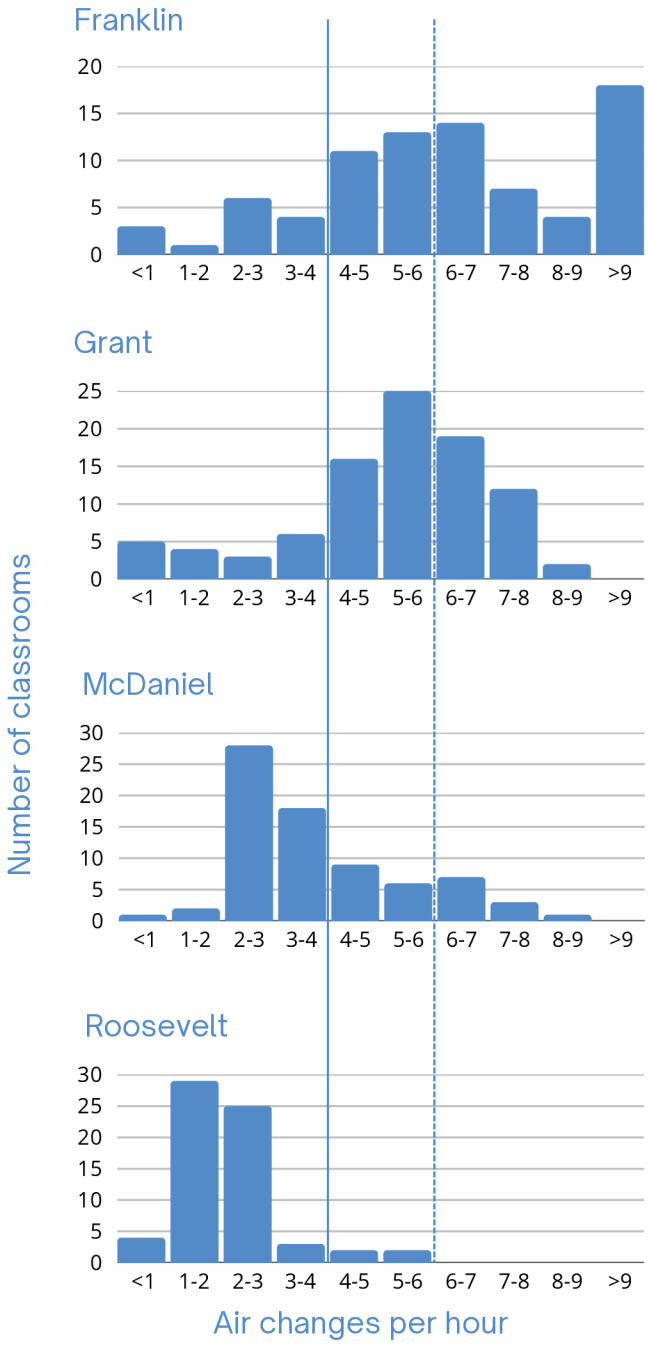
Lessons from modernized schools to guide PPS's clean air plan:
6 air changes is a reachable target in future modernizations and new schools

Portland Public Schools is capable of reaching truly great airflow targets. The superintendent's office and the school board meeting room, for example, get 7.5 and 13.4 air changes per hour from the HVAC system in the central office. These spaces also have or were assigned two air purifiers in addition to the airflow provided by the HVAC, boosting their air change rates to even better air quality. But airflows measured in district leadership spaces are not the only data showing that 6 to 12 air changes are targets PPS can reach. Data from two modernized schools that have valid airflow reports show that 4 to 6 air changes from the HVAC system, plus in-room filtration to get classrooms closer to 12 air changes are realistic goals. Unfortunately, new and modernized schools that have airflow measurements show that PPS needs to set such goals and not leave airflow rates up to the discretion of building contractors.

High school modernizations — HVAC only



53% of classrooms at Franklin get 6 or more air changes per hour from the HVAC system alone.

Nearly 30% get more than 8.

36% of classrooms at Grant get 6 or more air changes per hour from the HVAC system alone.

72% get more than 4.5 air changes.

More than 4 to 6 air changes per hour from the HVAC alone was doable for most of these rooms.

6 air changes from the HVAC is doable in Wells, Cleveland, Jefferson, and all other future modernizations.

Only 15% of classrooms at McDaniel get 6 or more air changes per hour from the HVAC.

65% get less than 4 air changes.

No Roosevelt classrooms are above 6 air changes per hour.

89% of Roosevelt classrooms get less than 3 air changes.

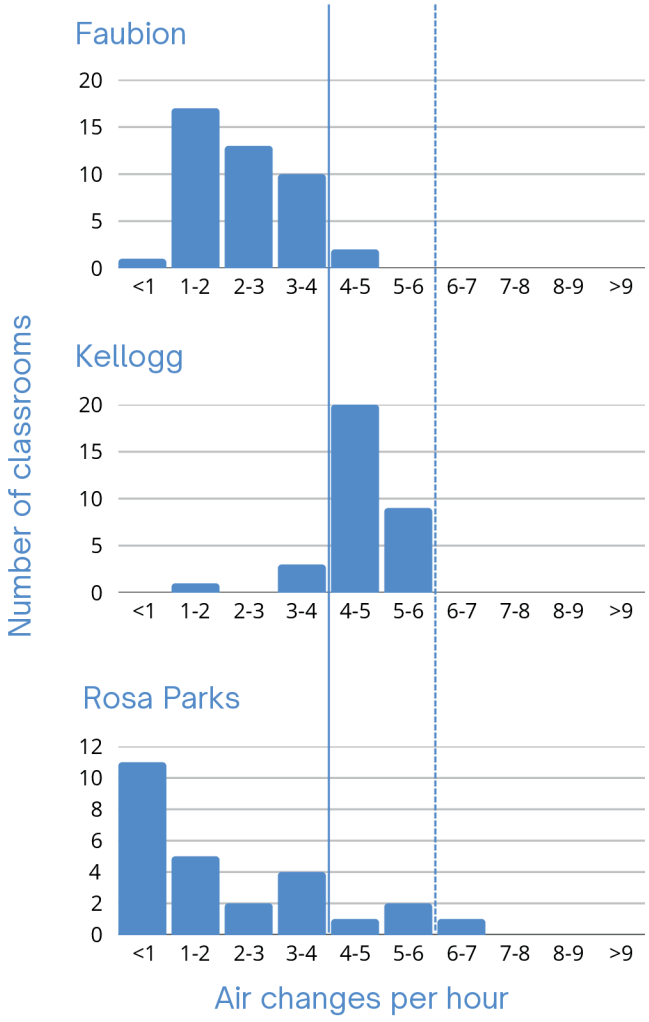
Failing to set airflow goals has left other modernized schools with extremely poor airflows

Lessons from other new and modernized schools: PPS needs goals

Airflow rates from the HVAC system in two more new buildings with valid airflow reports — Faubion K-8 School and Rosa Parks Elementary — are extremely poor, while they are average but below our minimum goal in Kellogg Middle School. In total, five new or modernized schools show low airflows in classrooms in their airflow reports.

Air quality outcomes in PPS's new and modernized schools have more examples of failure than success, but poor airflows are not inevitable. Two modernizations — Franklin and Grant — show that stronger airflows from PPS HVAC systems are achievable. The difference isn't age or construction quality — it's the absence of clear, health-based airflow targets. The pattern of low airflows in new schools also underlies our assessment that other schools with recent or ongoing HVAC overhauls, such as Harrison Park, Lincoln, and Bridger, likely do not meet health-based goals for clean airflow, and reinforces the need for PPS to adopt those goals explicitly going forward.

New elementary, middle schools, and K-8 schools — HVAC only



72% of Faubion classrooms get less than 3 air changes per hour from the HVAC system.

42% get less than 2 air changes.

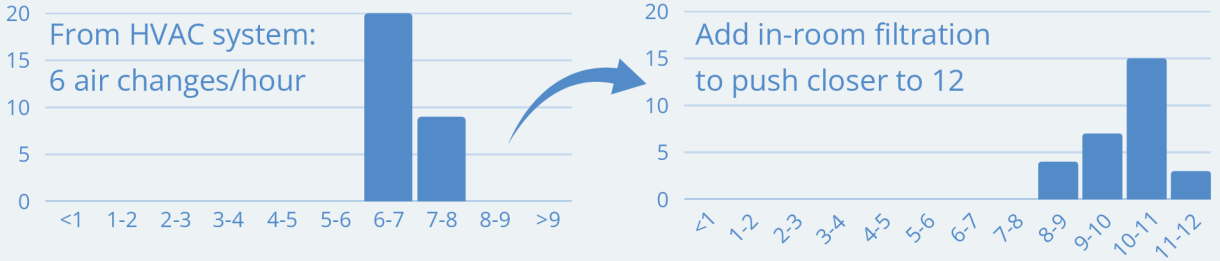
No Kellogg classrooms get above 6 air changes per hour from the HVAC. But 76% are above 4.5 air changes.

62% of Rosa Parks classrooms get less than 2 air changes per hour from the HVAC.

Only one classroom gets more than 6.

More examples of low airflows in new schools, underscoring the need for clean airflow goals.

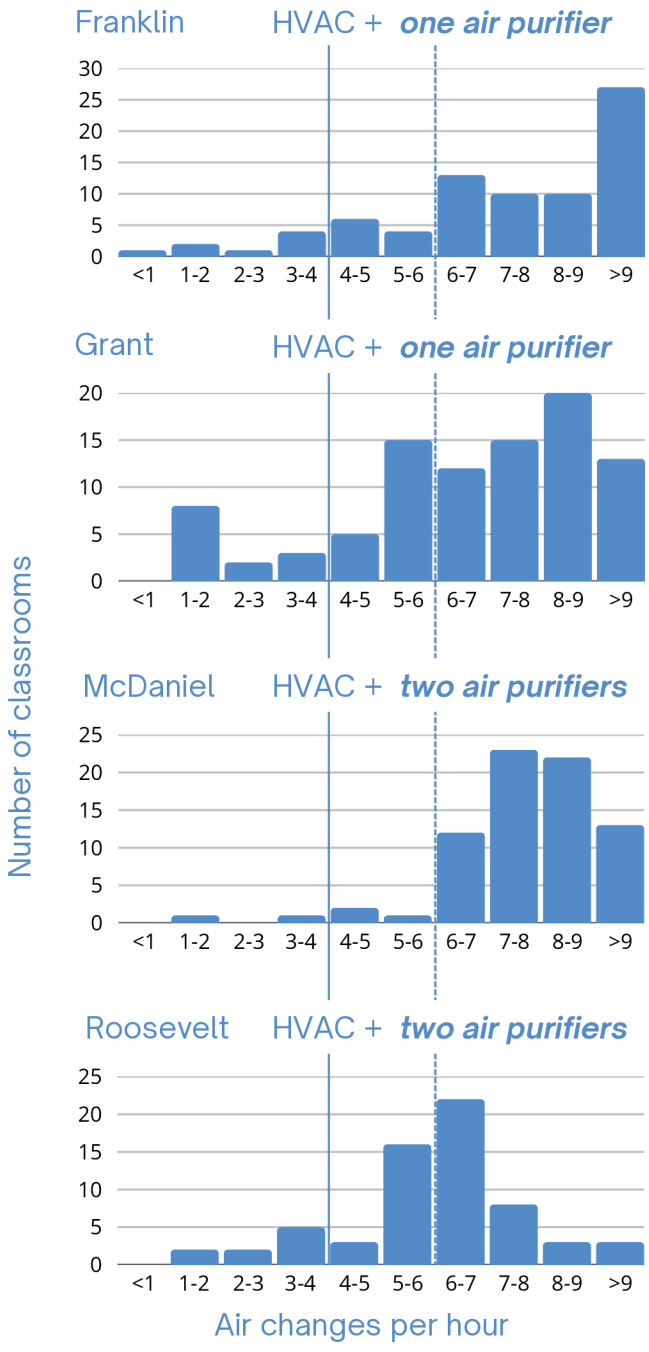
Ideal classroom airflow distributions



Lessons from modernized schools to guide PPS's clean air plan:
Closer to 12 air changes per hour is achievable with in-room filtration

Adding in-room filtration can get many classrooms above 6, and even closer to 12 air changes per hour. Franklin and Grant demonstrate this clearly: with just one Medify air purifier running at its reasonable noise level, a majority of classrooms are over 7 air changes per hour. At McDaniel and Roosevelt, two air purifiers are needed to move these buildings to health-based targets and the kinds of strong airflows most rooms at Franklin and Grant get with one unit. These clean airflow distributions echo our ideal classroom airflow distributions: the best path to safe, high-performing air quality in classrooms is HVAC systems that provide a strong baseline of clean airflow, paired with in-room filtration that builds on that baseline to reach 8, 9, 10, even 12 air changes. This isn't theoretical. It's already happening in parts of PPS. Reaching these levels of clean air districtwide just takes follow-through.

High school modernizations — HVAC + in-room filtration



62% of classrooms at Franklin get 7 or more air changes per hour from the HVAC system and the one assigned air purifier running at its reasonable noise level.

More than half of classrooms at Grant get 7 or more air changes per hour from the HVAC system and one assigned air purifier running at speed 2.

93% of classrooms in McDaniel can reach our goal of 6 or more air changes per hour with 2 air purifiers.

55% of classrooms in Roosevelt can reach our goal of 6 or more air changes per hour with 2 air purifiers.

One unit gets many rooms to 7, 8, 9, or more air changes per hour.

Some rooms do need more than one unit to reach 6 air changes.

Two units are needed to get these schools to a similar range of excellent airflows Franklin and Grant can get with just one unit.

The path to more clean air for less energy in new schools and HVAC overhauls: Balance HVAC airflows and in-room filtration

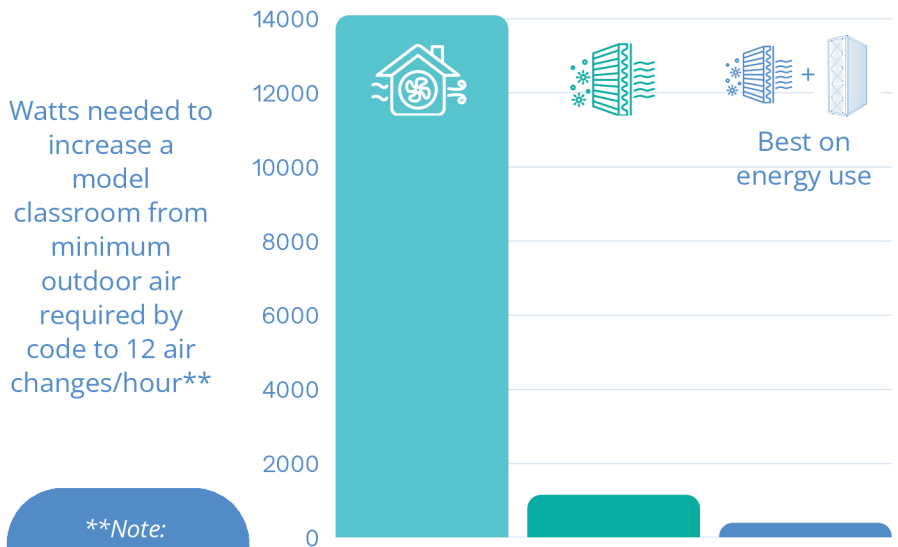
Although these 7 PPS schools' modernizations are complete, with no further HVAC upgrades on the horizon, their examples show why upcoming modernizations, new schools, and new HVAC systems planned under the new bond must go further in providing clean air for student and staff health and performance. But is aiming for 12 air changes per hour realistic, or would that require unsustainable amounts of energy?

Reaching 12 air changes per hour using traditional HVAC system design would indeed be far too energy intensive. Conditioning and moving 12 changes of air from outside to inside using standard HVAC systems would take huge amounts of power. Moving and heating that much cold outdoor air into a typical classroom during winter would consume over 14,000 watts of power. That's the same amount of energy needed to run 2 to 5 U.S. homes at peak hours with multiple appliances running.

Another conventional HVAC design relies on recirculating air through MERV 13 filters, but scaling this to 12 air changes per hour is far from efficient. While recirculating air through MERV 13 filters in the HVAC would avoid the extreme energy burden of 12 air changes of outdoor air, the energy penalty of that much cleaned air is still steep. At over 1100 watts of continuous fan power for our model classroom, recirculation only would be like running a high-powered microwave continuously in the classroom.

These realities of energy use by HVAC systems often result in engineers dismissing 12 air changes per hour in schools as impossible. But what sounds impossible with HVAC alone is readily achievable with the right balance. Pairing moderate HVAC airflows with well-designed in-room filtration makes 12 air changes per hour not only achievable but energy smart and health forward. Six air changes per hour could be added to most PPS classrooms using only 28 watts — about the same energy of 2 or 3 LED bulbs. The technology to do this is not futuristic — it is already on the market. Classroom-friendly units combine high efficiency with quiet operation, small footprints in the floorplan, and long-term reliability without daily teacher attention. When combined with a health-protective minimum of 6 air changes from the HVAC, high clean airflows of 12 air changes per hour are both practical and sustainable.

Classroom energy demands under different airflow scenarios*



***Note: We use air changes/hour to refer to effective or equivalent air changes per hour throughout this handout*

Watts to increase from:	Highly energy intensive	Lower but still too much energy use	Highly energy efficient
3.2 to 6 air changes/hour	**4516**	**370**	**370**
6 to 12 air changes/hour	**9575**	**784**	**28**
Total watts	**14091**	**1154**	**398**

**Scenarios are based on a 900-ft² classroom with a 9-ft ceiling and typical HVAC performance in winter. Zone air distribution effectiveness: 0.8. HVAC fan energy: 1250 CFM/745.7 W. MERV 13 effectiveness: 77%. Outdoor air scenario includes heating outdoor air from 40°F to 68°F using the sensible heat equation. In-room filtration scenario adds 28 W, based on measured draw of two classroom-tested units designed for and proven to provide high energy efficiency (ENERGY STAR 2025 Most Efficient).*