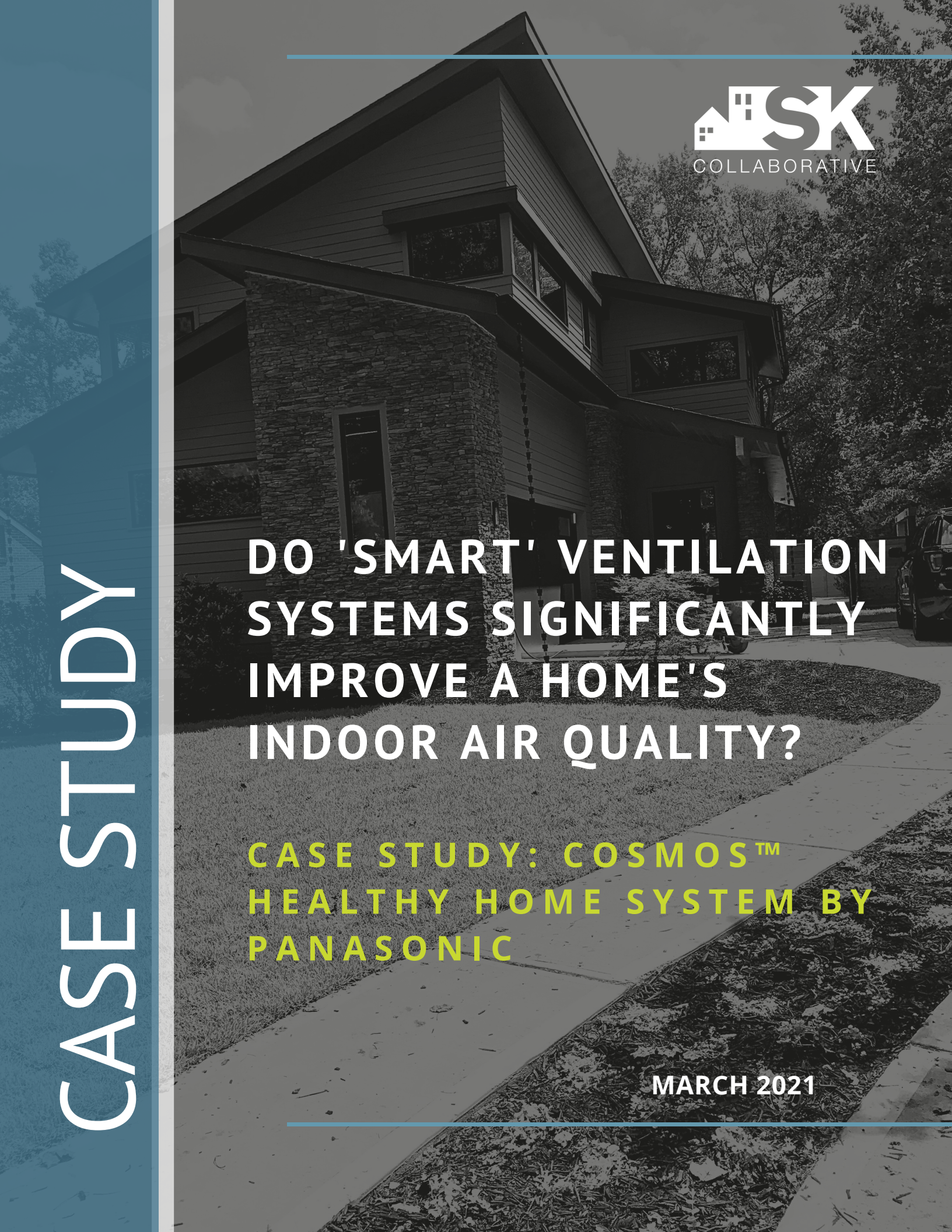
CASE STUDY



SK COLLABORATIVE

DO 'SMART' VENTILATION SYSTEMS SIGNIFICANTLY IMPROVE A HOME'S INDOOR AIR QUALITY?

CASE STUDY: COSMOS™ HEALTHY HOME SYSTEM BY PANASONIC

MARCH 2021

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Covid-19 has put indoor air quality, and specifically HVAC systems, front and center. While increasing the MERV filter is a good first step (as long as the system is designed for it), a next-step option is what's called a "smart" ventilation system. SMART is an acronym for “Self-Monitoring, Analysis and Reporting Technology;” in the case of home technology, it refers to interconnected sensors and devices that can perform tasks more autonomously than standard (non-smart) products. Smart ventilation systems use multiple fans and sensors to control contaminants such as volatile organic compounds, particulate matter, carbon dioxide, and humidity.

This case study presents the results of a pilot test of a new smart ventilation system - Panasonic’s Cosmos™ Healthy Home System.

BACKGROUND

Even before Covid-19, Americans spent an average of 90% of their time inside.[1] Most people don't realize the air they’re breathing is two to five (and occasionally up to 100) times more polluted than the outside air.[2] It took Covid to turn home air purification and ventilation improvement from a niche market to one of the fastest growing sectors of the HVAC industry, with new systems available from manufacturers such as Panasonic.

In February 2020, SK Collaborative collaborated with Leslie Dean Petosa, General Contractor at Arlene Dean Homes to pilot test Panasonic’s Cosmos™ Healthy Home System on her personal home under construction in Decatur, GA. Petosa’s residence was certified under the National Green Building Standard (NGBS). It was built to be extremely tight through careful duct and envelope air sealing so that the amount of conditioned air entering and leaving through cracks and gaps is minimal. While this is great for energy savings, it could be a problem without a high-quality, controlled-ventilation system.

“We were in a unique position due to our relationship with both Panasonic and the builder (Arlene Dean Homes) that we could provide direct support with the install and commissioning,” said Samantha Morton, Single Family Program Manager at SK Collaborative, who has worked with Petosa on other green certified homes. Petosa, SK Collaborative, and Panasonic hope to use the data collected to study how the system works in the long run.

"This information will provide Panasonic greater insight into its product, while giving the builder a greater understanding of the indoor air quality (IAQ) of her personal home and new tools to manage her investment. This data can also be used by her company to review how their normal construction practices perform as built," said Morton.

Arlene Dean Homes and SK Collaborative signage in front of Petosa residence.

THE AIR WE BREATHE: BY THE NUMBERS

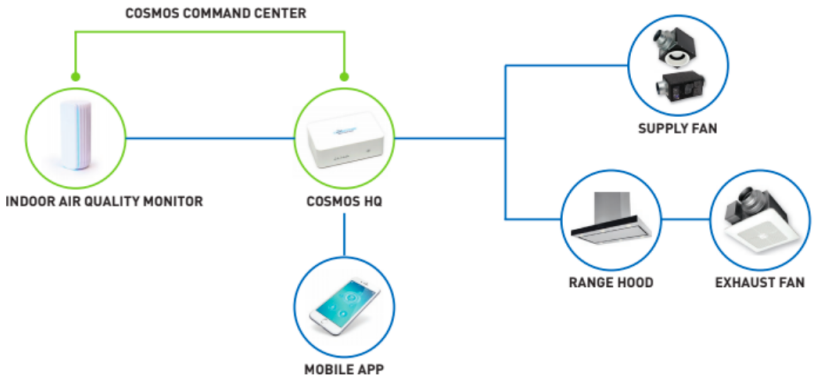
- Comparative risk studies performed by EPA's Science Advisory Board (SAB) consistently rank indoor air pollution among the top five environmental risks to public health."[3]
- The term "sick building syndrome" (SBS), was coined in the 1970s for symptoms reported by building occupants temporally associated with them being in that building.[4]
- Allergic diseases are among the major causes of illness and disability in the United States, affecting as many as 40-50 million Americans.[5]
- Studies have shown better air improves students' performance. The $900 billion Dec. 2020 Covid-19 stimulus bill included a $54.3 billion fund to help upgrade HVAC systems in K-12 schools, many of which harbor unhealthy learning environments."[6]

A 'SMART' APPROACH TO BETTER AIR FILTRATION

Cosmos™, a new indoor air system from Panasonic, "is the first system of its kind to actively monitor and optimize residential indoor air quality through the use of Panasonic ventilation products," said Darrin Cooke, Panasonic Southeast Construction Sales Representative. It uses a smart hub "control center", multiple sensors, and ventilation fans throughout the house to tackle four major air contaminants: volatile organic compounds, fine particulate matter, carbon dioxide, and humidity. From formaldehyde to pet dander to mold, the homeowner sets the air quality levels via a smartphone app, which Cosmos maintains throughout the house. If any of the contaminants exceed these levels, the system will automatically make adjustments by expelling the toxins and bringing in new, filtered replacement air.

- **Volatile Organic Compounds (VOCs)** - Potentially toxic gases emitted from furniture, carpeting, shower curtains, flooring, wood, paint and other common materials and cleaners. Repeated exposure to chemicals such as formaldehyde, ammonia, xylene, benzene, and trichloroethylene can result in both acute and chronic health issues, such as E/N/T irritation; headaches, loss of coordination and nausea; damage to the liver, kidney, and central nervous system; and certain types of cancer.
- **Particulate Matter 2.5 (PM2.5)** - Tiny particles or droplets less than 2.5 microns in width which travel through the air, into the respiratory tract and lungs. For comparison, the diameter of a human hair is 80-100 microns in size. Invisible to the human eye, fine particles suspended in the air can be absorbed deep into the lungs, bloodstream, and other organs, and cause chronic bronchitis, reduced lung function, and even increased rates of lung cancer and heart disease.[7] Common sources of particulate matter include cooking vapors, burning candles & oil lamps, fireplaces, and kerosene space heaters.
- **Carbon Dioxide (CO2)** - Build-up can occur due to occupants in the building, the outdoor fresh air entering the building, and combustion by-products such as idling vehicles in garages. Can cause issues with cognitive function, headaches, lack of energy, and toxicity at extreme concentrations.
- **Humidity & Moisture** - Moisture from hot showers, baths, and leaks can lead to airborne mold spores and mildew, which can be hazardous to humans. Moisture can also cause structural damage to the building and rust on the fixtures.

Cosmos IAQ monitor, range hood, and bath ventilation fan.



Cosmos system components and operation diagram.

The Cosmos system's customizable presets also let the user create personalized settings based on events. If there are visitors, the homeowner can adjust the settings to temporarily increase the fresh air and ventilation for the added volume of occupants.

Cosmos connects the home's ventilation components into a unified indoor air system. This "smart" setup allows the system to operate continuously and automatically on a holistic level. In theory, the homeowner only needs to use a phone to set the "scenes" or conditions for desired air quality and then the system does the rest. Components that are normally separate - like bath fans and a range hood - are interconnected and able to work together to reduce humidity and toxins.

In the Petosa residence, there are IAQ sensors located throughout the building, which monitor the level of indoor pollutants. The home is equipped with the Panasonic Whisper Range Hood, Panasonic Whisper Green bath fans, Panasonic Whisper Fresh supply fan, as well as the Panasonic Intelli-Balance ERV. The kitchen range hood, bath exhaust, and other fans all “talk” to one another to keep the air quality at optimal levels. While not directly connected to other system components, the smart ERV runs continuously and is able to self adjust to high speed when the bath is in use.

Cosmos HQ, component of system command center.

Energy efficient lighting fixtures in the Petosa Residence. Photo: Trevette Brown / Arlene Dean Homes.

VENTILATION 101: DIFFERENT AIR CHANGE METHODS

Historically, builders have used one of three types of ventilation to bring air in and out of a building: natural, mechanical, or a hybrid (a combination of both mechanical and natural). Natural ventilation brings air in and out of the building naturally via planned openings such as windows, doors, vents, etc. By contrast, mechanical ventilation relies on fans to supply or exhaust air into/out of a building using either a positive or negative pressure system. Balanced systems, like an Energy Recovery Ventilation (ERV) is a combination of supply and exhaust in a single piece of equipment.

Mechanical ventilation is the approach most commonly applied to modern day buildings. Within this broad category, there are several subsets of whole house ventilation:

OVERVIEW OF MECHANICAL VENTILATION SYSTEMS

Ventilation System	Description	Pros	Cons
Exhaust	Expels air from the house while replacement air infiltrates through leaks in the building's exterior or intentional, passive vents. Typically has a single fan connected to a centrally-located, single exhaust point in the house. Some designs connect the fan to ducts from several rooms.	• Relatively inexpensive and simple to install. • Works well in cold climates. • Often uses existing equipment like bath exhaust fans.	• Can draw pollutants into living space. • Not appropriate for hot humid climates. • Relies in part on random air leakage • Can increase heating and cooling costs. • May require mixing of outdoor and indoor air to avoid drafts in cold weather. • Can cause backdrafting in combustion appliances.
Supply	Uses a fan to pressurize the home, forcing outside air into the building while air leaks out of the building through holes in the shell, exhaust fan ducts, and intentional vents (if any exist). Typically, a duct is run from the exterior into the return plenum of the HVAC system with a mechanical damper at the exterior. A dedicated fan may be installed.	• Relatively inexpensive and simple to install. • Allows better control than exhaust systems. • Minimizes pollutants from outside living space. • Prevents backdrafting of combustion gases from fireplaces and appliances. • Allows filtering of pollen and dust in outdoor air. • Allows dehumidification of outdoor air • Works well in hot or mixed climates.	• Can cause moisture problems in cold climates. • Will not temper or remove moisture from incoming air. • Can increase heating and cooling costs. • May require mixing of outdoor and indoor air to avoid drafts in cold weather.
Balanced	If properly designed/installed, neither pressurizes nor depressurizes the home. Instead, introduces and exhausts equal quantities of fresh outside air and polluted indoor air. Typically has two fans and two duct systems.	• Appropriate for all climates.	• Can cost more to install and operate than exhaust or supply systems. • Will not temper or remove moisture from incoming air • Can increase heating and cooling costs.
Energy Recovery Ventilators (ERV) & Heat Recovery Ventilators (HRV)	A type of balanced ventilation. Both types include a heat exchanger, one or more fans, and controls. They may be central, whole-house systems with either their own duct system or shared ductwork, or a separate system with independent ductwork. With an energy- recovery ventilator, the heat exchanger transfers a certain amount of water vapor along with heat energy, while a heat-recovery ventilator only transfers heat.	• Lower energy penalty than other ventilation systems. • Available as both small wall-mounted models or central ventilation systems. • Cost-effective in climates with extreme winters or summers and high fuel costs. • Most units filter incoming outside air prior to distribution.	• Can cost more to install than other ventilation systems. • May not be cost-effective in mild climates. • May be difficult to find contractors with experience and expertise to install these systems. • Requires freeze and frost protection in cold climates. • Requires more maintenance than other ventilation systems.

(Adapted from U.S. Dept. of Energy's "Comparison of Whole-House Ventilation Systems", https://www.energy.gov/energysaver/weatherize/ventilation/whole-house-ventilation).

A SMARTER APPROACH TO VENTILATION?

Smart ventilation, as defined by the Air infiltration and Ventilation Centre, is a system that continually adjusts "to provide the desired IAQ benefits while minimizing energy consumption, utility bills and other non-IAQ costs (such as thermal discomfort or noise)."[8] Natural, mechanical, or hybrid systems can be made "smart" through automated sensors, timers, and other features that make the process more efficient. Cosmos, for example, is among the growing number of smart mechanical ventilation systems.

"Cosmos truly is 'smart' because it takes the homeowner out of the equation. It doesn't rely on them to monitor air quality manually and manage multiple systems," said Morton. It ventilates only when needed to minimize over-ventilation and maximize energy savings. It also solves the problem of increased humidity, a common reason builders are reluctant to integrate mechanical systems into buildings. Unlike systems that may bring in fresh, moisture-rich air directly from the outdoors, Cosmos can sense and automatically adapt the humidity levels to those optimal for occupant comfort and building durability.

"Before this house, I wasn't really a 'home automation girl,'" said Petosa. But she has become a fan of the ease and convenience it brings. "Most people just have one, maybe two HVAC filters. I have six. And they're reusable; just wash them out, dry them, and use them again."

"Cosmos truly is 'smart' because it takes the homeowner out of the equation. It doesn't rely on them to monitor air quality manually and manage multiple systems," - Samantha Morton, Single Family Program Manager, SK Collaborative

Cosmos by Panasonic - or any system - is not a panacea. As with any mechanical ventilation system, bringing in more outdoor air will also increase the energy needed to heat and cool that air. However, smart technology is making headway in this area. According to the Lawrence Berkeley National Laboratory, smart ventilation systems can cut energy demand by:

➢ Using sensors that control when ventilation occurs (e.g. prioritizing times of low inside/outside temperature difference),
➢ Accounting and compensating for other ventilation components (e.g. kitchen and bathroom exhaust fans, clothes dryers),
➢ Decreasing air flow when building is unoccupied,
➢ Ventilating more/less at varying times to maximize efficiency (e.g. operating more when the air outside is cleaner and less when it is more polluted).[9]

RESULTS: TESTING THE SYSTEM

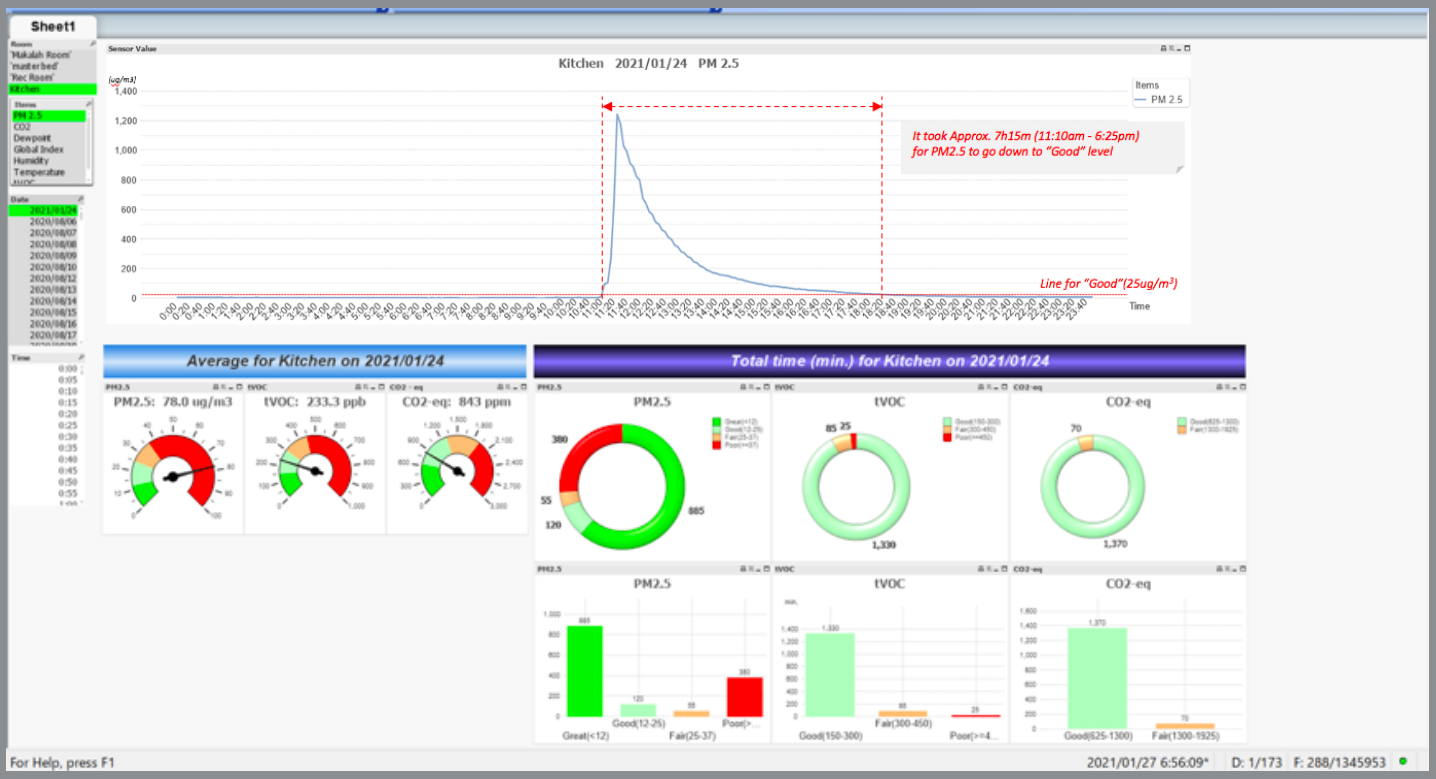
Kitchen and dining room, Petosa Residence. Photo: Trevette Brown / Arlene Dean Homes.

To test the system, Morton and Petosa ran a simple experiment: cooking bacon with and without Cosmos running. Cooking has the potential to release many harmful toxins into the home. Foods like bacon, which are high in fat and lose water quickly, are especially prone to high emissivity of fine particulate matter.

The test was conducted over the course of two days and measured the total Particulate Matter 2.5 (PM2.5) in the air before, during, and after cooking. This data was used to determine the total amount of time it took for the air to return to "good" PM2.5 conditions (25ug/m3).

On the first day, the Cosmos was turned off during the experiment to create a performance baseline. The team turned it back on for the second day of the cooking test.

Fig. 2. Kitchen IAQ Without Cosmos System in Operation (Baseline)



RESULTS: TESTING THE SYSTEM (CONT.)

Fig. 3. Kitchen IAQ With Cosmos System in Operation

As an added variable for analysis, Morton and Petosa performed the bacon cooking twice concurrently on the second day. This additional data established an average and showed consistency between the first and second intervals.

Interestingly, the Day 1 data indicated that it took a total of approximately 7 hours and 15 minutes for the PM2.5 level to return to acceptable conditions without the Cosmos system in operation. On Day 2, with Cosmos running, it only took an average of 58 minutes for each cooking event for the PM2.5 to return to the appropriate level.

In other words, without needing to make manual adjustments, Cosmos was able to restore the healthy PM2.5 levels 6 hours and 18 minutes - or 7.5 times - faster than the typical (non-Cosmos) return rate.

Cosmos IAQ Monitor. Photo: Trevette Brown / Arlene Dean Homes.

LESSONS LEARNED (SO FAR)

While the end product is a very satisfactory system, setup and testing had its challenges. During the install, we experienced issues with the range hood connectivity, bath fans requiring multiple electrician trips, a data backlog in the hub, and a few defective modules. Although we expected the IAQ sensors to be preset, we learned that they required manual inputs that were complicated to establish. Additionally, the current generation of Cosmos does not allow for smart integration with the ERV system -- an important piece we hope to see in future iterations.

However, once the system was up and operational, we found it to be extremely effective at achieving desired goals of indoor air quality. In the case of the two day cooking experiment, the system required 750% less time to return the PM2.5 rates back to healthy levels than cooking without it operating. Once installed, Cosmos performed as expected, automatically adjusting IAQ levels without the need for manual intervention or the risk of human error.

The newness of the system coupled with COVID-19 restrictions meant an increased need for technical assistance, but decreased availability of onsite support. And manufacturers like Panasonic don't typically perform the actual install. This raises an important question of who does or should install the system? In this pilot project, SK Collaborative - as an extension of its green building consulting services - was able to support the builder with the system installation. With the growing availability of smart ventilation technology, we see a need for third-party installers who can implement the system. Similarly, we predict a corresponding need for system experts who can help guide the homeowner and/or builder with the initial setup of the system and assist with troubleshooting the inevitable IAQ problems that are uncovered.

SK Collaborative finds Panasonic's Cosmos™ Healthy Home System a solid choice in the expanding market for smart ventilation systems. We'll continue to monitor the Petosa residence pilot system and report back on it as well as other new products (and jobs) in the growing healthy home market.

SK Collaborative applies proven green building techniques to real-life situations. We work with developers, builders, remodelers, contractors, and architects to identify cost-effective techniques that can help earn financial incentives through tax credits, utility rebates and financing discount programs. Our services range from consulting, design reviews and charrettes to envelope sealing inspections, testing, training, and building certification under LEED, EarthCraft, National Green Building Standard, ENERGY STAR, Enterprise Green Communities, FitWel, and Green Globes. SK Collaborative is your one stop resource in Making Buildings Better.

Arlene Dean Homes specializes in custom new home construction, green-building, and residential remodeling in Decatur, Georgia and other Atlanta neighborhoods. Arlene Dean lives among the Decatur homes she's built over nearly twenty years – a vibrant streetscape embracing historic Craftsman bungalows and flat-roof contemporary homes alike – and she demonstrates a steadfast commitment to homeowners and the community. The unique mother-daughter general contractor team, Arlene Dean and Leslie Petosa, are hands-on, visiting each job site daily to ensure smooth progress and quickly address any concerns. They bring a detailed eye and proactive approach to each project. By choosing the most desirable neighborhoods, the right design professionals, topnotch contractors, and quality materials, Arlene Dean provides uncommon value relative to comparably priced homes.

Panasonic System Solutions Company of North America, a division of Panasonic Corporation of North America, delivers game-changing technology solutions that gives customized experiences to drive better outcomes—for our customers and our customers' customers. Panasonic designs and manufactures reliable, flexible and dependable products and solutions to help create, capture and deliver information of all types, especially where, when and how it is needed. The complete suite of Panasonic professional solutions for government and commercial enterprises of all sizes addresses unified business communications, mobile computing, security and surveillance, retail point-of-sale, office productivity, audio and visual systems (projectors, displays & digital signage) and professional video production.

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