Organizations such as the Lawrence Berkeley National Laboratory (LBL) have developed a low NOx Ring Burner that can be used for residential and commercial gas cooking devices, as well as other appliances such as water heaters and furnaces.

RESIDENTIAL OTHER COMBUSTION SOURCES

NOx emissions from other residential combustion sources are primarily generated by natural gas and liquefied petroleum gas (LPG) units that are not water heating, space heating, and cooking equipment. Those sources are varied, but primarily consist of swimming pool heaters, laundry dryers, and barbecue grills.

The emerging zero emission technology for heating pools is the swimming pool heat pump. Heat pumps used for heating pools transfer heat from the outdoors into the water. Heat pump pool heaters work efficiently as long as the outside temperature remains above the 45ºF–50ºF range. The warm climate of South Coast AQMD favors the application of pool heat pumps. As a pool heat pump works slower than a gas heater to heat the pool, it is better suited when a consistent pool temperature for a long period of time is desired. The most economical way to run this type of heater is to let the unit run automatically to keep “topping up” the heat.

The laundry market is composed of both gas and electric devices. Heat pump laundry dryers have been commercially available for years as a higher energy efficiency alternative to electric resistance heating models. However, the market presence of this technology remains low in the United States likely due to the higher cost. As noted in the 2013 Department of Energy’s study, under a demonstration project funded by the U.S. Department of Energy, a modified heat pump clothes dryer delivered 40 – 50 percent energy savings with 35 ºF lower fabric temperatures and similar drying times for regular loads. ENERGY STAR certified heat pump dryer models are available for the following brands: Asko, Beko, Blomberg, LG, Miele, Samsung, and Whirlpool.

The barbecue grill market is another area where zero emission technologies are commercially available. The Hearth, Patio & Barbecue Association conducted a study in 2013 that found 61 percent of users opted for gas barbecue grills and 10 percent of users owned electric barbecue grills according to www.statista.com. In 2018, gas barbecue grill sales in the United States amounted to about $1.32 billion. Hearth, Patio & Barbecue Association believes that the electric-grill market is expected to continue to grow at an average rate of seven percent a year[1].

COMMERCIAL WATER HEATING

For commercial buildings, the most common zero emission water heating technologies include an integrated heat pump with a water tank packaged as a single unit and a split heat pump water heater with a water tank that can be located as far as 50 feet apart. Most of the integrated heat pump water heaters are sized for residential and light commercial applications.

To date, commercial heat pump water heaters have not been deployed in substantial quantities due to their high cost. Heat pump water heaters generate both hot water and cool air; therefore, they can be used simultaneously for water heating and space cooling which can substantially offset their higher capital costs relative to a single function natural gas or an oil-fueled unit.

Another common zero emission water heating technology is the electric resistance water heating with storage. The 2019 cost effectiveness study for the new non-residential construction reach code[2] investigated several potential all-electric design options for commercial buildings. The study found that while heat pumps are more feasible for some commercial buildings, electric resistance water heating with storage is more feasible for other buildings.

The common low NOx water heating technologies include fuel cell water heaters and natural gas heat pump water heaters. Fuel cell technology for combined heat and power is an important commercial technology in some countries when supplying heat and power to a single large building or providing heat and power to a wide range of properties. Natural gas heat pump systems can provide space cooling, heating, and hot water for a wide range of buildings, from single family homes to commercial buildings; however, the most common application is commercial settings.

Lower NOx emissions could also be achievable based on the current burner technology with or without modification. Staff reviewed 181 source tests conducted in 2017-2021 for models

[1] https://www.theatlantic.com/science/archive/2021/07/grilling-emissions-environment/619394/

[2] https://sfdbi.org/sites/default/files/2019%20NRNC%20Cost-Eff-PublicDraft.pdf

certified to meet the 20 ppm NOx emissions of Rule 1146.2 and identified 50 models whose test results showed performance below 12 ppm.

COMMERCIAL SPACE HEATING

There are several ways to heat a commercial building. A common means of heating these buildings is a forced air furnace as part of roof top system. Commercial furnaces are generally larger with a higher BTU rating than residential furnaces as they typically provide heat for a larger space. Some commercial buildings use boilers for both space and water heating which are addressed separately under the commercial water heating control measure. Space heating furnaces with a rated heat input capacity between 175,000 and 2,000,000 BTU per hour that are mainly used in commercial buildings. These units are currently exempt from South Coast AQMD NOx rules but are addressed in the 2022 AQMP.

According to an Electrification Futures Study[3] conducted by the National Renewable Energy Laboratory (NREL) in 2012, electricity accounted for less than five percent of energy used for space heating in commercial buildings. Therefore, commercial space heating represents a substantial opportunity for electrification through the increased adoption and use of high efficiency electric heat pumps.

Heat pumps are the primary zero emission technology used in commercial applications. The building electrification movement and policies in California are sending a strong market signal, giving equipment manufacturers confidence regarding the demand for heat pumps for various building applications. Manufacturers are further expanding the technology profile to address special demands not only in the residential sector but also in the commercial sector. Nevertheless, the heat pump commercial market is not as mature as in the residential market. On this basis, the implementation for a zero NOx emission standard for space heating and cooling in commercial buildings would start later than that for residential buildings.

An alternative to the zero emission requirement would be low NOx technologies. The low NOx technologies include, but not are limited to, fuel cells, natural gas heat pumps that are scaled for commercial application, and lower NOx furnaces.

[3] Electrification Futures Study: A Technical Evaluation of the Impacts of an Electrified U.S. Energy System | Energy Analysis | NREL

COMMERCIAL COOKING

There are many different types of commercial cooking devices with a variety of designs, burner types, and energy usage. A Frontier Energy study for CEC indicated 70 percent of the 795,000 total primary cooking appliances identified in 2008-2009 were gas-fueled cooking appliances.[4] This study also identified nine major commercial cooking categories with both gas and electric options - braising pans, broilers, fryers, griddles, ovens, pasta cookers, ranges, steam cookers, and steam kettles - and thirty subcategories. In the South Coast Air Basin, commercial cooking accounts for about 7 percent of total emissions from commercial combustion sources in 2018.

Although Rule 1153.1 – Emissions of Oxides of Nitrogen from Commercial Food Ovens regulates NOx emissions from certain permitted food equipment, the majority of commercial cooking devices are not currently regulated by South Coast AQMD or any other agencies. Replacing existing gas burners with zero emission and low NOx appliances through future rule development and incentive programs can reduce emissions from commercial cooking devices.

Electric cooking devices and induction cooktops offer the most reductions with no emissions on site and have been commercially available for years. Electric cooking devices include a coil or infrared heating element that generates heat by electric current and are often inexpensive due to their simple design. High efficiency induction cooktops do not have an open flame and transfer heat directly through magnetic cookware which minimizes heat loss to ambient air. Consequently, this reduces cooking times and NOx emissions and adds extra safety in food preparation. Although electric options are available for most commercial cooking appliances, in some applications the use of electric cooking appliance may change taste, texture, appearance, and other qualities of the cooked food product.

Commercially available lower NOx burners include ribbon burners, radiant burners, in-shot burner technology, and modern power burners that can also provide NOx reductions compared to conventional burners. South Coast AQMD is funding two burner projects with the Gas Technology Institute (GTI) to develop, test, and demonstrate (1) a high efficiency and low NOx combo ribbon burner combustion system for commercial baking ovens and (2) two new low NOx deep fat fryer designs.

In addition, Lawrence Berkeley National Laboratory (LBL) has developed a low-NOx Ring Burner that can be used for residential and commercial gas cooking devices, as well as other appliances such as water heaters and furnaces. Additional research and development with an Original Equipment Manufacturer (OEM) are needed for the LBL Ring Burner to meet the American National Standards Institute (ANSI) cooktop standards for commercialization.

[4] California Energy Commission, "Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment" [CEC-500-2014-095] (2014).

STATE AND LOCAL AGENCY POLICIES

California state and local agencies are developing policies for appliances used in residential and commercial buildings, working towards a carbon neutral goal and concurrent NOx emission reductions. Building electrification, such as replacing natural gas water heaters, space heating furnaces, cooking tops, or laundry dryers with all-electric units, has become a key strategy.

CALIFORNIA ENERGY COMMISSION TITLE 24 ELECTRIC-READY REQUIREMENTS

The California Energy Commission (CEC) is the State's primary energy policy and planning agency. The 2022 Title 24 building code update that will be effective as of January 1, 2023, encourages inclusion of market-ready electric products in new construction, such as electric heat pumps for climate control and water heating. The standards require single-family homes to be electric-ready, including electrical circuits for space heating, water heating, cooking/ovens, and clothes dryers. The 2022 update also extends solar and introduces battery storage standards to building types such as high-rise multi-family (apartments and condos), hotel-motel, office, medical office, retail and grocery stores, restaurants, and schools.

CALIFORNIA AIR RESOURCES BOARD (CARB)

Based on the January 31, 2021 draft plan, CARB would develop and propose zero GHG emission standards for space and water heaters sold in California; CARB could also work with air districts to further tighten district rules to drive zero emission technologies. The draft plan proposes 100 percent sales of new space and water heaters (for either new construction or replacement of burned-out equipment in existing buildings) would meet zero emission standards beginning in 2030.

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Bay Area Air Quality Management District conducted a Public Workshop on October 7, 2021, for Regulation 9, Rule 4 – Nitrogen Oxides from Fan Type Residential Central Furnaces, and Regulation 9, Rule 6 – Nitrogen Oxides Emissions from Natural Gas-Fired Water Heaters. The draft amendments to those rules include the introduction of a proposed zero NOx emissions standard for natural gas-fired furnaces and water heaters. Staff is considering a longer-term compliance date of 2027 to 2031, depending on equipment type, use, and size.

CITY OF BERKELEY

In December 2019, Berkeley City Council approved the addition of a new Chapter 12.80 to the Berkeley Municipal Code prohibiting natural gas infrastructure in new buildings. The ordinance prohibits natural gas infrastructure, typically used to provide water and space heating, cooking, and other uses in new buildings of all types, residential and non-residential. It applies to any new building permits issued after January 1, 2020. The code includes pathways for either all-electric construction or mixed-fuel construction that exceeds the efficiency requirements of the Energy Code. It also extends solar photovoltaic system requirements for single family and low-rise residential buildings to also include nonresidential buildings, high-rise residential, and hotels/motels.

City of Berkeley Natural Gas Prohibition & Reach Code for Electrification

Planning and Development Department
Office of Energy and Sustainability

City of Berkeley
Existing Buildings Electrification Strategy

On November 30, 2021, Berkeley City Council adopted a plan to transition existing buildings in Berkeley from natural gas appliances to all-electric alternatives, focusing on low-rise residential buildings. The strategy includes an in-depth analysis of Berkeley's building stock, conducted with support from the Building Electrification Institute.

CALIFORNIA CITIES AND COUNTIES BUILDING ELECTRIFICATION POLICIES

According to an article by Sierra Club (July 22, 2021, California's Cities Lead the Way to A Gas-Free Future), over 50 California cities and counties have adopted building codes to support all-electric new construction, as part of their effort to help the State meet its binding climate target of reaching carbon neutrality by 2045. Among them, over 40 cities and counties mandate all-electric appliances for residential new buildings and some for commercial new buildings. Most of those cities are near the Bay Area.

On Friday, May 27, 2022, the Los Angeles City Council voted to ban most gas appliances and hookups in new construction which will require all new residential and commercial buildings in Los Angeles to be built to achieve zero-carbon emissions.

STATE AND LOCAL INCENTIVES

The Technology and Equipment for Clean Heating (TECH) Clean California, launched in December 2021, is a $120 million initiative designed to help advance the State's mission to achieve carbon neutrality by 2045. This will be done by driving the market adoption of low-emissions space and

THE SWITCH IS ON

water heating technologies for existing single and multi-family homes across California, which is a notable source of the State's carbon footprint. About 40 percent of the program benefits will be targeted towards low-income and disadvantaged communities. The initiative was developed as part of California Senate Bill 1477 and is funded by California gas corporation ratepayers under the auspices of the California Public Utilities Commission.

The City of Santa Monica's Office of Sustainability and the Environment is currently offering rebates for electrification of buildings by replacing existing gas equipment with electric equipment such as heat pump HVAC, heat pump water heaters, heat pump or condensing clothes dryers, service panel upgrades, and cooking devices. Rebates will only be issued for existing buildings, including single family residences, multi-family residences, and small businesses.

In December 2021, Southern California Edison applied for approval of its building electrification programs, proposing to reduce greenhouse gas emissions and improve indoor air quality in buildings through the installation of about 250,000 electric heat pumps across its service area. If approved by the California Public Utilities Commission, the overall plan would provide $677.2 million for programs to help accelerate the growth of the building electrification market over a four-year period.

South Coast AQMD's CLEANair Furnace Rebate Program was an incentive program that encouraged consumers to choose space heating products with less air polluting emissions. When it was first established in 2018, the incentives were for early implementation of lower NOx furnaces. The program was expanded in 2020 to incentivize all-electric heat pumps replacing gas furnaces with a set aside amount for those unit replacements in disadvantaged communities. The CLEANair Furnace Rebate Program could be utilized as a platform for future incentives in the residential and commercial sector.

BARRIERS TO IMPLEMENTING ZERO EMISSION APPLIANCES

Despite the great benefit and feasibility for the installation of zero emission appliances, there are some barriers to their implementation. First, with regards to the cost effectiveness for older buildings and affordability for disadvantaged communities, cost of replacing appliances could be a substantial barrier. While the upfront costs of zero emission appliances may be higher than the traditional natural gas units, the upfront cost will be even higher if an electrical upgrade is

required in an older building (e.g., pre-1979). For example, CEC's analysis for 2022 Title 24 development estimated an electric heat pump for residential space heating and cooling would require an additional purchase cost of $100 to $450. During the Rule 1111 rulemaking in 2020, electrical panel upgrades in older homes for heat pump installation was estimated to cost around $2000. The cost effectiveness calculated with the additional electrical panel upgrade cost for older buildings could be much higher than the threshold staff has been referencing in recent years during rulemaking to determine the feasibility. Even with the unit's lifetime operational cost savings, it may not be cost effective to implement zero emission appliances in some older buildings. A regulatory off-ramp could be considered in this situation. Relevant to consumer incomes, the affordability of zero emission appliances for disadvantaged communities could be a concern with the higher upfront cost. Incentive programs will play a key role in building electrification measures with an emphasis on prioritizing incentives for disadvantaged communities

Furthermore, the size and location of mechanical/plumbing areas, as well as other aspects of building layout, can significantly impact the feasibility for older buildings. CEC's Title 24 all-electric ready requirements recognized and provided exemptions for certain special design buildings. In addition, since the jurisdiction of the South Coast AQMD comprises more than one climate zone, feasibility for heat pumps in a cooler climate zone, such as the mountain communities, would be subject to special evaluation. Heat pumps face a challenge in colder climates where their capacity for providing heat and the efficiency of the equipment reduces as the outdoor temperature drops. Manufacturers are expanding their heat pump profiles to have a broader coverage. Staff will work with manufacturers and other stakeholders to understand the feasibility of current or future technologies on potentially challenging applications such as incompatible building layouts and cooler climate zones.

Lastly, for rental properties, property owners may not be as motivated to upgrade their building with zero emission appliances as tenants, instead of the property owners, are often responsible for utility costs and would benefit from the resulting utility savings. Staff will assess the need for incentives and other programs to motivate property owners to make the needed investment in advanced technologies. When the use of zero emission appliances is found to be infeasible, regulatory off-ramps (e.g., low NOx technologies) would be needed. Incentive programs and outreach activities would also be required to address some of the barriers and accelerate the zero emission appliance adoption.

SOUTH COAST AQMD'S PROPOSED APPROACH

The South Coast AQMD's approach for residential and commercial building control measures will be coordinating with local and state agencies to build upon existing programs. For both residential and commercial buildings, South Coast AQMD would develop and propose zero NOx emission standards for space heating, water heating, and cooking appliances for installation in

new buildings and replacement at the end of useful life for units in existing buildings. A transitional alternative of low NOx technologies would be allowed when installing a zero emission unit is determined to be infeasible.

The target of this regulatory approach is to implement zero emission technologies for 50 percent of the applicable sources and implement low NOx technologies for the remaining 50 percent by 2037. An in-depth analysis would be required during future rule development to determine when regulatory off-ramps should be provided. To implement zero emission technologies for 50 percent of the applicable sources by 2037, ten percent are estimated to be from new buildings and 40 percent from existing buildings. Implementation is projected to begin in 2029 for residential buildings and in 2031 for commercial buildings. With CEC's Title 24 code update for the readiness of new building electrification, the implementation for new buildings could occur earlier than existing buildings (in 2024).

CONCLUSION

Additional NOx emission reductions could be achieved with state and local incentive programs that have been launched or are being proposed. The South Coast AQMD's proposed incentives will also promote replacement with zero emission appliances in existing buildings with a focused on disadvantaged communities. The incentive approach would not only promote more participation in building electrification but also provide an opportunity to improve some of the inequities.

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