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WHITE PAPER

Proposed Ventilation and Energy Efficiency Verification/Repair Program for School Reopening

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This paper presents a proposal for a Ventilation and Energy Efficiency Verification/Repair Program that would prepare schools for reopening during the COVID-19 crisis and provide lasting improvements in indoor air quality. This program includes a procedure to verify school facilities have functioning heating, ventilation, and air conditioning (HVAC) systems and filtration systems that meet or exceed recommendations for reopening schools set forth by the World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC), and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), as well as any applicable local and state agency school reopening guidance. Providing adequate ventilation and filtration, however, can increase energy demand if not done correctly or where a system is already inefficient or poorly maintained. The program would also ensure that systems are operating efficiently and will identify recommendations for efficiency and safety upgrades.

This program would require recipients to (1) assess, maintain, adjust, and, if necessary, repair existing heating, ventilation and air conditioning (HVAC) systems to verify proper and efficient operation, as well as compliance with health and safety standards; (2) install carbon dioxide (CO_2) sensors in classrooms to verify that proper ventilation is maintained throughout the school year; and (3) prepare an HVAC Assessment Report documenting the work performed and identifying any additional system Testing, Adjusting and Balancing (TAB) requirements, upgrades, replacements or other measures recommended to improve health and safety, and/or efficiency of the HVAC system. School Facilities that comply with these requirements would be able to provide the final HVAC Ventilation Verification Report to students, parents, school personnel, and the public as a demonstration that adequate measures have been taken to ensure the HVAC system is operational and meets all applicable codes and standards.

State building codes generally specify minimum ventilation rates based on building occupancy type which are often based on the national ASHRAE standard "62.1-2019 Ventilation for Acceptable Indoor Air Quality". In California, the Building Energy Efficiency Standards requires minimum ventilation rates for classrooms, for which the current rates have been in place since 1992.[1] In California, The California Education Code requires school districts to maintain schools in good repair, including HVAC systems that are functional, supply adequate ventilation

[1] See Cal. Code Regs, tit. 24, Part 6, Section 120.1 and Table 120.1-A (Minimum Ventilation Rates).

to classrooms, and maintain interior temperatures within acceptable ranges.[2] Despite these requirements, significant research has demonstrated that poor performing HVAC systems and underventilation of classrooms continues to be a persistent problem in California.

A 2003 report to the Legislature by the California Air Resources Board and the State Department of Health Services found significant indoor air quality problems in California schools, including problems with ventilation, temperature and humidity, air pollutants, floor dust contaminants, moisture, mold, noise, and lighting. The report found that ventilation with outdoor air was inadequate during 40% of classroom hours and seriously deficient during 10% of classroom hours, in both portable classrooms and traditional classrooms.[3]

A 2020 report by the University of California-Davis Western Cooling Efficiency Center (WCEC) and the Indoor Environment Group of Lawrence Berkeley National Laboratory found over half of new HVAC systems in schools had significant problems within three years of installation, and that the vast majority of classrooms in California continue to fail to meet minimum ventilation rates.[4] Nearly 20% of classrooms had average daily maximum CO_2 concentrations above 2,000 ppm, where an adequately ventilated classroom should not exceed a concentration of 1,100 ppm. The researchers recommended periodic testing of HVAC systems and continuous real-time CO_2 monitoring to detect and correct these problems.

Looking beyond research conducted in California, a 2020 report by the United States Government Accountability Office (GAO) estimates that 41% of school districts need to update or replace the HVAC systems in at least half of their schools. This would represent approximately 36,000 schools requiring an update or replacement their HVAC systems. Per the report, "*If not addressed, HVAC issues can result in health and safety problems*."[5]

The persistence of underperforming HVAC systems and inadequate ventilation rates in the classroom is of particular concern as states and provinces look to reopen schools during the COVID-19 pandemic. An April 2020 paper by ASHRAE found that viruses such as COVID-19 can spread through the air in two ways. Larger droplets travel between 6 and 7 feet before dropping to the ground, but smaller droplets can evaporate and become aerosolized, remaining airborne for extended periods.[6] SARS-CoV-2 virus has been found within aerosols for 3 hours in

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[2] Cal. Education Code §§ 17070.75 & 17002.

[3] Whitmore, et al., California Portable Classrooms Study, Phase II: Main Study, Final Report, Volume II., Report to the California Air Resources Board and California Department of Health Services (2003) at pp. xxii & xxiii (https://ww2.arb.ca.gov/sites/default/files/classic//research/apr/past/00-317_v2.pdf).

[4] Chan, et al, Ventilation rates in California classrooms: Why many recent HVAC retrofits are not delivering sufficient ventilation, Building and Environment Journal 167 (2020) (https://www.sciencedirect.com/science/article/pii/S0360132319306365).

[5] *K-12 Education School Districts Frequently Identified Multiple Building Systems Needing Updates or Replacement* (Rep. No. GAO-20-494). (June 4th, 2020). United States Government Accountability Office. https://www.gao.gov/assets/710/707374.pdf

[6] ASHRAE, ASHRAE Position Document on Infectious Aerosols. ASHRAE (April 2020), (https://www.ashrae.org/file%20library/about/position%20documents/pd_infectiousaerosols_2020.pdf)

one study[7] and viable up to 16 hours in another study[8]. Additionally, 239 scientists have signed on open letter urging the WHO to recognize and mitigate the potential for airborne spread of COVID-19.[9] Increasing filtration levels and ventilation rates removes and dilutes these aerosolized viruses, reducing the risk of infection for occupants. For that reason, WHO[10], the CDC[11] and ASHRAE[12] recommend ensuring HVAC systems operate properly, increasing ventilation rates, and installing filters with a minimum efficiency rating value (MERV) of 13 or better where possible in order to reduce the spread of COVID-19. A May 2020 report by Dr. Jovan Pantelic at U.C. Berkeley further recommends continuous CO_2 monitoring and maintaining relative humidity in the range of 40%-60%.[13]

These steps can however increase energy consumption, particularly in systems that are already inefficient due to age, deferred maintenance or improper installation. Studies have shown that the efficiency of an HVAC system is highly dependent on the quality of its installation. Poor quality installation of HVAC systems results in a 20% to 30% increase in energy use.[14] Moreover, poor quality installation is pervasive. A study by the California Energy Commission found that over 50% of new HVAC systems and 85% of replacement HVAC systems that they evaluated were not performing correctly due to poor quality installation.[8] Utility-funded studies have found the vast majority of HVAC installers don't have the technical training, knowledge,

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[7] Van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, et al. Aerosol and surface stability of SARS-Cov-2 as compared with SARS-Cov-1. N Engl J Med. 2020;382:1564-7. https://www.nejm.org/doi/full/10.1056/nejmc2004973.

[8] Fears, A. C., Klimstra, W. B., Duprex, P., Hartman, A., Weaver, S. C., Plante, K. S....Roy, C. J. (June 22, 2020). Persistence of Severe Acute Respiratory Syndrome Coronavirus 2 in Aerosol Suspensions. *Emerging Infectious Diseases*, *26*(9), 2168-2171. https://dx.doi.org/10.3201/eid2609.201806

[9] Lidia Morawska, Donald K Milton, It is Time to Address Airborne Transmission of COVID-19, *Clinical Infectious Diseases*, , ciaa939, https://doi.org/10.1093/cid/ciaa939

[10] World Health Organization, Considerations for school-related public health measures in the context of COVID-19 (September 14, 2020) (https://www.who.int/publications-detail/considerations-for-school-related-public-health-measures-in-the-context-of-covid-19); World Health Organization, Considerations for public health and social measures in the workplace in the context of COVID-19 (May 10, 2020) (https://www.who.int/publications-detail/considerations-for-public-health-and-social-measures-in-the-workplace-in-the-context-of-covid-19); World Health Organization, Q&A: Ventilation and air conditioning in public spaces and buildings and COVID-19 (July 29, 2020) https://www.who.int/news-room/q-a-detail/q-a-ventilation-and-air-conditioning-in-public-spaces-and-buildings-and-covid-19

[11] Centers For Disease Control and Prevention, Operating schools during COVID-19: CDC's Considerations (February 3, 2021) https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/schools.html; Centers For Disease Control and Prevention, Interim Guidance For Businesses and Employers Responding To Coronavirus Disease 2019 (COVID-19) (January 4, 2021) (https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-business-response.html)

[12][12] ASHRAE, ASHRAE Epidemic Task Force: Building Readiness (February 1, 2021) (https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-building-readiness.pdf); ASHRAE, ASHRAE Epidemic Task Force: Core Recommendations for Reducing Airborne Infectious Aerosol Exposure (January 6, 2021) (https://www.ashrae.org/file%20library/technical%20resources/covid-19/core-recommendations-for-reducing-airborne-infectious-aerosol-exposure.pdf); ASHRAE, ASHRAE Epidemic Task Force: Schools & Universities (October 7, 2021) (https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-reopening-schools-and-universities-c19-guidance.pdf);

[13] Pantelic, Using IoT Environmental Sensing to Reopen Spaces, SenseWare (May 2020) (https://cdn2.hubspot.net/hubfs/5238584/White%20Paper%20Senseware%20Covid.pdf).

[14] California Energy Commission, *Strategic Plan to Reduce the Energy Impact of Air Conditioners* (June 2008), CEC-400-2008-010, at p. (v) (http://www.energy.ca.gov/2008publications/CEC-400-2008-010/CEC-400-2008-010.PDF); see also Zabin, et. al, *Workforce Issues and Energy Efficiency Programs: A Plan for California's Utilities*, Don Vial Center for Employment in the Green Economy (2014), at pp. 32-34 and Appendix 2B (http://laborcenter.berkeley.edu/workforce-issues-and-energy-efficiency-programs-a-plan-for-californias-utilities/).

skills, or abilities to properly install systems, resulting in high failure rates for job performance on even routine tasks.[15]

This program would prepare schools to reopen with functional ventilation systems that are verified as having been tested, adjusted, and if necessary repaired or replaced, by qualified personnel in order to provide recommended ventilation rates as reliably and energy efficiently as possible. Ventilation rates will be documented in an HVAC Assessment Report submitted to the program administrator and available to the public upon request.

Improving the performance of school HVAC systems not only saves energy and provides a safer and healthier building environment, it also has a significant correlation to student performance. In a 2017 literature review, W. J. Fisk summarized that 8 studies reported statistically significant improvements in some measures of student performance associated with increased ventilation rates or lower CO_2 concentrations, with performance increases up to 15%.[16]

A 2018 report in the Environment International Journal found that short-term CO_2 exposure beginning at 1000 ppm affects cognitive performance, including decision making and problem resolution.[17] The Wisconsin Department of Health states that CO_2 levels between 1000 and 2000 ppm are associated with drowsiness and attention issues. CO_2 levels above 2000 ppm affect concentration and can cause headaches, increased heart rate, and nausea.[18]

This program will thus also provide the additional benefit of addressing the numerous studies finding that the widespread underventilation of classrooms is negatively impacting student health and learning.

[15] SCE Energy Efficiency Business Plan 2018-2025 at p. 63; SDG&E Energy Efficiency Business Plan 2018-2025 at p. 216; PG&E Energy Efficiency Business Plan (2018-2025), Residential Appendix at p. 30; see also C. Zabin, et. al, *Workforce Issues and Energy Efficiency Programs: A Plan for California's Utilities*, Don Vial Center for Employment in the Green Economy (2014), at p. 34 (http://laborcenter.berkeley.edu/workforce-issues-and-energy-efficiency-programs-a-plan-for-californias-utilities/).

[16] Fisk, W. J., The ventilation problem in schools: literature review, Indoor Air. 2017;27:1039–1051 (https://onlinelibrary.wiley.com/doi/epdf/10.1111/ina.12403)

[17] Azuma, et al, Effects of low-level inhalation exposure to carbon dioxide in indoor environments: A short review on human health and psychomotor performance, Environment International 121 (2018) (https://www.sciencedirect.com/science/article/pii/S0160412018312807).

[18] Wisconsin Department of Health Services, Carbon Dioxide (Dec. 20, 2019) (https://www.dhs.wisconsin.gov/chemical/carbondioxide.htm).

PROPOSED REQUIREMENTS:

School Ventilation and Efficiency Verification and Repair Program. The appropriate state or province agency shall create and administer a School Ventilation and Efficiency Verification and Repair Program that shall allocate grants to Local Educational Agencies (LEAs) to prepare schools to reopen with functional ventilation systems that are tested, adjusted, and if necessary repaired, by qualified personnel in order to provide recommended ventilation rates as reliably and energy efficiently as possible. Recipients shall: (1) assess, maintain, adjust, and, if necessary, repair existing HVAC systems to ensure ventilation rates meet or exceed the standards set forth in ASHRAE 62.1-2019 Ventilation for Acceptable Indoor Air Quality, Table 120.1-A of the 2019 Title 24 California Building Energy Efficiency Standards, or current locally adopted Mechanical Code; (2) provide MERV 13 filtration or better where feasible, or the maximum MERV filtration compatible with the system design and airflow requirements; (3) install CO_2 sensors in classrooms as an indication that proper ventilation is maintained throughout the school year; and (4) prepare an HVAC Ventilation Verification Assessment Report documenting the work performed and identifying any additional system balancing, upgrades, replacements or other measures recommended to improve the health, safety, and/or efficiency of the HVAC system. School facilities that comply with these requirements shall provide the final Ventilation Verification Report to students, parents, school personnel, and the public as a demonstration that adequate measures have been taken to ensure the HVAC system is operational and meets all applicable codes and standards.

An LEA that accepts a grant under this Program for verification of a school facility shall perform all of the following tasks for all air handling units, exhaust units, roof top units and unitary and single zone equipment in that facility:

Assessment, Maintenance, Adjustment and Repair of Existing Facility Ventilation System.

1. Filtration. Consistent with the recommendations of the ASHRAE Guidance for Reopening Schools and Universities, MERV 13 or better filtration shall be installed in the facility's HVAC system where feasible. Qualified Testing Personnel shall review system capacity and airflow to determine the highest Minimum Efficiency Reporting Value (MERV) filtration that can be installed without adversely impacting equipment, shall replace or upgrade filters where needed, and shall verify that such filters are installed correctly. Recommendations for additional maintenance, frequency of filter replacement, replacement or upgrades to allow for more protective filtration shall be recorded in the HVAC Assessment Report.

2. Ventilation and Exhaust. Following the assessment of the filtration, Qualified Testing Personnel shall assess the ventilation rates in the facility classrooms, auditoriums, gymnasiums, nurses' offices, restrooms, and other occupied areas to determine whether they meet the minimum ventilation rate requirements set forth in ASHRAE 62.1-2019 Ventilation for Acceptable Indoor Air Quality, Table 120.1-A of the 2019 Title 24 California Building Energy Efficiency Standards, or current locally adopted Mechanical Code. Assessment shall include:

(i). Calculation of the required minimum outside air ventilation rates for each occupied area based on the anticipated occupancy and the minimum required ventilation

rate per occupant set forth in ASHRAE 62.1-2019 Ventilation for Acceptable Indoor Air Quality, Table 120.1-A of the 2019 Title 24 California Building Energy Efficiency Standards, or current locally adopted Mechanical Code. Calculations shall be based on maximum anticipated classroom or other occupied area occupancy rates and determined by the performing technician.

(ii). Measurement of Outside Air per Section B of NRCA-MCH-02-A – Outdoor Air Acceptance[19] and verification of whether the system provides the minimum outside air ventilation rates calculated in subsection (i).

(iii). Verification of coil velocities and unit discharge air temperatures required to maintain desired indoor conditions and to avoid moisture carry over from cooling coils.

(iv). Verification that separation between outdoor air intakes and exhaust discharge outlets meet code requirements.

(v). Confirmation that the air handling unit is bringing in outdoor air and removing exhaust air as intended by the system design.

(vi) Measurement of all exhaust air volume for exhaust fans, including restrooms. Document any discrepancies from system design.

(vii) Energy Recovery Ventilation (ERV) system operation and leakage concerns should be addressed according to the recommendations of the ASHRAE Building Readiness document[20].

3. Economizer. For systems with economizers, Qualified Testing Personnel shall test system economizer dampers per Section B of NRCA-MCH-05-A – Air Economizer Controls[21] and repair any economizer dampers and controls that are not properly functioning. Recommendations for additional maintenance, replacement or upgrades shall be recorded in the HVAC Assessment Report.

4. Demand Control Ventilation.
If installed, Demand Control Ventilation (DCV) systems shall be verified for proper operation. The ASHRAE Epidemic Task Force recommends that DCV systems be disabled during the COVID 19 pandemic. However, an alternative option is to lower the CO2 setpoint of the DCV system to 750 ppm, as recommended by the WCEC[22], which will provide additional ventilation while still saving energy during reduced occupancy periods.

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[19] State of California, California Energy Commission. (01/20). OUTDOOR AIR ACCEPTANCE - CEC-NRCA-MCH-02-A (Vol. 2019, p. 2). CA. https://energycodeace.com/download/39543/file_path/fieldList/2019-NRCA-MCH-02-A%20Outdoor%20Air.pdf

[20] ASHRAE, ASHRAE Epidemic Task Force: Building Readiness (February 1, 2021) (https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-building-readiness.pdf);

[21] State of California, California Energy Commission. (01/20). Air Economizer Controls Acceptance - CEC-NRCA-MCH-05-A (Vol. 2019, p. 2). CA. https://energycodeace.com/download/39547/file_path/fieldList/2019-NRCA-MCH-05-A-AirEconomizerControls.pdf

[22] The CO_2 set point of 750 ppm is recommended by the UC Davis Western Cooling Efficiency Center. A setpoint of 750 ppm will approximately double the ventilation provided when compared to a typical setpoint of 1,000-1,100 ppm.

If the demand control ventilation cannot maintain average daily maximum CO_2 levels below 1,100 ppm, it shall be disabled until the DCV system can be repaired, unless disabling the control would adversely affect operation of the overall system. When disabling a demand control ventilation system, the system must be configured to meet the minimum ventilation rate requirements and tested and adjusted in accordance with section 2.

DCV systems shall be tested by per Section B of NRCA-MCH-06-A – Demand Control Ventilation Systems Acceptance[23]. Recommendations for additional maintenance, replacement or upgrades shall be recorded in the HVAC Assessment Report.

5. Air Distribution and Building Pressurization

(i). Survey readings of inlets and outlets to verify all ventilation is reaching the served zone and that there is adequate distribution. Verify if inlets and outlets are balanced within tolerance of the system design. Document measured values and deficiencies. If the original system design values are not available, document available information and note unavailability of system design values in the HVAC Assessment Report.

(ii). Verification of building and space pressure to ensure:

a. Pressure differential is within tolerance of design.
b. Building is not over pressurized.
c. Contaminant rooms to be temporarily occupied by sick students or staff, maintain a negative pressure, as designed.

6. General Maintenance. Qualified Testing Personnel or a Skilled and Trained Workforce shall verify coil condition, condensate drainage, cooling coil air temperature differential (entering and leaving dry bulb), heat exchanger air temperature differential (entering and leaving dry bulb), and drive assembly. Recommendations for additional maintenance, replacement or upgrades shall be recorded in the HVAC Assessment Report.

7. Operational Controls. Qualified Testing Personnel shall review control sequences to verify systems will maintain intended ventilation, temperature and humidity conditions during school operation. Verify a daily flush is scheduled for 3 changes of building volume using outdoor air as demonstrated by a calculation of flush times per ASHRAE Guidance for Building Readiness or otherwise applicable local or state guidance.
Verify that HVAC system operational times (occupied hours and flush times), exhaust fans operation times, setpoints, and enabled features meet ASHRAE Guidance for Reopening and Operating Schools and Buildings or otherwise applicable local, state, or provincial guidance.

8. CO_2 Monitoring. As an indicator of proper ventilation throughout the school year, all classrooms shall be equipped with a CO_2 monitor that:

[23] State of California, California Energy Commission. (01/20). Demand Control Ventilation Systems Acceptance - CEC-NRCA-MCH-06-A (Vol. 2019, p. 2). CA. https://energycodeace.com/download/39548/file_path/fieldList/2019-NRCA-MCH-06-A-DemandControlVentilation.pdf

(i) Is hard-wired or plugged-in and mounted to the wall between 3 – 6 feet above the floor and at least 5 feet away from the door and operable windows.

(ii) Displays the CO_2 readings to the teacher through a display on the device or other means such as a web-based application or cell-phone application.

(iii) Notifies the teacher through visual indicator on the monitor (e.g., indicator light) or other alert such as e-mail, text, or cell phone application, when the CO_2 levels in the classroom have exceeded 1,100 ppm.

(iv) Maintains a record of previous data which includes at least the maximum CO_2 concentration measured.

(v) Has a range of 400 - 2000 ppm or greater.

(vi) Is certified by the manufacturer to be accurate within 75 ppm at 1,000 ppm CO_2 concentration and is certified by the manufacturer to require calibration no more frequently than once every five years.

If a classroom CO_2 concentration exceeds 1,100 ppm more than once a week as observed by the teacher or the facilities staff, the classroom ventilation rates shall be adjusted by Qualified Adjusting Personnel to ensure peak CO_2 concentrations in the classroom remain below the maximum allowable CO_2 PPM setpoint. Verification of the installation of CO_2 Monitors in all classrooms shall be included in the HVAC Assessment Report.

10. Limited or No Existing Mechanical Ventilation. In cases where there is limited or no existing mechanical ventilation, the assessment would then focus on available options and provide the design professional with documentation to provide ventilation options with limited assumptions.

(i) Verify the functionality and document nameplate data on any existing HVAC equipment (i.e., heating only units, exhaust fans, etc.)
(ii) Verify and document the location of windows and doors that can be opened.
    a. Verify if windows have any switches or controls that initiate exhaust fans, motorized dampers or other devices.
(iii) Verification or installation of the CO_2 sensor per section 8.
(iv) Collection of the following information, in addition to any information requested by a design professional to evaluate options for adding mechanical ventilation.
    a. Verify existing mechanical, architectural, structural drawings match current conditions.
        i. Provide a sketch of actual roof penetrations, penetration type (i.e., vent pipe) and approximate locations if different from drawings.
    b. Document locations of any vents could contaminate Outside Air (OSA) intake locations.
    c. Document locations for potential installation of mechanical ventilation

d. Photograph existing building, existing mechanical equipment (if applicable) and potential locations for mechanical ventilation equipment.
e. Document roof and wall type/material to the best of the technician's ability.
f. Document if existing mechanical equipment can be altered to provide outside air (OSA) or if a Dedicated Outside Air System (DOAS) is required.
g. Obtain information on central plant capacity (if applicable)
h. Document whether outside air conditions may make reliance on windows or other sources of non-filtered outside air potentially hazardous to occupants.
i. Document recommendations for adding mechanical ventilation and filtration where none currently exists or for replacing a mechanical ventilation system where the current system is non-operational or is unable to provide recommended levels of ventilation and filtration.

9. HVAC Assessment Report. Qualified Testing Personnel shall prepare an HVAC Assessment Report for each school facility. The HVAC Assessment Report shall include the following information:

(i) Name and address of school facility and person/contractor preparing and certifying Report.

(ii) Description of assessment, maintenance, adjustment and repair activities and outcomes.

(iii) Document HVAC equipment model number, serial number, general condition of unit, and any additional information that could be used to assess replacement and repair options given potential for increased energy efficiency benefits.

(iv) Verification that all requirements of the program have been satisfied.

(v) Either verification that MERV 13 filters have been installed or verification that the maximum MERV-rated filter that the system is able to effectively handle has been installed and what that MERV-rating is.

(vi) The verified ventilation rates for facility classrooms, auditoriums, gymnasiums, nurses' offices, restrooms, offices, and other occupied areas and whether those rates meet the requirements determined in Section 2. If ventilation rates do not meet requirements in Section 2, then an explanation for why the current system is unable to meet those rates should be provided.

(vii) The verified exhaust for facility classrooms, auditoriums, gymnasiums, nurses' offices', restrooms, and other occupied areas and whether those rates meet the requirements determined in Section 2.

(viii) Clearly define system deficiencies and provide recommendations for additional maintenance, replacement, or upgrades, such as upgrading systems to allow for additional ventilation and filtration and/or to improve energy efficiency.

(ix) Reports shall clearly document initial operating verifications, adjustments and/or repairs, and final operating verifications.

(x) Verification of installation of CO_2 Monitors, including make and model of monitors.

The HVAC assessment report must verify that all work has been performed by qualified personnel, including the provision of the contractor's name and license, acceptance test technician name and certification number (where applicable), TAB technician name and certification number (where applicable) and verification that all construction work has been performed by a skilled and trained workforce.

The LEA shall maintain a copy of the HVAC Assessment Report and make it available to any member of the public upon request.

10. Design Professional Review. A design professional shall review the assessment report and determine what, if any, additional adjustments, or repairs would be necessary to meet the minimum ventilation and filtration requirements, determine whether any cost-effective energy efficiency upgrades or replacements are warranted or recommended.

Factors to determine HVAC replacements and upgrades:

- Consider the general condition of the unit and the cost to repair the unit versus cost to replace. Consider equipment service life and maintenance costs with the ASHRAE Service Life and Maintenance Cost Database. [24] Replacement costs should consider potential energy savings.
- Consider energy usage over life of unit by a comparison of the unit's Seasonal Energy Efficiency Ratio (SEER) to that of potential replacement options.[25]
- Improper airflow and temperature differentials determined in the assessment should be diagnosed as they signal reduced energy efficiency.[26]
- Units containing R-22 refrigerant or has a history of refrigerant leaks to be considered for replacement.
- Units with manual thermostats shall be upgraded to programmable thermostats.
- Units without a functional economizer to be considered for repair or economizer upgrade.
- Units with indoor fan motors not meeting the NEMA Premium Efficiency Electric Motor standard should be considered for a replacement with a NEMA Premium Efficiency Electric Motor.
- Units with a Fixed Orifice (FXO) to be considered for replacement with a unit with a Thermostatic Expansion Valve (TXV).

[24] "ASHRAE: Service Life and Maintenance Cost Database." *ASHRAE*, http://xp20.ashrae.org/publicdatabase
[25] 2017 Standard for Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment. AHRI, 2017.
[26] Kim, Woohyun and Braun, James E., "Impacts of Refrigerant Charge on Air Conditioner and Heat Pump Performance" (2010). International Refrigeration and Air Conditioning Conference. Paper 1122.
http://docs.lib.purdue.edu/iracc/1122

11. Repairs and Adjustment. If installed HVAC systems or system components fail to meet minimum ventilation requirements, as determined in Section 2 – Ventilation and Exhaust, corrective work shall be prioritized for further funding. Additionally, buildings with limited or no mechanical ventilation shall be prioritized for funding.

All repairs or installation of upgrades or replacements shall be performed by a Skilled and Trained Workforce.

Qualified Personnel Definitions

Certified Testing, Adjusting and Balancing (TAB) Technician. A technician certified to perform testing, adjusting, and balancing of HVAC systems by the Associated Air Balance Council (AABC), the National Environmental Balancing Bureau (NEBB), or the Testing, Adjusting and Balancing Bureau (TABB).

Design Professional. A licensed mechanical engineer, certified industrial hygienist (CIH), or mechanical design professional as defined by state or provincial guidelines.

Qualified Adjusting Personnel. Qualified Adjusting Personnel shall either be: (1) a Certified TAB technician; or (2) a skilled and trained workforce under the supervision of a certified TAB Technician.

Qualified Testing Personnel. Qualified Testing Personnel shall either be: (1) a certified TAB technician.; or (2) a person certified to perform ventilation assessments of heating, ventilation, and air conditioning system as a technician through a program accredited by ANSI under the ISO/IEC 17024 standard.

Skilled and Trained Workforce. A skilled and trained workforce is a workforce in which at least sixty percent of the workers are graduates of a registered apprenticeship program, in state or province for which the work is being performed, for the applicable construction occupation.

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