Amp Up for Commercial Kitchen All-Electric Retrofits: San Francisco International Airport (SFO) Case Study

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Abstract

With a strategic goal to achieve net zero carbon emissions by 2030, San Francisco International Airport (SFO or the Airport) has a responsibility to reduce Airport-controlled emissions by eliminating its direct natural gas use and by providing adequate electrical capacity for tenants to transition to all-electric equipment. Existing terminal food and beverage tenants' monthly energy use averaged 60% from natural gas and 40% from electricity in 2022, illuminating a significant effort required to achieve full electrification. To aid in this transition, this study collected utility consumption and existing electrical service sizes of 121 Airport terminal tenants, as well as inventoried natural gas equipment for 44 tenants to: (1) analyze the breadth and occurrence of natural gas cookline equipment and (2) recommend the first standard electrical service size for all-electric terminal tenants by business type. Fryers and ranges were the most common natural gas appliances in service across the 231 natural gas equipment pieces inventoried. If these natural gas appliances were converted to electric power, this study determined the tenants' existing maximum power use will likely double in the most conservative scenario, assuming lower efficiency electric alternative equipment will be selected. After Airport stakeholder engagement and review of the results, the study determined that 100-200 amp (480V) electric service size should be the recommended standard for leased spaces with commercial kitchens and 50-100 amp (208V) service should be recommended for retail spaces undergoing future tenant improvement projects. With established standards, SFO can confidently plan for future all-electric tenants and ensure sufficient electrical capacity is provided. These results are being used to not only guide buildout of future SFO terminal tenant spaces and match equipment rebates/incentives for all-electric replacements, but also help define the appropriate level of base building and upstream electrical capacity. While this study focuses on SFO, these results may prove useful to other multi-tenant properties looking to right-size electric service sizes for future electrification.

Background

SFO is a large hub airport that welcomed 50 million passengers in 2023 and strives to lead the aviation sector in sustainability and resilience. SFO's goal is to be the first airport in the world to achieve "triple zero" – net zero energy facilities, net zero carbon operations, and zero waste to landfill by 2030. SFO reports this progress annually in a Zero Annual Report (Zero Annual Report 2023). On the path to Airport decarbonization, SFO reports on its Scope 1, 2, and 3 emissions in its Greenhouse Gas Emissions Inventory (Greenhouse Gas Emissions Inventory 2022). Scope 1 emissions, those emissions directly under the airport's control, constitute 0.2% of the SFO's total annual emissions. Scope 2 emissions are zero as SFO purchases carbon-free electricity. Scope 3 emissions, those that the airport can influence but does not control, represent 99.8% of total emissions at SFO, in large part from aircraft fuel emissions (Greenhouse Gas

Emissions Inventory 2022). To reduce Scope 1 emissions and achieve SFO's strategic goal of net zero carbon by 2030[1], building electrification is an essential initiative.

Building electrification seeks to transition buildings from the use of carbon-intensive fuels, such as natural gas, to electricity. In 2020, the City of San Francisco codified all-electric requirements for City buildings undergoing new construction or major renovations in Chapter 7 of the San Francisco Environment Code. These requirements were expanded in April 2023 to require all-electric equipment replacements in existing buildings and tenant improvements.

Building electrification is challenging yet presents a tremendous opportunity to curb Scope 1 Airport-controlled carbon emissions by 90% and realize varied co-benefits, such as increased health, comfort, and safety for employees, tenants, and customers. SFO's Scope 1 emissions are predominantly from natural gas use in the terminal central utility plant with it representing 87% of 2022 emissions. (Greenhouse Gas Emissions Inventory 2022). The use of natural gas produces air pollution that has been associated with asthma and increased respiratory disease (Lebel 2023). All-electric buildings eliminate this exposure and unnecessary human health risk. Challenges to an all-electric future, include, but are not limited to, securing an increase in campus electric service from the utility provider and corresponding expansion of upstream electrical infrastructure, which both take significant time, planning, and funding. For businesses, full electrification may increase their utility costs given the disparity between electricity and gas rates in California (Monsur, Kuck, and Honegger 2022). Additionally, electric appliances, particularly hot water heaters, can have a higher purchase cost. Specific to kitchen electric equipment as an alternative to natural gas, cookline staff and restaurant management can have reservations on equipment performance impacting food delivery time, taste and appearance. All of these physical constraints and operational preferences should be thoughtfully considered and addressed when deciding on appropriate paths forward.

SFO's approach to existing building electrification is separated into three distinct areas based on complexity and location namely (1) terminal tenants (TT), (2) terminal central utility plant, and (3) field buildings as outlined in SFO's Electrification Action Plan (EAP) prepared for existing buildings (Electrification Action Plan 2021). SFO's EAP identifies key stakeholders and timebound tasks so electrification projects can be implemented; monitored for progress; and adapted based upon changing regulatory, resource, and financial constraints. Campus-wide the terminal complex uses 36% of total natural gas, with 31% of that used at the central utility plant for space heating and approximately 5% used for cooking across 44 food and beverage TT. The remaining 64% of campus-wide natural gas is used at 34 field buildings for various end uses.

In December 2022, SFO had 149 TT that provide food, beverage, and retail services to passengers and are grouped into six distinct categories for the purposes of this analysis. Food and beverage services account for 57% of TT across a range of quick serve (i.e., counter service), sit-down (i.e., table service), coffee (i.e., caffeinated beverages and light bites) and lounges (i.e., buffet style food with spacious seating). Retail spaces account for the remaining 43% of TT and are separated into news (i.e., snacks and souvenirs) and specialty (i.e., luggage, technology, beauty stores, etc.) categories (Table 1).

In addition to the distinct differences in passenger services provided, TT also differ in terms of energy use intensity (EUI), physical size, and electrical service size.[2] EUI values are

[1] Scope 1 and 2 emissions only

[2] TT EUI values include electricity to distribute space conditioning within tenant spaces but exclude electricity and natural gas used at the terminal central plant to create high temperature hot water and chilled water used for space conditioning.

generated using metered data corresponding to each TT space. The EUI from January through December 2022 was largest for quick serve and sit-down categories, at 926 kbtu/sqft and 556 kbtu/sqft, respectively (Table 1), as they have the most appliances in their back-of-house area to support custom food preparation. Coffee (392 kbtu/sqft) and news (112 kbtu/sqft) typically have several open refrigerators offering to-go food options. Specialty (66 kbtu/sqft) and lounge (64 kbtu/sqft) categories have the lowest EUI resulting primarily from lighting and plug loads and the large footprint characteristic of lounge spaces. Differences among the categories were also reflected in the large range in average tenant category space sizes (680sqft to 10,100sqft) and average electric service size (60 to 361Amps) as seen in Table 1 and Table 3, respectively. This variability in existing TT electric service size, allocated at various points over the terminal (re)development timeline, presents uncertainty in future electric capacity planning, which could result in oversizing the base building service and investing in unnecessary upstream infrastructure costs. Therefore, this analysis looks to collect and analyze the data needed to support and normalize future TT all-electric buildouts and develop a recommended electric service size standard that can be used for future Airport capital projects, capacity planning, and tenant improvement projects.

Table 1: Terminal tenant categories by square footage, EUI, and total quantity

	Category	Average Size (sqft)	Energy Use Intensity (EUI) (kbtu/sqft)	Qty of Terminal Tenants
Food & Beverage	Quick Serve	1,320	926	37
	Sit-Down	2,900	556	12
	Coffee	680	392	20
	Lounge	10,100	64	16
Retail	News	1,400	112	19
	Specialty	1,740	66	45
				Total: 149

Methodology

Since SFO is at the forefront of airport electrification and little benchmarking information exists on all-electric service sizes for terminal tenants across the aviation industry, this analysis relies on data from 121 of 149 existing SFO TT (Table 2) (excluding those TT with incomplete datasets) as a foundation for developing electric service recommendations. First, significant effort via conducting site visits and reviewing as-builts was required to assemble basic existing TT meter information such as meter location, electrical service size, and utility meter number. Next, monthly utility consumption and maximum amperes from January through December 2022 were downloaded, analyzed and summarized by TT category. Due to differing electric meter vintages, 53 out of the 121 TT included in the analysis did not have maximum amperes data for 2022, so metered electricity consumption (kWh) was used and converted to amperes.

Table 2: Quantity of terminal tenants used in this analysis and the number using natural gas

	Category	Qty Terminal Tenants Included in Analysis	Qty of Terminal Tenants that use Natural gas
Food & Beverage	Quick Serve	37	28
	Sit-Down	11	12[3]
	Coffee	19	1
	Lounge	14	3
Retail	News	14	0
	Specialty	26	0
		Total: 121	Total: 44

A pivotal step in developing recommended all-electric service sizes was cataloging the existing natural gas equipment used by TT and the electrical requirements of comparable electric equipment alternatives (e.g., natural gas 36" griddle conversion to electric 36" griddle). For water heaters, electric resistance was used as the default assumption instead of heat pumps due to retrofit conditions and airflow requirements. TT equipment type (i.e., fryer, stove), energy source (i.e., natural gas, electricity), and quantities were available through SFO's Green Business program database, which previously conducted energy audits for all TT. Four of 44 TT that use natural gas did not have an equipment inventory in the database. In these instances, tenants were benchmarked to another tenant within the same category with similar utility usage and comparable food offerings. For one business without a clear benchmark, their equipment was documented during a site visit. Electric equipment alternatives were primarily sourced from the U.S. Environmental Protection Agency ENERGY STAR product database, and if unavailable, then industry marketplaces, and assumed to be the most energy intensive to be conservative when calculating the conversion estimate. The electrical requirements to operate electric equipment alternatives were summed for all existing natural gas equipment, added to the maximum 2022 actual amperes for each tenant and examined across all tenants in each tenant category. For TT that do not have natural gas, such as News and Specialty, the maximum amperes alone were used as the baseline. Using this all-electric, existing TT amperage analysis, coupled with electric infrastructure cost breakpoints (i.e., 100A, 200A, 400A) and considering SFO stakeholder request for consistency and ease of implementation, the electric service size recommendations were developed.

Results

This analysis, and corresponding results, bring attention to a complex, but essential piece of terminal tenant electrification for airports and other campuses and facilities with mixed-use leaseholds / tenants. The results section is divided into four parts, with each section offering key findings that build upon each other. First, the utility consumption analysis shows the breakdown of natural gas and electricity use for each TT category. Next, electrical service utilization seeks

[3] While all 12 sit-down restaurants use natural gas, one is not used in the analysis due to incomplete data.

to highlight the existing service sizes within each TT category, compared to the percentage of this service that is currently being used. The following section describes the composition of natural gas equipment for SFO's TT, and the amperes required to fully electrify this equipment. Finally, future electric service size standard recommendations and their potential applications are summarized.

Utility Consumption

Natural gas constitutes a majority of energy use for both mixed-fuel quick serve and sit-down TT at SFO, with smaller contributions to those lounges and coffee TT using gas. From the analysis of monthly utility consumption of the 121 TT, the average breakdown of natural gas to electricity consumption in a month was derived for each of the four food and beverage TT categories (Table 2). The 78 TT that are already all-electric are excluded from the following calculation on energy use leaving 44 TT, specifically 26 quick serve TT, 11 sit-down TT, 2 lounge TT and 1 coffee TT that use natural gas. Figure 1 shows that both quick serve and sit-down TT receive 60% of their month's energy from natural gas, while the lounge and coffee TT in this analysis received 29% and 10% from natural gas, respectively. Considering the majority of energy for quick serve and sit-down restaurants comes from natural gas, transitioning them to all-electric is likely to have a substantial impact on their electricity consumption, and thus the electrical capacity required to accommodate their operations.

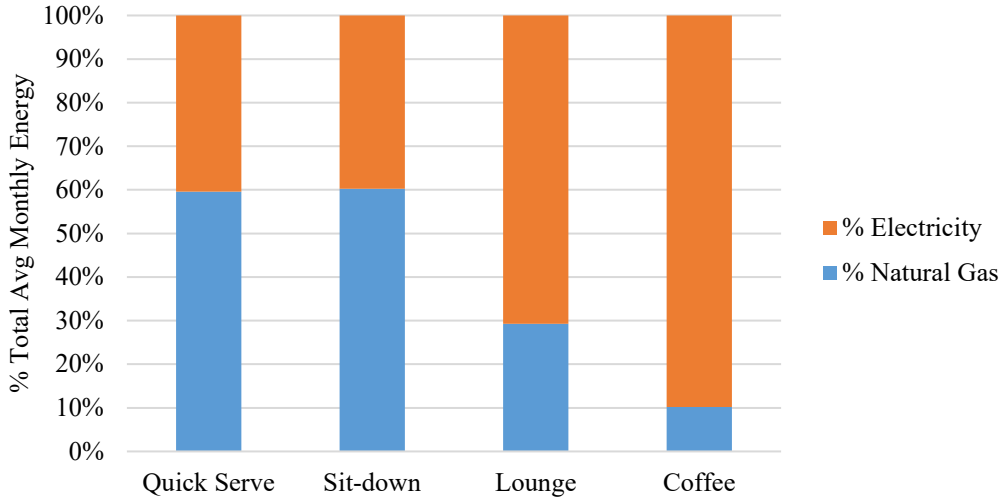

Figure 1: Percentage of total monthly energy received from natural gas and electricity averaged from Jan-Dec 2022; Total TT using natural gas (44): comprised of quick serve (26), sit-down (11), lounge (2), and coffee (1)

Electric Service Utilization

With 40% to 90% of TT monthly utility consumption being electricity (Figure 1), electric service size also varied considerably. Electric service size represents the total power available to a building or tenant. Electric service sizes are often found on the main breaker in a house electrical panel or at a circuit breaker on tenant metering panel at SFO. Existing TT electrical service sizes ranged by 2 to 3 times within the same TT category (Table 3). The largest difference exists within lounges (50A to 1470A) where there is significant variation in square

footage (Table 1), kitchen configuration, and vintage of electrical metering infrastructure. Table 3 offers a breakdown of the existing electrical service minimum, maximum, and average for each TT category.

Table 3: Existing electric service size amps (480V)

	Category	Min	Max	Average
Food & Beverage	Quick Serve	70	300	165
	Sit-Down	150	250	202
	Coffee	50	225	103
	Lounge	50	1470	376
Retail	News	50	125	60
	Specialty	22	250	61

For an illustrative example, Figure 2 highlights quick serve electrical service sizes ranging from 70A to 300A. With this existing range, it is difficult to determine a reasonable amount to provide for a new quick serve restaurant, which is essential in preparation for full building or Airport terminal electrification. Absent standards and guidance on TT all-electric needs, newer terminal designs have been providing higher electrical service sizes to TT, on average.

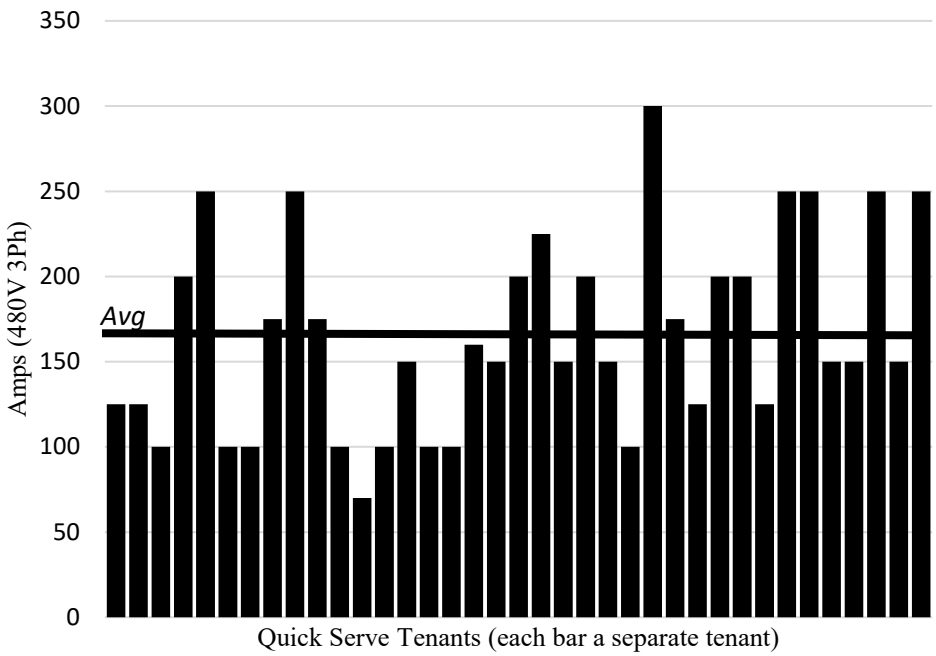

Figure 2: Electric service sizes in amps (480V) for SFO's quick serve tenants (average of 165 amps represented by black line)

While electrical service sizes vary, it is critical to understand how much capacity tenants use to provide justification for and insight on an appropriate electric service size standard. Examining electric power data from January through December 2022 shows significant unused electric capacity across all TT categories (Table 4). On average, the maximum usage from any 15-minute increment in 2022 was 22-44% of the existing electric service (Table 4). As an example, Figure 3 overlays the peak electrical consumption of quick serve TT in orange over their allotted electric service size shown in black. On average, quick serve TT use 35% of their electric service capacity. More specifically, TT #1, shown in Figure 3, has 125A electric service size and used a maximum of 50 Amps in 2022, or 40% of the total electric service size.

Conducting these types of load analyses are important as oversupplying electrical capacity can have rippling consequences that could lead to increased infrastructure and utility costs, space requirements, and electric capacity constraints elsewhere on campus. In relation to building electrification, this unused electrical capacity might be sufficient in some circumstances to meet additional electricity requirements created by conversion from natural gas to electricity. While unused capacity might be perceived as an overdesign, it is important to remember that electrical design is complex, ever evolving and adheres to codes, standards and industry best practices to ensure safety and reliability.

Table 4: Percentage of electric service size used (15-minute increment) in 2022 by TT category

	Category	Min	Max	Average
Food & Beverage	Quick Serve	11	58	35
	Sit-Down	11	46	30
	Coffee	14	74	44
	Lounge	11	73	32
Retail	News	11	60	31
	Specialty	3	68	22

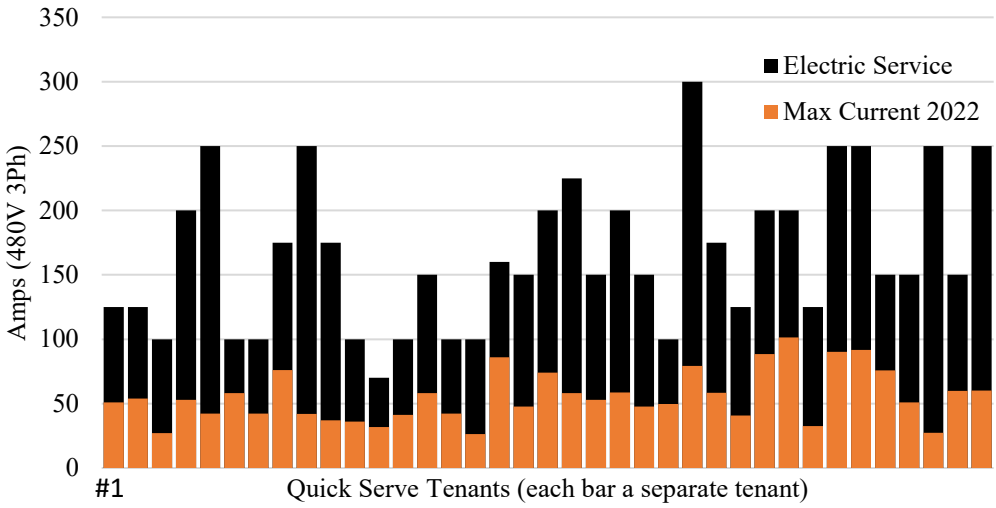

Figure 3: Quick serve tenant electrical service size (black) overlaid with maximum amps (orange) used at any point in 2022.

Natural Gas Equipment Conversion

Existing natural gas equipment is used to estimate the additional electric capacity requirements for an all-electric tenant future. This analysis consolidated natural gas equipment for SFO's TT (Figure 4). Fryers were the most numerous natural gas appliance of the 14 types documented, followed by ranges, water heaters, griddles, and charbroilers.

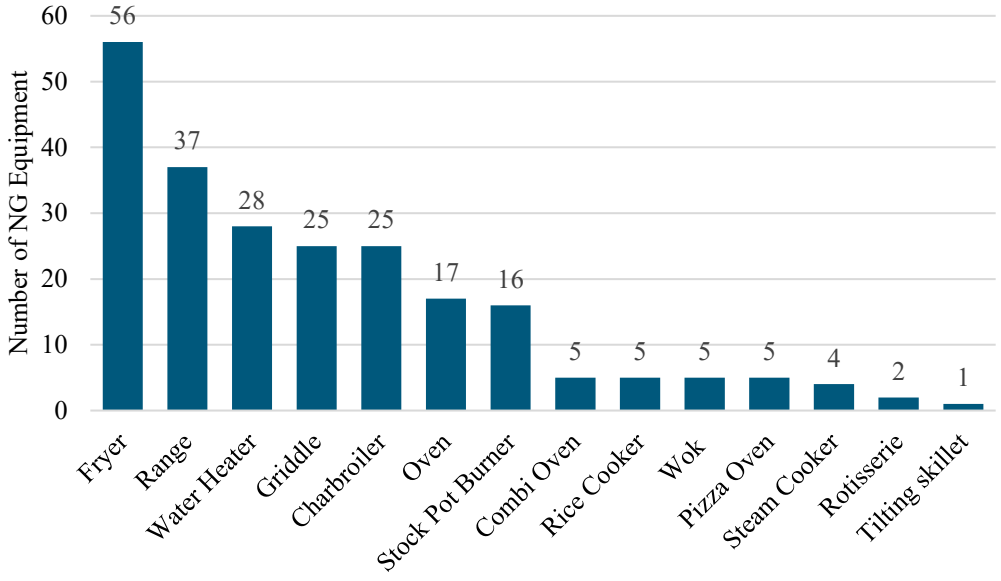

Figure 4: Number of natural gas appliances in TT leaseholds by appliance type

With a natural gas equipment inventory for each TT, the amps required to accommodate electrification was estimated assuming the most energy-intensive equivalent electric equipment from the developed list would be selected to replace gas appliances. Figure 5 overlays the

estimated amperes to electrify the natural gas equipment for SFO's quick serve TT with their maximum amperes for 2022. On average, natural gas conversion to electricity requires an additional 71 amps for quick serve restaurants (Figure 5), effectively doubling amp requirements in many cases. The amps required to convert sit-down TT to all-electric is slightly higher at 115 amps due to typically larger kitchens with more natural gas equipment. For the three lounges and one coffee tenant with natural gas equipment, the average additional amperes required are 86 and 49 amps, respectively.

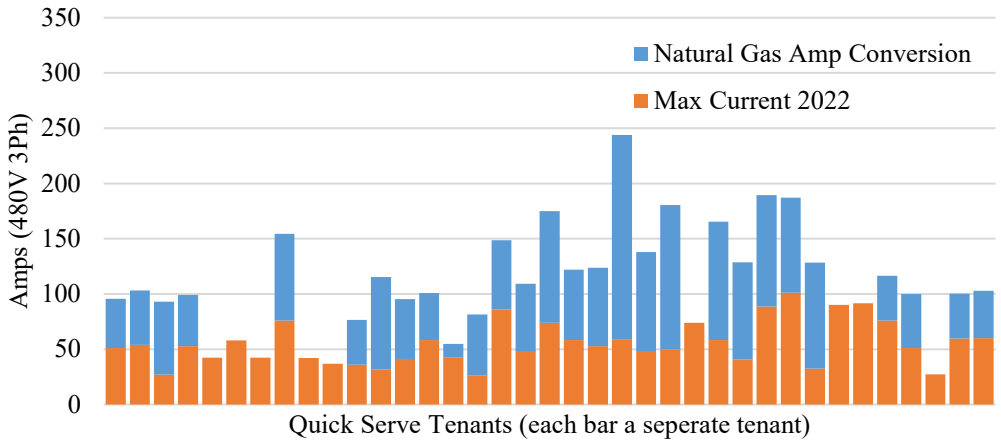

Figure 5: Quick serve peak amps for 2022 (orange) with calculated amps to convert natural gas equipment to an electric alternative (blue). All-electric tenants only include their maximum current amps (orange).

Recommended Future Electrical Service Size Standards

These recommended electric service size standards are intended to be used by SFO to evaluate whether electrical service requests for future tenant improvement are reasonable. Since new TT will be required to operate all-electric, SFO needs an established upper-bound to make informed decisions regarding TT electrical service requests. These recommended standards could also be used for project planning and delivery or evaluation of upstream electrical infrastructure.

Several factors came into play when creating these recommended electrical service size standards. First, this study examined if existing tenants could meet the standard based on their peak electrical current and capacity to convert natural gas equipment to electric. This ensures that the standard is reasonably achievable. Another key consideration when developing these standards was electrical infrastructure cost breakpoints to support standard electric service sizes (e.g., 100, 200 and 400A). In practice, if the electrical service size recommendation was 250A, the upstream electrical infrastructure would be built out to support 400A, eliminating any gains by limiting the service size to 250A. Furthermore, only 80% of the provided full load amp capacity can be utilized by the tenant (NEC 2023), meaning if SFO provides 200A, only 160A can be used. Finally, given the assumption that TT would choose the most energy-intensive option, it is likely that the estimated electrical capacity required to transition away from natural gas equipment is somewhat overestimated given that tenants may opt for energy efficient appliances and equipment will continue to become more efficient in the future.

This approach was replicated across all TT categories and resulted in the electric service size standard recommendation of 200A (480V) for future quick serve, sit-down, and lounge TT (Table 5). For coffee TT, the recommended electric service size standard is 100A (480V). For retail categories news and specialty, SFO provides lower voltages (208V) and the recommended electric service size standards are 100A and 50A, respectively. While these recommended electric service sizes are intended for new TT, understanding the impact for existing tenants brings grounding to the feasibility of implementation. Across four categories, 86-100% of existing TT would have sufficient electric service if they went all-electric and were given the recommended electric services (Table 5). The other two categories, Sit-down and lounges, had the smallest percentages (45-71%) of existing TT being at or below the new recommended electric service sizes given an all-electric retrofit, although an additional 9% and 14% of TT are within single digits above the recommended electric service size.

Table 5: Existing and new recommended electrical service standard with percentage of current tenants meeting new recommended standard based on natural gas equipment conversion

Category	Existing Electric Service (480V) Range [Min-Max (Avg)]	New Rec. Electric Service Standard (480V)	New Rec. Electric Service Standard (208V)	Percentage of Existing TT below New Rec. Electric Service Standard
Quick Serve	70-300A (165A)	200A		86%
Sit-Down	150-250A (202A)	200A		45%
Coffee	50-225A (103A)	100A		94%
Lounge	50-1470A (376A)	200A		71%
News	50-125A (60A)		100A	100%
Specialty	22-250A (61A)		50A	88%

There may be unique TT buildouts that do not fit neatly into the categories outlined above, such as large retailers and food halls. For these special concepts, these electric service size recommendations could be added together based on the multiple tenant categories proposed. Generally, it would be prudent to evaluate the desired concept and needed capacity in more detail.

Conclusions

Terminal tenant electrification is challenging and multifaceted but necessary to achieve SFO's net zero carbon 2030 future. Achieving an all-electric future requires SFO to balance various perspectives and motivations of tenants, airlines, Airport staff and the traveling public. These varying interests result in a broad range of Airport policies, projects and collaborations that can be layered to achieve monumental change over time. By itself, recommending electric service size standards may seem to only influence decisions when easiest to electrify, at initial space build-out; however, the expanded influence of TT electric service sizes involves

consistency and clarity for future TT leaseholders, a prioritization plan for SFO staff to install upstream electrical infrastructure, and accountability to the public to meet SFO's bold climate goals. Furthermore, the results from this study may prove useful to other multi-tenant properties with electrification ambitions beyond airports, such as shopping malls, sports stadiums, and universities.

Even with future adoption of these recommended standards, implementation and adoption challenges remain. From a physical electrical infrastructure perspective, all the upstream electrical infrastructure needs to be evaluated and possibly modified to accommodate TT going all-electric. As a result of this study, work is underway to conduct electrical infrastructure site surveys in two key boarding areas with a high number of tenant turnover in the next five years. From a TT perspective, close partnerships are paramount in making an all-electric future a reality as leases span 7 to 12 years with some existing leases that use natural gas expire after 2030. Aligning these existing TT with SFO's 2030 net zero carbon goals would necessitate equipment replacements likely before the equipment's end-of-life and possibly electrical infrastructure upgrades mid-lease. Future work is being planned to examine possible incentives, partnerships or other mechanisms to aid this transition outside of the initial TT space build-out. Inside restaurants, concerns exist amongst TT on how the transition to electric might impact food preparation and taste, overall kitchen operations and staff training. All of these physical, logistical, cost, and food quality hurdles are distinct and can be significant to overcome. Active engagement and collaboration with TT to find solutions that do not create undue burden for SFO's TT, whilst still allowing for health and environmental co-benefits to be felt by those who work and fly at SFO alike is the road ahead.

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