

# Beyond zero: Activating triple zero airports

Received: 4th November, 2021



## ERIN COOKE

Sustainability & Environmental Policy Director, San Francisco International Airport, USA

Erin Cooke has dedicated her career to mitigating climate change by building more sustainable communities and campuses. She currently works as San Francisco International Airport's (SFO's) first Sustainability Director, where she brokers and implements net zero investments across SFO's US\$7.4bn capital programme. Since joining SFO, Erin has led the airport to cut greenhouse gas emissions by 41 per cent, operationalise its first zero net energy building, ban plastic food ware and water bottles and become the global leader in Sustainable Aviation Fuel deliveries. Erin also serves on the Board of Directors of the Institute for Sustainable Infrastructure (ISI) and the ACI World Environment Standing Committee (WeNSC). Prior to SFO, Erin was the City of Cupertino's first Sustainability Manager, where she drafted the City's first Climate Action Plan and launched a community choice energy programme (Silicon Valley Clean Energy). Erin also worked on the climate teams at the Conservation Law Foundation, NASA's Goddard Institute of Space Studies and the National Park Service. She is a LEED AP and holds an MPA from Columbia University, BS and a BA from the University of Massachusetts and is the proud mama of Izzy and Graham.

San Francisco International Airport, P.O. Box 8097, San Francisco, CA 94128, USA  
Tel: +1 650-821-5065; E-mail: Erin.Cooke@Flysfo.com



## ANTHONY BERNHEIM

Healthy & Resilient Buildings Program Manager, San Francisco International Airport, USA

Anthony Bernheim, FAIA, LEED Fellow, is a visionary and respected leader in smart, energy efficient, high performance building. Beginning as early as the 1980s, he has devoted his career to pioneering the impact of buildings on global health, indoor environmental quality and human health. He has a record of designing and implementing a holistic approach and process to sustainability, contributing to improving human health, comfort and wellness in the built environment and global health. He is currently the Healthy & Resilient Buildings Program Manager, Planning, Design, & Construction, at San Francisco International Airport. Anthony has a history of public service, having served as a member of the US Green Building Council (USGBC) Board of Directors (both National and Northern California) in diverse capacities and on key committees since 2003. In 2020, he received the Airports Going Green Award recognising 'Leadership in Development Practices for High Performance Buildings, Representing Outstanding Achievement in Pursuit of Sustainability within the Aviation Industry'.

San Francisco International Airport, P.O. Box 8097, San Francisco, CA 94128, USA  
Tel: +1 650-821-7607; E-mail: Anthony.bernheim@flysfo.com

## Abstract

*San Francisco International Airport (SFO) was the first airport to adopt a triple zero goal — zero energy, zero carbon and zero waste — in 2016. Five years in, this ambition is actively being implemented by subject matter expert ambassadors across campus. Airport staff and partners have co-created delivery plans, operationalised strategies and reported results on activating net zero and decarbonised buildings, doubling onsite renewables, procuring all-electric shuttle buses and light-duty vehicles, delivering sustainable aviation fuel to all aircraft, eliminating single-use plastics and so many more 'zero' gains. SFO staff have taken up the mantle by introducing new ideas and approaches, as well as seeking out a variety of third-party certifications to demonstrate our continued commitment to the health of our planet, passengers and*

employees. This is just the beginning. The path to zero is high-impact, highly collaborative work that requires the partnership of our design and construction teams, airlines, business partners, individuals and, most importantly, a global network of airports who have the aspiration AND passion for new and unexpected ways of incorporating sustainability into the way we work, how we develop our facilities and how we operate as our direct means to abate the climate crisis. Outlined herein is SFO's path to zero, with the intention of defining a joint roadmap for airport partners to team up to ensure we each serve an active role in supporting the health of our communities, workforce and shared, but threatened, planet.

## Keywords

*Climate change, guiding principles, zero net energy, zero carbon, zero waste, decarbonisation*

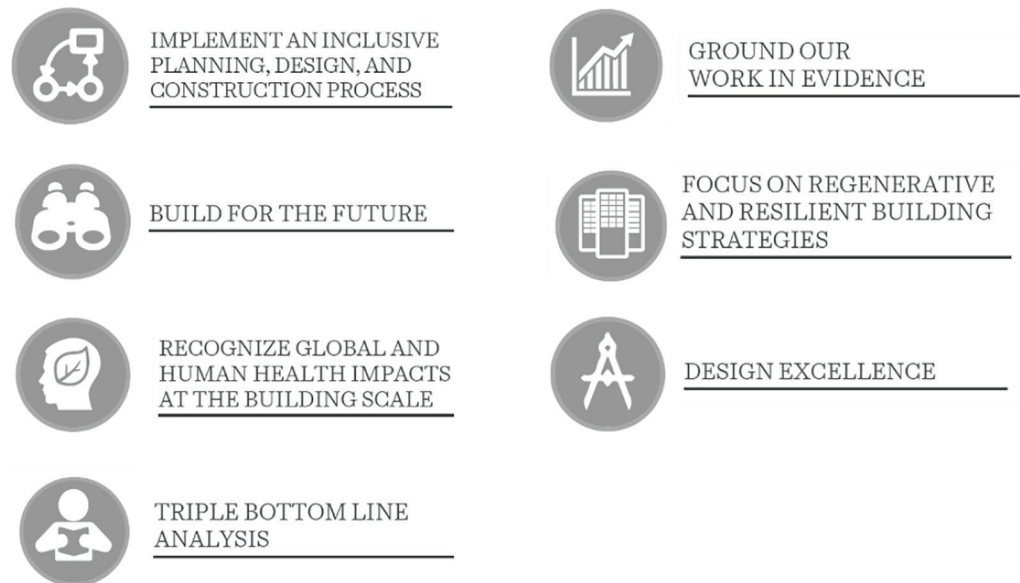
## WHERE WE STARTED

As an airport in service to our communities, and one that is a department of the environmentally leading City and County of San Francisco, SFO has long committed to design, build and operate in a way that is good for, and safeguards, the health of our people and our planet. This is eternally our *modus operandi* and dates further back than the year Google Maps went live<sup>1</sup> and we published our first Sustainability Report.<sup>2</sup> SFO leads by example, by not just authoring, but actively implementing solutions and services to address the climate crisis, while inspiring those within and beyond our operational boundary to do the same. We build for our collective future, which requires our team to always go beyond code and compliance minimums, as set by both our building guidelines and governance model, to innovate and achieve leading edge sustainability practices in all that we design and do. Our call to climate action comes from our mission-minded passengers who expect SFO to deliver sustainability throughout their journey and from our workforce who prioritise sustainability as a key criterion when seeking employment.

On our campus, this started with the development of seven Guiding Principles of Sustainability (Figure 1) to cultivate and encourage our current project design

and construction teams to explore deep sustainability concepts and set performance goals prior to selecting final design strategies and construction methods. These guiding principles encompassed holistic systems thinking as an approach to building efficiency and improved indoor environments, allowing project teams to present multiple innovative solutions for review and selection alongside their code compliance/LEED® (Leadership in Energy and Environmental Design green building rating system) and other green building certification measures as baseline requirements. This process recognises that sustainable building technology and materials are constantly evolving and improving as the construction and manufacturing industry responds to the demand to produce more environmentally preferable products.

Informed and inspired by these Guiding Principles, SFO set its 2017 Strategic Plan<sup>3</sup> by calling for campus-wide 'zero' net energy, carbon and waste — an aggressive set of goals that also prioritise health, resilience and water stewardship. The Strategic Plan includes seven high-level goals, supported by 32 key objectives. These are supported by more than 160 initiatives created by individual Airport Divisions tasked with leading the work but also working together. While some may see this as a 'moonshot' that would



**Figure 1** Guiding principles of sustainability

be impossible to accomplish in the time set, this strategic aspiration was a call to action to SFO employees, project teams, tenants and peer airports to safeguard finite natural resources and ensure the longevity of our airport, community and climate threatened planet. It also offers our campus alignment on an airport's contribution to other industry-wide goals, such as those established by the International Civil Aviation Organization<sup>4</sup> and more recently set by Airports Council International (ACI) World,<sup>5</sup> Air Transport Action Group<sup>6</sup> and Airlines for America.<sup>7</sup> How exactly? The way we both organised, set our steps, and allocated our work became our zero-super strength.

### Step 1: Building our bench

Zero goals/targets are widely used and promoted by many airports worldwide yet the understanding of what these constitute in terms of organisational/operational boundaries, base years, target

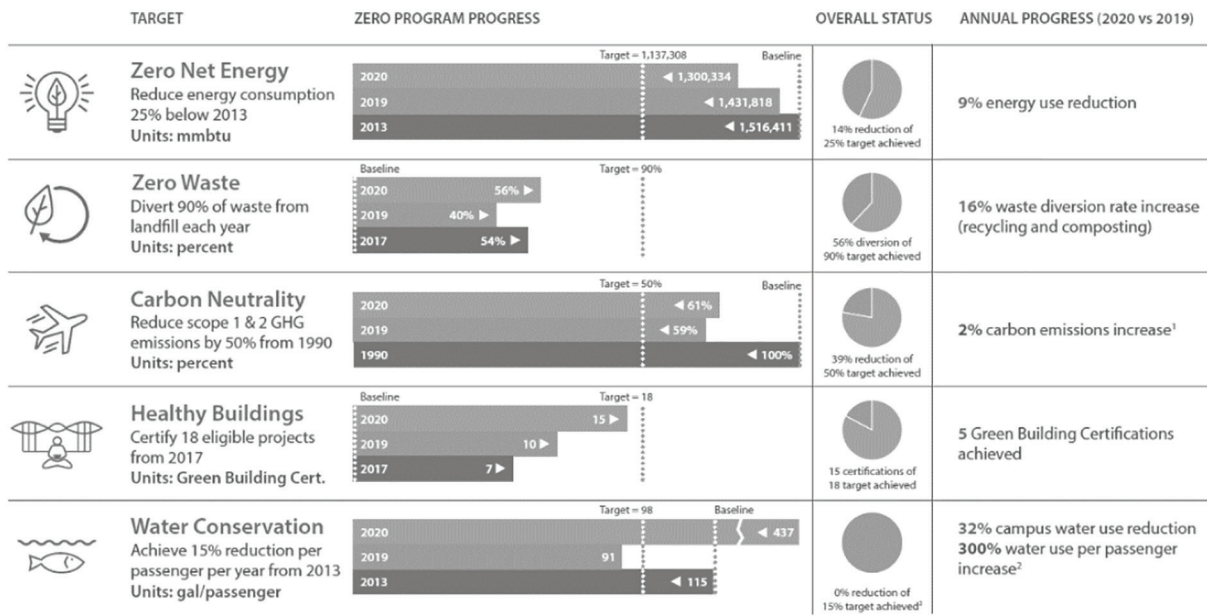
levels, activity and sources etc is highly inconsistent. SFO's approach includes the following goals:

- **Zero Net Energy** — SFO is focusing this goal building by building where the energy used by that building can be matched with the amount of renewable energy generated onsite per year.
- **Zero Waste** — SFO is targeting a minimum of 90 per cent diversion from landfill or incineration by 2030 using methods like recycling and composting in alignment with the definition set by the Zero Waste International Alliance.<sup>8</sup>
- **Zero Emissions** — SFO is working to reduce and balance greenhouse gas emissions arising from our Scope 1 and 2 activities with removal out of the atmosphere by 2030, in alignment with industry standards and guidance, including those set by the Airport Carbon Accreditation.<sup>9</sup>

SFO's Executive Leadership team is fully committed to delivering 'zero' and have

## 2020 ZERO ANNUAL REPORT

SFO



<sup>1</sup>Carbon emissions increased in 2020 primarily due to 4% additional terminal square footage from Terminal 1 Center and Boarding Area B projects and 45% increase in refrigerant leaks which are hard to detect.  
<sup>2</sup>Overall, campus water used decreased by 32% in 2020 but coupled with an annual passenger traffic reduction of 64% due to COVID-19 resulted in a 300% increase in water use per passenger

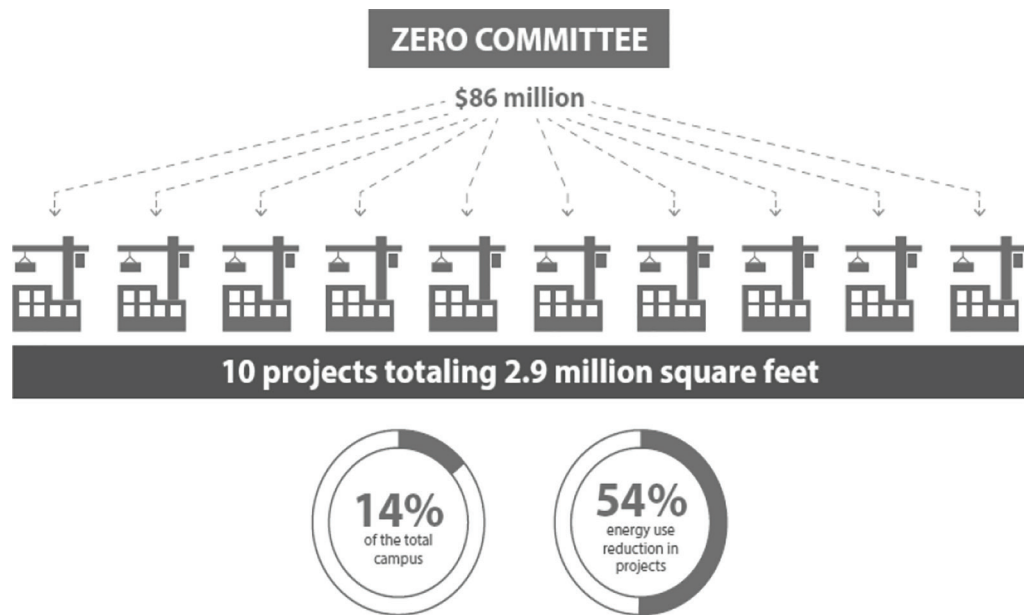
2020 SFO ZERO Annual Report

Figure 2 SFO 2020 Zero Annual Report indicating annual progress

these, and other, strategic plan goals embedded in their annual performance plans. Beyond direct commitments, they hired SFO's first Sustainability Director to lead all things zero the same year it adopted its plan. Although Airport Divisions were each tasked with delivering zeroes within their spheres of influence, SFO's Sustainability Director worked with each to collaboratively develop a set of Objectives and Key Results (OKRs) and performance dashboards, now reported quarterly through the airport's intranet and annually through a Zero Annual Report<sup>10</sup> (Figure 2). She also worked with SFO's newly hired Healthy and Resilient Buildings Program Manager, tasked with guiding the airport's US\$7.4bn high-impact capital improvement programme projects to network zero with the airport's broader

environmental programmes, through a series of mission-focused working groups highlighted below:

- Reaching for Number One (R4N1):**  
 Launched in 2010, these elective Committees are based on a vision to create a more effective and cohesive workplace environment to guide SFO into the future. Since its origin, SFO prioritised forming a Sustainability Committee focused on piloting energy and water conservation, waste management and resilience initiatives as part of the fabric of our airport's culture. (Fun fact — it was formerly sponsored by SFO's current Director [Ivar Satero]). Here, hundreds of staff have shared what aspect of sustainability they care most about and have been empowered to act upon it to amplify SFO's related ambition. This



**Figure 3** SFO ZERO Committee investments produce 54% energy use reduction

group served as the gateway bringing zero to the SFO masses and stands today, launching pilots focused on green infrastructure, Geographic Information Systems (GIS)-based performance dashboards, and green purchasing, while running a monthly ‘Zero Hero’ Speaker Series featuring the sustainability projects and leaders at SFO. Learn more about the SFO’s R4N1 by watching our 10-Year Anniversary Video.<sup>11</sup>

- **ZERO Committee:** Beyond sustainability as a cultural value, SFO prioritised zero net energy and health measures through the formation of SFO’s approximately 20-member interdisciplinary and inter Division ZERO Committee — Zero Energy and Resilient Outcomes — which launched in 2017 to invest US\$100m in projects across our current US\$7.4bn Ascent Program that could achieve our Strategic Plan Goals. Sponsored by the Airport’s Project Management Office, engineers, architects, zero waste and facilities experts meet

monthly to review projects and consider enhancements that could go beyond code — which is LEED Gold Minimum per our City and County Environment Code — and help the airport hit zero. Funding was provided for strategic enhancements including Heating, Ventilation and Air Conditioning (HVAC) systems improvements (eg Radiant heating and cooling in hold rooms, connection to future all-electric central utility plant), on-site renewables (photovoltaic panel system), building envelope (dynamic glazing), smart equipment (ground transportation equipment electric charging stations) and for improved health and wellbeing (multi-filter outdoor air filtration system). To date, the ZERO Committee has reviewed 41 projects, invested US\$86m across 10, and netted dramatic 54 per cent energy use intensity reduction (*measured in kBtu/sq.ft./yr.*) and energy savings over baseline buildings, helping us curb operational and utility expenses for these new assets (Figure 3). Through the



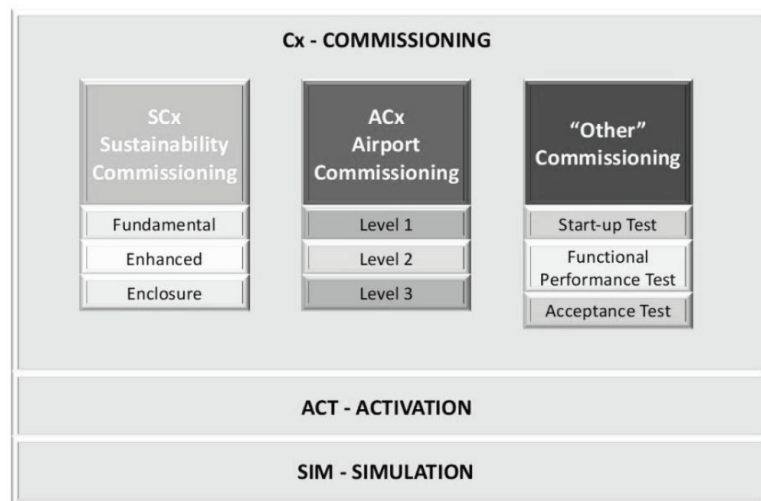


Figure 4 SFO Commissioning, activation and simulation process

integration of these enhancements into the new buildings, our campus-wide energy use has dropped 14 per cent from our 2013 baseline and resulted in over US\$6m savings annually.

- Commissioning, Activation and Simulation:** While SFO continues to invest in its capital improvement programme by upgrading buildings and infrastructure, it needed to confirm that all new facilities are ready for occupancy, functionally ready to perform efficiently and able to provide healthy indoor environments. In 2017, an Activation Planning Services (APS) team was established to develop a standardised airport-wide Commissioning, Activation, and Simulation (CAS) programme. The APS team developed a SFO-specific CAS process, with a user manual and checklists to guide each design and construction project through the process. These projects use a Sustainability Commissioning process, based on LEED Fundamental and Enhanced commissioning, to confirm energy efficiency and improved indoor air quality and the Airport Commissioning process to confirm that the airport's special

systems are fully functional and ready for operation. The activation process includes trials of each system, followed by training for the airport and airline personnel who will operate these systems. Once the activation phase is completed, each facility goes through a simulation where airport and airline personnel act as passengers and test out the facility (Figure 4). The CAS programme is now implemented for all new airport facilities prior to occupancy using standardised commissioning plans, checklists, test procedures and reports.

The benefits of the CAS programme are:

Commissioning prepares the building for the occupants. Activation prepares the occupants for the building. Simulation tests the facility and staff readiness prior to operation.

Integrated into the Sustainability Commissioning programme is indoor air quality testing in conformance with the California State standards and the LEED Indoor Air Quality Assessment Credit to assure that prior to occupancy,

the indoor air in new buildings is clean and safe for the occupants. The test results, documented in a report, provides a benchmark for future air quality monitoring and testing. So far, the zero investments and the CAS programme have only addressed 13 per cent of our building stock, but lessons learned are being applied via an ongoing retro-commissioning (RCx) pilot programme to confirm that each new building continues to operate efficiently and continues to provide healthy indoor environments and that modifications to existing buildings can be made to match these new buildings' level of performance. Additionally, buildings that operate efficiently will reduce long-term operating costs, as detailed in SFO's Net Zero Energy Plan,<sup>12</sup> which is guiding the pilot. This Plan, if fully implemented, would reduce SFO's annual energy use by 60 per cent or 1.3bn kBtu/year. This is equivalent to the annual energy use of 27,000 households. Findings from this pilot may be shared in a future paper.

- **Environmental Working Group (EWG):** Foundational to meeting aspirational goals are ensuring alignment and awareness of zero work among compliance and operations teams. To that end, SFO's approximately 25-member EWG convenes quarterly and includes representatives from Environmental Health & Safety, Wellness, Facilities Environmental Operations, Planning, Project Management, Engineering and Landside Operations to each share challenges, key projects and industry insights as ambassadors of SFO and its surrounding environment. This group also organises employee engagement events, hosts trainings and develops policies and protocols to ensure environmental aims are met.

## Step 2: Way pointing and piloting to scale

Teams convened to help the airport deliver its zero goals sought to do so efficiently and effectively by establishing clear plans that define actionable waypoints, targets and timelines. Subject matter experts through the forums mentioned above brainstormed, integrated and refined a rich playbook of strategies and plans that set in motion SFO's foundational pilots and scalable projects that align with each zero goal. This included a Zero Waste Plan; Zero Net Energy Plan; Carbon Neutral/Climate Action Plan; Sustainability & Social Equity Plan; Sustainable Aviation Fuel Supply Chain, Logistics, Infrastructure and Financing Study; Zero Emissions Vehicle Roadmap; and Electrification Action Plan.<sup>13</sup>

Building project teams also piloted new technologies in small projects. An example of this was the use of two different types of dynamic glazing on two different buildings prior to it becoming a standard on the Harvey Milk Terminal 1 and on the Courtyard 3 Connector Building (and office tower). The Airport's facilities team is also testing various indoor air quality sensors located in the airport terminals and office buildings. A further study of this evolving indoor and outdoor air quality sensor technology is planned for the latter part of 2021, leading to the development of an air quality framework and an implementation plan.

## Step 3: Narrowing and targeting our impact

One key question asked by each above referenced strategy document and all SFO's teams, as we moved from pilot to project, is 'where can we drive impact?'

Building operations are responsible for almost 30 per cent of global greenhouse gas emissions.<sup>14</sup> This source of emissions is widely recognised and addressed by building codes and emissions reduction targets. Less widely recognised, but not less critical, is the embodied and sequestered carbon of building materials, which account for over 20 per cent of global greenhouse gas emissions.<sup>15</sup> Because embodied carbon impacts occur at the start of a building project, rather than accumulating over its lifetime, embodied carbon will represent about 74 per cent of the greenhouse gas emissions of new construction between 2020 and 2030, and about half of the emissions between 2020 and 2050.<sup>16</sup> Embodied carbon and other Scope 3 emissions are, therefore, an important priority.

Reducing embodied carbon impacts from the built environment is now a priority. The Airport recently implemented an updated version of the SFO Sustainable Planning, Design and Construction Standards that will establish requirements and stretch goals for upcoming project performance. Major materials, such as concrete and steel were identified as products where embodied carbon reduction should initially be achieved. For concrete, CarbonStar® technical specification<sup>17</sup> for concrete intensity quantification and verification is being used. Concrete used at SFO is intended to achieve a maximum CarbonStar CO<sub>2</sub>e rating of 200 lb./yd<sup>3</sup>, with stretch goals of reaching 0 lb./yd<sup>3</sup> and -200 lb./yd<sup>3</sup> when using sequestered carbon to replace Portland Cement and aggregate. The embodied carbon in construction calculator (EC3) tool<sup>18</sup> will be used to document the embodied carbon in concrete, steel and for other building products that are used on future projects.

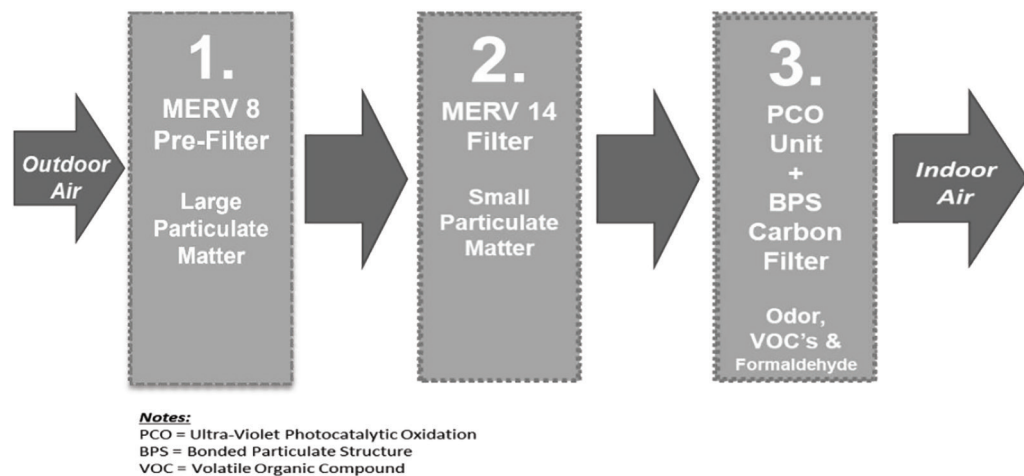
SFO strives to take a leadership role in mitigating the climate crisis and is

actively implementing the following strategies: Sustainable Aviation Fuel (SAF), building electrification, carbon reduction, building deconstruction, building material decarbonisation, water reduction technologies, zero emission vehicles and circular economy policies. These climate change mitigating actions are foundational to our ambition of achieving net zero carbon and in enabling our onsite operators in doing the same. Whereas over 99 per cent of SFO's campus greenhouse gas emissions arise from the activities of our airlines and concession tenants, we recognise that our efforts on the ground — among our infrastructure and base buildings — are critical to support the fuel switching and electrification of fleets and within our partners' leaseholds. To that end, we're planning for 2,400 new load-managed EV chargers, including Level 3/DC Fast chargers, to serve our passengers, employees, fleet and ridesharing/hailing drivers per Electric Vehicle Readiness Plan and deliver the recommendations of our Sustainable Aviation Fuel Logistics, Supply Chain and Financing Feasibility Study<sup>19</sup> to further encourage our airlines to uplift SAF from SFO, which already has deliveries from two producers via pipeline and over the rack.

#### **(Surprise!) Step 4: Creating Opportunity from the Confluence of Crises**

Also of note, SFO's zero goals have served as a key tenet of our campus' pandemic and economic recovery to resilience pathway.<sup>20</sup> As an airport located in Northern California — a region within a state that continues to be one of the hardest hit by droughts and wildfires fuelled by our changing climate — we acknowledged that our ambitions of a zero-campus





**Figure 5** Outdoor and recirculated air filtration system

needed to be operationalised to recover from the current pandemic and to respond to the next climate hazard event. SFO has tactically prioritised triple bottom line (social equity, environmental, and financial responsibility) investments that have yielded long-term operational benefits for our airport and health benefits for our passengers, workers, and surrounding community, which have ensured a safe and sustainable return to service for our campus and region. Project teams provided triple bottom line cost benefit analysis (TBL-CBA) to airport executives allowing them to make informed decisions on the selection of proposed long-term sustainability strategies. TBL-CBA accounts for capital investment cost and life cycle operating and maintenance costs over the lifespan of each building asset. Examples TBL-CBA use include the decision to use dynamic glazing to reduce glare in lieu of high-performance clear glazing combined with window shades, and the use of radiant heating and cooling system combined with displacement ventilation in lieu of the more traditional ceiling hot and cold air supply.

The combination of pandemic and multiple simultaneous wildfires in California raised awareness regarding health and wellbeing in the airport's buildings. Questions were asked about how to reduce the spread of COVID-19 aerosolised particles and fine particulate matter from the wildfires, while maintaining healthy, breathable indoor air. The answer to these questions was already top of mind due to pre-planning work done during the design of new airport buildings, as noted above. Armed with an understanding of the outdoor ambient air quality (based on air quality testing) and guidelines for healthy indoor air quality (based on the California air quality guidelines,<sup>21</sup> LEED Certification,<sup>22</sup> WELL Building Standard<sup>23</sup> and Fitwel Certification<sup>24</sup>), outdoor air filtration systems were selected to reduce and eliminate large and fine particulate matter (aerosolised COVID-19 particles and fire smoke particulate matter), volatile organic compounds, formaldehyde and jet fuel odour (Figure 5). Since these filtration systems were already in place, the airport was well prepared to provide a high level of air quality at

all times and demonstrated that early design decisions can provide an excellent path to resilience and one that we plan to model across other assets to prepare our campus for future climate and other hazard events.

### Step 5: Partnering with our planetary-protecting peers

SFO's people-inspired, performance-based and pilot-driven approach to zero is ever-evolving as we continue to push towards achieving our strategic ambition. We hope that by sharing SFO's journey to zero we offer an applied case study of how all airports have the power to drive fundamental, lasting change in this industry, by setting bold goals and creating a structure that allows collaborators to clearly understand how they can make their own meaningful contribution. When we each make that commitment, our collective actions become a part of the greater change we seek to make, not only in our communities and sector, but for the broader world. Let's reach together, teach and learn from each other, and harness the zero heroism our planet's future depends upon.

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