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## **PURDUE'S BIOWALL**

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## PURDUE'S BIOWALL

### THE NEED

Indoor air quality is a serious issue in buildings, particularly for newer energy efficient designs that are air tight and limit interactions with fresh outdoor air. It is difficult to balance the desire for energy conservation with the need to maintain a healthy indoor environment. The Environmental Protection Agency (EPA) classifies indoor air quality as one of the top health concerns in the U.S. According to experts from Lawrence Berkeley National Laboratory, asthma, Sick Building Syndrome (SBS), allergies, and other respiratory illnesses are highly associated with poor indoor environments. Health risks are not the only problem; polluted indoor air was also found to negatively affect productivity, costing the U.S. up to \$150 billion a year.

Mechanical ventilation, energy recovery ventilation, and infiltration (air that leaks into a building) are commonly used to introduce fresh air. These are all valid approaches, but a living plant-based filter is an innovative complement to these traditional technologies. A Biowall has the potential to improve indoor air quality while reducing the quantity of air needed for ventilation, creating the potential for energy savings. Figure 1 shows a Biowall prototype being evaluated in the ReNEWW House, a research home located near the Purdue University campus (<http://www.renewhouse.com/>).



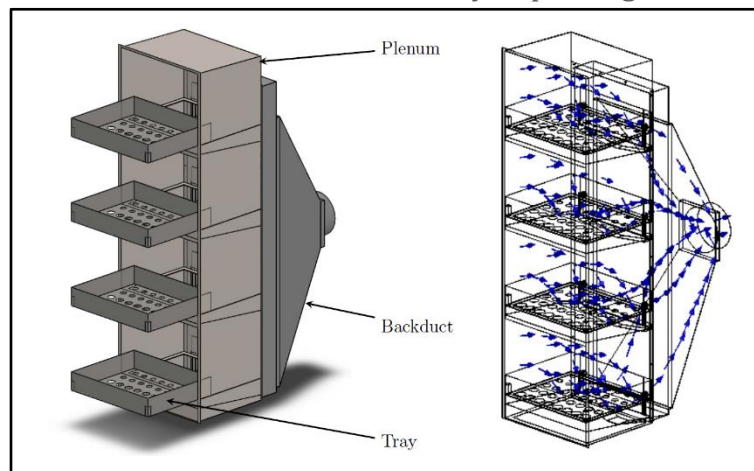
FIGURE 1 A BIOWALL IS BEING EVALUATED IN THE RENEWW HOUSE



## THE TECHNOLOGY

The Biowall ([www.purdue.edu/biowall](http://www.purdue.edu/biowall)) is a novel botanical air filtration system being developed and commercialized to improve indoor air quality in buildings. The current version of the device integrates with the central heating and cooling system of a home and leverages the natural ability of plants to metabolize airborne contaminants to sustainably improve indoor air quality.

The Biowall structure and its airflow pattern in the ReNEWW House are shown in Figure 2. It consists of several trays of plants that are open to the living area of a home. The device is connected to the return air ductwork, which results in air being drawn through the plant foliage and roots. Microorganisms associated with the plants break down contaminants in the air, thereby improving indoor air quality.



**FIGURE 2 BIOWALL STRUCTURE AND AIRFLOW PATTERN**

### *WHAT NEED DOES IT ADDRESS?*

A Biowall improves indoor air quality by removing Volatile Organic Compounds (VOCs) that are emitted from many household products and construction materials. VOC's are very common in nature, but VOC's that are created as a by-product of human activity can be harmful. Adhesives and paint emit toluene and benzene, while new clothing and carpets off-gas formaldehyde, and these are just some of the examples of VOCs found in buildings.

A Biowall also addresses a more fundamental human need by working in harmony with nature. The plants in a Biowall are an appealing visual display that are an integral part of the functionality of the home. The sustainability component of a Biowall is one of its key selling points.



### ***HOW DOES IT ADDRESS THE NEED?***

Biofiltration uses microorganisms associated with the root structures of plants to break down contaminants in the air, thereby improving indoor air quality. This technology has its “roots” in earlier research conducted by NASA in support of deep-space travel. In the 1980s NASA researcher Bill Wolverton quantified the VOC-removal potential of various plant species. More studies have been conducted to expand this research, but the psychological and particulate aspects were not investigated until Alan Darlington found biofilters that could improve employee morale without introducing an abundance of allergens. Several companies have introduced versions of a Biowall that target larger commercial spaces. The Purdue Biowall is unique because it targets residences, where homeowners will have an active interaction with the device.

### **THE BENEFITS**

Purdue’s Biowall has several attractive and unique features:

- It targets Indoor Air Quality problems that have been increasing due to 1) air pollution and 2) energy efficient spaces that limit interactions with the outdoors
- It integrates with the central HVAC system of a home so that a single strategically located Biowall can have a beneficial impact IAQ throughout the space
- It leverages natural and sustainable characteristics of plants to improve IAQ without a mechanical filter
- It adds an appealing natural aesthetic to a home, with the potential for using different plant varieties to achieve seasonally appropriate color patterns
- It gives the homeowner a stake in the control and management of comfort and health in their living space

### **STATUS**

Purdue’s first Biowall was displayed in 2011, when a student team built a net-zero home for the Solar Decathlon competition. Figure 3 shows the external view of the home to the left and the installed Biowall to the right. The Biowall was a tremendous success with more than 20,000 people who toured the house. That public support encouraged the research team to continue investigating and improving this device.



Figure 3. Purdue's 2011 net zero energy home featuring a Biowall.

Starting in 2013, the Biowall research was moved to the Applied Energy Laboratory, where an environmental chamber is available for more controlled testing. Figure 4 shows a test apparatus used to evaluate growth media, measure VOC removal, and develop control strategies to optimize plant health. The insert in Figure 4 shows the Spider Plants, Golden Pothos, and English Ivy that were grown.



Figure 4. Biowall test apparatus in an environmental chamber.

Since 2016, a full scale Biowall has been installed and evaluated in the RENEWW house , a research home sponsored by Whirlpool Corporation and located close to the Purdue University campus. This field demonstration is allowing further refinement of the Biowall device in terms of optimizing lighting, watering, and air flow. This field demonstration is also generating interest from potential partners with an interest in commercializing this device.



## BARRIERS

The potential barriers to full scale commercialization include:

- A field demonstration that conclusively demonstrates a Biowall's positive impact on residential IAQ.
- A lack of performance-based standards for Indoor Air Quality that allow for devices like a Biowall.
- A lack of recognition by code officials who review, inspect, and improve building plans and construction.
- The lack of a commercialization partner with a distribution network for selling, installing, and maintaining Biowalls.

## POINTS OF CONTACT

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