If You Can't Stand the Heat, Get Into the Kitchen: SD DOAS Technology, Integrated HVAC Systems, and the Case for Smarter Space Conditioning for Commercial Kitchens in Hot, Humid Climates

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ABSTRACT

Commercial kitchens in hot, humid climate zones are the jalapeños of the commercial building world—intensely hot, unapologetically humid, and demanding attention. With energy intensities five to seven times greater than typical commercial spaces and significant make-up air requirements, these facilities face a perfect thermodynamic storm. Climate change is turning up the heat further, and rising electricity prices are making every BTU count.

This paper argues that the solution lies in an integrated HVAC approach built around two complementary innovations: the Very High Efficiency Dedicated Outdoor Air Unit (VHE DOAS) concept, which separates ventilation from space conditioning for dramatically improved system-level efficiency; and Solid Desiccant Dedicated Outdoor Air Unit (SD DOAS) technology, which further separates latent (moisture) load management from sensible (temperature) cooling to tackle hot, humid outside air. Together—integrated with high-efficiency heat pump RTUs, advanced filtration, smart controls, and optimized distribution—these approaches deliver 40–85% reductions in HVAC energy use, meaningful peak demand cuts, and measurably better working conditions for kitchen staff.

This is not merely an academic exercise. A decade of field demonstration by the Northwest Energy Efficiency Alliance (NEEA) and Pacific Northwest National Laboratory (PNNL) has proven the VHE DOAS concept across 16 commercial projects averaging 66% HVAC savings. Real-world SD DOAS deployments in a Houston warehouse and Florida commercial kitchen are now extending this performance to hot, humid climates. With data centers driving a historic surge in electricity demand and reshaping grid economics, the urgency of demand reduction has never been greater.

So, you can come for the energy savings and stay cool for the duration.

Introduction

Hot, loud, fast-paced, and exhausting—the commercial kitchen is one of the most demanding work environments in the built environment. In hot, humid climate zones across the Southeast, mid-Atlantic, and Midwest, kitchen operators face outside conditions that make efficiency challenging for even a well-designed makeup air unit (MAU). Traditional approaches to kitchen ventilation—conventional rooftop units handling both outside air conditioning and space cooling in a single undifferentiated package—are the HVAC equivalent of using a meat thermometer to manage a walk-in freezer: a useful tool that is not well suited for the job.

This paper proposes a different recipe. It builds the case for a fully integrated HVAC system strategy for commercial kitchens in hot, humid climates, organized around one of two distinct but complementary innovations in dedicated outside air system (DOAS) technology. The first is the VHE DOAS design approach—well suited for hot dry climates and delivering efficiency by separating ventilation from space conditioning so that each function can be optimized independently. The second is the SD DOAS design approach, with the application of solid desiccant materials to tackle the unique latent load challenge of hot, humid outside air, separating moisture management from temperature control.

The paper is organized around five main sections. Section 1 documents the growing energy burden of space conditioning in hot, humid climates and the particular intensity of commercial kitchen end uses. Section 2 examines the two DOAS innovations in technical detail, distinguishes their respective contributions, and describes how they integrate with high-efficiency heat pump RTUs, filtration, controls, and distribution systems to form a complete HVAC strategy. Section 3 presents real-world case study evidence from SD DOAS deployments in a warehouse in Houston and a commercial kitchen in Florida, including both energy savings and peak demand reduction outcomes. Section 4 discusses codes and standards drivers. Section 5 discusses pressure on the grid from data center development, and implications for operators, engineers, utility programs, and policymakers.

Section 1: The Energy Burden of Hot, Humid Space Conditioning

Hot, Humid Climates: When Humidity Is Not Welcome to the Dinner Party

The ASHRAE climate zone classification system—codified in ASHRAE 90.1 and the International Energy Conservation Code (IECC)—identifies a substantial swath of the United States as hot, humid territory: ASHRAE Climate Zones 1A, 2A, 3A, 4A, and 5A encompass the Gulf Coast, Southeast, portions of the mid-Atlantic, and Midwest, including major commercial markets like Houston, Miami, New Orleans, Atlanta, Tampa, Charlotte, New York, and Chicago.

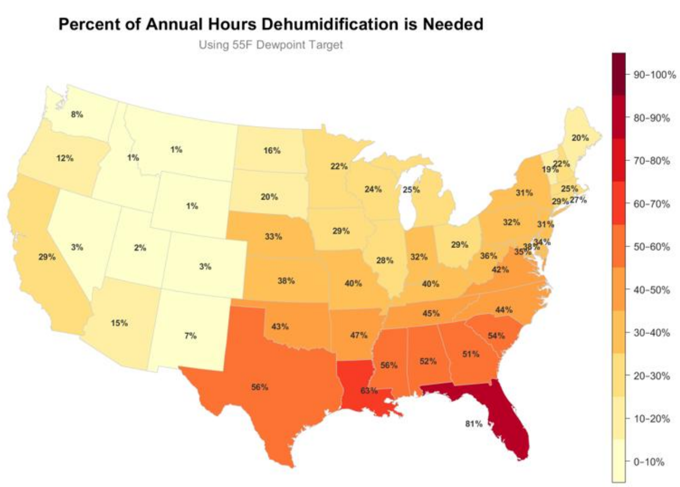

Fig 1. U.S. Map with Percentage of hours where dehumidification is needed for 55-degree dew point target. *Source:* Transaera Inc.

In these zones, the HVAC challenge is fundamentally a moisture problem wrapped in a temperature problem. Outside design conditions can reach 96°F dry bulb at 80°F wet bulb in Houston, and similar extremes prevail across Florida for six months of the year. At these conditions, the latent heat load—the energy required to remove moisture from incoming outside air—can be upwards of 4-7 times higher than the sensible load on a seasonal basis (Harriman, et al, 1997). Conventional packaged RTUs address this by deep-cooling supply air well below the dew point to condense moisture, then reheating to a comfortable temperature. It is an approach that works, like pumping water uphill through a garden hose—technically possible, but wildly inefficient.

The fundamental problem is the coupling of technical challenges: conventional systems bundle temperature and humidity control into a single refrigeration loop, using one tool to do two different jobs. The energy waste this produces is particularly punishing in high-latent-load environments, and the commercial kitchen—with its significant outside air requirements—is the most demanding environment of all.

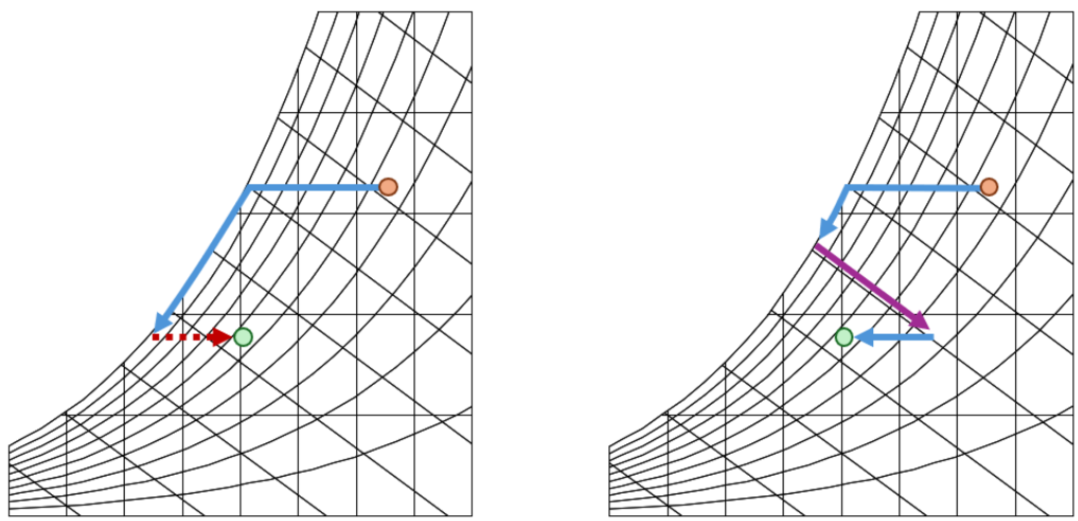

Fig 2. Diagrammatic psychrometric chart demonstrating latent heat removal using desiccant-based approach (left) and vapor compression-based approach (right). *Source:* Transaera Inc.

Climate Change Is Turning Up the Heat

The energy burden of cooling in hot, humid climates is increasing. NOAA and the U.S. Global Change Research Program's Fifth National Climate Assessment (2023) document sustained warming trends across the Southeast, with summer heat extremes becoming more frequent and intense. For HVAC systems, this means increasing design cooling loads, higher run-time fractions, and accelerated equipment degradation. Systems sized for the design conditions of the past few decades are already operating closer to their limits; systems sized for today's conditions may be marginal within a decade or two.

Simultaneously, electricity prices across the US are rising. Grid infrastructure investments, fuel cost volatility, and—critically—the surging power demands of data center development (discussed further in Section 4) are all pushing commercial electricity rates upward. The combination of rising cooling loads and rising energy prices creates a compounding cost pressure that is structurally different from the simpler rate design challenge these markets faced a generation ago.

Commercial Kitchens: Where the Heat Is Already Off the Scoville Scale

Food service establishments consume five to seven times more energy per square foot than typical commercial spaces (Goel et al. 2018). The explanation is straightforward: commercial kitchens concentrate high-output cooking equipment—ranges, fryers, ovens, steamers, and dishwashers—at densities that would be unusual even in an industrial manufacturing setting. Cooking hood exhaust rates are substantial, and health codes require that 100% of exhausted air be replaced with fresh outside air, fully conditioned from ambient state.

This 100% outside air requirement is the crux of the HVAC challenge. Unlike most commercial spaces, where ASHRAE 62.1 ventilation rates can be met with 15–30% outside air fractions (moderating outside air loads with recirculated indoor air), commercial kitchens must process every cubic foot of incoming air from scratch.

Energy costs can represent over 20% of facility operating costs for a full-service restaurant, more in areas with higher temperatures and humidity, and/or higher utility rates (ETO, USEIA). In a sector characterized by thin margins, the energy bill is one of the largest controllable costs, and in hot, humid climates it is dominated by space conditioning. For operators already managing the pressure of rising food costs, labor costs, and utility rates inflated by data center demand, a 40%+ reduction in HVAC energy use is not an abstraction—it is a viable path to profitability that can put food on the table for operators.

Section 2: Two Innovations, Two Integrated Strategies

Concept 1: VHE DOAS — Separating Ventilation from Space Conditioning

The Very High Efficiency Dedicated Outside Air System (VHE DOAS) concept, championed by the Northwest Energy Efficiency Alliance (NEEA) beginning in 2015, is built on a single, powerful design principle: ventilation and space conditioning do different jobs, so let different systems do them.

In a VHE DOAS design, a dedicated ventilation unit—the DOAS—uses either HRV/ERV technology to handle all outside air intake, filtering, heat recovery, and conditioning to a near-neutral supply condition. Separate space conditioning equipment (fan coils, VRF systems, or heat pump RTUs) handles only the internal sensible loads, with outside air dampers closed or minimized. This decoupling enables each system to be right-sized and optimized for its specific function, eliminating the competing demands that make conventional single-package systems inherently inefficient.

The VHE DOAS specification adds rigor to this concept with specific performance requirements: sensible heat recovery effectiveness of 82% or greater per AHRI 1060-2018, fan power of 0.77 W/cfm or less, and a fully decoupled ventilation architecture. When these requirements are met for buildings in favorable climate zones, the system is capable of achieving HVAC energy savings of 40–85% compared to conventional RTU configurations (O'Neil, Pratt, and Bulger 2024). Field demonstrations across 16 projects in the Pacific Northwest documented a consistent post-conversion HVAC energy use intensity of approximately 14.8 kBtu/sq ft per year, regardless of starting point—a remarkably performance target for engineers and utility programs (O'Neil, Pratt, and Bulger 2024).

A critical long-term validation came from the 2023 PNNL re-evaluation study (Yoder et al. 2023), which followed up on eight VHE DOAS demonstration sites originally monitored through the NEEA/IMT program. All sites maintained or improved their energy savings over the monitoring period, averaging 48% whole-site savings compared to the pre-conversion system. Occupant comfort improved measurably: respondents were 43% more satisfied and 30% less dissatisfied post-conversion. These findings establish that the VHE DOAS concept delivers durable performance, not just favorable first-year numbers.

Concept 2: Solid Desiccant DOAS (SD DOAS) — Separating Latent Load from Sensible Cooling

The VHE DOAS concept's energy recovery ventilator (ERV) or heat recovery ventilator (HRV) achieves excellent performance in Pacific Northwest climates, where latent loads are modest and sensible heat recovery is the dominant energy-saving mechanism. In hot, humid climate zones, however, the picture changes. Incoming outside air can be carrying latent loads equal to or exceeding sensible loads, and even a high-efficiency ERV must still rely ultimately on mechanical cooling and condensation to remove moisture beyond what energy recovery can handle. Deep overcooling to below the dew point—followed by reheat—remains the standard for latent control in conventional systems in hot and humid climates, and it is an energy-intensive standard.

SD DOAS technology addresses this limitation by introducing a second, distinct decoupling: separating latent load management (moisture removal) from sensible cooling (temperature reduction). Rather than relying on condensation as the primary dehumidification mechanism, at the component level, SD DOAS units use solid desiccant adsorption to remove water vapor from the incoming air stream immediately downstream of the primary cooling coil. The adsorption process does not require deep cooling—it operates through physical chemistry, using the affinity of a high-surface-area sorbent material for water vapor molecules.

The sorbent material. The most advanced current implementation of this principle uses metal-organic framework (MOF) compounds as the sorbent. MOFs are highly engineered porous crystalline materials with internal surface areas exceeding 7,000 square meters per gram in some configurations, and tunable pore chemistry that can be optimized for selective water vapor adsorption. The 2025 Nobel Prize in Chemistry recognized the foundational contributions of MOF research to materials science, underscoring the rigor of the scientific basis for this approach. In the SD DOAS application, MOF material is coated onto a continuously rotating sorption wheel. Incoming outside air passes through the adsorption zone of the wheel, where water vapor is removed just after the air stream reaches the primary cooling coil. The wheel then rotates through a regeneration zone, where low-grade thermal energy—recovered internally from the system's heat pump refrigeration cycle—drives the desorbed moisture out of the sorbent, restoring its capacity. The regeneration loop requires no external heat source or supplemental fuel.

By removing moisture just downstream of the primary cooling coil, the SD DOAS architecture eliminates the need for deep overcooling and eliminates reheat in most operating conditions. The primary cooling coil handles only the sensible load and delivers pre-cooled air to the sorbent material, which is operating at a much more favorable sensible heat ratio and higher efficiency than a conventional dehumidifying coil. The upstream refrigeration circuit—active only when outside conditions demand pre-conditioning—provides a first stage of latent and sensible removal under extreme conditions and can shut off entirely during moderate weather. Electronically commutated (EC) fans and inverter-driven compressors throughout the system provide variable-speed operation that minimizes part-load energy consumption during the many hours when outside conditions are favorable.

It is important to understand how the SD DOAS and VHE DOAS are different. VHE DOAS is about system architecture: decouple ventilation from space conditioning. SD DOAS is about ventilation unit performance: within that decoupled architecture, achieve deeper latent load reduction with significantly less energy than conventional condensation-based dehumidification requires. In hot, humid climate applications, both concepts are needed: decoupling ventilation and sensible cooling, as well as decoupling latent load and sensible load reductions to enable right-sizing and coordination of the full HVAC system, and the unit performance to handle the exceptional latent loads that hot, humid outside conditions impose.

The Fully Integrated HVAC System: More Than the Sum of Its Parts

The energy performance documented for VHE DOAS and SD DOAS systems is achieved not just by the ventilation units themselves, but by the integration of those units into a complete integrated HVAC system designed as a coherent whole. For commercial kitchen applications in hot, humid climates, the SD DOAS integrated system includes five mutually reinforcing components.

High-efficiency heat pump RTUs in recirculation mode. When the SD DOAS handles all outside air supply and latent loads, packaged RTUs serving the kitchen space operate with outside air dampers closed. In recirculation mode, RTU coils handle only the internal sensible load—dominated by cooking equipment heat gains—at a much more favorable operating condition than when conditioning humid outside air. This allows RTU equipment to be downsized relative to a conventional system, improving part-load efficiency and reducing first cost. Critically, the 2021 Washington State Energy Code (Section C403.1.4) now mandates heat pump technology for space heating in all new commercial buildings, a requirement that aligns perfectly with the integrated system architecture described here. All-electric heat pump RTUs also enable the full decarbonization benefits of the integrated system as the grid continues to add renewable generation.

High-efficiency filtration. Commercial kitchen exhaust air carries grease aerosols, particulates from cooking processes, and elevated concentrations of combustion products. Upstream filtration on the DOAS outside air intake and return air for exhaust protects the sorbent wheel from fouling, maintains system performance, and delivers cleaner air to occupants. High-efficiency filters (up to MERV 13 filtration—now required by California's Title 24 for air supplied to occupied spaces through mechanical systems (Section 120.1)) can be selected in accordance with operating requirements. High-efficiency filtration on the return side of RTU equipment captures particulates from cooking activities before they degrade heat exchanger performance.

Advanced controls and demand-controlled kitchen ventilation (DCKV). Modern commercial kitchen HVAC systems can coordinate exhaust fan modulation, DOAS airflow, and RTU operation in real time through integrated control platforms. ASHRAE 90.1-2022's optional new Total System Performance Ratio (TSPR) (Addendum AG: Sections 6.2.2 and 6.6.2, and Appendix L) compliance pathway explicitly credits DOAS with low fan power and demand-controlled ventilation among the measures contributing to system-level efficiency. State codes in Washington (Section C406.2) similarly award efficiency credits for high-performance DOAS implementations. Advanced controls enable the system to reduce airflow during off-peak cooking periods, respond to occupancy signals, and coordinate demand response during grid stress events—turning the kitchen HVAC system from a passive load into a grid-interactive asset.

Optimized distribution and ductwork design. The energy savings achievable through SD DOAS and heat pump RTUs can be substantially eroded by poorly designed distribution systems. Low-pressure ductwork, proper sealing, and supply air delivery strategies matched to the kitchen configuration are essential to realizing the full potential of the advanced system. The NEEA/betterbricks VHE DOAS Design Guide (NEEA betterbricks) provides detailed guidance on ductwork design principles that should inform commercial kitchen applications. In some configurations, displacement ventilation—delivering conditioned outside air at low velocity near the work zone, allowing it to rise and stratify as it absorbs heat—can further improve both thermal comfort and indoor air quality for kitchen workers.

Commissioning, monitoring, and ongoing verification. The PNNL persistence study (Yoder et al. 2023) found that properly commissioned VHE DOAS systems maintain their energy savings over time. ASHRAE 90.1-2022 now mandates energy management control systems with 15-minute interval monitoring for buildings over 25,000 square feet, and the trend in leading state codes is toward broader monitoring requirements. For commercial kitchens, submetered HVAC energy data enables operators to verify performance, detect degradation, and optimize system operation—recovering savings that might otherwise erode over time.

Section 3: Case Studies: SD DOAS in Commercial Kitchens

Why Commercial Kitchens Are the Perfect DOAS Food Lab

The commercial kitchen is, in a sense, the ultimate stress test for DOAS technology in hot, humid climates. Every design challenge is present in concentrated form: 100% outside air, extreme latent loads, long operating hours, high internal heat gains, demanding filtration requirements, and occupants who are intimately aware of thermal comfort.
The sector also offers a compelling economic proposition. The approximately one million commercial food service establishments in the United States represent a large and geographically concentrated market for SD DOAS technology, with disproportionate representation in hot, humid regions where the savings potential is greatest (Goel et al. 2018). Ghost kitchen and commissary operations—a growing segment driven by the rise of delivery-only food service—operate at particularly high utilization rates with dense cooking equipment, maximizing both the energy intensity of the baseline and the savings potential of advanced HVAC solutions.

Houston Deployment: 18 Months in the Hot, Humid Crucible

Houston, Texas sits at the deep end of Climate Zone 2A—summer design conditions of approximately 96°F dry bulb and 80°F wet bulb, among the most extreme in the continental United States for combined heat and humidity. If you can make a DOAS system work here for 18 consecutive months without losing performance, you've earned your seat at the table in the hot, humid climate conversation.
The first commercial deployment of the SD DOAS technology was installed at a large commercial warehouse customer site in Houston in August 2024. Sustained field monitoring over 18 months documented an Integrated Seasonal Moisture Removal Efficiency (ISMRE) of 11.4—a measure of how efficiently the system removes moisture across all seasonal operating conditions, analogous to SEER for sensible cooling. This performance level reflects the value of

solid-state adsorption-based dehumidification under real-world hot, humid conditions: sustained moisture removal without the efficiency penalties of deep overcooling and reheat that afflict conventional vapor compression-based HVAC systems at peak conditions.

The Houston deployment also validated the durability of the MOF sorbent material under sustained operation in a hot, humid environment—thousands of adsorption-regeneration cycles without measurable degradation in moisture removal capacity. This persistence parallels the findings of the PNNL VHE DOAS long-term study (Yoder et al. 2023), which documented that all eight monitored sites maintained or improved their energy savings over the multi-year monitoring period.

Florida Commercial Kitchen: Energy Savings and Peak Demand Performance

Two 40-ton SD DOAS units have been permanently installed at a commercial commissary kitchen facility in Florida, operating as a real-world validation of the integrated HVAC system approach described in this paper. The site represents a commissary kitchen model: high cooking density, extended operating hours, and a continuous outside air demand that makes the HVAC system run hard virtually every hour the kitchen is open.

Preliminary modeling results based on site operating conditions and measured airflow rates indicate the potential for greater than 40% annual electricity savings relative to a conventional DOAS baseline configuration. This is consistent with the upper range of energy savings documented in VHE DOAS field demonstrations (O'Neil, Pratt, and Bulger 2024), reflecting the additional efficiency benefit of the advanced desiccant latent load management over conventional condensation-based approaches. On-site metering and formal M&V activities are ongoing.

In the case of On-peak Electrical Demand Reduction (OPEDR)—a performance metric of increasing importance given grid pressures from data center growth—preliminary projections indicate approximately 20% reduction in peak demand relative to the conventional baseline DOAS configuration. This translates directly to monthly demand charge savings that can represent a substantial fraction of total utility cost for commercial kitchen operators, particularly in Florida utility service territories where demand charges are significant. Peak demand reduction also contributes to grid stability during the hot summer afternoons when both kitchen HVAC loads and data center cooling loads are simultaneously at their maximum.

Table 1 summarizes the energy savings and peak demand performance data available from the case study deployments alongside VHE DOAS field demonstration data for context.

System Configuration	HVAC Energy Savings	Annual Energy Reduction	Peak Demand Reduction	Source
Conventional RTU (baseline)	0% (reference)	—	—	—
VHE DOAS: decoupled vent. + high-efficiency heat pump	40–85% HVAC savings (avg. 66%)	50% avg. whole-building EUI reduction	Not separately reported (PNW climate)	O'Neil et al. 2024

VHE DOAS — long-term persistence study (8 sites)	48% avg. whole-site savings	Sustained multi-year	Not separately reported	Yoder et al. 2023
SD DOAS (MOF desiccant) + recirculating RTUs — projected, commercial kitchen, FL	>40% annual electricity savings vs. conventional DOAS	Full M&V in progress	~20% peak demand reduction projected	Transaera 2026

Table 1. DOAS system performance summary: energy savings and peak demand reduction. *Sources:* O'Neil, Pratt, and Bulger (2024); Yoder, Piazza, and Pratoomratana (2023); Transaera (2026). (Note to reviewers: more detailed data will be included in the final draft of the paper once received)

Design Lessons for Hot, Humid Kitchen Applications

Filtration is not optional. Grease aerosols and cooking particulates are the nemesis of HVAC systems and especially sorbent wheel media. Upstream MERV 13 (or better) filtration on the DOAS outside air intake, combined with grease filter arrays appropriate to the return air exhaust configuration, is non-negotiable. Pressure drop monitoring across the sorption wheel provides early warning of any fouling-related performance degradation.

Controls coordination is where the savings live. The energy savings projected in the Florida deployment are achievable only when DOAS airflow, kitchen exhaust fan operation (DCKV), and RTU recirculation mode are properly coordinated. Integrated controls that track cooking activity, outside conditions, zone temperature, and humidity simultaneously enable the system to minimize energy use while maintaining code-required ventilation rates and acceptable kitchen conditions. This is not set-and-forget; it requires commissioning attention and ongoing monitoring.

Distribution design matters. Low-velocity, low-pressure DOAS supply air distribution to kitchen work zones provides thermal and IAQ benefits for kitchen workers and minimizes supply-exhaust short-circuiting. Proper duct sealing reduces the leakage that can erode both energy performance and ventilation effectiveness. The NEEA/betterbricks VHE DOAS Design Guide (2023) provides foundational guidance that should be adapted to kitchen-specific configurations.

Rooftop integration requires early coordination. Commercial kitchen rooftops are real estate. Exhaust equipment, grease collection systems, utility penetrations, and structural constraints all compete for space. Establishing DOAS unit footprint, curb configuration, potential airflow conflicts, and service access requirements at the earliest stage of the design process avoids costly late-stage redesigns.

Section 4: Building Codes and Standards: The Policy Tailwind

National Model Codes Are Embracing DOAS

Commercial kitchen HVAC has historically been an underregulated frontier in building energy codes—a space where high energy intensity persisted partly because codes focused more on envelope and lighting than on the HVAC systems that dominate kitchen energy use. That is changing. The latest generation of model codes and leading state codes are increasingly creating requirements and incentives that favor the integrated DOAS approach.

ASHRAE 90.1-2022, the foundational national model energy standard for commercial buildings, includes multiple provisions that directly support and incentivize DOAS adoption. Addendum cv to 90.1-2022 establishes minimum efficiency requirements for direct-expansion DOAS (DX-DOAS) units, including minimum ISMRE2 ratings under AHRI 920-2020, formalizing DOAS performance standards at the national model code level for the first time. The new optional TSPR compliance pathway in Section 6 allows HVAC system efficiency trade-offs, with low DOAS fan power and demand-controlled ventilation among the credited measures. Section 11.5.2.2.6 (Addendum p to 90.1-2022) provides an energy credit—the H06 credit—for DOAS with zone fan control that cycles zone heating/cooling fans off when not required, directly incentivizing the decoupled architecture that is central to the VHE DOAS approach. ASHRAE 62.1-2022, governing ventilation rates, defines specific outside air requirements for food service spaces that create the 100% outside air framework within which DOAS technology provides its greatest benefits.

The 2021 International Energy Conservation Code (IECC) and its commercial provisions, which form the baseline code for most U.S. jurisdictions, have tracked toward requiring energy recovery with DOAS systems in climate zones where energy recovery is cost-effective—including the hot, humid zones of primary interest to this paper. Together, ASHRAE 90.1-2022 and the IECC commercial provisions create a national model code framework that has moved decisively toward DOAS as a preferred ventilation strategy in commercial buildings.

Leading State Codes Are Setting Higher Bars

Several states have adopted energy codes that go beyond national model code requirements and that specifically recognize and incentivize DOAS integrated design approaches.

Washington State's 2021 Energy Code (WSEC-C), which became effective statewide on March 15, 2024, represents the most prescriptive DOAS code requirement in the nation. Section C403.3.5 requires DOAS systems used for ventilation to achieve 68% sensible heat recovery effectiveness (up from 60% in the 2018 code) or 60% enthalpy recovery effectiveness—approaching VHE DOAS performance levels. Section C403.1.4 separately requires heat pump technology for space heating in all new commercial buildings, aligning Washington code with the all-electric integrated system approach described in this paper. The prescriptive efficiency credit framework in Section C406.2 awards credits for high-performance DOAS implementations, and Section C406.3 requires building load management credits that can be met through advanced HVAC controls and demand response capabilities. The City of Seattle's 2021 Energy Code largely mirrors the state code but with additional stringency provisions. Washington's adoption of these requirements—informed by the NEEA VHE DOAS demonstration program—demonstrates that code requirements for SD DOAS performance could be a next step for codes in hot, humid states and can be technically achievable, cost-effective, and administratively manageable.

California's 2022 Title 24 Part 6 (effective January 1, 2023) added new prescriptive requirements for DOAS systems, including multi-speed fan requirements, restrictions on supply air reheating above 60°F when cooling is needed, and requirements that DOAS supply air be delivered directly to occupied spaces. Title 24 Section 120.1 mandates MERV 13 filtration for all air supplied to occupied spaces through mechanical systems—a requirement that applies directly to DOAS outside air systems. While California's commercial kitchen energy code requirements are still evolving (the CASE report process has documented the gap in Title 24 coverage of commercial kitchen mechanical systems), these provisions create a strong baseline for SD DOAS deployment in areas of the nation's largest commercial building market. NEEA's engagement with California code stakeholders—documented in the Kevin Rose Comments on the 2025 California Energy Code Rulemaking—reflects the ongoing effort to incorporate VHE DOAS provisions into California's code framework.

Other states in hot, humid climate zones—including Florida (2021 IECC and ASHRAE 90.1-2019 with Amendments), Texas (2015 IECC and ASHRAE 90.1-2013), Georgia (2015 IECC and ASHRAE 90.1-2013 with amendments), and North Carolina (2015 IECC and ASHRAE 90.1-2013 with amendments)—have varied on adopting the most recent versions of the IECC or ASHRAE 90.1 as their baseline commercial energy codes, with varying levels of amendments. None have yet matched Washington State's specific VHE DOAS performance requirements, but the trajectory of national model code development and the growing evidence base from field demonstrations provide a strong foundation for advocacy in these jurisdictions. The economic case for SD DOAS code requirements in hot, humid climates is arguably even stronger than it is for VHE DOAS in the Pacific Northwest: higher cooling loads, more extreme latent conditions, and longer cooling seasons, amplify the energy savings of SD DOAS relative to the baseline.

Section 5: Broader Context: The Grid Pressure Cooker

Data Centers and the New Electricity Demand Landscape

The energy case for SD DOAS technology in commercial kitchens and other high-intensity commercial buildings does not exist in isolation. It is part of a larger and increasingly urgent story about electricity demand growth that is reshaping the economics of energy use across every sector of the U.S. economy.

Data center construction, driven by the explosive growth of artificial intelligence workloads and cloud computing, is fundamentally changing the electricity demand landscape. The consulting firm Grid Strategies found that utility five-year peak demand growth forecasts rose from 38 GW in 2023 to 128 GW in 2024—a tripling in projected growth in a single year (Grid Strategies 2025). The U.S. Energy Information Administration projects that commercial computing will account for 20% of commercial sector electricity consumption by 2050—potentially exceeding space cooling and ventilation as the largest commercial end use (EIA 2025). S&P Global forecasts U.S. data center grid power demand at 75.8 GW by 2026, growing to 134 GW by 2030 (S&P Global 2025).

The implications for commercial building energy costs are direct and significant. Data centers are concentrated in specific regions—Virginia, Texas, Georgia, Oregon, Ohio, and Florida among the largest markets—and their grid interconnection requests are driving substantial utility infrastructure investments whose costs are often socialized across all ratepayers. Carnegie Mellon University research estimates that data centers and cryptocurrency mining could increase average U.S. electricity bills by 8% by 2030, with increases exceeding 25% in the highest-demand markets (Pew Research 2025). For commercial kitchen operators in Virginia, Texas, Georgia, and Florida—all hot, humid climate states with major data center markets—this represents a compounding cost pressure on an already energy-intensive operation.

The response to this challenge cannot be supply-side alone. The time required to permit, finance, and construct new generation, transmission, and distribution infrastructure means that demand-side efficiency and peak demand reduction will be essential tools for managing grid stress in the near to medium term. Commercial buildings—the largest single category of commercial electricity consumers—have a central role to play. And within the commercial sector, the most energy-intensive buildings—including commercial kitchens—represent the highest-value targets for efficiency investment.

DOAS Technology as a Key Ingredient for the Grid Recipe

The peak demand reduction benefits of SD DOAS technology are not incidental—they are a direct result of the system's fundamental operating principles. By removing moisture from incoming outside air through solid-state adsorption rather than deep vapor compression-based cooling, the SD DOAS unit substantially reduces peak air conditioning load for latent heat removal during the hot, humid summer afternoons when both kitchen HVAC and data center cooling demands are simultaneously at their maximum. The approximately 20% peak demand reduction projected from the Florida commercial kitchen deployment, delivered at scale, can provide significant grid capacity and reliability benefits.

Advanced controls integration extends this benefit. DOAS systems with demand response capability can shift pre-cooling and pre-dehumidification loads to off-peak hours, reducing demand during grid stress events without compromising kitchen conditions during service. The Duke University Nicholas Institute's 2025 'Rethinking Load Growth' report found that flexible commercial loads accepting curtailment for as little as 0.25 to 1% of annual hours could allow utilities to integrate 76–126 GW of new demand without proportionate generation or transmission expansion (ITIF 2025). Commercial HVAC systems with controls capable of grid-interactive operation are part of that flexibility portfolio.

Conclusions and Recommendations

SD DOAS technology and the integrated HVAC strategy described in this paper serve multiple purposes simultaneously. They reduce operating costs for commercial kitchen operators. They improve the working environment for kitchen staff. They enable compliance with increasingly stringent energy codes. And they reduce the electricity demand burden on grids that are already straining under the weight of data center growth. That is not one solution to one problem—it is a recipe for value across multiple dimensions. As any good cook knows, the best dishes are the ones where every ingredient earns its place.

This paper has presented an integrated case for SD DOAS technology in commercial kitchens in hot, humid climates, built on three main arguments. First, two distinct and complementary DOAS innovations—the VHE DOAS architecture that separates ventilation from space conditioning, and the SD DOAS approach that further separates latent load management from sensible cooling—provide a path to 40–85% HVAC energy savings and ~20% peak demand reduction that is validated by field evidence. Second, the combination of climate change, rising energy prices, and data-center-driven grid pressure is making the status quo of conventional RTU-based kitchen HVAC increasingly costly and unsustainable. Third, this technology trajectory is increasingly supported by building codes and standards, creating a regulatory tailwind that will accelerate adoption.

The integrated HVAC system strategy that includes DOAS is not merely an aspirational framework. It is a practical design approach that can be implemented with currently available technology, using the VHE DOAS Design Guide (NEEA /betterbricks/ 2023) as a foundational reference and adapting its principles to the specific demands of commercial kitchen environments in Climate Zones 1A, 2A, 3A, 4A, and 5A. The evidence from Houston and Florida provides initial real-world validation; ongoing M&V will provide the robust performance data needed to support broader adoption.

Variations in local and seasonal climate conditions, system sizing, and operating approach could impact performance and savings. As deployment of these technologies expands, additional actual performance data will be available and provide an opportunity for additional and ongoing evaluation of performance outcomes.

The following recommendations are offered to different stakeholder groups:

- Operators and facility managers: Evaluate SD DOAS and integrated HVAC system designs as a priority for new construction, major renovation, and major equipment replacement.
- Engage utility programs administrators about available incentives; in several hot, humid states, programs are beginning to include DOAS technology in commercial incentive offerings. Work with engineers who are fluent in decoupled ventilation design and familiar with commercial kitchen-specific applications.
- Mechanical engineers and specifiers: Adopt the SD DOAS decoupling principle as the baseline design approach for commercial kitchens in Climate Zones 1A, 2A, 3A, 4A, and 5A. Specify VHE DOAS in low-latent-load applications and SD DOAS with desiccant-based technology for high-latent-load applications. Include peak demand reduction in performance specifications and owner-cost analyses.
- Utility programs administrators: Develop or expand commercial kitchen HVAC incentive offerings to include SD DOAS and integrated system approaches in hot, humid climate zones. Partner with technology developers and early adopters to develop deemed savings values—including both energy and peak demand savings—based on monitored field data. Draw on the NEEA program model for program design.
- State energy offices and codes authorities in hot, humid states: Engage with the VHE DOAS evidence base from NEEA and PNNL and evaluate opportunities to incorporate SD DOAS performance requirements into state energy codes, modeled on the Washington State precedent. Prioritize commercial kitchen HVAC system design as an underregulated high-energy-intensity end use with significant savings potential. Coordinate with utility programs to accelerate market transformation.

Commercial kitchens have always run hot. In a world of rising temperatures, rising energy prices, and rising grid stress, the question is no longer whether better HVAC technology is needed. The numbers speak too clearly for that. The question is how quickly the market will get the recipe right. The ingredients are all on the counter. SD DOAS technology, the VHE DOAS design framework, high-efficiency heat pump RTUs, smart controls, and the growing push from codes and standards, together, form a value meal that is technically proven, economically compelling, and increasingly required. It's time to turn up the efficiency, not the thermostat.

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